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CBSE BOARD
CLASS XII
SOLVED PAPER 2020

# CHEMISTRY today

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JEE (Main & Advanced) & NEET

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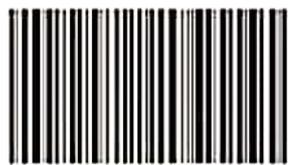
CONCEPT MAP

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JEE MAIN
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TEST DRIVE
CLASS XI-XII

# CHEMISTRY today

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# CHEMISTRY MUSING

Chemistry Musing was started from August '13 issue of Chemistry Today. The aim of Chemistry Musing is to augment the chances of bright students preparing for JEE (Main and Advanced) / NEET with additional study material.

In every issue of Chemistry Today, 10 challenging problems are proposed in various topics of JEE (Main and Advanced) / NEET. The detailed solutions of these problems will be published in next issue of Chemistry Today.

The readers who have solved five or more problems may send their solutions. The names of those who send atleast five correct solutions will be published in the next issue. We hope that our readers will enrich their problem solving skills through "Chemistry Musing" and stand in better stead while facing the competitive exams.

## JEE MAIN/NEET

**1.** $X$, $Y$ and $Z$ in the following reactions sequence are

$$X \xrightarrow{\text{Br}_2 \text{ water}} \text{Decolourisation}$$

$$X \downarrow \text{Conc. } H_2SO_4$$

Addition product

$$X \xrightarrow{HBr} Y \xrightarrow{NaOH} Z \xrightarrow{[O]} CH_3CH_2CH_2-\overset{\overset{\displaystyle O}{\|}}{C}-CH_2CH_3$$

(a) $X = CH_3CH_2CH=CHCH_3$,
$Y = CH_3CH_2CH(Br)CH(Br)CH_2CH_3$,
$Z = CH_3CH_2CH_3$
(b) $X = CH_3CH=CHCH_3$,
$Y = CH_3CH(Br)CH(Br)CH_3$,
$Z = CH_3CH_2CH_2OH$
(c) $X = CH_3CH_2CH=CHCH_2CH_3$,
$Y = CH_3CH_2\underset{\underset{\displaystyle Br}{|}}{C}HCH_2CH_2CH_3$,
$Z = CH_3CH_2CH_2\underset{\underset{\displaystyle OH}{|}}{C}HCH_2CH_3$
(d) $X = CH_3CH_2CH_2CH=CHCH_3$,
$Y = CH_3CH_2CH_2CH_2CH_2CH_2Br$,
$Z = CH_3CH_2CH_2CH_2OH$
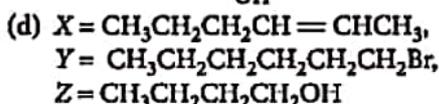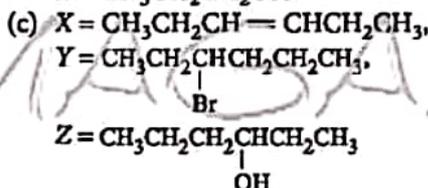
**2.** A colourless mixture of two compounds 'A' and 'B' (in excess) is soluble in $H_2O$. 'A' turns blue litmus red and 'B' turns red litmus blue. 'A' gives white precipitate with 'B' which dissolves in excess of 'B' forming 'C'. 'A' when placed in moist air atmosphere gives fumes and can form dimer. 'A' gives white precipitate with $NH_4Cl$ and $NH_4OH$ which is soluble in 'B'. 'A', 'B' and 'C' respectively are
(a) AgCl, KOH and KCl
(b) $AlCl_3$, NaOH and $NaAlO_2$
(c) $PbCl_2$, KOH and $Al(OH)_3$
(d) $MgCl_2$, NaH and $NaAlO_2$

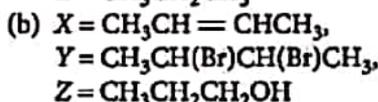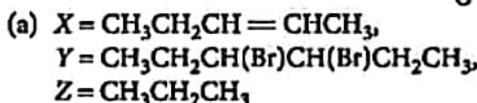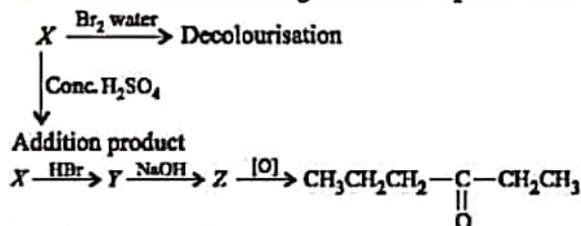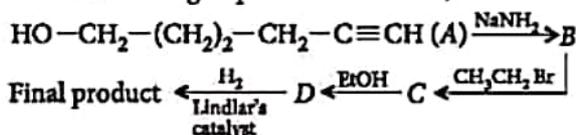**3.** Select reagents and conditions from the following list, and choose the correct option listing them in the order to convert ethyl 3-oxobutanoate to ethyl 4-oxopentanoate.

(1) Sodium ethoxide in ethanol
(2) Ethanol + Acid catalyst
(3) $H_3O^+$; Heat
(4) $CO_2$ then $H_3O^+$
(5) Mg in ether
(6) $PBr_3$
(7) $NaBH_4$ in alcohol
(8) $CH_2I_2$ in ether; Zn – Cu
(9) $BrCH_2COOC_2H_5$
(10) $(CH_3CO)_2O$; Pyridine
(a) 1, 9, 3, then 2
(b) 7, 6, 5, 10, then 2
(c) 3, 7, 6, 5, 10, then 2
(d) 8, 3, then 2

**4.** For the following sequence of reactions,

$$HO-CH_2-(CH_2)_2-CH_2-C\equiv CH \; (A) \xrightarrow{NaNH_2} B$$

$$\text{Final product} \xleftarrow[\text{Lindlar's catalyst}]{H_2} D \xleftarrow{EtOH} C \xleftarrow{CH_3CH_2Br} |$$

If $A$ is treated with excess of $NaNH_2$, then final product will be $X$ and if $A$ is treated with only one equivalent of $NaNH_2$, then final product will be $Y$. (Remaining reagents are reacted as indicated in both the cases). Which of the following justify $X$ and $Y$ correctly?
(a) $X$ and $Y$ both are same molecules but $X$ will be in higher yield.
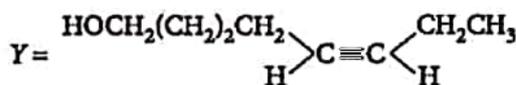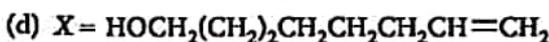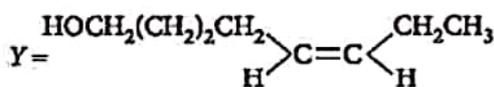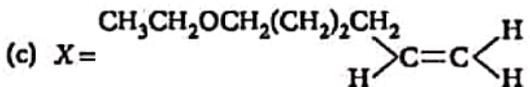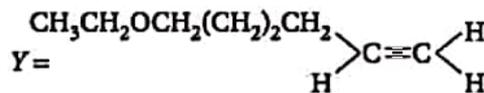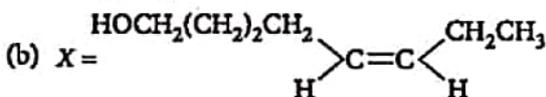
(b) $X = \underset{H}{\overset{HOCH_2(CH_2)_2CH_2}{>}}C=C\underset{H}{\overset{CH_2CH_3}{<}}$
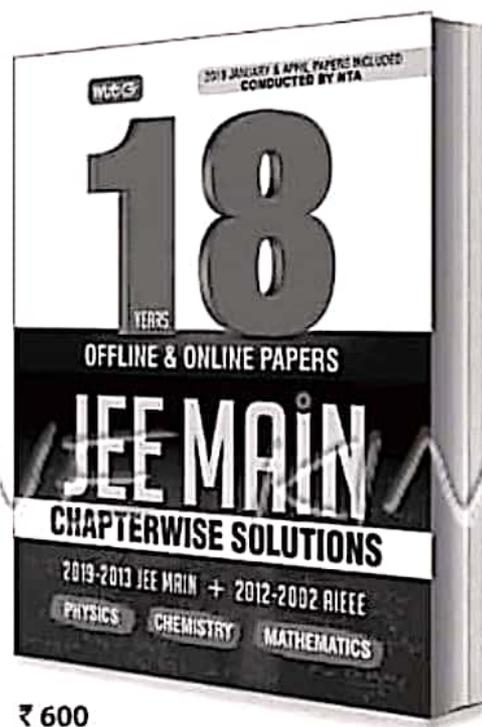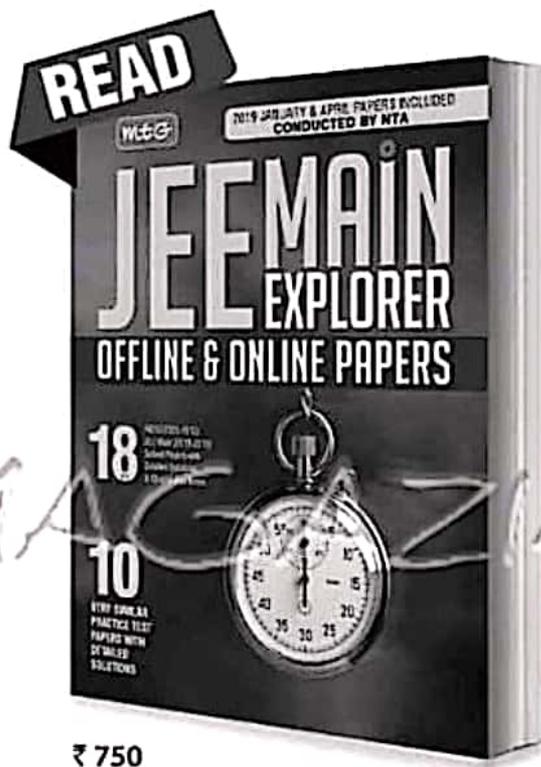
$Y = \underset{H}{\overset{CH_3CH_2OCH_2(CH_2)_2CH_2}{>}}C=C\underset{H}{\overset{H}{<}}$

(c) $X = \underset{H}{\overset{CH_3CH_2OCH_2(CH_2)_2CH_2}{>}}C=C\underset{H}{\overset{H}{<}}$

$Y = \underset{H}{\overset{HOCH_2(CH_2)_2CH_2}{>}}C=C\underset{H}{\overset{CH_2CH_3}{<}}$

(d) $X = HOCH_2(CH_2)_2CH_2CH_2CH=CH_2$

$Y = \underset{H}{\overset{HOCH_2(CH_2)_2CH_2}{>}}C\equiv C\underset{H}{\overset{CH_2CH_3}{<}}$

5. Consider the following sequence of reactions,

$$P_4 \xrightarrow[\text{salt}]{Ba(OH)_2/\Delta} A \xrightarrow{H_2SO_4} B(\text{oxoacid}) \xrightarrow{\Delta} C_{(\text{oxoacid})}$$

$$C_{(\text{oxoacid})} \begin{cases} \xrightarrow{250°C} (\text{oxoacid}) & Y \\ & \downarrow 600°C \\ \xrightarrow{600°C} (\text{oxoacid}) & Z \end{cases}$$
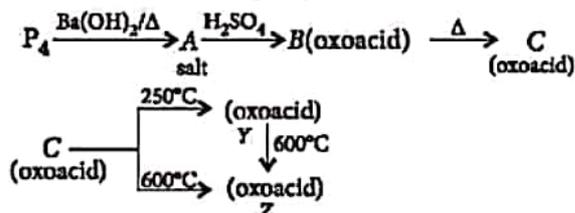
In the above sequence of reactions C and Z are respectively
(a) $H_3PO_2$ and $H_3PO_4$ (b) $H_3PO_4$ and $H_4P_2O_7$
(c) $H_3PO_4$ and $HPO_3$ (d) $H_3PO_3$ and $H_3PO_4$

6. 1 mole of an ideal gas $A$ ($C_{v,m} = 3R$) and 2 moles of an ideal gas $B$ are $\left( C_{v,m} = \dfrac{3}{2}R \right)$ taken in a container and expanded reversibly and adiabatically from 1 litre to 4 litres starting from initial temperature of 320 K. $\Delta U$ for the process is
(a) $-240\,R$ (b) $240\,R$
(c) $480\,R$ (d) $-960\,R$.

Tollens' reagent is used for the detection of aldehyde when a solution of $AgNO_3$ is added to glucose with $NH_4OH$ then gluconic acid is formed.

$Ag^+ + e^- \longrightarrow Ag;\ E^°_{red} = 0.8\ V$

$C_6H_{12}O_6 + H_2O \longrightarrow$ Gluconic acid $+ 2H^+ + 2e^-$;
$(C_6H_{12}O_7)$    $E^°_{oxd} = -0.05\ V$

$[Ag(NH_3)_2]^+ + e^- \longrightarrow Ag_{(s)} + 2NH_3;\ E^°_{red} = 0.337\ V$
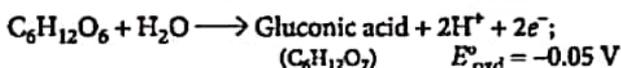
[Given : $2.303 \times RT/F = -0.0591$ and $F/RT = 38.92$ at 298 K]

7. When ammonia is added to the solution, pH is raised to 11. Which half-cell reaction is affected by pH and by how much?
(a) $E_{oxd}$ will increase by a factor of 0.65 from $E^°_{oxd}$.
(b) $E_{oxd}$ will decrease by a factor of 0.65 from $E^°_{oxd}$.
(c) $E_{red}$ will increase by a factor of 0.65 from $E^°_{red}$.
(d) $E_{red}$ will decrease by a factor of 0.65 from $E^°_{red}$.

8. Ammonia is always added in this reaction. Which of the following must be incorrect?
(a) $NH_3$ combines with $Ag^+$ to form a complex.
(b) $[Ag(NH_3)_2]^+$ is a stronger oxidising agent than $Ag^+$.
(c) In absence of $NH_3$ silver salt of gluconic acid is formed.
(d) $NH_3$ has affected the standard reduction potential of glucose/gluconic acid electrode.

9. Hydroxylamine reduces iron(III) according to the equation,

$2NH_2OH + 4Fe^{3+} \rightarrow N_2O\uparrow + H_2O + 4Fe^{2+} + 4H^+$

Iron(II) thus produced is estimated by titration with a standard permanganate solution. The reaction is,

$MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$

A 10 mL sample of hydroxylamine solution was diluted to 1 litre. 50 mL of this diluted solution was boiled with an excess of iron(III) solution. The resulting solution required 12 mL of 0.02 M $KMnO_4$ solution for complete oxidation of iron(II). The weight of hydroxylamine in one litre of the original solution is _____.
$(H = 1, N = 14, O = 16, K = 39, Mn = 55, Fe = 56)$

10. In a certain reaction, $B^{n+}$ is getting converted to $B^{(n+4)+}$ in solution. The rate constant of this reaction is measured by titrating a volume of the solution with a reducing agent which reacts only with $B^{n+}$ and $B^{(n+4)+}$. In the process, it converts $B^{n+}$ to $B^{(n+2)+}$ and $B^{(n+4)+}$ to $B^{(n-1)+}$. At $t = 0$, the volume of the reagent consumed is 25 mL and at $t = 10$ minutes, the volume used is 32 mL. The rate constant for the conversion of $B^{n+}$ to $B^{(n+4)+}$ is found out in the form of $x \times 10^{-2}$ min$^{-1}$. The value of $x$ is _____.
(Assuming it to be a first order reaction.)

# GEAR UP FOR JEE MAIN 2020

### with Numerical Value Type Questions

1. The compound used for the preparation of $UF_6$ in the enrichment of $^{235}_{92}U$ is
   (a) $AlF_3$  (b) $CaF_2$  (c) HF  (d) $ClF_3$

2. The turbidity of a polymer solution measures
   (a) light absorbed by solution
   (b) light transmitted by the solution
   (c) light scattered by the solution
   (d) none of the above.

3. 8 mol of a gas $AB_3$ are introduced into a 1.0 $dm^3$ vessel. It dissociates as, $2AB_{3(g)} \rightleftharpoons A_{2(g)} + 3B_{2(g)}$
   At equilibrium, 2 mol of $A_2$ is found to be present. The equilibrium constant for the reaction is
   (a) 2 $mol^2\ L^{-2}$  (b) 3 $mol^2\ L^{-2}$
   (c) 27 $mol^2\ L^{-2}$  (d) 36 $mol^2\ L^{-2}$.

4. For a $P$-$V$ diagram shown below,
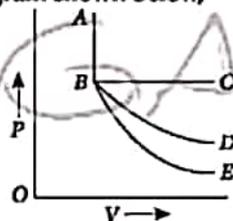
   

   Which of the following options is correct?
   (a) $AB$ represents adiabatic process.
   (b) $AB$ represents isothermal process.
   (c) $AB$ represents isobaric process.
   (d) $AB$ represents isochoric process.

5. Chile saltpetre is the ore of
   (a) Ca  (b) Na  (c) Mg  (d) K

6. The correct decreasing order of acidic characters of the following is

   I.  CH≡CH   II.    III. 
   (a) I > II > III       (b) II > I > III
   (c) III > II > I       (d) I > III > II

7. Tetraethyl lead (TEL) in petrol was used as anti-knocking agent, which creates lead pollution. In order to avoid lead pollution, the substituent of TEL is used in unleaded-petrol. The substituent is denoted as
   (a) AK–33–X       (b) BK–33–X
   (c) CK–33–X       (d) DK–33–X

8. A hydrocarbon of formula, $C_6H_{10}$ absorbs only one molecule of $H_2$ upon catalytic hydrogenation. Upon ozonolysis, the hydrocarbon yields a compound of the following structure,

   

   The hydrocarbon is
   (a) cyclohexane       (b) cyclohexyne
   (c) cyclohexene       (d) cyclobutane.

9. Functionally active form of vitamin D is
   (a) cholecalciferol       (b) ergocalciferol
   (c) dehydrocholesterol   (d) calcitriol.

10. Milk turns sour at 40°C three times as faster as at 0°C. The energy of activation for souring of milk is
    (a) 4.694 kcal       (b) 2.605 kcal
    (c) 6.623 kcal       (d) none of these.

11. Which of the following molecules is most suitable to disperse benzene in water?

    (a) 

    (b) 

    (c) 

    (d) 
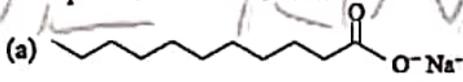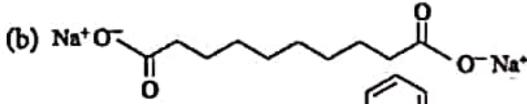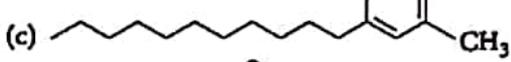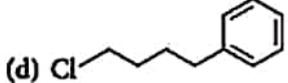
12. Two ionic solids $AB$ and $CB$ crystallise in the same lattice. If $\frac{r_{A^+}}{r_{B^-}}$ and $\frac{r_{C^+}}{r_{B^-}}$ are 0.50 and 0.70, respectively then the ratio of edge length of $AB$ and $CB$ is
    (a) 0.68  (b) 0.78  (c) 0.88  (d) 0.98

13. The hybridisation, oxidation number of central metal ion and shape of Wilkinson's catalyst are
    (a) $dsp^2$, +1, square planar
    (b) $sp^3$, +4, tetrahedral
    (c) $sp^3d$, +2, trigonal bipyramidal
    (d) $d^2sp^3$, +6, octahedral.

14. If $x_M$, $x_P$, and $x_V$ are mole fraction, pressure fraction and volume fraction respectively of a gaseous mixture, then which of the following relations is correct?

    (a) $x_M = \dfrac{1}{x_P} \times \dfrac{1}{x_V}$ 

    (b) $\dfrac{1}{x_M} = x_P = \dfrac{1}{x_V}$

    (c) $x_M = x_P \times x_V$ 

    (d) $\dfrac{1}{x_P} = \dfrac{1}{x_M} = \dfrac{1}{x_V}$

15. What is the value of effective nuclear charge for $4s$ electron of zinc atom?

    (a) 23.65    (b) 21.15    (c) 4.35    (d) 8.85

16. Mercury sticks to the surface of the glass when it comes in contact with

    (a) $Hg_2O$    (b) $HNO_3$    (c) $O_3$    (d) grease.

17. In the following reactions sequence, X is

    $X \xrightarrow{\text{Bromination}} Y \xrightarrow{\text{NaNO}_2/\text{HCl}} Z \xrightarrow[\text{C}_2\text{H}_5\text{OH}]{\text{Boiling}} \downarrow$

    $\text{Sym -tribromobenzene}$

    (a) benzoic acid
    (b) salicylic acid
    (c) phenol
    (d) aniline.

18. Roasted gold ore $+ CN^- + H_2O \xrightarrow{O_2} [X] + OH^-$

    $[X] + Zn \longrightarrow [Y] + Au$

    [X] and [Y] respectively are

    (a) $X = [Au(CN)_2]^-$ ; $Y = [Zn(CN)_4]^{2-}$
    (b) $X = [Au(CN)_4]^{3-}$ ; $Y = [Zn(CN)_4]^{2-}$
    (c) $X = [Au(CN)_2]^-$ ; $Y = [Zn(CN)_6]^{4-}$
    (d) $X = [Au(CN)_4]^{3-}$ ; $Y = [Zn(CN)_6]^{4-}$

19. In the following reactions sequence, T is

    $\text{Glycerol} \xrightarrow{\text{HCl}} P \xrightarrow{[\text{O}]} Q \xrightarrow{\text{HCN}} R \xrightarrow{\text{KCN}_{(alc.)}} S \xrightarrow{\text{H}_2\text{O}/\text{H}^+} T$

    (a) citric acid
    (b) ascorbic acid
    (c) tartaric acid
    (d) saccharic acid.

20. An ester (A) with molecular formula, $C_9H_{10}O_2$ was treated with excess of $CH_3MgBr$ and the compound so formed was treated with conc. $H_2SO_4$ to form olefin (B). Ozonolysis of (B) gave ketone with formula, $C_8H_8O$ which shows positive iodoform test. The structure of (A) is

    (a) $C_6H_5COOC_2H_5$
    (b) $CH_3OCH_2COC_6H_5$
    (c) $CH_3CO-C_6H_4-COCH_3$
    (d) $C_6H_5COOC_6H_5$

### NUMERICAL VALUE TYPE

21. Equal weights of ethane and hydrogen are mixed in an empty vessel at 25°C. The fraction of the total pressure exerted by hydrogen is _____.

22. 19 g fused $SnCl_2$ was electrolysed using inert electrodes. 0.119 g Sn was deposited at cathode. If nothing was given out during electrolysis, the ratio of mass of $SnCl_2$ and $SnCl_4$ in fused state after electrolysis is _____.

23. The freezing point of 0.02 mole fraction of acetic acid in benzene is 277.4 K. Acetic acid exists as a dimer. Freezing point of benzene is 278.4 K and heat of fusion of benzene is 10.042 kJ mol$^{-1}$. The equilibrium constant for dimerisation is _____.

24. A stationary $He^+$ ion emitted a photon corresponding to the first line of the Lyman series. That photon liberated a photoelectron from a stationary H-atom in ground state. The velocity of photoelectron is $x \times 10^8$ cm sec$^{-1}$ then the value of $x$ is _____.
    ($R_H = 109678$ cm$^{-1}$)

25. The H—O—H bond angle in the water molecule is 105°, the H—O bond distance being 0.94 Å. The dipole moment for the molecule is 1.85 D. The charge on the oxygen atom is $x \times 10^{-10}$ esu-cm then the value of $x$ is _____.

#########

### SOLUTIONS

1. **(d)**: $ClF_3$ is used for preparation of $UF_6$ in the enrichment of $^{235}_{92}U$.
   $U_{(s)} + 3ClF_{3(l)} \longrightarrow UF_{6(g)} + 3ClF_{(g)}$

2. **(c)**

3. **(c)** :

   $$2AB_{3(g)} \rightleftharpoons A_{2(g)} + 3B_{2(g)}$$

   Initial: 8, 0, 0
   At eq.: $\dfrac{8-2x}{1}$, $\dfrac{x}{1}$, $\dfrac{3x}{1}$

   Since, volume $= 1$ dm$^3 = 1$ L
   At eq. $[A_2] = 2$ mol $= x$
   $\therefore [AB_3] = 8 - 2 \times 2 = 4$ M
   $[A_2] = 2$ M
   $[B_2] = 3 \times 2 = 6$ M

   $$K = \dfrac{[B_2]^3 [A_2]}{[AB_3]^2} = \dfrac{6 \times 6 \times 6 \times 2}{4 \times 4} = 27 \text{ mol}^2 \text{ L}^{-2}$$

4. **(d)** : In AB process, volume does not change hence, it is isochoric process.

5. **(b)**        6. **(b)**

7. **(a)** : AK–33–X ; its chemical name is cyclopentadienylmanganese tricarbonyl.

8. **(c)**        9. **(d)**

10. **(a)** : $T_1 = 0°C = 273$ K ; Rate constant $= k_1$
    $T_2 = 40°C = 40 + 273 = 313$ K, $k_2 = 3k_1$

$$\log \frac{k_2}{k_1} = \frac{E_a}{2.303R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$$\Rightarrow \log \frac{3k_1}{k_1} = \frac{E_a}{2.303 \times 2}\left(\frac{1}{273} - \frac{1}{313}\right)$$

$$E_a = \frac{273 \times 313}{40} \times 2.303 \times 2 \times \log 3$$

$$= 4694 \text{ cal} = 4.694 \text{ kcal}$$

**11. (c)**

**12. (c) :** $\dfrac{r_{A^+}}{r_{B^-}} = 0.50$ and $\dfrac{r_{C^+}}{r_{B^-}} = 0.70$

$$\Rightarrow \frac{r_{A^+} + r_{B^-}}{r_{B^-}} = 1 + 0.5 = 1.5$$

Similarly, $\dfrac{r_{C^+} + r_{B^-}}{r_{B^-}} = 1.70$ ∴ $\dfrac{r_{A^+} + r_{B^-}}{r_{C^+} + r_{B^-}} = \dfrac{1.5}{1.70} = 0.88$

Also, $a_{AB} = 2(r_{A^+} + r_{B^-})$ and $a_{CB} = 2(r_{C^+} + r_{B^-})$

∴ $\dfrac{a_{AB}}{a_{CB}} = \dfrac{1.5}{1.70} = 0.88$

**13. (a)**

**14. (c) :** $x_M = \dfrac{n_1}{n_T}$; $n_1$ = Moles of one gas,

$n_T$ = Total no. of moles of mixture of gases

$x_P = \dfrac{P_1}{P_T}$; $\begin{cases} P_1 = \text{Pressure of one gas} \\ P_T = \text{Total pressure of mixture of gases} \end{cases}$

$x_V = \dfrac{V_1}{V_T}$; $\begin{cases} V_1 = \text{Volume of one gas}; \\ V_T = \text{Total volume of mixture of gases} \end{cases}$

According to gas equation,

$P_1 V_1 = n_1 RT$ ...(i)

and, $P_T V_T = n_T RT$ ...(ii)

From eqns. (i) and (ii), we get

$n_1 = \dfrac{P_1 V_1}{RT}$ ...(iii)   $n_T = \dfrac{P_T V_T}{RT}$ ...(iv)

Divide eqn. (iii) by eqn. (iv),

$$\frac{n_1}{n_T} = x_M = \frac{P_1 V_1 \times RT}{RT \times P_T V_T} = \frac{P_1}{P_T} \times \frac{V_1}{V_T} = x_P \times x_V$$

∴ $x_M = x_P \times x_V$

**15. (c) :** For Zn (Z = 30): $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2$
For 4s electron :
1 electron shields from the same group,
18 electrons shield from the penultimate shell,
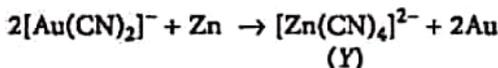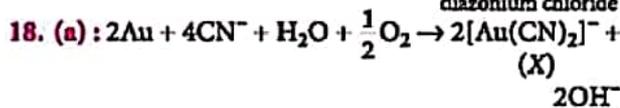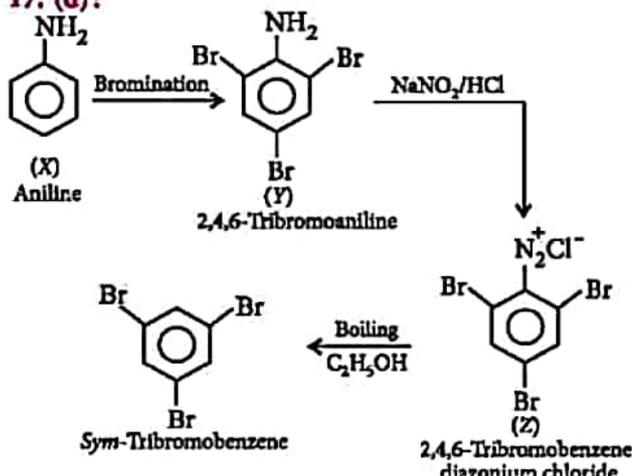10 electrons shield from the inner shells.
Different contributions are calculated by using Slater's rule as follows :
$1 \times 0.35 + 18 \times 0.85 + 10 \times 1.0 = 25.65$
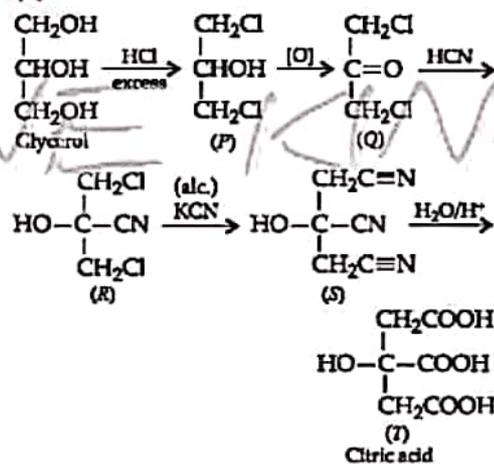Effective nuclear charge = $Z - \sigma = 30 - 25.65 = 4.35$

**16. (c)**

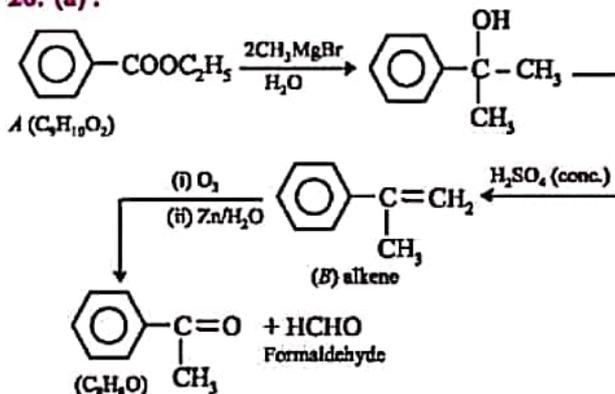**17. (d) :**



**18. (a) :** $2Au + 4CN^- + H_2O + \dfrac{1}{2}O_2 \rightarrow 2[Au(CN)_2]^- + 2OH^-$
                                                                    (X)

$2[Au(CN)_2]^- + Zn \rightarrow [Zn(CN)_4]^{2-} + 2Au$
                                        (Y)

**19. (a) :**



**20. (a) :**

**21. (0.94) :** Suppose $x$ g of each gas is present.

Number of moles of $H_2 = x/2$

Number of moles of $C_2H_6 = x/30$

Mole fraction of $H_2 = 15/16$

Mole fraction of $C_2H_6 = 1/16$

Pressure exerted is directly proportional to mole fraction.

∴ Fraction of total pressure exerted by $H_2 = 15/16$
$$= 0.94$$

**22. (71.34) :**

The redox changes during electrolysis of $SnCl_2$ are,

Anode : $2Cl^- \longrightarrow Cl_2 + 2e^-$

Cathode : $Sn^{2+} + 2e^- \longrightarrow Sn$

Also, $Cl_2$ formed at anode reacts with $SnCl_2$ to give $SnCl_4$.

$SnCl_2 + Cl_2 \longrightarrow SnCl_4$

Now, eq. of $SnCl_2$ lost during electrolysis = Eq. of $Cl_2$ formed during electrolysis = Eq. of Sn formed during

electrolysis $= \dfrac{0.119}{119/2} = 2 \times 10^{-3}$

∴ Eq. of $SnCl_4$ formed $= 2 \times 10^{-3}$

Total loss in eq. of $SnCl_2$ during complete course
= Eq. of $SnCl_2$ lost during electrolysis + Eq. of $SnCl_2$ lost during reaction with $Cl_2$
$$= 2 \times 10^{-3} + 2 \times 10^{-3} = 4 \times 10^{-3}$$

Initial eq. of $SnCl_2 = \dfrac{19}{190/2} = 2 \times 10^{-1}$

∴ Eq. of $SnCl_2$ left in solution
$= 2 \times 10^{-1} - 4 \times 10^{-3} = 0.196$

∴ $\dfrac{\text{Mass of } SnCl_2 \text{ left}}{\text{Mass of } SnCl_4 \text{ formed}} = \dfrac{0.196 \times (190/2)}{0.002 \times (261/2)} = 71.34$

**23. (3.39) :** For benzene, $K_f = \dfrac{MRT_f^2}{1000 \Delta H_{fus} \text{(cal/ g)}}$

$$= \dfrac{78 \times 8.314 \times (278.4)^2}{1000 \times 10.042 \times 10^3}$$

$$= 5.0 \text{ K molality}^{-1}$$

Also, $\Delta T = 278.4 - 277.4 = 1.0$

For acetic acid in benzene,

$$2CH_3COOH \rightleftharpoons (CH_3COOH)_2$$

Before association :    $C$          $0$

After association :    $C(1-\alpha)$     $(C\alpha)/2$

∴ $K_c = \dfrac{C\alpha/2}{C^2(1-\alpha)^2}$      ...(i)

where, $\alpha$ is degree of association.

Also, $\Delta T = K_f \times$ molality $\times [1 - (\alpha/2)]$    ...(ii)

$\left( \because \text{ Total particles at equilibrium} = 1 - \alpha + \dfrac{\alpha}{2} = 1 - \dfrac{\alpha}{2} \right)$

Given, mole fraction of acetic acid $= 0.02 = \dfrac{n}{n+N}$

∴ Mole fraction of benzene $= 0.98 = \dfrac{N}{n+N}$

Now, molality of acetic acid in benzene $= \dfrac{w \times 1000}{m \times W}$

$$= \dfrac{w \times 1000}{m \times \dfrac{W}{M} \times M} = \dfrac{n \times 1000}{N \times M} = \dfrac{0.02 \times 1000}{0.98 \times 78} = 0.262 \text{ m}$$

∴ From eqn. (ii),

$1 = 5 \times 0.262 \times (1 - \alpha/2)$

∴ $\alpha = 0.48$

From eqn. (i), (Assuming, molarity = molality), we get

$$K_c = \dfrac{0.262 \times 0.48}{2 \times (0.262)^2 \times (1 - 0.48)^2} = 3.39$$

**24. (3.09) :** Photon energy liberated from $He^+ = hc/\lambda$

In first line of Lyman series, $E = hcR_H \times Z^2 \left( \dfrac{1}{1^2} - \dfrac{1}{2^2} \right)$

$= 6.626 \times 10^{-27} \times 3.0 \times 10^{10} \times 109678 \times 2^2 \times [3/4]$

$= 6.54 \times 10^{-11}$ erg

This energy is used in liberating electron from H-atom from ground state and therefore,

$6.54 \times 10^{-11} = E_1$ of H + K.E. of electron given out

∵ K.E. $= 6.54 \times 10^{-11} - E_1$ of H

$= 6.54 \times 10^{-11} - 13.6 \times 1.602 \times 10^{-12}$
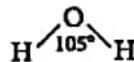
$= 6.54 \times 10^{-11} - 2.178 \times 10^{-11}$

$= 4.362 \times 10^{-11}$ erg

∴ $\left( \dfrac{1}{2} \right) mu^2 = 4.362 \times 10^{-11}$

or $u^2 = \dfrac{4.362 \times 10^{-11} \times 2}{9.108 \times 10^{-28}}$

∴ $u = 3.09 \times 10^8$ cm sec$^{-1}$

**25. (3.23) :** Given bond angle in water molecule is 105°.

$$\overset{O}{\underset{H \quad H}{\diagup \, 105° \, \diagdown}}$$

$\mu_{(H_2O)} = \sqrt{\mu_{OH}^2 + \mu_{OH}^2 + 2\mu^2 \cos(105°)}$

Since, $H_2O$ has two vectors of O—H bond acting at 105°. Let dipole moment of O—H bond be '$a$'.

∴ $1.85 = \sqrt{2a^2(1 + \cos 105°)}$

or $a$, i.e., $\mu_{O-H} = 1.52$ debye $= 1.52 \times 10^{-18}$ esu cm

Now, $\mu_{O-H} = \delta \times d$

∴ $1.52 \times 10^{-18} = \delta \times 0.94 \times 10^{-8}$

∴ $\delta = 1.617 \times 10^{-10}$ esu

Since, O acquires $2\delta$ charge i.e., one $\delta$ charge from each bond and thus, charge on O-atom

$= 2\delta = 2 \times 1.617 \times 10^{-10} = 3.23 \times 10^{-10}$ esu-cm.

◆◇

# JEE Main

## NUMERICAL VALUE TYPE QUESTIONS

1. A plant virus is found to consist of uniform cylindrical particles of 150 Å in diameter and 5000 Å long. The specific volume of the virus is 0.75 cm$^3$/g. If the virus is considered to be a single particle and its molar mass is $x \times 10^7$ g mol$^{-1}$ then the value of $x$ is _____.

2. A solution containing 4.5 mmol and 15 mmol of $Cr_2O_7^{2-}$ and $Cr^{3+}$ respectively and shows a pH of 2.0. The potential of half reaction is _____. (Standard potential of the reaction is 1.33 V.)

3. 0.4 g of an organic compound was Kjeldahlised and ammonia evolved was absorbed into 50 mL of N/2 $H_2SO_4$. The residual acid solution was diluted with water to make the volume 150 mL. 20 mL of this solution required 31 mL of N/20 NaOH solution for complete neutralisation. The percentage of nitrogen in the compound is _____.

4. The standard enthalpy of the decomposition of $N_2O_4$ to $NO_2$ is 58.04 kJ and standard entropy of this reaction is 176.7 J/K. Therefore, the standard free energy change (in kJ) for this reaction at 25°C is _____.

5. A compound with molecular formula, $C_4H_{10}O_3$ is converted by the action of acetyl chloride to a compound with molar mass 190. The original compound consists of —OH groups _____.

6. The conductivity of a saturated solution of $CaF_2$ is $3.86 \times 10^{-5}$ S cm$^{-1}$ and that of water used for solution is $0.15 \times 10^{-5}$ at 291 K. If ionic conductances of $Ca^{2+}$ and F$^-$ at infinite dilution are 51.0 and 47.0 S cm$^2$ eq$^{-1}$ then the solubility of $CaF_2$ in solution is $x \times 10^{-2}$ g L$^{-1}$. The value of $x$ is _____.

7. n-Butane is produced by monobromination of ethane followed by the Wurtz reaction if the bromination takes place with 90% yield and the Wurtz reaction with 85% yield. Then volume (in litres) of ethane at NTP required to produce 55 g of n-butane is _____.

8. Iron sulphide is heated in air to form A, an oxide of sulphur. A is dissolved in water to give an acid. The basicity of this acid is _____.

9. The gaseous reaction, $A_{(g)} \longrightarrow 2B_{(g)} + C_{(g)}$ is found to be first order. If the reaction is started with $p_A = 90$ mm Hg, the total pressure after 10 minutes is found to be 180 mm Hg. The rate constant of the reaction is $x \times 10^{-3}$ s$^{-1}$. The value of $x$ is _____.

10. A metal complex having composition $[Cr(NH_3)_4Cl_2Br]$ has been isolated in two forms (A) and (B). The form (A) reacts with $AgNO_3$ to give a white precipitate which is readily soluble in dilute aqueous ammonia, whereas (B) gives a pale yellow precipitate which is soluble in concentrated ammonia. Magnetic moments (spin-only value) of both the complexes will be _____.

### SOLUTIONS

1. **(7.1)** : Radius of the cylindrical particle,

$$r = \frac{150 \times 10^{-8}}{2} \text{ cm} = 75 \times 10^{-8} \text{ cm}$$

Length, $l = 5000 \times 10^{-8}$ cm

∴ Volume of particle, $V = \pi r^2 l$

$= 3.14 \times (7.5 \times 10^{-7})^2 \times 5.0 \times 10^{-5} = 8.83 \times 10^{-17}$ cm$^3$

Mass of one cylindrical particle,

$$m = \frac{V}{d} = \frac{8.83 \times 10^{-17} \text{ cm}^3}{0.75 \text{ cm}^3 / \text{g}} = 1.18 \times 10^{-16} \text{ g}$$

Molar mass of the particle, $M = m \times N_A$ (since, virus is considered to be a single particle.)

$= (1.18 \times 10^{-16} \text{ g}) (6.023 \times 10^{23}) = 7.1 \times 10^7$ g mol$^{-1}$

2. **(1.067)** : Cell reaction may be written as :

$Cr_2O_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O; \quad n = 6$

Now, applying Nernst equation,

$$E = E° - \frac{0.0591}{n} \log \frac{[Cr^{3+}]^2}{[Cr_2O_7^{2-}][H^+]^{14}}$$

$[Cr^{3+}] = 15$ mmol $= 15 \times 10^{-3}$ M

$[Cr_2O_7^{2-}] = 4.5$ mmol $= 4.5 \times 10^{-3}$ M

pH $= -\log [H^+] = 2$; Thus, $[H^+] = 10^{-2}$

$$E = 1.33 - \frac{0.0591}{6} \log \frac{(15 \times 10^{-3})^2}{(4.5 \times 10^{-3})(10^{-2})^{14}}$$

$$E = 1.33 - \frac{0.0591}{6} \log(5 \times 10^{26}) = 1.067 \text{ V}$$

**3. (46.81):** Let the volume of N/2 $H_2SO_4$ left unused by ammonia = $V$ mL

$V$ mL of this solution was diluted with water upto 150 mL. 20 mL of dilute solution is neutralising 31 mL of N/20 NaOH. Normality of diluted solution can be calculated as,

$N_1 V_1 = N_2 V_2$

or $N_1 \times 20 = \frac{N}{20} \times 31$ ; $\therefore N_1 = \frac{N}{20} \times 31 \times \frac{1}{20} = \frac{31}{400} \times N$

Normality of 150 mL of acid solution = $\frac{31 \times N}{400}$

$V$ mL of N/2 $H_2SO_4$ can be calculated as,

$N_1 V_1 = N_2 V_2$ or $V \times \frac{N}{2} = \frac{31 \times N}{400} \times 150$

$\therefore V = \frac{31 \times 150 \times 2}{400} = 23.25$ mL

Thus, volume of N/2 $H_2SO_4$ left = 23.25 mL

Thus, volume of acid used to neutralised $NH_3$ = 50 − 23.25 = 26.75 mL of N/2 normality

This will be volume of $NH_3$ liberated with normality N/2.

$\% N = \frac{1.4 \times V \times N_1}{W} = \frac{1.4 \times 26.75 \times 1}{0.4 \times 2} = 46.81\%$

**4. (5.39):** Standard enthalpy of decomposition ($\Delta H$) = 58.04 kJ

Standard entropy ($\Delta S$) = 176.7 J/K = 176.7 × 10⁻³ kJ/K

and temperature ($T$) = 25°C = 298 K

Change in free energy ($\Delta G$) = $\Delta H - T\Delta S$

= 58.04 − 298 × (176.7 × 10⁻³) = 58.04 − 52.65 = 5.39 kJ

**5. (2):** In acetylation, replacement of −H of −OH occurs by $CH_3CO-$ group.

$$-OH + Cl-\overset{\overset{O}{\|}}{C}-CH_3 \longrightarrow -OCOCH_3 + HCl$$

*i.e.*, H-atom of mass 1 u is lost and an acetyl group of mass 43 u is added. Net gain, 43 − 1 = 42 for every acetyl group introduced.
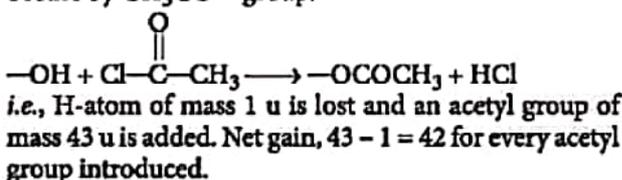
Mass difference of final to original = 190 − 106 = 84

Therefore, number of −OH groups in the original compound = 84/42 = 2

**6. (1.99):** $\kappa_{CaF_2}$ + water = 3.86 × 10⁻⁵

$\kappa_{water}$ = 0.15 × 10⁻⁵

$\kappa_{CaF_2}$ = 3.86 × 10⁻⁵ − 0.15 × 10⁻⁵ = 3.71 × 10⁻⁵ S cm⁻¹

$\Lambda^°_{CaF_2} = \lambda^°_{Ca^{2+}} + 2\lambda^°_{F^-} = 51.0 + 2(47.0) = 145$ S cm² mol⁻¹

Solubility of $CaF_2$

$= \frac{\kappa \times 1000}{\Lambda^°_m} = \frac{3.71 \times 10^{-5} \times 1000}{145}$ mol L⁻¹

(Mol. wt. of $CaF_2$ = 78)

$= \frac{3.71 \times 10^{-5} \times 1000}{145} \times 78$ g L⁻¹ = 1.99 × 10⁻² g L⁻¹

**7. (55.5):** $\underset{30\text{ g}}{C_2H_6} + Br_2 \longrightarrow \underset{109\text{ g}}{C_2H_5Br} + HBr$

$\underset{2 \times 109\text{ g}}{2C_2H_5Br} + 2Na \longrightarrow \underset{58\text{ g}}{C_4H_{10}} + 2NaBr$
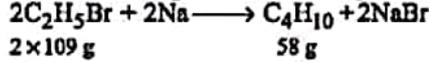
55 g butane will be produced from $= \frac{2 \times 109}{58} \times 55$ g ethyl bromide.

As the yield is 85%, the actual ethyl bromide required

$= \frac{2 \times 109}{58} \times 55 \times \frac{100}{85} = 243.2$ g
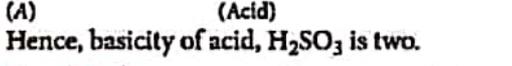
243.2 g of ethyl bromide will be produced from

$= \frac{30}{109} \times 243.2 = 66.93$ g ethane

As the yield is 90%, the actual ethane required

$= \frac{100}{90} \times 66.93 = 74.37$ g

Volume of the ethane at NTP $= \frac{74.37}{30} \times 22.4 = 55.5$ L

**8. (2):** $4FeS_2 + 11O_2 \longrightarrow 2Fe_2O_3 + 8SO_2$

$\underset{(A)}{SO_2} + H_2O \longrightarrow \underset{(Acid)}{H_2SO_3} \rightleftharpoons 2H^+ + SO_3^{2-}$

Hence, basicity of acid, $H_2SO_3$ is two.

**9. (1.15):**

| | $A_{(g)} \rightarrow$ | $2B_{(g)}$ | $+ C_{(g)}$ |
|---|---|---|---|
| Initial pressure : | $p_A$ | 0 | 0 |
| Final pressure : | $p_A - p$ | $2p$ | $p$ |

Total pressure $= p_A - p + 2p + p = 180$ mm Hg

$p_A = 90$ mm Hg; Then, $p_A + 2p = 180$

$p = \frac{180 - 90}{2} = 45$ mm Hg

$k = \frac{2.303}{t} \log \frac{p_A}{p_A - p} = \frac{2.303}{10 \times 60} \log \frac{90}{45} = 1.15 \times 10^{-3}$ s⁻¹

**10. (3.87):** Since (A) when treated with $AgNO_3$ forms a white ppt (of AgCl) which is readily soluble in dil. $NH_{3(aq)}$ so, (A) has atleast one Cl⁻ ion (ionisable chlorine atom). Moreover, since the coordination number of chromium is 6 so, the formula of the compound (A) is $[Cr(NH_3)_4BrCl]Cl$.

Since, compound (B) when treated with $AgNO_3$ forms a pale yellow ppt (of AgBr) soluble in concentrated $NH_{3(aq)}$ so, (B) has a Br⁻ (ionisable bromine atom) in the ionisation sphere. So, the formula of compound (B) is $[Cr(NH_3)_4Cl_2]Br$. Cr in both A and B is in +3 state *i.e.*, $Cr^{3+}$.
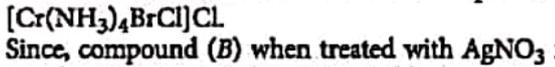


In both cases $d^2sp^3$ hybridisation occurs.

Spin magnetic moment of A or B :

In both cases $n = 3$ ($n$ = number of unpaired electrons)

$\therefore$ Spin magnetic moment $= \sqrt{n(n+2)}$

$= \sqrt{3(3+2)} = \sqrt{3 \times 5} = \sqrt{15}$ or 3.87 B.M.

◆◆

1. Which of the following ions does not exist?
   (a) $[SiCl_6]^{2-}$ (b) $[GeF_6]^{2-}$
   (c) $[CCl_6]^{2-}$ (d) $[SnCl_6]^{2-}$

2. In which of the following reactions there is no change in oxidation number?
   (a) $SO_2 + 2H_2S \rightarrow 2H_2O + 3S$
   (b) $2Na + O_2 \rightarrow Na_2O_2$
   (c) $Na_2O + H_2SO_4 \rightarrow Na_2SO_4 + H_2O$
   (d) $4KClO_3 \rightarrow 3KClO_4 + KCl$

3. A compound has a haemoglobin-like structure. It has one Fe atom. It contains 4.6% of Fe. The approximate molecular mass of the compound is
   (a) 1100 g mol$^{-1}$ (b) 1217.4 g mol$^{-1}$
   (c) 1428.8 g mol$^{-1}$ (d) 1612.5 g mol$^{-1}$

4. Two elements whose electronegativities are 1.2 and 3.0, the bond formed between them would be
   (a) ionic (b) covalent
   (c) coordinate (d) metallic.

5. White lung cancer is caused by
   (a) paper (b) asbestos
   (c) silica (d) none of these.

6. Periodic oxidation of 1,2-cyclopentanediol is

   (a)  (b) 

   (c)  (d) $\overset{O}{\overset{\|}{C}}HCH_2CH_2CH_2\overset{O}{\overset{\|}{C}}H$
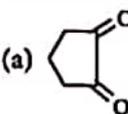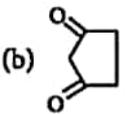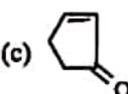
7. Teflon, styron and neoprene are all
   (a) co-polymers
   (b) condensation polymers
   (c) homopolymers (d) monomers.

8. The e.m.f. of the cell,
   $Zn \mid Zn^{2+}(0.01\ M) \parallel Fe^{2+}(0.001\ M) \mid Fe$
   at 298 K is 0.2905 V. The value of the equilibrium constant for the cell reaction is

   (a) $\dfrac{0.32}{e^{0.0295}}$ (b) $\dfrac{0.32}{10^{0.0295}}$

   (c) $\dfrac{0.26}{10^{0.0295}}$ (d) $\dfrac{0.32}{10^{0.0591}}$

9. For a particular reversible reaction at temperature T, $\Delta H$ and $\Delta S$ were found to be both positive, If $T_e$ is the temperature at equilibrium, the reaction would be spontaneous when
   (a) $T = T_e$ (b) $T_e > T$ (c) $T > T_e$ (d) $T_e = 5T$

10. The degeneracy of hydrogen atom that has energy equal to $-\dfrac{R_H}{9}$ (where, $R_H$ is Rydberg constant) is
    (a) 4 (b) 6 (c) 9 (d) 12

11. An ideal gas at pressure $P_0$ in a vessel. If the masses of all the molecules are halved and their rms speeds doubled, the resulting pressure P will be
    (a) $4P_0$ (b) $2P_0$ (c) $P_0$ (d) $P_0/2$

12. Among $CaH_2$, $NH_3$, $NaH$ and $B_2H_6$ which are covalent hydrides?
    (a) $NH_3$ and $B_2H_6$ (b) $NaH$ and $CaH_2$
    (c) $NaH$ and $NH_3$ (d) $CaH_2$ and $B_2H_6$
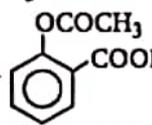
13. The compound  is used as a/an
    (a) antiseptic (b) antibiotic
    (c) analgesic (d) pesticide.

14. Haworth's projection of $\alpha$-D-glucose is
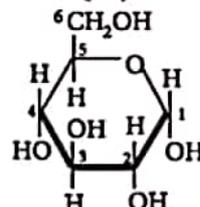
    (a)  (b) 
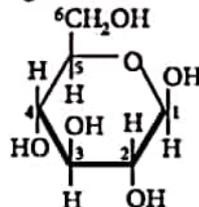
    (c) both of these (d) none of these.

15. Two nodal planes are present in
    (a) $\pi^*2p_x$ (b) $\sigma2p_z$ (c) $\pi2p_x$ (d) $\pi2p_y$

16. Anti-Markovnikov's addition of HBr is not observed in
    (a) propene          (b) 1-butene
    (c) but-2-ene        (d) pent-2-ene.

17. $K_p/K_c$ for the reaction,
    $CO + 1/2O_2 \rightleftharpoons CO_2$ is
    (a) $\sqrt{RT}$          (b) $\dfrac{\sqrt{RT}}{2}$
    (c) 1                    (d) none of these.

18. Which of the following xenon compounds has the same number of lone pairs as in $I_3^-$ ?
    (a) $XeO_4$ (b) $XeF_4$ (c) $XeF_2$ (d) $XeO_3$

19. For a second order reaction in which both the reactants have equal initial concentration, the time taken for 20% completion of reaction is 500 seconds. What will be the time taken for 60% completion of the reaction?
    (a) 500 sec          (b) 1000 sec
    (c) 3000 sec         (d) 1500 sec

20. Arrange (I) $Ce^{3+}$, (II) $La^{3+}$ (III) $Pm^{3+}$ and (IV) $Yb^{3+}$ in increasing order of their ionic radii.
    (a) $IV < III < I < II$ (b) $I < IV < III < II$
    (c) $IV < III < II < I$ (d) $III < II < I < IV$

21. The correct order of the packing efficiency in different types of unit cells is
    (a) fcc < bcc < simple cubic
    (b) fcc > bcc > simple cubic
    (c) fcc < bcc > simple cubic
    (d) bcc < fcc > simple cubic.

22. Which of the following is least basic?
    (a) $O_2N$—⟨O⟩—$NH_2$ (b) $CH_3O$—⟨O⟩—$NH_2$
    (c) $C_6H_5$—⟨O⟩—$NH_2$ (d) $EtO_2C$—⟨O⟩—$NH_2$

23. A 0.001 molal solution of $Pt(NH_3)_4Cl_4$ in water has a freezing point depression of 0.0054 °C. If $K_f$ for water is $1.80\ °C\ m^{-1}$, the correct formulation for the above molecule is
    (a) $[Pt(NH_3)_4Cl_3]Cl$ (b) $[Pt(NH_3)_4Cl_2]Cl_2$
    (c) $[Pt(NH_3)_4Cl]Cl_3$ (d) $[Pt(NH_3)_4Cl_4]$

24. Anhydrous mixture of KF and HF contains which type of ions?
    (a) $K^+, H^+, F^-$     (b) $(KF)^+ (HF)^-$
    (c) $KH^+, F^-$         (d) $K^+, HF_2^-$

25. Gold numbers of protective colloids $A$, $B$, $C$ and $D$ are 0.50, 0.01, 0.10 and 0.005 respectively. The correct order of their protective powers is
    (a) $D < A < C < B$     (b) $C < B < D < A$
    (c) $A < C < B < D$     (d) $B < D < A < C$

26. For the following conversion, $X$ will be



    (a) $CH_3OH, H_2SO_4$
    (b) $CH_3OH, CH_3O^-Na^+$
    (c) $H_2O/H_2SO_4$ followed by $CH_3OH$
    (d) $CH_3MgBr$ /ether followed by $H_3O^+$

27. The major role of fluorspar ($CaF_2$) which is added in small quantity in the electrolytic reduction of alumina dissolved in fused cryolite ($Na_3AlF_6$) is
    1. as a catalyst
    2. to make the fused mixture very conducting
    3. to lower the fusion temperature
    4. to decrease the rate of oxidation of carbon at the anode.
    (a) 2,3   (b) 1,2   (c) 2,3,4   (d) 3,4

28. The final product $D$ in the given sequence of reactions is
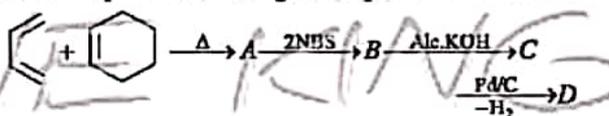


    (a) benzene          (b) tetralin
    (c) decalin          (d) naphthalene.

29. In the given conformation $C_2$ is rotated about $C_2$—$C_3$ bond anticlockwise by an angle of 120°, then the conformation obtained is
    (a) fully eclipsed conformation
    (b) partially eclipsed conformation
    (c) gauche conformation
    (d) staggered conformation.
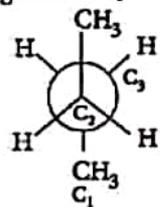
30. The correct name of $(CO)_3Fe\overset{CO}{\underset{CO}{\overbrace{\phantom{--}}}}Fe(CO)_3$ is

(a) tri-μ-carbonyl*bis*(tricarbonyl)iron(0)
(b) hexacarbonyl iron(III)tricarbonylferrate(0)
(c) tricarbonyl iron(0) tricarbonyliron(0) tricarbonyl
(d) nonacarbonyl iron.

31. The ionic radii of $N^{3-}$, $O^{2-}$, $F^-$, $Na^+$ follow the order
(a) $N^{3-} > O^{2-} > F^- > Na^+$
(b) $N^{3-} > Na^+ > O^{2-} > F^-$
(c) $Na^+ > O^{2-} > N^{3-} > F^-$
(d) $O^{2-} > F^- > Na^+ > N^{3-}$

32. 5 g sample of bleaching powder is treated with excess acetic acid and KI solution. The liberated $I_2$ required 50 mL of N/10 hypo. The per cent of available chlorine in the sample is
(a) 3.55    (b) 7.0    (c) 35.5    (d) 28.2

33. MeO—⟨O⟩—CHO + (X)
$\downarrow$ base
⟨O⟩—CH=CHCOOH
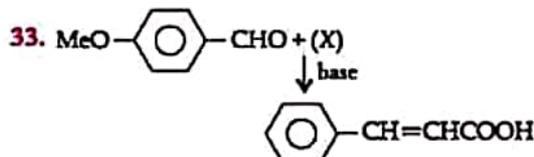
The compound X is
(a) $CH_3COOH$    (b) $BrCH_2COOH$
(c) $(CH_3CO)_2O$    (d) OHC—COOH

34. On passing $I$ ampere of current for time $t$ sec through 1 litre of 2 M $CuSO_4$ solution (atomic weight of Cu = 63.5), the amount $m$ of Cu (in g) deposited on cathode will be
(a) $m = \dfrac{It}{(63.5 \times 96500)}$    (b) $m = \dfrac{It}{(31.25 \times 96500)}$
(c) $m = \dfrac{I \times 96500}{(31.25 \times t)}$    (d) $m = \dfrac{31.75 \times I \times t}{96500}$

35. Which of the following structures permits *cis-trans* isomerism?
(a) $X_2C=CY_2$    (b) $XYC=CZ_2$
(c) $X_2C=CXY$    (d) $XYC=CXZ$

36. For the change, $C_{diamond} \rightarrow C_{graphite}$ ; $\Delta H = -1.89$ kJ, if 6 g of diamond and 6 g of graphite are separately burnt to yield $CO_2$, the heat liberated in first case is
(a) less than in the second case by 1.89 kJ
(b) less than in the second case by 11.34 kJ
(c) less than in the second case by 14.34 kJ
(d) more than in the second case by 0.945 kJ.

37. 0.85% aqueous solution of $NaNO_3$ is apparently 90% dissociated at 27°C. The osmotic pressure will be ($R = 0.082$ atm $K^{-1}$ $mol^{-1}$)
(a) 2.210 atm    (b) 4.674 atm
(c) 3.049 atm    (d) 5.012 atm.

38. In the accompanied diagram, $E_R$, $E_P$ and $E_X$ represent the energy of the reactants, products and activated complex respectively. Which of the following is the activation energy for the backward reaction?
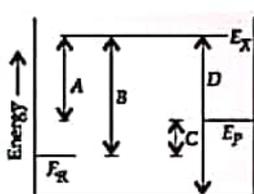
(a) A    (b) B    (c) C    (d) D

39. Which of the following organometallic compounds is σ- and π-bonded?
(a) $[Fe(\eta^5\text{-}C_5H_5)_2]$    (b) $[PtCl_3(\eta^2\text{-}C_2H_4)]$
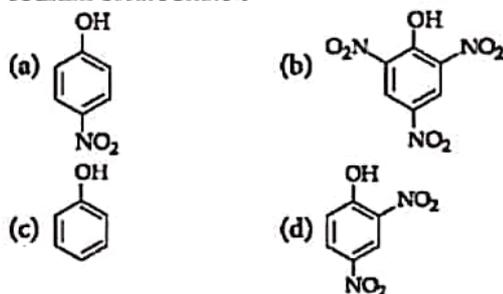(c) $[Co(CO)_5NH_3]^{2+}$    (d) $Al(CH_3)_3$

40. A cylinder contains nitrogen gas and a small amount of liquid water at a temperature 25°C. (The vapour pressure of water is 23.8 mm Hg). The total pressure is 600 mm Hg. A piston is pushed into the cylinder until the volume is halved. What is the final total pressure?
(a) 1176.2 atm    (b) 1.55 atm
(c) 1152.4 atm    (d) 1.98 atm

41. Which of the following ions has correct decreasing order $X - O$ bond length? (where $X$ is the central atom.)
(a) $ClO_4^-$, $SO_4^{2-}$, $PO_4^{3-}$, $SiO_4^{4-}$
(b) $SiO_4^{4-}$, $PO_4^{3-}$, $SO_4^{2-}$, $ClO_4^-$
(c) $SiO_4^{4-}$, $PO_4^{3-}$, $ClO_4^-$, $SO_4^{2-}$
(d) $SiO_4^{4-}$, $SO_4^{2-}$, $PO_4^{3-}$, $ClO_4^-$

42. Which of the following derivatives of phenol is most likely to give effervescence with dilute solution of sodium bicarbonate ?

(a) [phenol with NO₂ para structure]
(b) [2,6-dinitro-4-nitro phenol structure]
(c) [plain phenol structure]
(d) [2,4-dinitrophenol structure]

43. The correct sequence of decreasing number of π-bonds in the structures of $H_2SO_3$, $H_2SO_4$ and $H_2S_2O_7$ is
(a) $H_2SO_3 > H_2SO_4 > H_2S_2O_7$
(b) $H_2SO_4 > H_2S_2O_7 > H_2SO_3$
(c) $H_2S_2O_7 > H_2SO_4 > H_2SO_3$
(d) $H_2S_2O_7 > H_2SO_3 > H_2SO_4$

**44.** The number of radial nodes and angular nodes for *d*-orbital can be represented as
(a) $(n-2)$ radial nodes + 1 angular node
  $= (n-1)$ total nodes
(b) $(n-1)$ radial nodes + 1 angular node
  $= (n-1)$ total nodes
(c) $(n-3)$ radial nodes + 2 angular nodes
  $= (n-l-1)$ total nodes
(d) $(n-3)$ radial nodes + 2 angular nodes
  $= (n-l)$ total nodes.

**45.** The solubility order for alkali metals fluoride in water is
(a) $LiF < RbF < KF < NaF$
(b) $RbF < KF < NaF < LiF$
(c) $LiF > NaF > KF > RbF$
(d) $LiF < NaF < KF < RbF$

## SOLUTIONS

**1. (c) :** Carbon cannot expand its valency beyond 4 due to unavailability of *d*-orbitals.

**2. (c) :** $\overset{+1\ -2}{Na_2O} + \overset{+1\ +6\ -2}{H_2SO_4} \longrightarrow \overset{+1\ +6\ -2}{Na_2SO_4} + \overset{+1\ -2}{H_2O}$
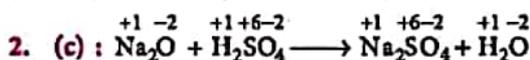
**3. (b):** 1 g-atom of Fe (56 g Fe) is present in 1 mole of the compound.
As 4.6 g of Fe is present in 100 g of the compound.
∴ 56 g of Fe will be present in $\frac{100}{4.6} \times 56$ g
$= 1217.4$ g of the compound

**4. (a) :** Electronegativity difference = 3.0 – 1.2 = 1.8. If the electronegativity difference is more than 1.7, then bond will have ionic character. If the electronegativity difference is between 0.4 to 1.7, then bond will have polar covalent character and if the electronegativity difference is less than 0.4. Then bond will have non-polar covalent character.

**5. (b)**

**6. (d) :**
HO–[cyclopentane ring]–OH $\xrightarrow{HIO_4}$ $\overset{O}{\overset{\|}{H}C}CH_2CH_2CH_2\overset{O}{\overset{\|}{C}H}$
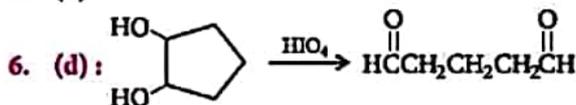
**7. (c) :** Teflon (polytetrafluoroethylene), styron (polystyrene) and neoprene (polychloroprene) all are homopolymers.

**8. (b) :** $Zn + Fe^{2+} \longrightarrow Fe + Zn^{2+}$
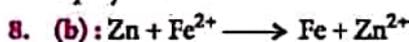
$E_{cell} = E_{cell}^{\circ} - \frac{0.0591}{n} \log \frac{[Zn^{2+}]}{[Fe^{2+}]}$

Given, $E_{cell} = 0.2905$

$0.2905 = E_{cell}^{\circ} - \frac{0.0591}{2} \log \frac{0.01}{0.001}$

or, $E_{cell}^{\circ} = 0.2905 + 0.0295 \log 10$
$= 0.2905 + 0.0295 = 0.32$ V  (∵ $\log 10 = 1$)

$E_{cell}^{\circ} = \frac{0.0591}{n} \log K_{eq}$  (∵ $E_{cell} = 0$ at equilibrium)

or $0.32 = \frac{0.0591}{2} \log K_{eq}$  ∴ $K_{eq} = 10^{0.32/0.0295}$
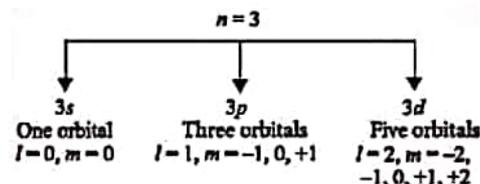
**9. (c) :** $\Delta G = \Delta H - T\Delta S$. At equilibrium, $\Delta G = 0$. Also, $\Delta G$ should be negative for a spontaneous reaction. So, $T > T_e$ in order to make $\Delta G$ negative, because both $\Delta H$ and $\Delta S$ are positive.

**10. (c) :** Energy in H atom $\dfrac{-R_H}{n^2}$
But, Given that, $E = -\dfrac{R_H}{9}$
∴ $n^2 = 9 \Rightarrow n = 3$
As here, $n = 3$ thus, there are three orbitals.

$n = 3$

| | | |
|---|---|---|
| 3s | 3p | 3d |
| One orbital | Three orbitals | Five orbitals |
| $l = 0, m = 0$ | $l = 1, m = -1, 0, +1$ | $l = 2, m = -2, -1, 0, +1, +2$ |

Degeneracy = $1 + 3 + 5 = 9$

**11. (b) :** $u_{rms} = \sqrt{\dfrac{3RT}{M}} = \sqrt{\dfrac{3PV}{M}}$,

$u_1 = \sqrt{\dfrac{3P_0V}{M}}$ ...(i)  $2u_1 = \sqrt{\dfrac{3PV}{M/2}}$ ...(ii)

On dividing eqn. (i) by (ii),

∴ $\dfrac{1}{2} = \sqrt{\dfrac{P_0}{2P}}$  or  $2P = 4P_0$, $\Rightarrow$ $P = 2P_0$

**12. (a) :** N and B belong to *p*-block and they form hydride by sharing of electrons *i.e.*, by forming covalent bond. So, they form covalent hydrides.

**13. (c) :** The given compound is acetylsalicylic acid, *i.e.* aspirin which is used as an analgesic.

**14. (a)**

**15. (a) :** $\pi^*2p_x$ has two nodal planes perpendicular to each other.

**Monthly Test Drive CLASS XII  ANSWER KEY**

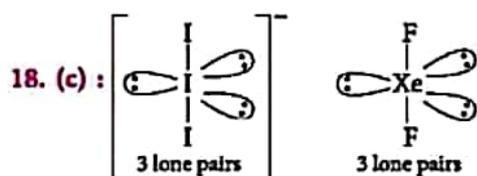| 1. (d) | 2. (d) | 3. (b) | 4. (d) | 5. (c) |
|---|---|---|---|---|
| 6. (d) | 7. (d) | 8. (c) | 9. (b) | 10. (c) |
| 11. (b) | 12. (a) | 13. (a) | 14. (a) | 15. (c) |
| 16. (b) | 17. (d) | 18. (a) | 19. (c) | 20. (c,d) |
| 21. (a,c,d) | 22. (b,c,d) | 23. (a,c) | 24. (3) | 25. (6) |
| 26. (3) | 27. (a) | 28. (c) | 29. (a) | 30. (d) |

**16. (c) :** Anti-Markovnikov's addition of HBr is observed only with unsymmetrical alkenes, i.e., propene, 1-butene and pent-2-ene. Since 2-butene is symmetrical, therefore, anti-Markovnikov's addition of HBr is not observed in this case.

**17. (d) :** $CO_{(g)} + \dfrac{1}{2}O_{2(g)} \rightleftharpoons CO_{2(g)}$
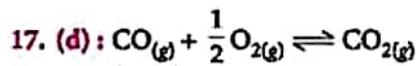
$\Delta n = 1 - \left(1 + \dfrac{1}{2}\right) = -\dfrac{1}{2}$

Since $K_p = K_c (RT)^{\Delta n}$

$\therefore \quad K_p = K_c (RT)^{-1/2}$

$\dfrac{K_p}{K_c} = (RT)^{-1/2} ; \dfrac{K_p}{K_c} = \dfrac{1}{(RT)^{1/2}} = \dfrac{1}{\sqrt{RT}}$

**18. (c) :**



3 lone pairs       3 lone pairs

**19. (c) :** For a second order reaction, $k = \dfrac{1}{t} \times \dfrac{x}{a(a-x)}$

Since $x = \dfrac{20}{100} = 0.2$, $a = 1, t = 500$ s

$k = \dfrac{1 \times 0.2}{500 \times 1(1-0.2)} = \dfrac{1}{500 \times 4}$   ...(i)

When $x = 60\% \Rightarrow 60/100 = 0.6$

then, $k = \dfrac{1}{t} \times \dfrac{0.6}{1(1-0.6)}$   ...(ii)

Substituting the value of $k$ from eq. (i) to eq. (ii)

$\therefore \quad \dfrac{1}{500 \times 4} = \dfrac{1}{t} \times \dfrac{0.6}{0.4} \Rightarrow t = 3000$ seconds

**20. (a) :** Ionic radii decrease across lanthanide series due to lanthanide contraction. As all ions are in +3 O.S., ionic radii will follow the trend of atomic radii.

$\therefore \quad La^{3+} > Ce^{3+} > Pm^{3+} > Yb^{3+}$

**21. (b) :** Packing efficiency,
for $sc$ unit cell = 52.4%
for $bcc$ unit cell = 68%
for $fcc$ unit cell = 74%
Thus, the order of packing efficiency is
$fcc > bcc >$ simple cubic.

**22. (a) :** $NO_2$ is the most powerful electron withdrawing group and hence $p$-nitroaniline is the weakest base.

**23. (b) :** $\Delta T_f = iK_f \cdot m \Rightarrow i = \dfrac{\Delta T_f}{K_f \cdot m}$

$i = \dfrac{0.0054}{1.80 \times 0.001} = 3$

It means 3 ions are produced on dissociation hence, formula must be $[Pt(NH_3)_4Cl_2]Cl_2$.

**24. (d) :** $KF + HF \longrightarrow HF_2^- + K^+$
$HF_2^-$ ion is formed due to hydrogen bonding.

**25. (c) :** For a protective colloid, lesser the value of gold number, better is the protective power. Thus, the correct order of protective power is $A < C < B < D$.

**26. (a) :**
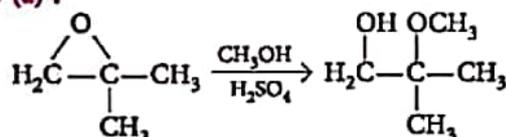


**27. (a) :** Fluorspar ($CaF_2$) is added in small quantity in the electrolytic reduction of alumina dissolved in fused cryolite ($Na_3AlF_6$) to make the fused mixture more conducting as alumina is a bad conductor of electricity and to lower the m.pt. of fused mixture as alumina has very high m.pt.

**28. (d) :**



**29. (c) :**



Gauche conformation
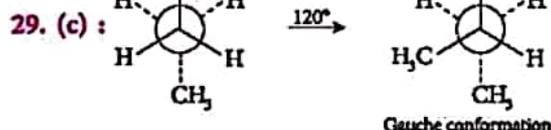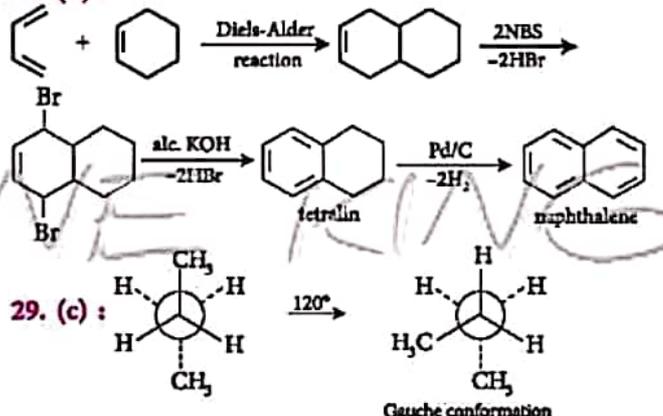
**30. (a)**

**31. (a) :** Ionic radii of isoelectronic species decrease with increase in nuclear charge. Thus, the order is
$N^{3-} > O^{2-} > F^- > Na^+$

**32. (a) :** meq. of bleaching powder = meq. of $Cl_2$
= meq. of hypo

$\dfrac{w_{Cl_2}}{35.5} \times 1000 = 50 \times \dfrac{1}{10} \Rightarrow w_{Cl_2} = 0.1775$ g

$\therefore$ Per cent $Cl_2 = \dfrac{0.1775}{5} \times 100 = 3.55\%$

**33. (c) :** $X$ is acetic anhydride. This is an example of Perkin's reaction.

**34. (d) :** According to Faraday's law of electrolysis,
$m \propto It$ or $m = ZIt$
where $I$ = current, $t$ = time and

$$Z = \frac{\text{Equivalent weight of substance}}{96500}$$

Eq. wt. of Cu $= \frac{63.5}{2}$      ($\because Cu^{2+} + 2e^- \rightarrow Cu$)

$\therefore \quad Z = \frac{63.5}{2 \times 96500}$

Now, $m = \frac{63.5 \times I \times t}{2 \times 96500} = \frac{31.75 \times I \times t}{96500}$

**35. (d) :** The conditions for geometrical isomerism in alkene is the two atoms or groups which are attached to the particular carbon atom must be different.

**36. (d) :**
$C_D \rightarrow C_G;$     $\Delta H = -1.89$ kJ    ...(i)
$C_D + O_2 \rightarrow CO_2;$     $\Delta H = -q_1$ kJ    ...(ii)
$C_G + O_2 \rightarrow CO_2;$     $\Delta H = -q_2$ kJ    ...(iii)

By eqs, [(ii) – (iii)], we get
$C_D \rightarrow C_G;$     $\Delta H = -q_1 + q_2$
$\therefore \quad -q_1 + q_2 = -1.89$
or $q_2 - q_1 = -1.89$ for 12 g $C_{D \rightarrow G}$
Thus, for 6 g $C_{D \rightarrow G}$
$q_2 - q_1 = \frac{-1.89}{2} = -0.945$ kJ

**37. (b) :** Molecular weight of $NaNO_3 = 85$ g mol$^{-1}$
Molarity $= \frac{W \times 1000}{M \times V} = \frac{0.85 \times 1000}{85 \times 100} = 0.1$ mol L$^{-1}$
$NaNO_3$ solution is 90% dissociated.
$$NaNO_3 \rightleftharpoons Na^+ + NO_3^-$$
$1-0.9$       $0.9$     $0.9$
van't Hoff factor, $i = 1 - 0.9 + 0.9 + 0.9 = 1.9$
$\therefore \quad \pi = 1.9 \times 0.1 \times 0.082 \times 300 = 4.674$ atm
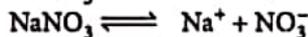
**38. (a) :** For backward reaction, activation energy is the energy difference between product and activated complex.

**39. (c) :** Metal carbonyls are $\sigma$- as well as $\pi$-bonded.

**40. (b) :** $P_1 = 600 - 23.8 = 576.2$ mm of Hg; $V_2 = \frac{V_1}{2}$

According to Boyle's law, $P_1 V_1 = P_2 V_2$
$576.2 \times V_1 = P_2 \times \frac{V_1}{2}$
$P_2 = 1152.4$
The final total pressure $= 1152.4 + 23.8 = 1176.2$ mm
of Hg $= \frac{1176.2}{760} = 1.55$ atm

**41. (b) :** More will be the electronegativity of $X$, lesser will be the bond length of $X$—O bond.

**42. (b) :** 2, 4, 6-Trinitrophenol, which is highly acidic gives effervescence with dilute solution of $NaHCO_3$.

**43. (c) :** Number of $\pi$-bonds,



$H_2S_2O_7 = $ HO–S–O–S–OH ($\pi$ bonds = 4)

$H_2SO_4 = $ HO–S–OH ($\pi$-bonds = 2)

$H_2SO_3 = $ HO–S̈–OH ($\pi$-bond = 1)
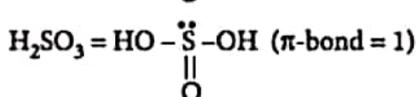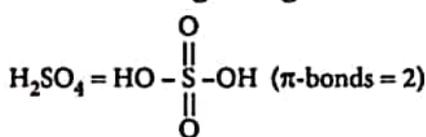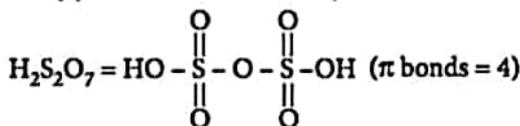
**44. (d) :** For $d$-orbital, radial nodes $= (n - l - 1)$
$= (n - 2 - 1) = n - 3$, angular nodes $= l = 2$
and total number of nodes $= n - 1$

**45. (d) :** Higher the lattice enthalpy lower will be

solubility *i.e.*, lattice enthalpy $\propto \dfrac{1}{\text{Solubility}}$

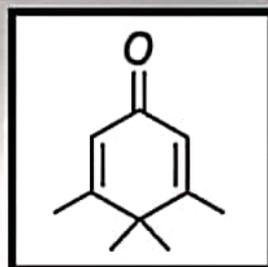Since the lattice enthalpies of alkali metals follow the order Li > Na > K > Rb.
Hence, the correct order of solubility is
LiF < NaF < KF < RbF.

######### 

**COMIC CAPSULE**

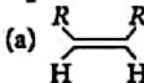Penguinone ($C_{10}H_{14}O$) is an organic compound and its name comes from the fact that it resembles a penguin.
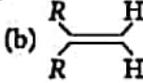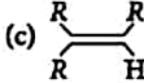
# PRACTICE PAPER

# BITSAT

Exam date: 16th to 25th May 2020

1. 2.0 g of oxygen contains number of atoms equal to that in
   (a) 4.0 g of sulphur
   (b) 7.0 g of nitrogen
   (c) 0.5 g of hydrogen
   (d) 2.3 g of sodium.

2. What is the product [A] in the following reaction?
   $$Cl\text{—}\bigwedge\text{—}Cl + Mg \longrightarrow [A]$$
   (a) $\triangle$
   (b) $ClMg\text{—}\bigwedge\text{—}MgCl$
   (c) Both (a) and (b)
   (d) None of these

3. The isoelectric point of a colloidally dispersed material is the pH value at which
   (a) the dispersed phase migrate in an electric field
   (b) the dispersed phase does not migrate in an electric field
   (c) the dispersed phase has pH equal to 7
   (d) the dispersed phase has pH equal to zero.

4. The quantity of electricity needed to electrolyse completely 1 M solution of $CuSO_4$, $Bi_2(SO_4)_3$, $AlCl_3$ and $AgNO_3$ each will be
   (a) 2 F, 6 F, 3 F and 1 F respectively
   (b) 6 F, 2 F, 3 F and 1 F respectively
   (c) 2 F, 6 F, 1 F and 3 F respectively
   (d) none of the above.

5. 100 g sample of HCl solution of relative density 1.17 contains 31.2 g of HCl. What volume of this HCl solution will be required to neutralise exactly 5 L of $\dfrac{N}{20}$ KOH solution?
   (a) 25 mL    (b) 29.2 mL (c) 34.2 mL (d) 250 mL

6. IUPAC name of the following compound is
   $$NC\text{—}CH_2\text{—}\overset{\overset{\displaystyle O}{\|}}{C}\text{—}\underset{\underset{\displaystyle SO_3H}{|}}{CH}\text{—}CH_2\text{—}CH_2\text{—}COOH$$

   (a) 6-carboxy-3-oxo-4-sulphohexanenitrile
   (b) 1-cyano-2-oxo-3 sulphohexan-6-oic acid
   (c) 7-cyano-5-oxo-4-sulphoheptan-1-oic acid
   (d) 6-cyano-5-oxo-4-sulphohexan-1-oic acid.

7. Diborane is a Lewis acid forming addition compound $B_2H_6\cdot2NH_3$ with $NH_3$, a Lewis base. This
   (i) is ionic and exists as $[BH_2(NH_3)_2]^+$ and $[BH_4]^-$ ions
   (ii) on heating, converted to borazine, $B_3N_3H_6$ (called inorganic benzene).
   Which of the following options is correct for diborane?
   (a) Only (i)
   (b) Only (ii)
   (c) Both are correct.
   (d) None is correct.

8. Copper is extracted from copper pyrites ore by heating in a blast furnace. The method is based on the principle that
   (a) copper has more affinity for oxygen than sulphur at high temperature
   (b) iron has less affinity for oxygen than sulphur at high temperature
   (c) sulphur has less affinity for oxygen at high temperature
   (d) copper has less affinity for oxygen than sulphur at high temperature.

9. The unit cell of a binary alloy composed of A and B metals, has a ccp structure with A atoms occupying the corners and B atoms occupying centres of each face of the cube. If during the crystallisation of this alloy, in the unit cell, two A atoms are missed, the overall composition per unit cell is
   (a) $AB_6$
   (b) $A_4B$
   (c) $AB_8$
   (d) $A_6B_{24}$

10. The correct order of decreasing second ionisation enthalpy of Ti(22), V(23), Cr(24) and Mn(25) is
    (a) Mn > Cr > Ti > V
    (b) Ti > V > Cr > Mn
    (c) Cr > Mn > V > Ti
    (d) V > Mn > Cr > Ti

24 CHEMISTRY TODAY | APRIL '20

11. What is the maximum wavelength of light that would excite an electron from the $n = 1$ to the $n = 3$ level of atomic hydrogen?
   (a) 1 nm    (b) $10^{-7}$ nm (c) 103 nm  (d) 487 nm

12. 1-Propanol and 2-propanol can be distinguished by
   (a) oxidation with alkaline $KMnO_4$ followed by reaction with Fehling's solution
   (b) oxidation with acidic dichromate followed by reaction with Fehling's solution
   (c) oxidation by heating with copper followed by reaction with Fehling's solution
   (d) oxidation with concentrated $H_2SO_4$ followed by reaction with Fehling's solution.

13. Which are correct statements about $P_4O_6$ and $P_4O_{10}$?
   (i) Both form oxyacids $H_3PO_3$ and $H_3PO_4$ respectively.
   (ii) In $P_4O_6$, each P is joined to four O and in $P_4O_{10}$, each P is joined to six O atoms.
   (iii) In $P_4O_6$, each P is joined to three O and in $P_4O_{10}$, each P is joined to four O atoms.
   (iv) In $P_4O_6$, each P is joined to three O and in $P_4O_{10}$, each P is joined to five O atoms.
   (a) Only (i) and (iii)    (b) Only (i) and (iv)
   (c) Only (ii) and (iii)   (d) Only (iii) and (iv)

14. The compound A on heating gives a colourless gas and a residue that is dissolved in water to obtain B. Excess of $CO_2$ is bubbled through aqueous solution of B, C is formed which is recovered in the solid form. Solid C on gentle heating gives back A. The compound A is
   (a) $CaCO_3$              (b) $Na_2CO_3$
   (c) $K_2CO_3$             (d) $CaSO_4 \cdot 2H_2O$

15. $K_a$ for HCN is $5 \times 10^{-10}$ at 25°C. For maintaining a constant pH of 9, the volume of 5 M KCN solution required to be added to 10 mL of 2 M HCN solution is
   (a) 4 mL    (b) 7.95 mL (c) 2 mL    (d) 9.3 mL.

16. Three different solutions were prepared by dissolving same amount of the following complexes I, II, III in water. The freezing points of these solutions were then determined. The correct orders of freezing points will be
   I.   $[Co(NH_3)_3(NO_2)_3]$
   II.  $[Co(NH_3)_5(NO_2)]^{2+}[Co(NH_3)_2(NO_2)_4]_2$
   III. $[Co(NH_3)_4(NO_2)_2][Co(NH_3)_2(NO_2)_4]$
   [Given : $K_f(H_2O) = 1.86$°C/m]
   (a) I > II > III          (b) III > II > I
   (c) II > I > III          (d) I = II = III

17. Which one of the following has an optical isomer?
   (a) $[Zn(en)_2]^{2+}$        (b) $[Zn(en)(NH_3)_2]^{2+}$
   (c) $[Co(en)_3]^{3+}$        (d) $[Co(H_2O)_4(en)]^{3+}$

18. Which one of the following will react fastest with $H_2$ under catalytic hydrogenation condition?
   (a) 
   (b) 
   (c) 
   (d) 
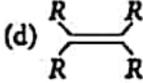
19. When 50 cc of 0.2 N $H_2SO_4$ is mixed with 50 cc of 1 N KOH the heat liberated is
   (a) 11.46 J               (b) 57.3 kJ
   (c) 573 kJ                (d) 0.573 kJ

20. Which of the following amino acids contains sulphur and is an essential amino acid?
   (a) Isoleucine            (b) Methionine
   (c) Proline               (d) Glutamine

21. Which of the following statements is correct regarding the slag obtained during the extraction of a metal like copper or iron?
   (a) The slag is lighter and has higher melting point than the metal.
   (b) The slag is lighter and has lower melting point than the metal.
   (c) The slag is heavier and has higher melting point than the metal.
   (d) The slag is heavier and has lower melting point than the metal.

22. The heat of formation of $CH_3OCH_{3(g)}$ is
   [Given : $B.E._{H-H} = 103$ kcal, $B.E._{C-H} = 87$ kcal $B.E._{C-O} = 70$ kcal, $B.E._{O=O} = 177$ kcal; Heat of vapourisation of 1 gram atom of carbon = 125 kcal.]
   (a) –14.5 kcal            (b) – 15.4 kcal
   (c) + 14.5 kcal           (d) + 15.4 kcal

23. What is the correct order of decreasing stability of the following cations?
   $$CH_3-\overset{+}{C}H-CH_3 \qquad CH_3-\overset{+}{C}H-OCH_3$$
   $$\text{I} \qquad\qquad\qquad \text{II}$$
   $$CH_3-\overset{+}{C}H-CH_2-OCH_3$$
   $$\text{III}$$
   (a) II > I > III          (b) II > III > I
   (c) III > I > II          (d) I > II > III

24. Which has maximum number of oxo groups?
   (a) $H_2SO_4$  (b) $H_2SO_3$  (c) $H_3PO_3$  (d) $H_3PO_4$

**25.** Morphine, heroin and codeine drugs are the examples of
(a) tranquilizers
(b) narcotic analgesics
(c) non-narcotic analgesics
(d) antihistamines.

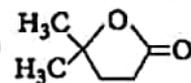**26.** According to Bronsted–Lowry concept of acids and bases, a conjugate acid-base pair can exist as

conjugate pair

$$HA + B^- \rightleftharpoons BH + A^-$$
Acid 1  Base 2     Acid 2  Base 1
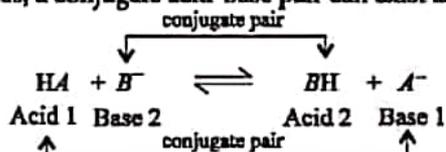
conjugate pair

Mark the option in which conjugate pair is not correctly matched.

| Species | Conjugate base | Conjugate acid |
|---|---|---|
| (a) $HCO_3^-$ | $CO_3^{2-}$ | $H_2CO_3$ |
| (b) $HPO_4^{2-}$ | $H_2PO_4^-$ | $PO_4^{3-}$ |
| (c) $NH_3$ | $NH_2^-$ | $NH_4^+$ |
| (d) $HS^-$ | $S^{2-}$ | $H_2S$ |

**27.** Identify (A) in the following reaction.

$$CH_3\overset{O}{\underset{||}{C}}CH_2CH_2\overset{O}{\underset{||}{C}}OCH_2CH_3 \xrightarrow[\text{(ii) } H_3O^+]{\text{(i) } CH_3MgBr \text{ (one mol)}} A$$

(a) $CH_3-\overset{OH}{\underset{CH_3}{\underset{|}{C}}}-CH_2CH_2-\overset{O}{\underset{||}{C}}-OCH_2CH_3$

(b) $CH_3-\overset{O}{\underset{||}{C}}-CH_2CH_2-\overset{O}{\underset{||}{C}}-CH_3$

(c) $\underset{H_3C}{\overset{H_3C}{>}}\!\!<\!\!\overset{O}{\diagdown}\!\!=\!O$

(d) $CH_3-\overset{CH_3}{\underset{OH}{\underset{|}{C}}}-CH_2CH_2-\overset{CH_3}{\underset{OH}{\underset{|}{C}}}-CH_3$

**28.** The addition of HCl to an alkene proceeds in two steps. The first step is the attack of $H^+$ ion to $\underset{}{>}C=C\underset{}{<}$ portion which can be shown as

(a) $H^+\frown\!>\!C\overset{\frown}{=}C\!<$
(b) $H^\bullet\,\,\overset{\frown}{>}\!C=C\!<$
(c) $H^\bullet\,\,\overset{\frown}{>}\!C\doteq C\!<$
(d) all are possible.
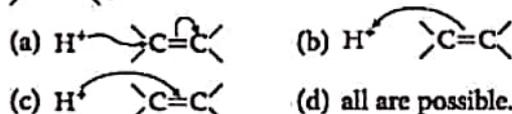
**29.** Which of the following lanthanide ions is paramagnetic ?
(a) $Ce^{4+}$
(b) $Yb^{2+}$
(c) $Lu^{3+}$
(d) $Eu^{2+}$

**30.** The orbital angular momentum for an electron revolving in an orbit is given by $\sqrt{l(l+1)}\cdot\dfrac{h}{2\pi}$. This momentum for an $s$-electron will be given by
(a) $+\dfrac{1}{2}\cdot\dfrac{h}{2\pi}$
(b) zero
(c) $\dfrac{h}{2\pi}$
(d) $\sqrt{2}\cdot\dfrac{h}{2\pi}$

**31.** In the reaction,
$$C_2O_4^{2-} + MnO_4^- + H^+ \longrightarrow Mn^{2+} + CO_2 + H_2O$$
which species acts as a reducing agent?
(a) $C_2O_4^{2-}$
(b) $MnO_4^-$
(c) $Mn^{2+}$
(d) $H^+$

**32.** The monomer of dacron is/are
(a) $HOCH_2 - CH_2OH$ and $\langle O \rangle$ with COOH and COOH
(b) caprolactam ring structure
(c) $HOCH_2-CH_2OH$ and $HOOC-\langle O \rangle-COOH$
(d) $F_2C = CF_2$
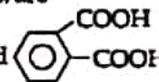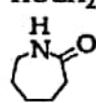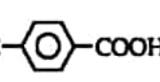
**33.** Electrode potentials of the given half-cells,
$Pt(H_2, p_1) \mid H^+(C_1)$ ; $Pt(Cl_2, p_2) \mid Cl^-(C_2)$;
(I) (II)   $Ag \mid Ag^+(C_3)$
(III)
(a) will increase on increasing $C_1$, $C_2$ and $C_3$
(b) will decrease on increasing $C_1$, $C_2$ and $C_3$
(c) both (a) and (b)
(d) none of the above.
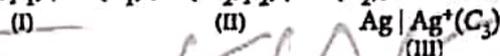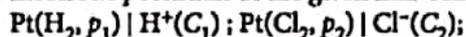
**34.** Which of the following cannot be used for the preparation of $H_2$?
(a) $Zn + HCl_{(dil)} \longrightarrow$
(b) $NaH + H_2O \longrightarrow$
(c) $Zn + HNO_{3(dil)} \longrightarrow$
(d) $HCOONa \xrightarrow{\Delta}$

**35.** Which of the following orders is not correct?
(a) B.E. : $C - C < C = C < C \equiv C$
(b) B.E. : $H - F > H - Cl > H - Br > H - I$
(c) B.E. : $sp - sp > sp^2 - sp^2 > sp^3 - sp^3$
(d) B.E. : $C \equiv C > C \equiv N > N \equiv N$

**36.** Which of the following statements regarding chemical properties of acetophenone are wrong?
I. It is reduced to methylphenylcarbinol by sodium and ethanol.
II. It is oxidised to benzoic acid with acidified $KMnO_4$.
III. It does not undergo electrophilic substitution like nitration at *meta*-position.

IV. It does not undergo iodoform reaction with iodine and alkali.
(a) Only I and II
(b) Only II and IV
(c) Only III and IV
(d) Only I and III.

37. Which of the following statements is false?
(a) The main reason for river water pollution is industrial and domestic sewage discharge.
(b) Surface water contains a lot of organic matter, mineral nutrients and radioactive materials.
(c) Oil spill in sea water causes heavy damage to fishery.
(d) Oil slick in sea water increases D.O. value.

38. Graph between $\log k$ and $1/T$ [where $k$ is rate constant (in $s^{-1}$) and $T$ is the temperature (in K)] is a straight line with $OX = 5$, $\theta = \tan^{-1} (1/2.303)$. Hence, $-E_a$ will be
(a) $2.303 \times 2$ cal
(b) $\dfrac{2}{2.303}$ cal
(c) $2$ cal
(d) none of these.
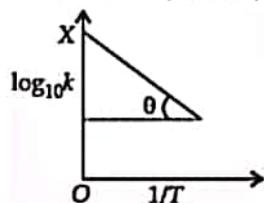


39. The reaction of benzenesulphonyl chloride with ethylamine yields
(a) $N$-ethylbenzenesulphonamide, insoluble in alkali
(b) $N$, $N$-diethylbenzenesulphonamide, soluble in alkali
(c) $N$, $N$-diethylbenzenesulphonamide, insoluble in alkali
(d) $N$-ethylbenzenesulphonamide, soluble in alkali.

40. Ionic radii are
(a) directly proportional to square of effective nuclear charge
(b) inversely proportional to effective nuclear charge
(c) inversely proportional to square of effective nuclear charge
(d) directly proportional to effective nuclear charge.

## SOLUTIONS

1. (a) : Number of atoms in 1 gram of an element
$$= \dfrac{6.023 \times 10^{23}}{\text{At. mass}} \times 1$$
∴ Number of atoms in 2 grams of oxygen
$$= \dfrac{6.023 \times 10^{23}}{16} \times 2 = \dfrac{6.023 \times 10^{23}}{8}$$
Number of atoms in 4 grams of sulphur
$$= \dfrac{6.023 \times 10^{23}}{32} \times 4 = \dfrac{6.023 \times 10^{23}}{8}$$

Number of atoms in 7 grams of nitrogen
$$= \dfrac{6.023 \times 10^{23}}{14} \times 7 = \dfrac{6.023 \times 10^{23}}{2}$$
Number of atoms in 0.5 grams of hydrogen
$$= \dfrac{6.023 \times 10^{23}}{1} \times 0.5 = \dfrac{6.023 \times 10^{23}}{2}$$
Number of atoms in 2.3 grams of sodium
$$= \dfrac{6.023 \times 10^{23}}{23} \times 2.3 = \dfrac{6.023 \times 10^{23}}{10}$$

2. (a) : $\underset{\underset{Cl}{|}}{CH_2} - \underset{}{CH_2} - \underset{\underset{Cl}{|}}{CH_2} \xrightarrow[\text{or 2Na}]{\text{Mg or Zn}} \triangle + MgCl_2$ or $ZnCl_2$ or $2NaCl$

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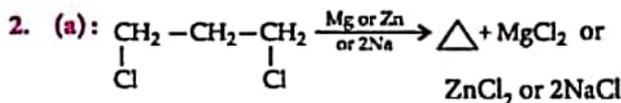
## Some Fascinating Facts Around the World!

**Lightning strikes produce Ozone, hence everything seems fresh after thunderstorms.**
Ozone, the triple oxygen molecule that acts as a saviour against ultraviolet rays, is created in nature by lightning. When it strikes, the lightning breakdown oxygen molecules in the atmosphere into radicals which reform into ozone.
The smell of ozone is very sharp, often described as similar to that of chlorine. This is why you get that "clean" smell sensation after a thunderstorm.

**Every hydrogen atom in your body is old as they were formed likely 13.5 billion years at the birth of the universe.**
At ground zero, before the big bang, the very first chemical element was hydrogen. All the other followed by fusing hydrogen into helium, which then fused into carbon and so on. Approximately 73% of the mass of the visible universe is in the form of hydrogen. Helium makes up about 25% of the mass, and everything else represents only 2%. By mass, hydrogen and helium combined make up less than 1% of the Earth.

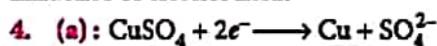**Can you write your address in the form of chemical elements? Sounds interesting!**
Famed chemist Glenn Seaborg was the only person who could write his address in chemical elements. He wrote Sg, Lr, Bk, Cf, Am. That's Seaborgium (Sg), named after Seaborg himself; Lawrencium (Lr), named after the Lawrence Berkeley National Laboratory; Berkelium (Bk), named after the city of Berkeley, the home of UC Berkeley; Californium (Cf), named after the state of California; Americium (Am), named after America.

**This time thanks giving goes to Saliva**
Food is a necessity for survival, however, food that tastes good is one of the greatest pleasures of life. You can thank your saliva for this, as without that moisture, you wouldn't be able to taste anything. Saliva works to break down the foods, which in turn dissolves the chemicals onto the tongue's taste receptors.

$\alpha$ and $\gamma$-dihalogen derivatives of an alkane on treatment with Mg or Zn or Na give cycloalkanes.

3. **(b):** Isoelectric point is that pH value at which no migration of dispersed phase takes place under the influence of electric field.
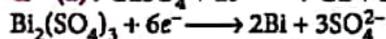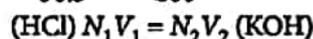
4. **(a):** $CuSO_4 + 2e^- \longrightarrow Cu + SO_4^{2-}$
$Bi_2(SO_4)_3 + 6e^- \longrightarrow 2Bi + 3SO_4^{2-}$
$AlCl_3 + 3e^- \longrightarrow Al + 3Cl^-$
$AgNO_3 + e^- \longrightarrow Ag + NO_3^-$
Since, in 1 M $CuSO_4$ solution, 1 M $Bi_2(SO_4)_3$ solution, 1 M $AlCl_3$ solution and 1 M $AgNO_3$ solution, 2 moles of electrons, 6 moles of electrons, 3 moles of electrons and 1 mole of electrons are needed to deposit Cu, Bi, Al and Ag at the cathode respectively.
But one mole of electrons = 1 F electricity
That's why number of Faradays required to deposit 1 M of each $CuSO_4$, $Bi_2(SO_4)_3$, $AlCl_3$ and $AgNO_3$ solution are 2F, 6F, 3F and F respectively.

5. **(a):** Normality of HCl solution
$= \dfrac{31.2}{36.5} \times \dfrac{1000 \times 1.17}{100} = 10$
(HCl) $N_1 V_1 = N_2 V_2$ (KOH)
$V_1 = \dfrac{1}{20} \times 5 \times \dfrac{1}{10} = 0.025 \text{ L} \Rightarrow 25 \text{ mL}$
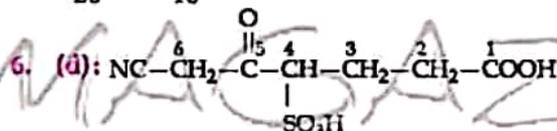
6. **(d):** 
$$\overset{6}{N}C - \overset{}{C}H_2 - \overset{\overset{O}{||}}{\underset{5}{C}} - \overset{4}{C}H - \overset{3}{C}H_2 - \overset{2}{C}H_2 - \overset{1}{C}OOH$$
$$\underset{SO_3H}{|}$$
6-Cyano-5-oxo-4-sulphohexan-1-oic acid

7. **(c):** The addition product, $B_2H_6\cdot2NH_3$ is considered as an ionic product and on heating to 200 °C, it forms a volatile compound called borazine.

8. **(a):** Extraction of copper from copper pyrite ore by heating it in a blast furnace is based on the fact that copper has more affinity for oxygen than sulphur at high temperature.

9. **(d):** 8 $A$ atoms are present at the corners but 2 $A$ atoms are missed,
hence, contribution of $A = 6 \times \dfrac{1}{8} = \dfrac{6}{8}$
$B$ atoms are present at the face centres,
hence, contribution of $B = 6 \times \dfrac{1}{2} = 3$
So, $A_{6/8}B_3$ or $A_6B_{24}$

10. **(c):** The electronic configurations of $M^+$ ions are
$Cr^+: 1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$ – Stable configuration
$Mn^+ : 1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$
$V^+ : 1s^2 2s^2 2p^6 3s^2 3p^6 3d^3 4s^1$
$Ti^+ : 1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^1$

In general, ionisation energy (both 1st and 2nd) increases from left to right across the period due to increase in effective nuclear charge. On this basis, the second ionisation energy values should exhibit the trend, Mn > Cr > V > Ti. But the actual observed order is Cr > Mn > V > Ti. Practically, only chromium is exceptional and rest others show the normal trend. This exceptional behaviour of chromium is due to the stable configuration ($3d^5$) that it achieves after the loss of first electron.

11. **(c):** $E_n = \dfrac{-2\pi^2 Z^2 e^4 m}{h^2 n^2} = \dfrac{-1312}{n^2}$ kJ mol$^{-1}$
$\Delta E = E_{final} - E_{initial}$
$\Delta E = -1312 \left[ \dfrac{1}{n_2^2} - \dfrac{1}{n_1^2} \right]$ kJ mol$^{-1}$
$\Delta E = -1312 \left[ \dfrac{1}{9} - \dfrac{1}{1} \right]$ kJ mol$^{-1}$
$= 1312 \times \dfrac{8}{9} \times \dfrac{1000}{6.023 \times 10^{23}}$ J atom$^{-1}$; $\Delta E = \dfrac{hc}{\lambda}$ or $\lambda = \dfrac{hc}{\Delta E}$
$\lambda = 6.626 \times 10^{-34} \times 3.0 \times 10^8 \times \dfrac{6.023 \times 10^{23} \times 9}{1312 \times 8 \times 1000}$
$= 0.103 \times 10^{-6}$ m = 103 nm

12. **(c):** 1-Propanol and 2-propanol in presence of Cu/$\Delta$ undergo dehydrogenation to give acetaldehyde and acetone respectively which can be distinguished by Fehling's solution since acetaldehyde reduces while acetone does not reduce Fehling's solution.
In contrast with alkaline $KMnO_4$ or acidic $K_2Cr_2O_7$, 1-propanol will first give propionaldehyde which will be readily oxidised to propionic acid while 2-propanol will first give acetone and then on further oxidation will give acetic acid. Both these acids cannot be distinguished by Fehling's solution. Option (d) is incorrect since conc. $H_2SO_4$ does not bring about oxidation of alcohols.
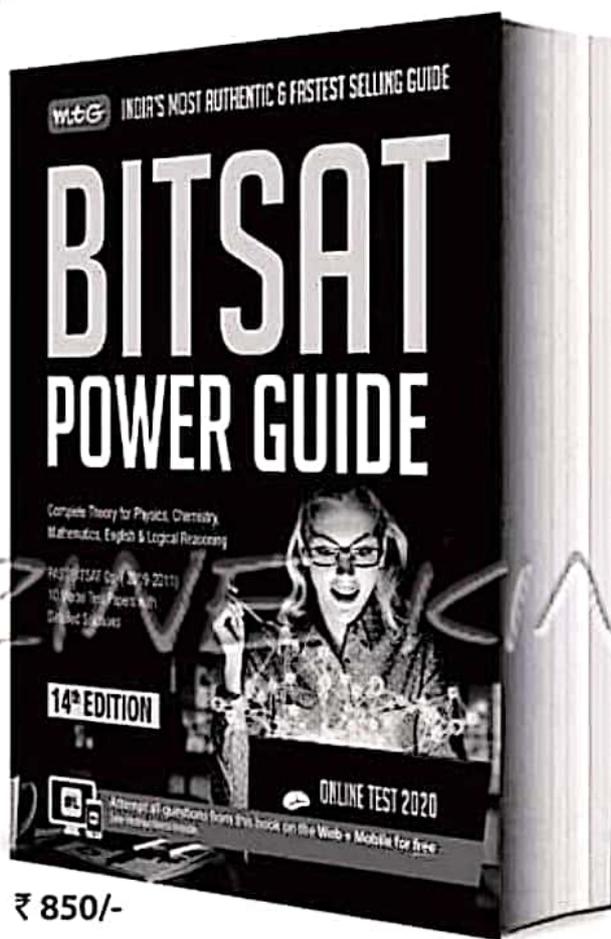
13. **(a):** $P_4O_6 + 6H_2O \longrightarrow 4H_3PO_3$
$P_4O_{10} + 6H_2O \longrightarrow 4H_3PO_4$
In $P_4O_6$, each P is joined to three O and in $P_4O_{10}$ each P is joined to four O atoms.



$P_4O_6$

$P_4O_{10}$

**14. (a) :** The reactions can be summarised as follows :

$A \xrightarrow{\Delta}$ colourless gas + residue

Residue + $H_2O \longrightarrow B \xrightarrow[\text{excess}]{CO_2} C \xrightarrow{\Delta} A$

This is possible only when $A$ is $CaCO_3$.

The reactions are as follows :

$\underset{(A)}{CaCO_3} \xrightarrow{\Delta} \underset{\text{(colourless gas)}}{CO_2} + \underset{\text{(residue)}}{CaO}$

$CaO + H_2O \longrightarrow \underset{(B)}{Ca(OH)_2} \xrightarrow[\text{(excess)}]{CO_2}$

$\underset{(C)}{Ca(HCO_3)_2} \xrightarrow{\Delta} \underset{(A)}{CaCO_3}$

**15. (c) :** $pH = pK_a + \log \dfrac{[Salt]}{[Acid]}$

$9 = -\log (5 \times 10^{-10}) + \log \dfrac{[Salt]}{[Acid]}$

$\log \dfrac{[Salt]}{[Acid]} = 9 + \log (5 \times 10^{-10})$

$= 9 + (0.699 - 10) = -0.3010$

$\dfrac{[Salt]}{[Acid]} = \text{Antilog} (-0.3010) = 0.5$

Suppose volume of 5 M KCN to be added = $V$ cc

Then total volume of HCN + KCN = $10 + V$ cc

In the final solution, $V$ cc of 5 M KCN = $(10 + V)$ cc of $x$ M KCN

Molarity of KCN, $x = \dfrac{5V}{10+V}$

Molarity of HCN, $y = \dfrac{10 \times 2}{10+V}$

As, $\dfrac{[Salt]}{[Acid]} = 0.5$ $\therefore$ $\dfrac{5V/(10+V)}{20/(10+V)} = 0.5$

$\Rightarrow V/4 = 0.5$ or $V = 2$ cc.

**16. (d) :** In each case, same number of mole particles are formed so $\Delta T_f$ is same.

I. $\dfrac{W \times 1}{248}$ = 'X' mol   (Only 1 particle formed)

II. $\dfrac{W}{744} \times 3 = \dfrac{W}{248}$ = 'X' mol (3 ions formed)

III. $\dfrac{W \times 2}{496} = \dfrac{W}{248}$ = 'X' mol (2 ions formed)

**17. (c) :** Optical isomers rarely occur in square planar complexes due to the presence of axis of symmetry. Optical isomerism is common in octahedral complexes of the general formula, $[Ma_2b_2c_2]^{n\pm}$, $[Mabcdef]$, $[M(AA)_3]^{n\pm}$, $[M(AA)_2a_2]^{n\pm}$, $[M(AA)_2ab]^{n\pm}$ and $[M(AB)_3]^{n\pm}$. Thus, among the given options, only $[Co(en)_3]^{3+}$ shows optical isomerism.



**18. (a) :** From amongst given olefins (a) and (b) are less stable (Saytzeff's rule). Moreover *syn*-isomer is more reactive than *anti*-because of steric hindrance.

**19. (d) :** No. of g equivalents of $H_2SO_4 = 0.2 \times 50 \times 10^{-3}$
$= 0.01$ g eq.

No. of g equivalents of KOH = $1 \times 50 \times 10^{-3} = 0.05$ g eq.

0.01 g eq. of $H_2SO_4 \equiv 0.01$ g eq. of KOH

Heat of neutralisation for 1 equivalent = 57.3 kJ $g^{-1}eq^{-1}$

For 0.01 g equivalent heat released = $57.3 \times 0.01 = 0.573$ kJ

**20. (b) :** Methionine is an essential amino acid which contains sulphur.



Methionine

**21. (b) :** Slag is lighter, has lower m.pt. than metal, hence it floats and can be skimmed off.

**22. (a) :** The formation of $CH_3OCH_3$ may be represented as :

$2C_{(s)} + 3H_{2(g)} + \dfrac{1}{2}O_{2(g)} \rightarrow H_3C - O - CH_3; \Delta H = ?$

It involves vapourisation of 2 gram atoms of solid carbon and breaking 3 moles of H – H bonds and $\dfrac{1}{2}$ mole of O=O bonds resulting in the formation of 6 C – H bonds and 2C – O bonds. Thus, the heat of formation of $CH_3 - O - CH_3$ is given by

$\Delta H = (2 \times 125 + 3 \times 103 + \dfrac{1}{2} \times 177) - (6 \times 87 + 2 \times 70)$

$= -14.5$ kcal

**Monthly Test Drive CLASS XI    ANSWER    KEY**

| | | | | |
|---|---|---|---|---|
| 1. (a) | 2. (c) | 3. (c) | 4. (b) | 5. (c) |
| 6. (d) | 7. (c) | 8. (a) | 9. (d) | 10. (c) |
| 11. (a) | 12. (a) | 13. (d) | 14. (c) | 15. (b) |
| 16. (a) | 17. (b) | 18. (b) | 19. (c) | 20. (b,c) |
| 21. (a,b) | 22. (b,c,d) | 23. (b,c,d) | 24. (7) | 25. (5) |
| 26. (7) | 27. (c) | 28. (b) | 29. (a) | 30. (a) |

**23. (a):** $CH_3 \rightarrow \overset{+}{C}H \leftarrow CH_3$   $CH_3 - \overset{+}{C}H \overset{\frown}{\leftarrow} \overset{\cdot\cdot}{O} - CH_3$

I — Stabilized by weak +I effect of the two methyl groups

II — Stabilized by strong +R effect of the -OCH$_3$ groups

$$CH_3 - \overset{+}{C}H \rightarrow CH_2 \rightarrow OCH_3$$

III — Destabilized by -I effect of the -OCH$_3$ group

Thus, the stability of carbocations decreases in the order II > I > III.

**24. (a):** Oxo group means M=O group.

HO—$\overset{\overset{O}{||}}{\underset{\underset{O}{||}}{S}}$—OH ($H_2SO_4$) 2-oxo groups

HO—$\overset{\overset{O}{||}}{S}$—OH ($H_2SO_3$) 1-oxo group

HO—$\overset{\overset{O}{||}}{\underset{H}{P}}$—OH ($H_3PO_3$) 1-oxo group

HO—$\overset{\overset{O}{||}}{\underset{OH}{P}}$—OH ($H_3PO_4$) 1-oxo group

**25. (b):** Morphine and many of its homologues compounds relieve pain and produce sleep. They come under narcotic analgesics.

**26. (b)**

**27. (c):**

$$CH_3 - \overset{\overset{O}{||}}{C} - CH_2 - CH_2 - \overset{\overset{O}{||}}{C} - O - CH_2CH_3 \xrightarrow[\text{1 mole}]{\text{(i) } CH_3MgBr}$$

$$CH_3 - \overset{\overset{OMgBr}{|}}{\underset{CH_3}{C}} - CH_2 - CH_2 - \overset{\overset{O}{||}}{C} - O - CH_2 - CH_3 \xrightarrow{\text{(ii) } H_3O^+}$$

$$CH_3 - \overset{\overset{OH}{|}}{\underset{CH_3}{C}} - CH_2CH_2\overset{\overset{O}{||}}{C}OCH_2CH_3 \xrightarrow[\text{cyclisation}]{-CH_3CH_2OH}$$

$\overset{H_3C}{\underset{H_3C}{>}}\overset{O}{\diagdown}{=}O$ (A)

**28. (b):** Addition of HCl to an alkene follows Markownikoff's rule and first step is the capture of proton by electron clouds of $\pi$-bond.

$$>C \overset{\frown}{=} C< + \overset{H^+}{\cdot} \longrightarrow >\overset{H^+}{C} - C<$$

**29. (d):** Ce → [Xe] $4f^1 5d^1 6s^2$; Ce$^{4+}$ → [Xe]
Yb → [Xe] $4f^{14} 6s^2$; Yb$^{2+}$ → [Xe] $4f^{14}$

Lu → [Xe] $4f^{14} 5d^1 6s^2$; Lu$^{3+}$ → [Xe] $4f^{14}$
Eu → [Xe] $4f^7 6s^2$; Eu$^{2+}$ → [Xe] $4f^7$

**30. (b):** The value of $l$ (azimuthal quantum number) for $s$-electron is equal to zero.

Orbital angular momentum $= \sqrt{l(l+1)} \cdot \dfrac{h}{2\pi}$

Substituting the value of $l$ for $s$-electron

$$= \sqrt{0(0+1)} \cdot \dfrac{h}{2\pi} = 0$$

**31. (a):** $\overset{+3}{C_2}O_4^{2-} + \overset{+7}{Mn}O_4^{-1} + H^+ \rightarrow \overset{+2}{Mn} + \overset{+4}{C}O_2 + H_2O$

Oxidation number increases (oxidation)

Reducing agent is that species whose oxidation number increases.

**32. (c)**

**33. (d):** $1/2\, H_2 \rightarrow H^+ + e^-$
$K = [H^+] = C_1$
$E = E° - 0.0591 \log C_1$
$E$ decreases if $C_1$ increases.

$Cl^- \longrightarrow \dfrac{1}{2}Cl_2 + e^-$ ; $K = \dfrac{1}{[Cl^-]} = \dfrac{1}{C_2}$

$E = E° + 0.0591 \log C_2$
$E$ increases if $C_2$ increases.
$Ag \rightarrow Ag^+ + e^-$
$E = E° - 0.0591 \log C_3$ ; $E$ decreases if $C_3$ increases.

**34. (c):** $4Zn + 10HNO_{3(dil)} \longrightarrow 4Zn(NO_3)_2 + N_2O + 5H_2O$

**35. (d):** $B.E. \propto \dfrac{1}{\text{At. size}}$
Hence, the order of bond energy is $C \equiv C < C \equiv N < N \equiv N$

**36. (c):** Acetophenone, ⬡—COCH$_3$ undergoes electrophilic substitution reaction and also gives positive iodoform test with iodine and alkali.

**37. (d)**

**38. (c):** $\log k = \log A - \dfrac{E_a}{2.303RT}$

$\text{Slope} = \dfrac{-E_a}{2.303R} = \tan\theta = \dfrac{1}{2.303}$ (given)

$-E_a = 2.303R \times \text{Slope} = 2.303R \times \dfrac{1}{2.303}$

By substituting the value of $R = 2$ cal K$^{-1}$ mol$^{-1}$ we get, $-E_a = 2$ cal

**39. (d)**

**40. (b):** Ionic radii is inversely proportional to effective nuclear charge. ◆◆

# JEE 2020
## PRACTICE PAPER
# ADVANCED

**PAPER - I**

**SECTION 1 (Maximum Marks : 12)**

- *This section contains FOUR (04) questions.*
- *Each question has FOUR options. ONLY ONE of these four options is the correct answer.*
- *For each question, choose the option corresponding to the correct answer.*
- *Answer to each question will be evaluated according to the following marking scheme :*

*Full Marks :* +3 *If ONLY the correct option is chosen.*

*Zero Marks :* 0 *If none of the options is chosen (i.e., the question is unanswered).*

*Negative Marks :* −1 *In all other cases.*

1. Traces of fluoride ions (F⁻) in drinking water (about 1 ppm) greatly reduce the incidence of dental cavities (tooth decay). What is the reason for reduction in cavities?
   (a) The enamel $[3Ca_3(PO_4)_2 \cdot CaF_2]$ on the surface of teeth is converted to much harder $[3Ca_3(PO_4)_2 \cdot Ca(OH)_2]$.
   (b) The enamel $[3Ca_3(PO_4)_2 \cdot Ca(OH)_2]$ on the surface of teeth is converted to much harder $[3Ca_3(PO_4)_2 \cdot CaF_2]$.
   (c) The enamel $[Ca(OH)_2]$ on the surface of teeth is converted to $CaF_2$.
   (d) The enamel $[Ca_3(PO_4)_2 \cdot Ca(OH)_2]$ on the surface of teeth is converted to much harder $[3Ca_3(PO_4)_2 \cdot CaF_6]$.

2. Reactant *P* gives products *Q* and *R*,
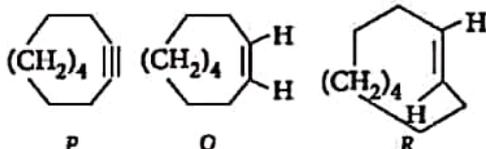


The possible reagents are
(I) 2Na/liq. NH₃
(II) H₂/Pd/CaCO₃ (quinoline)
(III) 2H₂/Pd/C

The correct statement with respect to the conversions is
(a) *Q* is obtained on treatment with reagent (I)
(b) *R* and *Q* are obtained on treatment with reagent (III)
(c) *R* is obtained on treatment with reagent (II)
(d) *R* is obtained on treatment with reagent (I).

3. *X*, *Y* and *Z* in the following reactions are respectively,
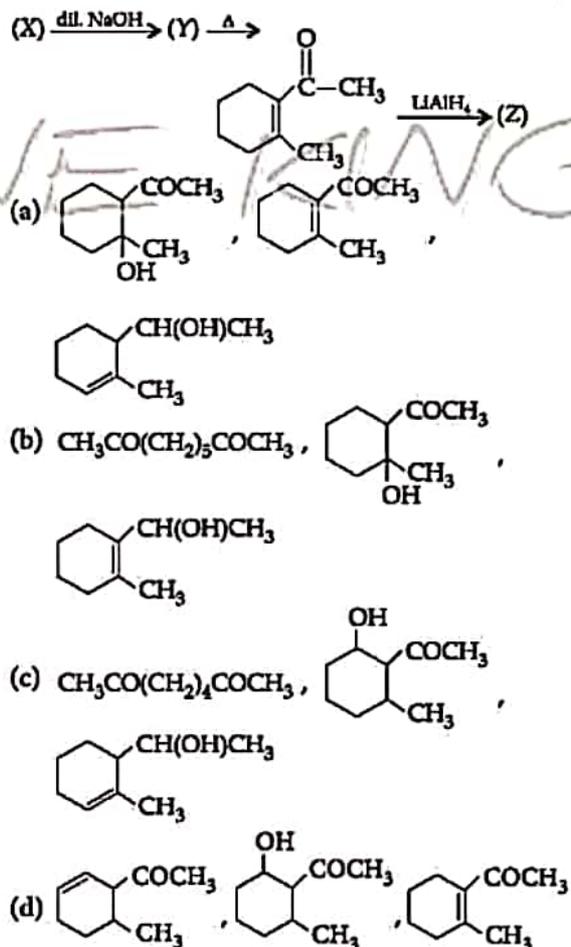
**4.** KI (excess) is added to the following solutions separately

(I) $CuSO_4$     (II) $HgCl_2$     (III) $Pb(NO_3)_2$

The correct observation is

(a) a white precipitate of $Cu_2I_2$ in (I), an orange precipitate of $HgI_2$ in (II) which further dissolves and a yellow precipitate of $PbI_2$ in (III) are formed

(b) white precipitates of $Cu_2I_2$, $HgI_2$ and $PbI_2$ are formed respectively

(c) yellow precipitate in each case is formed

(d) a white precipitate of $Cu_2I_2$ in (I), a blue precipitate of $K_2HgI_4$ in (II) and a yellow precipitate of $PbI_2$ in (III) are formed.

## SECTION 2 (Maximum Marks : 32)

- *This section contains EIGHT (08) questions.*
- *Each question has FOUR options. ONE OR MORE THAN ONE of these four option(s) is(are) correct answer(s).*
- *For each question, choose the option(s) corresponding to (all) the correct answer(s).*
- *Answer to each question will be evaluated according to the following marking scheme:*

*Full Marks :*    +4 *If only (all) the correct option(s) is (are) chosen.*

*Partial Marks :*    +3 *If all the four options are correct but ONLY three options are chosen.*

*Partial Marks :*    +2 *If three or more options are correct but ONLY two options are chosen and both of which are correct.*

*Partial Marks :*    +1 *If two or more options are correct but ONLY one option is chosen and it is a correct option.*

*Zero Marks :*    0 *If none of the options is chosen (i.e., the question is unanswered).*

*Negative Marks :*    –1 *In all other cases.*

- *For example, in a question, if (a), (b) and (d) are the ONLY three options corresponding to correct answers, then choosing ONLY (a), (b) and (d) will get +4 marks; choosing ONLY (a) and (b) will get +2 marks; choosing ONLY (a) and (d) will get +2 marks; choosing ONLY (b) and (d) will get +2 marks; choosing ONLY (a) will get +1 mark; choosing ONLY (b) will get +1 mark; choosing ONLY (d) will get +1 mark; choosing no option (i.e., the question is unanswered) will get 0 marks; and choosing any other combination of options will get –1 mark.*
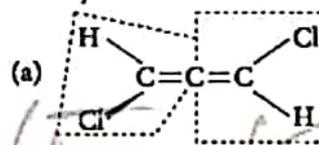
**5.** The diagram illustrates the energy changes of a set of reactions :
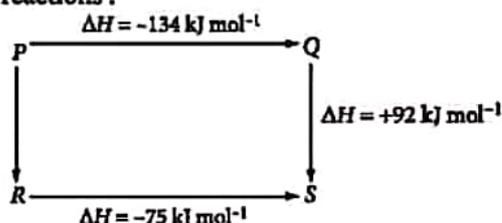


Which of the following statements is/are correct ?
(a) The enthalpy change for the reaction $P \rightarrow R$ is $-33$ kJ mol$^{-1}$.
(b) The enthalpy change for the transformation $R \rightarrow Q$ will be endothermic.
(c) The enthalpy change for the transformation $R \rightarrow Q$ will be exothermic.
(d) The enthalpy change for the transformation $S \rightarrow P$ will be $+42$ kJ mol$^{-1}$.

**6.** Which of the following is/are arranged in correct order as indicated?

(a) 
[Nucleophilic addition reaction]
(b) $CH_3COCl > (CH_3CO)_2O > CH_3COOCH_3 > CH_3CONH_2$ [Acyl $S_N2$ reaction]
(c) $CH_3CH_2COOH > CH_3COOH > HCOOH$
[Rate of esterification reaction]
(d) $CH_3COOCH_3 > CH_3COOC_2H_5 > CH_3COOC_3H_7$ [Rate of hydrolysis]

**7.** Of the following, the metal(s) that cannot be obtained by electrolysis of the aqueous solution of their salts is/are
(a) Ag  (b) Mg  (c) Cu  (d) Al

**8.** Few reactions along with their names are given below. Find the incorrect one(s) either with respect to name or product.

(a) 
(Sommelet reaction)

(b) 
(Wolff rearrangement)

(c) 
(Schotten-Baumann reaction)

(d) 
(Hoffmann rearrangement)
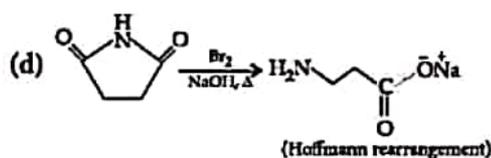
**9.** Select the correct statement(s) if 9.65 amperes current is passed for 1 hour through the cell,

$$Ag \mid Ag^+(1 \text{ M}) \parallel Cu^{2+}(1 \text{ M}) \mid Cu$$

(a) Ag will oxidise to $Ag^+$ and new $[Ag^+] = 1.36$ M
(b) $Ag^+$ will reduce to Ag and new $[Ag^+] = 0.64$ M
(c) $Cu^{2+}$ will reduce to Cu and new $[Cu^{2+}] = 0.82$ M
(d) Cu will oxidise to $Cu^{2+}$ and new $[Cu^{2+}] = 0.82$ M

**10.** The bond lengths and bond angles in the molecules of methane, ammonia and water may be represented as follows :
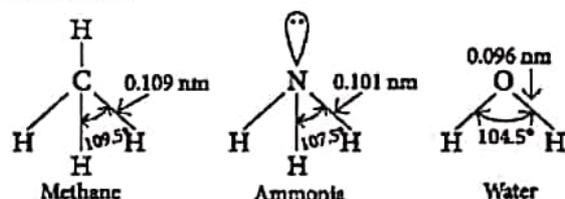


Choose the correct statement(s) regarding the trend.
(a) Bond angle increases due to increase in no. of non-bonding electron pairs.

(b) Increasing repulsion between hydrogen atoms cause bond length to decrease.

(c) Decreasing bond angle is caused due to decreasing bond pair-bond pair repulsion.

(d) Increasing $s$-characteristics in bonding hybridised orbital cause decrease in bond length.

11. With reference to the scheme given, which of the given statements about $T$, $U$, $V$ and $W$ is/are correct?
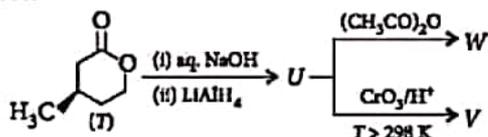


(a) $T$ is soluble in hot aqueous NaOH.

(b) $U$ is optically active.

(c) Molecular formula of $W$ is $C_{10}H_{18}O_4$.

(d) $V$ gives effervescence on treatment with aqueous $NaHCO_3$.

12. If there are three possible values $\left(-\frac{1}{2}, 0, +\frac{1}{2}\right)$ for the spin magnetic quantum number ($m_s$). Which of the following statements is/are correct regarding a hypothetical periodic table based on this condition?

(a) First period would have only 2 vertical columns.

(b) Second period would have 12 elements.

(c) Third period would have 12 elements.

(d) Second period would have 14 elements.

### SECTION 3 (Maximum Marks : 18)

- *This section contains SIX (06) questions. The answer to each question is a NUMERICAL VALUE.*
- *For each question, enter the correct numerical value of the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer. If the numerical value has more than two decimal places, truncate/round-off the value to TWO decimal places.*
- *Answer to each question will be evaluated according to the following marking scheme :*

*Full Marks :* +3 If ONLY the correct numerical value is entered.

*Zero Marks :* 0 In all other cases.

13. If you are initially provided with 224 g of pure chromite ore and 169.6 g of sodium carbonate then the minimum volume of air required at NTP to consume atleast one of the reactant completely, if air contains 20% by volume of oxygen gas, is _____.

14. A Duma's bulb of air weighs 22.567 g at 20°C and 755 mm Hg pressure. Filled with vapours of a substance at 120°C and at the same pressure then it weighs 22.8617 g. The capacity of the bulb is 200 mL. The molecular mass of the substance is _____.
(Density of air = 0.00129 g/mL)

15. The coordination number exhibited by $K^+$ when it forms a complex with salicylaldehyde is _____.

16. A tetrapeptide has —COOH group on alanine. This produces glycine (gly), phenylalanine (phe), valine (val) and alanine (ala) on complete hydrolysis. For this tetrapeptide, the number of possible sequences (primary structures) with —NH$_2$ group attached to a chiral centre is _____.

17. A 500 mL sample of an equilibrium mixture of gaseous $N_2O_4$ and $NO_2$ at 25 °C and 753 mm Hg was allowed to react with enough water to make 250 mL of solution at 25 °C. Assume that all the dissolved $N_2O_4$ is converted to $NO_2$ which disproportionates in water yielding a solution of nitrous acid and nitric acid. Assume that further disproportionation reaction goes to completion and that none of the nitrous acid disproportionates. The equilibrium constant ($K_p$) for, $N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$ is 0.113 at 25°C. The pH of the solution is _____.

18. An organic compound ($C_xH_{2y}O_y$) was burnt with twice the amount of oxygen needed for complete combustion to $CO_2$ and $H_2O$. The hot gases when cooled to 0°C and 1 atm pressure, measured 2.24 litres. The water collected during cooling weighed 0.9 g. The vapour pressure of pure water at 20°C is 17.5 mm Hg and is lowered by 0.104 mm when 50 g of the organic compound are dissolved in 1000 g of water. The molecular weight of the organic compound is _____.

## SECTION 1 (Maximum Marks : 32)

- *This section contains EIGHT (08) questions.*
- *Each question has FOUR options. ONE OR MORE THAN ONE of these four option(s) is(are) correct answer(s).*
- *For each question, choose the option(s) corresponding to (all) correct answer(s).*
- *Answer to each question will be evaluated according to the following marking scheme :*
- *Full Marks :*    *+4 If only (all) the correct option(s) is (are) chosen.*
- *Partial Marks :*    *+3 If all the four options are correct but ONLY three options are chosen.*
- *Partial Marks :*    *+2 If three or more options are correct but ONLY two options are chosen and both of which are correct.*
- *Partial Marks :*    *+1 If two or more options are correct but ONLY one option is chosen and it is a correct option.*
- *Zero Marks :*    *0 If none of the options is chosen (i.e. the question is unanswered).*
- *Negative Marks :*    *–1 In all other cases.*
- *For example, in a question, if (a), (b) and (d) are the ONLY three options corresponding to correct answers, then choosing ONLY (a), (b) and (d) will get +4 marks;*
- *choosing ONLY (a) and (b) will get +2 marks;*
- *choosing ONLY (a) and (d) will get +2 marks;*
- *choosing ONLY (b) and (d) will get +2 marks;*
- *choosing ONLY (a) will get +1 mark;*
- *choosing ONLY (b) will get +1 mark;*
- *choosing ONLY (d) will get +1 mark;*
- *choosing no option (i.e. the question is unanswered) will get 0 marks ; and*
- *choosing any other combination of options will get –1 mark.*

1. Which of the following statements is/are incorrect?
   - (a) Among $O_2^+$, $O_2$ and $O_2^-$ the stability decreases in the order $O_2^+ > O_2 > O_2^-$.
   - (b) $He_2$ molecule does not exist as the effect of bonding and anti-bonding molecular orbitals cancel each other.
   - (c) $C_2$, $O_2^{2-}$ and $Li_2$ are diamagnetic.
   - (d) In $F_2$ molecule, the energy of $\sigma 2p_z$ is more than $\pi 2p_x$ and $\pi 2p_y$.

2. The given graphs/data I, II, III and IV represent general trends observed for different physisorption and chemisorption processes under mild conditions of temperature and pressure. Which of the following choices about I, II, III and IV is/are correct?
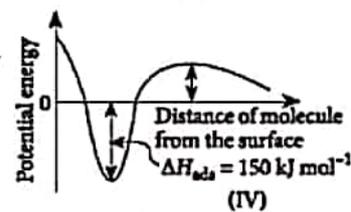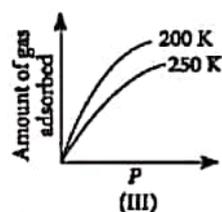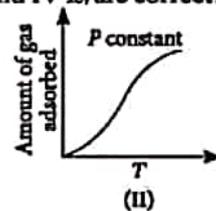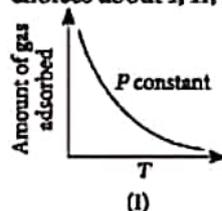


(I)      (II)

(III)      (IV)

$\Delta H_{ads} = 150 \text{ kJ mol}^{-1}$

   - (a) I is physisorption and II is chemisorption.
   - (b) I is physisorption and III is chemisorption.
   - (c) IV is chemisorption and II is chemisorption.
   - (d) IV is chemisorption and III is chemisorption.

3. Which of the following do/does not show optical activity?

   (a)

(b)



(c)



(d)



**4.** A metal has cubic close packing (*ccp*) arrangement, the layer sequence of which is shown as :



$Z = 0$  $Z = a/2$

$Z = a$
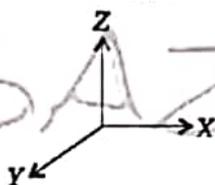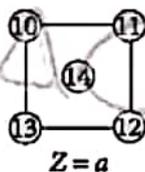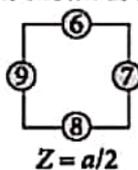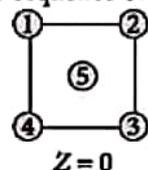
A face diagonal passes through the centre of atom 4 and the centre(s) of which other atom(s)?

(a) 1    (b) 2, 5    (c) 8, 12    (d) 9, 10

**5.** In the reaction, $2x + B_2H_6 \rightarrow [BH_2(x)_2]^+[BH_4]^-$, the amine(s) $x$ is/are

(a) $NH_3$         (b) $CH_3NH_2$
(c) $(CH_3)_2NH$    (d) $(CH_3)_3N$

**6.** In a closed flask of 5 litre, 1.0 g of $H_2$ is heated from 300–600 K. Which statement(s) is/are correct?

(a) The rate of collision increases.
(b) The energy of gaseous molecules increases.
(c) The number of moles of the gas increases.
(d) Pressure of the gas increases.

**7.** Mark out the correct statement(s).

(a) $AlCl_3$ exists as dimers, attaining an octet.
(b) In non-polar solvent $AlCl_3$ undergoes ionisation as $[AlCl_4]^- [AlCl_2]^+$
(c) In water, $AlCl_3$ ionises as $[Al \cdot 6H_2O]^{3+} + 3Cl^-$.

(d) At low temperature, $AlCl_3$ exists as a close packed lattice of $Cl^-$ with $Al^{3+}$ occupying octahedral holes.

**8.** Which of the following statements is/are true about the addition polymerisation?

(a) Addition polymerisation occurs between molecules containing double or triple bond.
(b) It takes place in the presence of organic peroxides.
(c) It proceeds via ionic mechanism in the presence of organic peroxides.
(d) Polythene and polystyrene are addition polymers.

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### Section 2 (Maximum Marks : 18)

- *This section contains SIX (06) questions. The answer to each question is a NUMERICAL VALUE.*
- *For each question, enter the correct numerical value of the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer. If the numerical value has more than two decimal places, truncate/round-off the value to TWO decimal places.*
- *Answer to each question will be evaluated according to the following marking scheme :*
- *Full Marks :    +3 If ONLY the correct numerical value is entered.*
- *Zero Marks :   0   In all other cases.*

**9.** 1.8 g hydrogen atoms are excited by radiations. The study of spectra indicates that 27% of the atoms are in $3^{rd}$ energy level, 15% of the atoms are in $2^{nd}$ energy level and rest of the atoms are in the ground state. Ionisation potential of H is 13.6 eV. The total energy (in kJ) involved when all the atoms return to ground state is _____ .

**10.** Amongst the following, the total number of compounds soluble in aqueous NaOH is _____ .
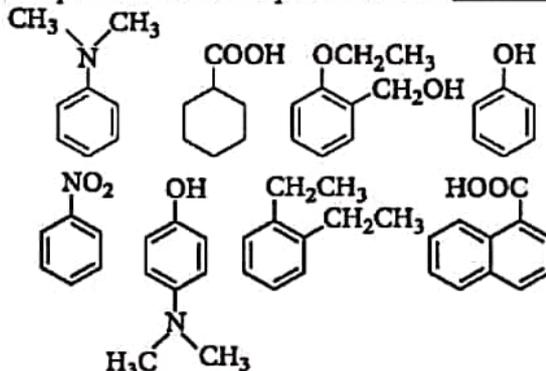


**11.** In a sample of pitchblende the ratio of $^{206}Pb : ^{238}U = 0.2 : 1$ by weight. If the disintegration constant of $^{238}U$ is $1.54 \times 10^{-10}$ per year and all Pb is supposed to be originated from uranium then, the age of the mineral is $1.35 \times 10^x$ years. The value of $x$ is _____ .

12. A 5.0 cm³ solution of $H_2O_2$ liberates 0.508 g of iodine from an acidified KI solution. The strength of $H_2O_2$ solution in terms of volume strength at STP is _____ .

13. Number of hydrogen ions, a single molecule of the following species will lose on treatment with excess of NaOH is _____ .
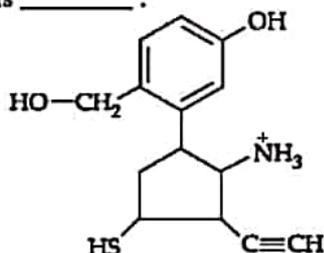


14. 19 g of molten $SnCl_2$ is electrolysed for some time. Inert electrodes are used. 0.119 g of Sn is deposited at the cathode. No substance is lost during the electrolysis. The ratio of the weights of $SnCl_2$ : $SnCl_4$ after electrolysis is $x : y$. The value of $x + y$ is _____ .

### SECTION 3 (Maximum Marks : 12)

- *This section contains TWO (02) List-Match sets.*
- *Each List-Match set has TWO (02) Multiple Choice Questions.*
- *Each List-Match set has two lists : List-I and List-II.*
- *List-I has Four entries (I), (II), (III) and (IV) and List-II has Six entries (P), (Q), (R), (S), (T) and (U).*
- *FOUR options are given in each Multiple Choice Question based on List-I and List-II and ONLY ONE of these four options satisfies the condition asked in the Multiple Choice Question.*
- *Answer to each question will be evaluated according to the following marking scheme :*

  *Full Marks : +3   If ONLY the option corresponding to the correct combination is chosen.*

  *Zero Marks : 0   If none of the options is chosen (i.e. the question is unanswered).*

  *Negative Marks : –1   In all other cases.*

**Answer Q. 15 and Q. 16 by appropriately matching the lists based on the information given in the paragraph.**

Noble gases neither have a tendency to lose nor to gain electrons and hence do not enter into chemical combination. However after the discovery of $Xe^+[PtF_6]^-$, a large number of xenon compounds mainly with most electronegative elements like fluorine and oxygen have been prepared.

In the following, List-I contains some reactions of xenon compounds and List-II contains products formed from the reactions given in List-I.

| | List-1 | | | List-II |
|---|---|---|---|---|
| I | $XeF_4 + H_2O \xrightarrow[\text{hydrolysis}]{\text{Complete}}$ | | p. | HF |
| II | $XeF_6 + H_2O \xrightarrow[\text{hydrolysis}]{\text{Complete}}$ | | q. | $XeO_3$ |
| III | $XeOF_4 + H_2O \xrightarrow[\text{hydrolysis}]{\text{Partial}}$ | | r. | $SiF_4$ |
| IV | $XeOF_4 + SiO_2 \longrightarrow$ | | s. | $XeO_2F_2$ |

15. Which of the following options has the correct combination considering List-I and List-II?
    (a) I → p, q
    (b) II → p, r
    (c) III → r, s
    (d) IV → p, s

**16.** Which of the following options has the correct combination considering List-I and List-II?
(a) I → p, r
(b) II → p, s
(c) III → p, q
(d) IV → r, s

**Answer Q. 17 and Q. 18 by appropriately matching the lists based on the information given in the paragraph.**

A reaction in which two or more molecules combine to form a larger molecule with the simultaneous loss of a small molecule such as water or methanol are called condensation reaction. The term is usually reversed for the reaction in which a new carbon-carbon bond is formed.

List-I includes starting materials and reagents of some chemical reactions. List-II gives structures of compounds that formed from the reactions of List-II.

| | List-I | | List-II |
|---|---|---|---|
| I. | MeCO(CH$_2$)$_4$COMe $\xrightarrow[\text{(ii) H}^+/\Delta]{\text{(i) OH}^-}$ | p. | (structure: cyclopentanone with CO$_2$Et) |

| II. | (CH$_2$)$_4$⟨CO$_2$Et, CO$_2$Et $\xrightarrow{\text{O}\bar{\text{H}}}$ | q. | (structure: Me, COMe cyclopentene) |
|---|---|---|---|
| III. | PhCHO + (acetic anhydride) $\xrightarrow{\text{CH}_3\text{COO}^-}$ | r. | (Ph)$_2$C—COO$^-$ with OH |
| IV. | PhCOCOPh $\xrightarrow{\text{OH}^-}$ | s. | Ph—CH=CH—COOH (structure with OH, O) |

**17.** Which of the following options has the correct combination considering List-I and List-II?
(a) I → q
(b) II → s
(c) III → r
(d) IV → p

**18.** Which of the following options has the correct combination considering List-I and List-II?
(a) I → p
(b) II → r
(c) III → s
(d) IV → q

## PAPER - I

**1. (b):** The F⁻ ions make the enamel on the teeth much harder by converting hydroxyapatite $[3Ca_3(PO_4)_2 \cdot Ca(OH)_2]$, the enamel on the surface of the teeth, into much harder fluorapatite, $[3Ca_3(PO_4)_2 \cdot CaF_2]$

**2. (d):**



**3. (b):**



**4. (a):** $2CuSO_4 + 4KI \longrightarrow Cu_2I_2 + 2K_2SO_4 + I_2$
White ppt.

$HgCl_2 + 2KI \longrightarrow HgI_2 + 2KCl$
Orange ppt.

$HgI_2 + 2KI \longrightarrow K_2HgI_4$
Soluble

$Pb(NO_3)_2 + 2KI \longrightarrow PbI_2 + 2KNO_3$
Yellow ppt.
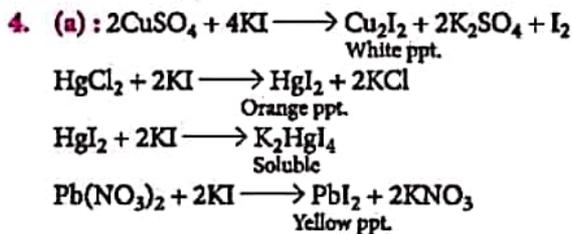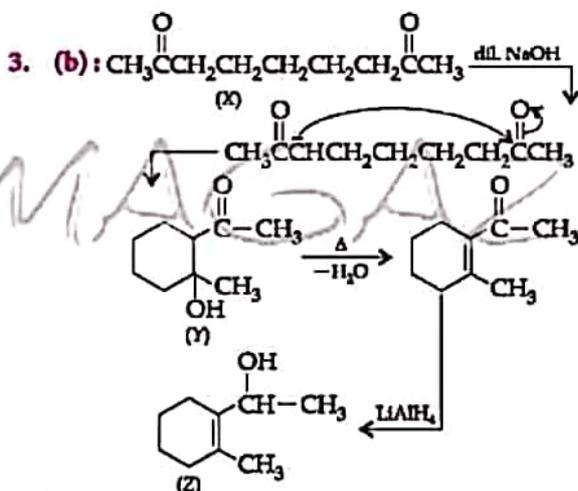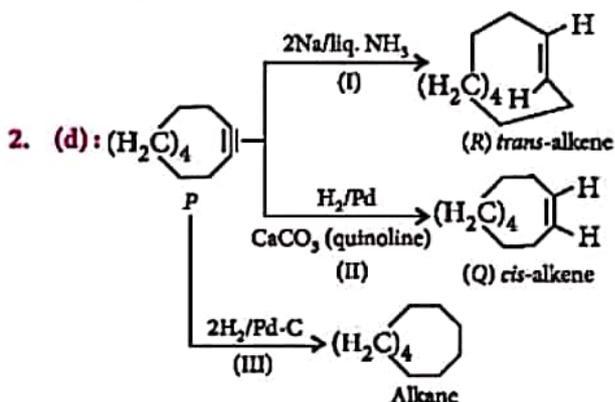
**5. (c,d):** $\Delta H_{PR} = \Delta H_{PQ} + \Delta H_{QS} + \Delta H_{SR}$
$= (-134) + 92 - (-75) = +33 \text{ kJ mol}^{-1}$
$\Delta H_{RQ} = \Delta H_{RS} + \Delta H_{SQ} = (-75) - (+92)$
$= -167 \text{ kJ mol}^{-1} < 0$
Therefore, the enthalpy change for the transformation $R \rightarrow Q$ will be exothermic.
$\Delta H_{SP} = \Delta H_{SQ} + \Delta H_{QP} = -(+92) - (-134) = 42 \text{ kJ mol}^{-1}$

**6. (a, b, d):** (a) Electron withdrawing groups favour nucleophilic addition.
(b) Good leaving group favours the process.
(c) Smaller acids are more reactive.
(d) Small alkyl groups in ester favour hydrolysis.

**7. (b, d):** The reduction potentials of both Mg and Al are less than that of water. Thus, the ions of both Mg and Al in aqueous solution cannot be reduced and in such a case water will be reduced.
$2H_2O + 2e^- \longrightarrow H_2 + 2OH^-$

**8. (a):**



It is the Hunsdiecker reaction.
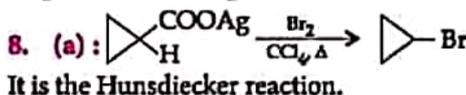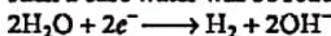
**9. (a,c):** $\dfrac{w}{E} = \dfrac{It}{96500} = \dfrac{9.65 \times 3600}{96500}$
$= 0.36$ eq. of $Ag^+ = 0.36$ eq. of $Cu^{2+}$
$= 0.36$ mole of $Ag^+ = 0.18$ mole of $Cu^{2+}$
Now, Ag will oxidise to $Ag^+$ and $Cu^{2+}$ will reduce to Cu.
And new $[Ag^+] = 1 + 0.36 = 1.36$ M
new $[Cu^{2+}] = 1 - 0.18 = 0.82$ M

**10. (d):** As bond angle decreases, hybridisation continuously changes, s-character increases in bonding hybridised orbital and thus, bond length decreases.

| $CH_4$ | $NH_3$ | $H_2O$ |
|---|---|---|
| no lone pair | 1 lone pair | 2 lone pairs |

Since, lp-lp > lp-bp > bp-bp, therefore, increase in lone pair-lone pair repulsion decreases the bond angle.

**11. (a,c,d):**

$(U) \xrightarrow[T > 298\ K]{CrO_3/H^+}$ (structure with COOH, COOH, H₃C) $(V)$
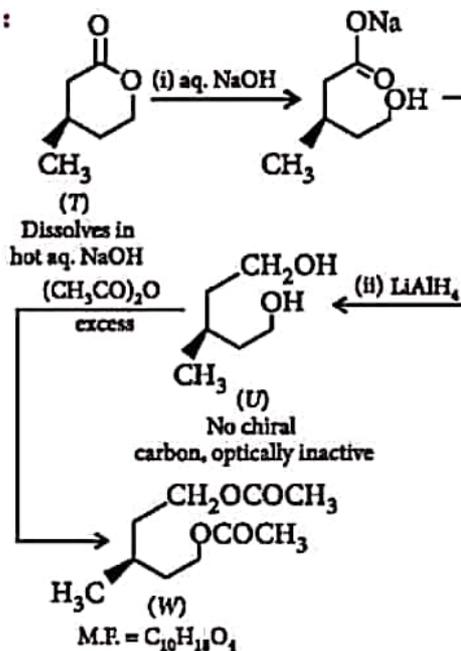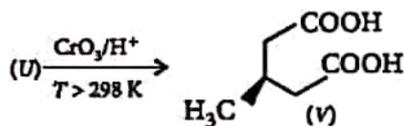
$V$ gives effervescence with $NaHCO_3$ due to evolution of $CO_2$.

**12. (b,c) :** After this hypothetical condition, every orbital can have 3 electrons. As in second orbit, 4 orbitals are there, so total no. of electrons is $4 \times 3 = 12$. Second period would have 12 elements and third period would also have 12 elements.

**13. (156.8) :** $4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \rightarrow 8Na_2CrO_4 + 2Fe_2O_3 + 8CO_2$
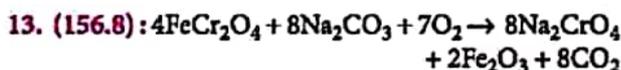
$n_{FeCr_2O_4} = \dfrac{224}{224} = 1$ mole; $n_{Na_2CO_3} = \dfrac{169.6}{106} = 1.6$ mole

Moles of $O_2$ required for complete consumption of $FeCr_2O_4 = \dfrac{7}{4} = 1.75$ moles

Moles of $O_2$ required for complete consumption of $Na_2CO_3 = \dfrac{1.6 \times 7}{8} = 1.4$ moles

Here, $Na_2CO_3$ is the limiting reactant.

∴ Minimum volume of $O_2$ required $= 1.4 \times 22.4$
$= 31.36$ L.

∴ Minimum volume of air required $= \dfrac{100}{20} \times 31.36$
$= 156.8$ L

**14. (86.59) :** Given,

$V_1 = 200$ mL $\qquad V_2 = ?$
$T_1 = (20 + 273) = 293\ K \qquad T_2 = 273\ K$
$P_1 = 755$ mm Hg $\qquad P_2 = 760$ mm

$\dfrac{P_1 V_1}{T_1} = \dfrac{P_2 V_2}{T_2}$

$V_2 =$ Volume of bulb at NTP $= \dfrac{200 \times 755}{293} \times \dfrac{273}{760}$
$= 185.122$ mL

Mass of air $= V_2 \times 0.00129 = 185.122 \times 0.00129 = 0.2388$ g
Mass of empty bulb $= (22.567 - 0.2388) = 22.3282$ g
Mass of vapours $= (22.8617 - 22.3282) = 0.5335$ g
Let the volume of vapour at NTP be $V$.

$V = \dfrac{200 \times 755}{393} \times \dfrac{273}{760} = 138$ mL

Mol. mass of the substance
$= \dfrac{\text{Mass of vapours}}{\text{Vol. of vapours at NTP}} \times 22400$

$= \dfrac{0.5335}{138} \times 22400 = 86.59$

**15. (6) :** Potassium form 6-coordinated bond with salicylaldehyde.



Salicylaldehyde
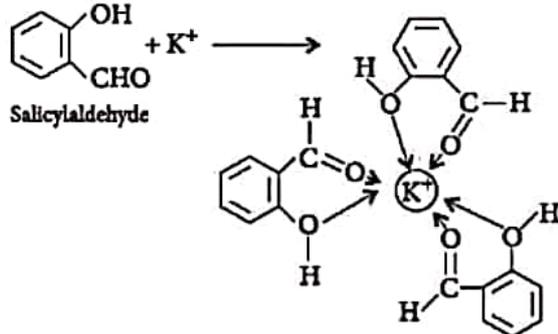
**16. (4) :** ala has free —COOH group, gly is optically inactive and will not have free —$NH_2$ group.
Possible structures are :
$H_2N$—phe—gly—val—ala—COOH
$H_2N$—phe—val—gly—ala—COOH
$H_2N$—val—phe—gly—ala—COOH
$H_2N$—val—gly—phe—ala—COOH
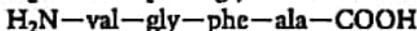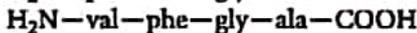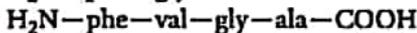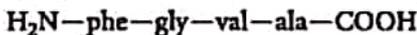
**17. (1.17) :** $N_2O_4 \rightleftharpoons 2NO_2$
Let $a$ moles of $N_2O_4$ and $b$ moles of $NO_2$ were present in equilibrium mixture.

∴ $(a + b) = \dfrac{PV}{RT} = \dfrac{753 \times 0.5}{760 \times 0.0821 \times 298} = 0.020$ ...(i)

$K_p = \dfrac{(n_{NO_2})^2}{(n_{N_2O_4})} \times \left[ \dfrac{P}{n_{NO_2} + n_{N_2O_4}} \right]$

∴ $0.113 = \dfrac{b^2}{a} \times \left[ \dfrac{753}{760 \times (a + b)} \right]$

$$\therefore \quad \frac{b^2}{a(a+b)}=0.114 \qquad \text{...(ii)}$$

By eqs. (i) and (ii)

$$\therefore \quad \frac{b^2}{a}=0.114\times0.020=2.3\times10^{-3} \qquad \text{...(iii)}$$

$b^2=2.3\times10^{-3}\,a=2.3\times10^{-3}\times(0.02-b)$

or $b^2+0.0023\,b-4.6\times10^{-5}=0$

$$\therefore \quad b=-\frac{0.0023\pm\sqrt{(0.0023)^2+4\times4.6\times10^{-5}\times1}}{2\times1}$$

$$=\frac{-0.0023\pm\sqrt{1.90\times10^{-4}}}{2}=5.73\times10^{-3}$$

$\therefore$ From eq. (i), $a=0.014$

$2NO_{2(aq)}+2H_2O_{(l)}\rightarrow HNO_{2\,(aq)}+H_3O^+{}_{(aq)}+NO_3^-{}_{(aq)}$

Total $NO_2$ moles $=5.73\times10^{-3}+2\times$ moles of $N_2O_4$
$$=5.73\times10^{-3}+2\times0.014=0.0337$$

$2NO_{2(aq)}+2H_2O_{(l)}\rightarrow HNO_{2(aq)}+H_3O^+_{(aq)}+NO_3^-{}_{(aq)}$

0.0337           0       0       0

0          $\frac{0.0337}{2}$    $\frac{0.0337}{2}$    $\frac{0.0337}{2}$
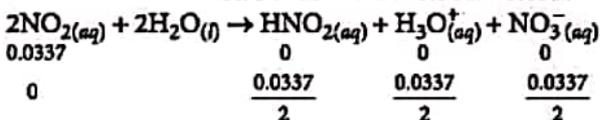
$$[H^+]=\frac{0.0337\times1000}{2\times250}=0.0674\,M$$

Also, $pH=-\log[H^+]=-\log0.0674=1.17$

**18. (151.6)** : Combustion of $C_xH_{2y}O_y$ can be represented as :

$C_xH_{2y}O_y+2xO_2\longrightarrow xCO_2+yH_2O$
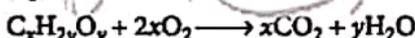
The moles of gases obtained after cooling $=x+x=2x$

$$\therefore \quad 2x=2.24 \Rightarrow x=\frac{2.24}{2}=1.12\text{ litres}$$

Number of moles of $CO_2$ $(x)=\frac{1.12}{22.4}=0.05$

Moles of $H_2O$ formed $(y)=\frac{0.9}{18}=0.05$

$x:y=0.05:0.05$

$x:y=1:1$

$x=1$ and $y=1$

$\therefore$ The empirical formula of the organic compound is $(CH_2O)$.

Now, $\dfrac{p^o-p_s}{p^o}=\dfrac{\dfrac{w_A}{M_A}}{\dfrac{w_A}{M_A}+\dfrac{w_B}{M_B}}$

or $\dfrac{0.104}{17.5}=\dfrac{\dfrac{50}{M_A}}{\dfrac{50}{M_A}+\dfrac{1000}{18}}\Rightarrow M_A=151.6$

Hence, molecular weight of compound $=151.6$

**1. (d)** : In $F_2$ molecule, the energy of $\sigma\,2p_z$ is less than $\pi2p_x$ and $\pi2p_y$.

$F_2$ molecule follows the order :

$\sigma1s^2<\sigma^*1s^2<\sigma2s^2<\sigma^*2s^2<\sigma2p_z^2<(\pi2p_x^2=\pi2p_y^2)<(\pi^*2p_x^2=\pi^*2p_y^2)<\sigma^*2p_z^0$

**2. (a,c)**: In graphs I and III, the amount of adsorption decreases with increase of temperature and increases with increase of pressure. Hence, they represent physisorption.

In graph II, amount of adsorption increases with increase in temperature. Hence, it represents chemisorption. Graph IV shows the formation of a chemical bond. Hence, it again represents chemisorption.

Thus, (a) and (c) are correct while (b) and (d) are incorrect.

**3. (c)** : Compound (c) shows optical inactivity as there is no chiral C-atom and a plane of symmetry is present in the compound.

**4. (b,c,d)** : $Z=0$ forms the bottom layer, $Z=a/2$ forms second layer above it and $Z=a$ forms the third layer. Atoms 5, 6, 7, 8, 9 and 14 are present at the face centres. Atoms 1, 2, 3, 4, 10, 11, 12 and 13 are present at the corners. 4, 5, 2 form one face diagonal; 4, 9, 10 form another face diagonal; 4, 8, 12 form one more face diagonal.
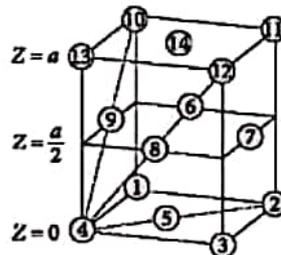


**5. (a,b,c)** : $B_2H_6$ reacts with $NH_3$, 1° and 2° amines and forms ionic compounds.
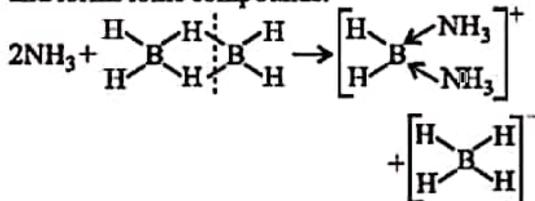


However, with 3° amine, $B_2H_6$ forms an adduct.

$B_2H_6+2N(CH_3)_3\longrightarrow 2(CH_3)_3N\rightarrow BH_3$

**6. (a,b,d)** : As the temperature increases number of collisions increases, hence pressure of gas molecules

increases. The energy of gas molecules also increases due to increase of temperature.

**7. (a,c,d) :** In non-polar solvent, $AlCl_3$ retains its dimeric form.

**8. (a,b,d) :** Addition reactions (electrophilic or free radical) are common for the alkenes and alkynes which are initiated by ions or free radicals.

**9. (832.50) :** 1 g H contains = $6.023 \times 10^{23}$ atoms

$\therefore$ 1.8 g H contains = $6.023 \times 10^{23} \times 1.8$
$= 10.84 \times 10^{23}$ atoms

No. of atoms in 3rd shell = $\dfrac{10.84 \times 10^{23} \times 27}{100}$
$= 292.68 \times 10^{21}$ atoms

No. of atoms in 2nd shell = $\dfrac{10.84 \times 10^{23} \times 15}{100}$
$= 162.6 \times 10^{21}$ atoms

When all the atoms return to 1st shell, then

(i) $E'_{(3 \to 1)} = (E_3 - E_1) \times 292.68 \times 10^{21}$

$= \left( -\dfrac{13.6}{9} + 13.6 \right) \times 1.602 \times 10^{-19} \times 292.68 \times 10^{21}$

$= 5.668 \times 10^5$ J

(i) $E''_{(2 \to 1)} = (E_2 - E_1) \times 162.6 \times 10^{21}$

$= \left( -\dfrac{13.6}{4} + 13.6 \right) \times 1.602 \times 10^{-19} \times 162.6 \times 10^{21}$

$= 2.657 \times 10^5$ J

$\therefore E = E' + E'' = 5.668 \times 10^5 + 2.657 \times 10^5$ J $= 832.50$ kJ

**10. (4) :** Out of the given compounds, those soluble in aq. NaOH are :

COOH    OH    OH    COOH
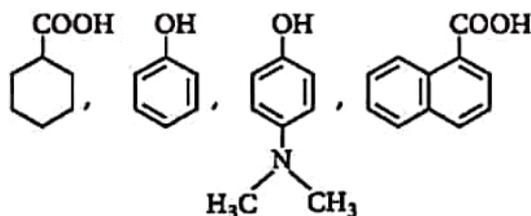
**11. (9) :**    $^{238}U \longrightarrow ^{206}Pb$

Initial moles :        $a$        0
Moles after time $t$ : $(a-x)$    $x$

$\dfrac{\text{Wt. of } ^{206}Pb}{\text{Wt. of } ^{238}U} = \dfrac{0.2}{1}$

$\therefore \dfrac{\text{Moles of } ^{206}Pb}{\text{Moles of } ^{238}U} = \dfrac{0.2 / 206}{1/238} = \dfrac{0.231}{1}$

or $\dfrac{x}{a-x} = 0.231$

On adding 1 to both sides,

$1 + \dfrac{x}{a-x} = 0.231 + 1 \Rightarrow \dfrac{a}{a-x} = 1.231$

Now, $\lambda = \dfrac{2.303}{t} \log \dfrac{a}{a-x}$

$\Rightarrow 1.54 \times 10^{-10} = \dfrac{2.303}{t} \log 1.231$

$t = 1.35 \times 10^9$ years

$\therefore x = 9$

**12. (4.48) :** $H_2O_2 + H_2SO_4 + 2KI \longrightarrow I_2 + K_2SO_4 + 2H_2O$
  34 g                                    254 g
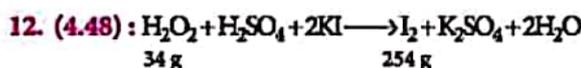
254 g of $I_2$ is produced by 34 g $H_2O_2$

$\therefore$ 0.508 g of $I_2$ will be produced by $\dfrac{34}{254} \times 0.508$ g
$= 0.068$ g $H_2O_2$

Hence, 5 mL of $H_2O_2$ solution contains $H_2O_2 = 0.068$ g

$\therefore$ 1 mL of $H_2O_2$ solution contains $H_2O_2 = \dfrac{0.068}{5}$ g

For volume strength of $H_2O_2$,

$2H_2O_2 \longrightarrow 2H_2O + O_2$
$2 \times 34 = 68$ g            22.4 L at STP
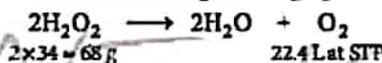
68 g of $H_2O_2$ produces $O_2$ at NTP = 22.4 L

$\therefore$ 1 mL (i.e., $\dfrac{0.068}{5}$ g) of $H_2O_2$ produces $O_2$ at NTP

$= \dfrac{22400}{68} \times \dfrac{0.068}{5} = 4.48$ mL

i.e., the volume strength of $H_2O_2$ solution is 4.48. ("Volume strength" indicates the mL of $O_2$ at STP obtained from 1 mL of $H_2O_2$ solution.)

**13. (3) :** HOCH$_2$

$H_2O$ is a stronger acid than $RC \equiv CH$ and $RCH_2OH$. Thermodynamics supports the formation of weaker acid.

**14. (72.34) :** $2SnCl_2 \longrightarrow$  Sn  +  $SnCl_4$
      $2\{119 + (2 \times 35.5)\}$    119    $119 + (4 \times 35.5)$
      $= 380$              $= 261$

119 g Sn is deposited on decomposition of 380 g $SnCl_2$.

∴ 0.119 g of Sn is deposited on decomposition of

$\frac{380}{119} \times 0.119 \text{ g} = 0.380 \text{ g SnCl}_2$

380 g of $SnCl_2$ decomposes to give $SnCl_4$ = 261 g

∴ 0.380 g $SnCl_2$ decomposes to give $SnCl_4$

$= \frac{261}{380} \times 0.380 \text{ g} = 0.261 \text{ g}$

Weight of $SnCl_2$ left after decomposition

= 19.000 − 0.380 g = 18.620 g

Weight of $SnCl_4$ formed = 0.261 g

Ratio of $SnCl_2 : SnCl_4$ is 18.620 : 0.261 or 71.34 : 1

⇒ 71.34 + 1 = 72.34

**15. (c)** : $XeF_4 + H_2O \xrightarrow[\text{hydrolysis}]{\text{complete}} 4Xe + 2XeO_3$

$\qquad\qquad\qquad\qquad + 24HF + 3O_2$

**16. (d)** : $2XeOF_4 + SiO_2 \longrightarrow 2XeO_2F_2 + SiF_4$

**17. (a)**          **18. (c)**

(I)



(II)



(III) Perkin condensation reaction.



(IV) Benzil-Benzilic acid rearrangement.

$PhCOCOPh \xrightarrow{OH^-} (Ph)_2C-COO^-$
$\qquad\qquad\qquad\qquad\qquad |$
$\qquad\qquad\qquad\qquad\quad OH$

## Moles Calculation



## Enzymatic Catalysed Reactions

| Enzymes | Reactions which are catalysed |
|---|---|
| Amylase | Starch → n × Glucose |
| Maltase | Maltose → 2 × Glucose |
| Lactase | Lactose → Glucose + galactose |
| Invertase | Sucrose → Glucose + fructose |
| Pepsin | Proteins → Amino acid |
| Trypsin | Polypeptides → Amino acid |
| Nuclease | DNA, RNA → Nucleotides |
| Urease | Urea → $NH_3$ + $CO_2$ |
| Carbonic anhydrase | $H_2CO_3$ → $CO_2$ + $H_2O$ |

## Important Orders of Organic Species

- $+I$-effect : $R_3\overset{-}{C}$ > ... > $NO_2$ > $SO_3H$ > $CN$ > $COOH$ > $F$ > $Cl$ > $Br$ > $I$ > $OH$ > $COOR$ > $OR$ > $C_6H_6$ > $CH$ > $CH_3$ > $H$
- $-I$-effect : $(CH_3)_3C$ > $(CH_3)_2CH$ > $CH_3CH_2$ > $CH_3$ > $T$ > $D$ > $H$
- $+R$-effect : $Cl$ > $Br$ > $I$ > $NH_2$ > $NHR$ > $NR_2$ > $NHCOR$ > $OH$ > $OR$ > $SR$ > $SH$ > $OCH_3$ > $OCOR$
- $-R$-effect : $NO_2$ > $CN$ > ... > $CHO$ > $COOR$ > $COOH$

- Stability of free radicals = ...
- Stability of carbocations = ...
- Stability of carbanions = ...

## Relations between Different Periodic Properties

| S. No. | Ionisation potential | Electron affinity | Electronegativity | Metallic character | Basic character | Acidic character |
|---|---|---|---|---|---|---|
| 1. | Atomic size | Atomic size | Atomic size | Atomic size | Atomic size | Atomic size |
| 2. | Effective nuclear charge | Effective nuclear charge | Effective nuclear charge | Ionisation potential | Ionisation potential | Effective nuclear charge |
| 3. | Shielding effect | Shielding effect | Ionisation potential | Effective nuclear charge | Electronegativity | Ionisation potential |
| 4. | Stability of fully and half-filled orbitals | Stability of fully and half-filled orbitals | s-character in hybrid orbitals | Electronegativity | Oxidation number | Electronegativity |
| 5. | Penetrating power | Oxidation number | p-character in hybrid orbitals | Oxidation number | Metallic character | Oxidation number |
| 6. | Oxidation number | | Oxidation number | Effective nuclear charge | | Metallic charge |

## Comparative Oxidising Nature of $KMnO_4$, $K_2Cr_2O_7$ and $H_2O_2$

### In Acidic Medium

### In Neutral Medium

### In Alkaline Medium



## Elimination vs Substitution Reactions



## Reducing Nature of Different Reagents

| Conversions | $LiAlH_4$/ether | $NaBH_4$/$C_2H_5OH$ | $H_2$/Metal | $B_2H_6$/THF |
|---|---|---|---|---|
| $-CHO$ → $-CH_2OH$ | ✓ | ✓ | ✓ | ✓ |
| $CO$ → $CHOH$ | ✓ | ✓ | ✓ | ✓ |
| $-COOH$ → $-CH_2OH$ | ✓ | ✗ | ✓ | ✓ |
| $-COCl$ → $-CH_2OH$ | ✓ | ✗ | ✓ | ✓ |
| $(RCO)_2O$ → $RCH_2OH$ | ✓ | ✗ | ✓ | ✓ |
| $-COOR$ → $-CH_2OH$ | ✓ | ✗ | ✓ | ✓ |

## Applications of Grignard Reagent

# Rank Enhancer

This column is specially designed to make your concepts crystal clear.

## METAL CARBONYLS

Compounds of metals with CO (carbon monoxide) as a ligand are called metal carbonyls.

### Classification Based on Number of Metals :

| Monomeric metal carbonyls | Polymeric metal carbonyls |
|---|---|
| 1. Those metal carbonyls which contain only one metal atom per molecule are called monomeric metal carbonyls. | 1. Metal carbonyls which contain two or more than two metal atoms per molecule are called polymeric metal carbonyls. |
| 2. More volatile | 2. Less volatile |
| 3. Either colourless or light coloured | 3. Deep coloured |
| 4. Examples: <br> (1) $Ni(CO)_4$ <br> (2) $Fe(CO)_5$ <br> (3) $Cr(CO)_6$ <br> (4) $V(CO)_6$ | 4. Examples: <br> (1) $Mn_2(CO)_{10}$ <br> (2) $Co_2(CO)_8$ |

### Bonding in Metal Carbonyls

Metal-carbon bond in metal carbonyls possesses both s- and p-character and they form two types of bonds :

- σ-Bond : It is formed by donation of lone pair of electrons from carbonyl carbon into a vacant hybrid d-orbital of metal.
- π-Bond : It is formed by sidewise overlapping of filled unhybrid d-orbital of metal with vacant $\pi^*$-orbital of carbon of CO.
- During bonds formation, carbon acts as σ donor and π-acceptor. These two interactions combinely called as synergic bond.
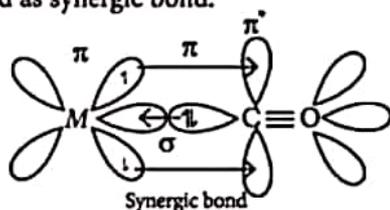


Synergic bond

### Consequences of Synergic Bond :

- Bond energy of CO : As metal-carbon π-bonding increases, bond between C and O weakens.

(a) If same metal with different +ve oxidation number then

+ve oxidation number of metal increases
⇓
its donating tendency decreases
⇓
$(M - C)$ π-bond weakens
⇓
$(C - O)$ bond becomes stronger
⇓

∴ Bond energy of $C - O$ Bond ∝ oxidation number of metal

(b) If isoelectronic : In anionic complexes, metal has a greater electron density to be dispersed, $M - C$, π bond strength increases, σ bond strength between $C - O$ decreases i.e.,

−ve charge on complex increases
⇓
more electron density on metal
⇓
$M - C$ π-bond becomes stronger
⇓
$C - O$ bond becomes weaker

∴ Bond energy of $C - O$ bond ∝ $\dfrac{1}{-\text{ve charge on complex}}$

**Example:** Decreasing order of bond energy of C—O bond:
$[Ni(CO)_4] > [Co(CO)_4]^- > [Fe(CO)_4]^{2-}$

- Bond order : We know, bond energy is directly proportional to bond order, we can use above concept for bond order.

Metal–carbon π bond strength increases
⇓
Carbon-oxygen bond strength decreases
⇓
Carbon-oxygen bond order decreases

*By K. Vijay Bhasker, Senior faculty at Sri Chaitanya Educational Institution, Visakhapatnam*

- **Bond length :** As we know bond length inversely proportional to bond energy and bond order.

  **Example :**

  $$\text{In } [V(CO)_5]^{3-} \ [Cr(CO)_5]^{2-} \ [Mn(CO)_5]^- \longrightarrow$$
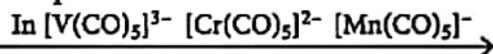
  Metal-carbon bond strength decreases
  Carbon-oxygen bond strength increases
  Carbon-oxygen bond order increases
  Carbon-oxygen bond length decreases

### Use of EAN Rule to Identify Oxidising Nature :

(1) EAN of V in $[V(CO)_6]$

$\Rightarrow$ At. No. + C.No. (2) – Ox. No.

$= 23 + 6(2) - 0 = 35$

To get next inert gas EAN, it gains an electron and reduces, acts as an oxidising agent.

$[V(CO)_6] + e^- \longrightarrow [V(CO)_6]^-$
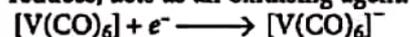
EAN = 35            EAN = 36

(2) EAN of Co in $[Co(CO)_4]$

$\Rightarrow$ At. No. + C.No. (2) – Ox. No.

$\Rightarrow 27 + 4(2) - 0 \Rightarrow 35$

To get next inert gas EAN, it dimerises and acts as an oxidising agent.

$2Co(CO)_4 \longrightarrow Co_2(CO)_8$
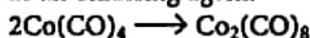
### Structures of Some Important Carbonyl Compounds :

1. $Ni(CO)_4$
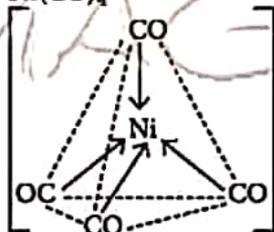


$sp^3$ hybridisation
Tetrahedral
EAN = 28 + 4(2) + 0
EAN = 36

2. $Fe(CO)_5$
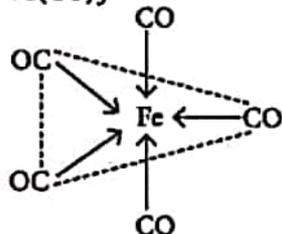


$sp^3d$ hybridisation
Trigonal bipyramidal
EAN = 26 + 5(2) + 0
EAN = 36

3. $Cr(CO)_6$
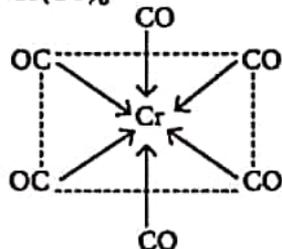


$sp^3d^2$ hybridisation
octahedral or Square bipyramidal
EAN = 24 + 6(2) + 0
EAN = 36

4. $Mn_2(CO)_{10}$
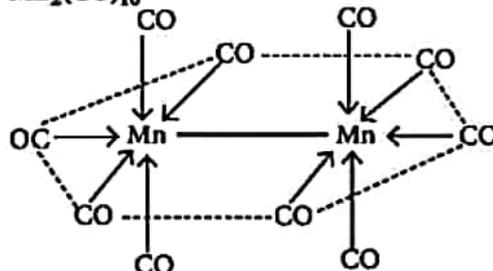


$sp^3d^2$ hybridisation
EAN = 25 + 5(2) + 1 = 36
(Metal-metal bond)

5. $[Co_2(CO)_8]$
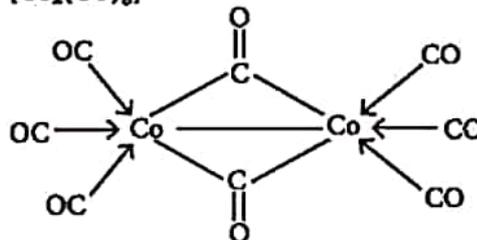


$dsp^3$ hybridisation
EAN = 27 + 3(2) + 2 + 1 = 36
(Co–C (Co–Co bond) bond)

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### PROBLEMS

1. Which of the following is/are paramagnetic?
   (a) $[V(CO)_6]^-$          (b) $[Cr(CO)_6]$
   (c) $[Co_2(CO)_8]$         (d) $[Fe(CO)_5]$

2. In which of the following metal-carbonyl compounds, metal-carbon bond order is lowest?
   (a) $[Fe(CO)_5]$           (b) $[Cr(CO)_6]$
   (c) $[Mn(CO)_6]^+$         (d) $[V(CO)_6]^-$

3. Oxidation number of Co in $Na[Co(CO)_4]$ is
   (a) 0      (b) +1      (c) –1      (d) +3

4. Bond between Cr and C in $Cr(CO)_6$ possesses
   (a) $\sigma$ character      (b) $\pi$ character
   (c) ionic character      (d) both (a) and (b).

5. Which of the following species is not expected to be a ligand?
   (a) NO                   (b) $NH_4^+$
   (c) $NH_2CH_2CH_2NH_2$   (d) CO

6. Correct order of C—O bond strength is
   (a) $[Ti(CO)_6]^{2-} > [V(CO)_6]^- > [Cr(CO)_6] > [Mn(CO)_6]^+$
   (b) $[Mn(CO)_6]^+ > [Cr(CO)_6] > [V(CO)_6]^- > [Ti(CO)_6]^{2-}$
   (c) $[V(CO)_6]^- > [Ti(CO)_6]^{2-} > [Mn(CO)_6]^+ > [Cr(CO)_6]$
   (d) $[Ti(CO)_6]^{2-} > [V(CO)_6]^- > [Mn(CO)_6]^+ > [Cr(CO)_6]$

**7.** What is the sum of bond order of Fe — C bond and C — O bond in $Fe(CO)_5$?

(a) $2\frac{1}{2}$  (b) 3

(c) 4  (d) $3\frac{1}{2}$

**8.** $Co(CO)_4$ attains stability by

(a) oxidation of Co  (b) reduction of Co

(c) dimerisation  (d) both (b) and (c).

**9.** EAN of $W(CO)_6$ is

(a) 36  (b) 54  (c) 86  (d) 84

**10.** Stable metal carbonyl among the following is/are

$Cr(CO)_6$  $Mn(CO)_6$  $Fe(CO)_5$
(I)  (II)  (III)
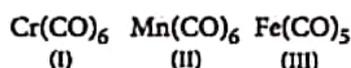
(a) I and II  (b) I and III

(c) II only  (d) II and III.

## SOLUTIONS

**1.** (a) : EAN = At.No. + C.No. (2) – Ox. No.

= 23 + 6(2) – 0 = 35

As it contains odd number of electrons, it is paramagnetic.

**2.** (c) : Due to –ve charge, $\pi$-bond strength increases and metal-carbon bond weakens and bond order is lowest.

**3.** (c) : Na + Co + 4(CO) = 0

+1 + Co + 4(0) = 0

Co = –1

**4.** (d) : In metal carbonyls, metal-carbon bond contains both $\sigma$ and $\pi$ bond characteristics.

**5.** (b) : $NH_4^+$ does not contain lone pair to act as a ligand.

**6.** (b) : More –ve charge density on metal, less is C — O bond strength.

**7.** (c) : Bond order between metal-carbon = 1

Bond order between carbon-oxygen = 3

Sum of bond orders = 4

**8.** (d) : EAN of $Co(CO)_4$ is 35. Hence, it dimerises and undergoes reduction of Co, acts as an oxidising agent.

**9.** (c) : EAN = At. No. + C. No. (2) – Ox. No.

= 74 + 6(2) – 0 = 86

**10.** (b) : EAN of $Mn(CO)_6$ is not equal to inert gas EAN. Hence, it is unstable.

# Scientist Who Made Us Proud

Karl Waldemar Ziegler was a German chemist who won the Nobel Prize in Chemistry in 1963, with Giulio Natta, for work on polymers. He is also known for his work involving free-radicals, multi-membered rings, and organometallic compounds, as well as the development of Ziegler–Natta catalyst. One of many awards Ziegler received was the Werner von Siemens Ring in 1960 jointly with Otto Bayer and Walter Reppe, for expanding the scientific knowledge of and the technical development of new synthetic materials.

**Karl Ziegler**
**(26 Nov. 1898 - 12 Aug. 1973)**

## Early Life and Education

- Karl Ziegler was born in Helsa near Kassel in Germany. An introductory physics textbook first sparked Ziegler's interest in science. It drove him to perform experiments in his home and to read extensively beyond his high school curriculum. He was also introduced to many notable individuals through his father, including Emil Adolf von Behring, recognized for the Diphtheria vaccine. His extra study and experimentation helped to explain why he received an award for the most outstanding student in his final year at high school in Kassel, Germany. He studied at the University of Marburg. However his studies were interrupted, as during 1918 he was deployed to the front as a soldier to serve in World War I. He received his Ph.D. in 1920, on "Studies on semibenzole and related links".

## Research and Contributions

- In 1926, he became a professor at the University of Heidelberg where he investigated the stability of radicals on trivalent carbons leading him to study organometallic compounds and their application in his research. He also worked on the syntheses of multi-membered ring systems. In 1933, Ziegler published his first major work on large ring systems, "Vielgliedrige Ringsysteme" which presented the fundamentals for the Ruggli-Ziegler dilution principle.

- Karl Ziegler was credited with much of the postwar resurrection of chemical research in Germany and helped found the German Chemical Society where he served as a president for five years. He was also the president of the German Society for Petroleum Science and Coal Chemistry, from 1954 to 1957. In 1971, The Royal Society, London, elected him as a Foreign Member.

## Known For

- Ziegler-Natta catalyst
- Ziegler process
- Wohl-Ziegler bromination
- Thorpe-Ziegler reaction
- Organoaluminium chemistry
- Organolithium reagent

## Awards

- Liebig Medal (1935)
- War Merit Cross 2nd Class (1940)
- Werner von Siemens Ring (1961)
- Nobel Prize for Chemistry (1963)

# CHEMISTRY MUSING

## SOLUTION SET 80

**1. (a) :** (a) *trans*-Dicyano*bis*(ethylenediamine)cobalt(III)
nitrate : *trans*-[Co(CN)$_2$(en)$_2$]NO$_3$



Enantiomorphic pair
*d*-and *l*-*cis*-[Co(CN)$_2$(en)$_2$]NO$_3$

*trans*-[Co(CN)$_2$(en)$_2$]NO$_3$
Optically inactive
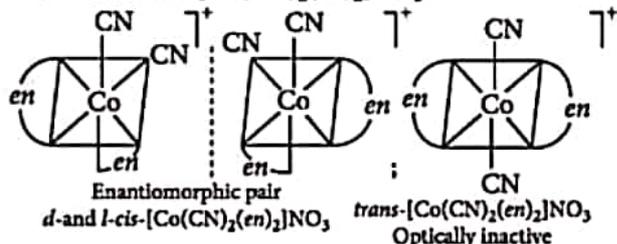
**(b)** *mer*-Triamminetrichloridoplatinum(IV)
chloride : *mer*-[Pt(NH$_3$)$_3$(Cl)$_3$]Cl



Facial (*Fac*)     Meridional (*Mer*)
Optically inactive
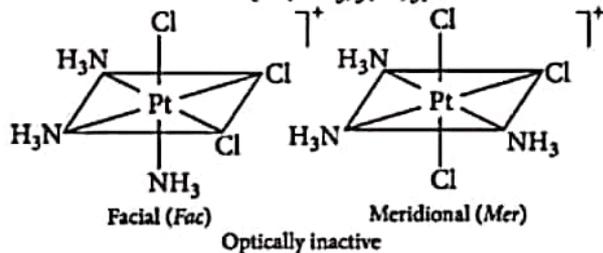
**(c)** *cis*-Diamminedinitrito-O-platinum(II):
*cis*-[Pt(NH$_3$)$_2$(ONO)$_2$]



Optically inactive
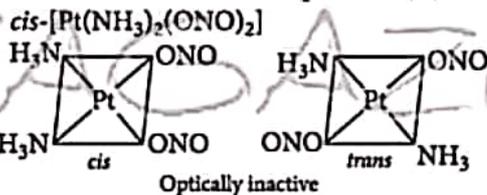
**(d)** *trans*-Tetraamminedichloridocobalt(III)
bromide : *trans*-[Co(NH$_3$)$_4$Cl$_2$]Br



Optically inactive

**2. (b):**



Aromatic compound
(*P*)

**3. (c) :**
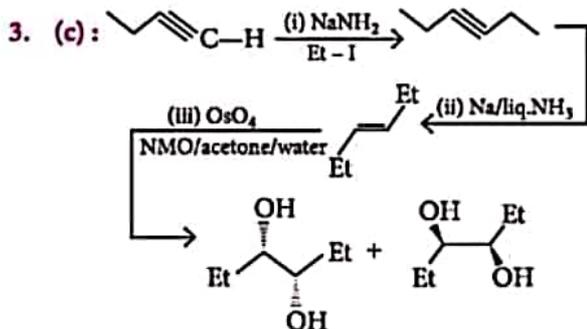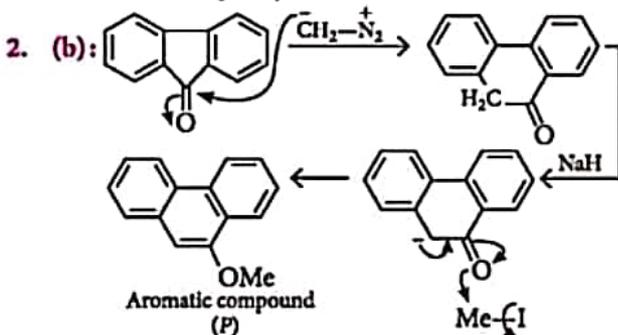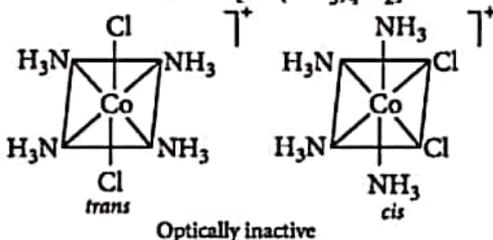


**4. (b):** $ZnS \xrightarrow{\text{Roasting}} ZnO + SO_2$

$ZnO + H_2SO_4 \rightarrow ZnSO_4 + H_2O$
   (dil.)

$ZnSO_4 \xrightarrow[\text{basic medium}]{H_2S \text{ in}} ZnS + H_2SO_4$
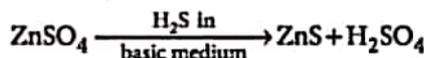
**5. (c) :** Let NaCl and CaCl$_2$ be *a*, *b* g respectively in 1 g
of a mixture.

$\therefore \quad a + b = 1$

Also, Meq. of CaCl$_2$ = Meq. of CaC$_2$O$_4$ = Meq. of
$\qquad\qquad\qquad$ KMnO$_4$ = 22 × 0.1 × 5 = 11

$\therefore$ Weight of CaCl$_2$ = $11 \times \dfrac{111}{2} \times \dfrac{1}{1000} = 0.61$ g

Weight of NaCl = 0.39 g

$\therefore$ Weight of CaCl$_2$ in 5 g mixture = 0.61 × 5
$\qquad\qquad\qquad\qquad\qquad\qquad = 3.05$ g

Weight of NaCl in 5 g mixture = 0.39 × 5 = 1.95 g

Now, $\Delta T = \dfrac{1000\,K_b}{W}\left[ \underbrace{(1+\alpha)\dfrac{w}{m}}_{\text{for NaCl}} + \underbrace{(1+2\alpha)\dfrac{w}{m}}_{\text{for CaCl}_2} \right]$

$= \dfrac{1000 \times 1.86}{100}\left[ (1+1) \times \dfrac{1.95}{58.5} + (1+2) \times \dfrac{3.05}{111} \right]$

$= \dfrac{1000 \times 1.86}{100} \times 0.149 = 2.77$ K

$\therefore$ Freezing point = 273 − 2.77 = 270.23 K



**COMIC CAPSULE**

DON'T DRINK WATER WHILE STUDYING.
BECAUSE CHEMISTRY SAYS THAT

CONCENTRATION DECREASES ON
ADDING WATER

**6.** **(a, b):** (a) $Cr_2O_7^{2-} + 14H^+ + 6I^- \longrightarrow 2Cr^{3+} + 3I_2 + 7H_2O$

$2S_2O_3^{2-} + I_2 \longrightarrow S_4O_6^{2-} + 2I^-$

(b) $2MnO_4^- + 16H^+ + 10I^- \longrightarrow 2Mn^{2+} + 5I_2 + 8H_2O$

$2S_2O_3^{2-} + I_2 \longrightarrow S_4O_6^{2-} + 2I^-$
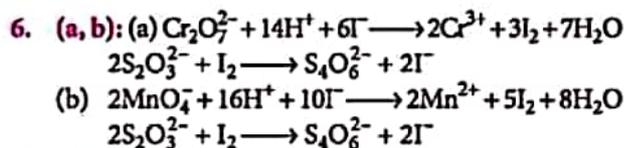
**7.** **(b):** Heat transferred to the calorimeter = Heat capacity of the calorimeter × Rise in temperature

$= 17.7 \text{ kJ K}^{-1} \times (0.5 \text{ K}) = 8.85 \text{ kJ}$

Molar mass of $CH_4 = 12 + 4 = 16 \text{ g mol}^{-1}$

Enthalpy of combustion of $CH_4$ at constant volume *i.e.*,

$$\Delta E = -\left(\frac{8.85}{0.16} \times 16\right) = -885 \text{ kJ mol}^{-1}$$

**8.** **(a):** $CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(l)}$

$\Delta H = \Delta E + \Delta n_g RT$

$= -885 + (-2 \times 8.314 \times 10^{-3} \times 300)$

$= -885 - 4.988 \text{ kJ mol}^{-1} = -889.988 \text{ kJ mol}^{-1}$

**9.** **(8):**
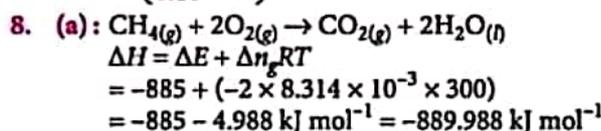
$$\begin{array}{ccc} C & H & N \\ 9 & : 1 : & 3.5 \\ \dfrac{9}{12} & : \dfrac{1}{1} : & \dfrac{3.5}{14} \\ \dfrac{3}{4} & : \dfrac{1}{1} : & \dfrac{1}{4} \\ 3 & : 4 : & 1 \end{array}$$

Empirical formula = $C_3H_4N$

$(C_3H_4N)_n = 108$

$(12 \times 3 + 1 \times 4 + 14)_n = 108$

$54n = 108 \Rightarrow n = 108/54 = 2$

Molecular formula = $C_6H_8N_2$

No. of H-atom in $C_6H_8N_2 = 8$

**10.** **(3):** $0.4 \text{ M of } A \xrightarrow{30 \text{ min.}} 0.2 \text{ M} \xrightarrow{30 \text{ min.}} 0.1 \text{ M}$ (for $A$)
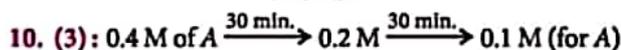
Temperature coefficient $= 2 = \dfrac{k(\text{at } 35°C)}{k(\text{at } 25°C)}$

$\Rightarrow \quad 2k \text{ (at } 25°C) = k \text{ (at } 35°C)$

Now, for second order reaction rate constant ($k$) is inversely proportional to half-life ($t_{1/2}$).

As, $k$ at $35°C$ gets doubled so, $t_{1/2}$ will be halved.

$0.4 \text{ M of } B \xrightarrow{20 \text{ min.}} 0.2 \text{ M} \xrightarrow{20 \text{ min.}} 0.1 \text{ M} \xrightarrow{20 \text{ min.}}$

$0.05 \text{ M}$ (for $B$)

$\therefore \quad \dfrac{[A]}{[B]} = \dfrac{0.1}{0.05} = 2 : 1$

Sum of ratio = $2 + 1 = 3$

◆◆

1. The magnetic moment of a certain complex (A) of Co was found to be 4.89 B.M. and the EAN is 36. Co also forms complex (B) with magnetic moment 3.87 B.M. and EAN is 37 and complex (C) with EAN, 36 but diamagnetic. Which of the following statements is true regarding the above observation?
   (a) The oxidation states of Co in (A), (B) and (C) are +3, +2 and +3, respectively.
   (b) The number of unpaired electrons in (A), (B) and (C) are 3, 4 and 0, respectively.
   (c) The spin multiplicities of Co in (A), (B) and (C) are 3, 2 and 1, respectively.
   (d) The oxidation states of Co in (A), (B) and (C) are +6, +8 and +1, respectively.

2. An organic compound A, $C_6H_{10}O$ on reaction with $CH_3MgBr$ followed by acid treatment gives compound, B. The compound, B on ozonolysis gives compound, C, which in presence of a base gives, D. The compound, B on reaction with HBr gives compound, E. The compounds D and E respectively are

   (a) ![COCH3 cyclopentene structure] , ![HC-Br cyclohexane structure]
   (b) ![CH3 cyclohexene structure] , ![Br cyclohexane with CH3 structure]
   (c) ![CH3 structure] , ![CH3 Br structure]
   (d) ![CH3 COCH3 structure] , ![Br cyclohexane structure]
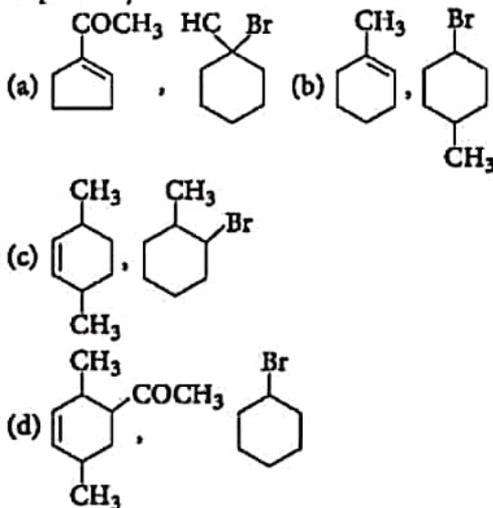
3. To 1 L of 1.0 M impure $H_2SO_4$ sample, 1.0 M NaOH solution was added and a plot was obtained as follows :
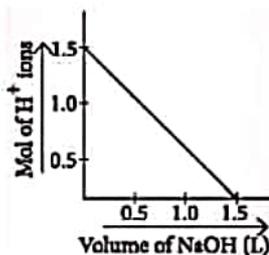
   The % purity of $H_2SO_4$ and the slope of curve, respectively, are

   ![Plot: Mol of H+ ions vs Volume of NaOH (L)]

   (a) 75%, – 1/2
   (b) 75%, – 1
   (c) 50%, – 1/3
   (d) 50%, – 1/4

4. The major product in the reaction is

   ![Ph-C≡C with Et, Me substituents, Dil.H2SO4 reaction]

   (a) ![Ph with Et, Me, OH, Me structure]
   (b) ![Ph with Et, OH, Me structure]
   (c) ![Ph with Et, Me, Me, OH structure]
   (d) both (b) and (c).
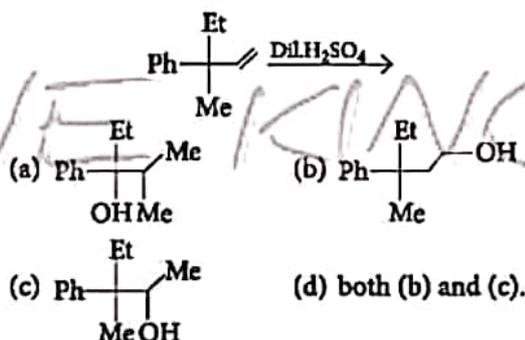
5. A quantity of air ($\gamma = 1.4$) at 300 K is compressed slowly in case I and suddenly to half of its volume in case II. Which of the following is correct regarding the change in temperature in both cases?
   (a) Case I, $\Delta T = 0$ K, case II, $\Delta T = 395.36$ K
   (b) Case I, $\Delta T = 395.36$ K, case II, $\Delta T = 95.36$ K
   (c) Case I, $\Delta T = 10$ K, case II, $\Delta T = 368.36$ K
   (d) Case I, $\Delta T = 0$ K, case II, $\Delta T = 95.36$ K

6. What will be the angular frequency of an electron occupying the second Bohr's orbit of $He^+$ ion?

7. An aromatic compound contains 69.4% carbon and 5.8% hydrogen. A sample of 0.303 g of this compound was analysed for nitrogen by Kjeldahl's method. The ammonia evolved was absorbed in

50 mL of 0.05 M sulphuric acid. The excess of acid required 25 mL of 0.1 M sodium hydroxide for neutralisation. Determine the molecular formula of the compound if its molecular weight is 121. Draw two possible structures for this compound.

8. A mixture contains NaCl and an unknown chloride MCl. (i) 1 g of this is dissolved in water. Excess of acidified $AgNO_3$ solution is added to it. 2.567 g of a white precipitate is formed. (ii) 1 g of the original mixture is heated to 300°C. Some vapours come out which are absorbed in acidified $AgNO_3$ solution. 1.341 g of a white precipitate is obtained. Find the molecular weight of the unknown chloride.

9. How many moles of sodium propionate should be added to one litre of an aqueous solution containing 0.020 mole of propionic acid to obtain a buffer solution of pH 4.75? What will be pH if 0.010 mole of hydrogen chloride is dissolved in the above buffer solution. (Dissociation constant of propionic acid, $K_a$ at 25°C = $1.34 \times 10^{-5}$)

10. A flask of 1 L having $NH_{3(g)}$ at 2.0 atm and 200 K is connected with another flask of volume 800 mL having $HCl_{(g)}$ at 8 atm and 200 K through a narrow tube of negligible volume. The two gases react to form $NH_4Cl_{(s)}$ with evolution of 43 kJ $mol^{-1}$ of heat. If heat capacity of $HCl_{(g)}$ at constant volume is 20 J $K^{-1}$ $mol^{-1}$ and neglecting heat capacity of flask, $NH_4Cl$ and volume of solid $NH_4Cl$ formed, calculate final temperature in flask. ($R = 0.08$ L-atm $K^{-1}$ $mol^{-1}$)

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## SOLUTIONS

**1. (a) :**

| Complex | Magnetic moment | No. of unpaired electrons | Electronic configuration | Oxidation state |
|---------|-----------------|---------------------------|--------------------------|-----------------|
| (A) | 4.89 B.M. | 4 | $Co \to 3d^6$; ⇅ 1 1 1 1 | +3 |
| (B) | 3.87 B.M. | 3 | $Co \to 3d^7$; ⇅ ⇅ 1 1 1 | +2 |
| (C) | 0 B.M. | 0 | $Co \to 3d^6$; ⇅ ⇅ ⇅ | +3 |

**2. (a) :**



**4. (a) :** The product is obtained by methyl shift.



**3. (b) :** I. Moles of NaOH = 1.0 M × 1.5 L = 1.5 mol
Moles of $H_2SO_4$ = 1.0 M × 1 L = 1.0 mol

$$2NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O$$
2 mol    1 mol

Moles of $H_2SO_4$ reacted with NaOH

$$= \frac{1}{2} \times 1.5 = 0.75 \text{ mol } H_2SO_4$$

% purity of $H_2SO_4 = \dfrac{0.75 \text{ mol} \times 100}{1.0 \text{ mol}} = 75\%$

II. For slope : $\dfrac{x}{a} + \dfrac{y}{b} = 1$; Slope $= \dfrac{-b}{a} = \dfrac{-1.5}{1.5} = -1$
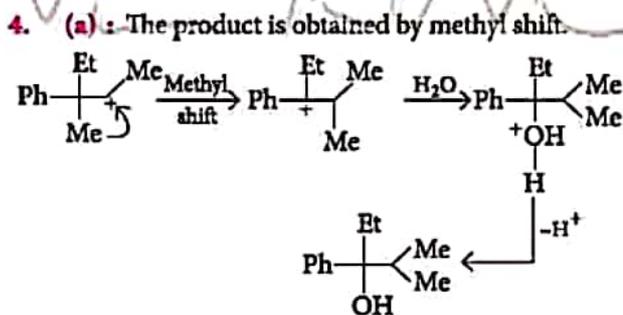
**5. (d) :** For case I, heat produced can be exchanged with surroundings due to slow process and hence, the change is isothermal, i.e., $\Delta T = 0$.

For case II, the change is adiabatic.

Thus, $T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$

$$300 \times V^{(1.4-1)} = T_2 \times \left(\frac{V}{2}\right)^{(1.4-1)}$$

$300 \times (2)^{(0.4)} = T_2$; $\log 300 + 0.4 \log 2 = \log T_2$

$2.477 + 0.120 = \log T_2$; $2.597 = \log T_2$

$T_2 = $ Antilog (2.597) = 395.36 K

Change in temperature ($\Delta T$) = $T_2 - T_1 = 95.36$ K

**6.** Velocity of electron in $He^+$ ion in an orbit $(v) = \dfrac{2\pi Z e^2}{nh}$

Radius of $He^+$ ion in an orbit $(r_n) = \dfrac{n^2 h^2}{4\pi^2 m e^2 Z}$

$\therefore$ Angular frequency,

$$\omega = \dfrac{v}{r_n} = \dfrac{2\pi Z e^2 \times 4\pi^2 m e^2 Z}{nh \times n^2 h^2} = \dfrac{8\pi^3 Z^2 m e^4}{n^3 h^3}$$

$\because$ $n = 2$, $m = 9.108 \times 10^{-28}$ g, $Z = 2$,
$h = 6.625 \times 10^{-27}$ erg sec
$e = 4.803 \times 10^{-10}$ esu

$$\omega = \dfrac{8 \times (22/7)^3 \times (2)^2 \times 9.108 \times 10^{-28} \times (4.803 \times 10^{-10})^4}{(2)^3 \times (6.625 \times 10^{-27})^3}$$

$= 2.06 \times 10^{16}$ sec$^{-1}$

**7.** To calculate percentage of nitrogen :
50 mL of 0.05 M $H_2SO_4$ = 50 mL of 0.1 N $H_2SO_4$
$\qquad\qquad\qquad\qquad\qquad$ [$\because N = 2 \times M$]
Excess of acid required 25 mL of 0.1 M or 0.1 N NaOH
$\qquad\qquad\qquad\qquad\qquad$ [$\because N = M$]
25 mL of 0.1 N NaOH = 25 mL of 0.1 N $H_2SO_4$
$\qquad\qquad\qquad\qquad\qquad$ [$N_1 V_1 = N_2 V_2$]
$\therefore$ Volume of 0.1 N $H_2SO_4$ used for neutralisation of $NH_3$ = 50 – 25 = 25 mL
Hence, % age of N

$= \dfrac{1.4 \times \text{normality of acid} \times \text{volume of acid}}{\text{weight of the compound}}$

Percentage of nitrogen $= \dfrac{1.4 \times 0.1 \times 25}{0.303} = 11.55\,\%$

Percentage of oxygen = 100 – (69.4 + 5.8 + 11.55) = 13.25%
**Empirical formula :**

| Element | % | Relative number | Simplest ratio of atoms |
|---------|------|-----------------|-------------------------|
| C | 69.4 | 69.4/12 = 5.8 | 5.8/0.825 = 7 |
| H | 5.8 | 5.8/1 = 5.8 | 5.8/0.825 = 7 |
| N | 11.55 | 11.55/14 = 0.825 | 0.825/0.825 = 1 |
| O | 13.25 | 13.25/16 = 0.828 | 0.825/0.828 = 1 |

Hence, empirical formula of the aromatic compound
$\qquad\qquad\qquad\qquad\qquad = C_7H_7NO$

Empirical formula weight
$= 7 \times 12 + 7 \times 1 + 1 \times 14 + 1 \times 16 = 84 + 7 + 14 + 16 = 121$

$n = \dfrac{\text{Molecular weight}}{\text{Empirical formula weight}} = \dfrac{121}{121} = 1$

Hence, molecular formula = $C_7H_7NO$.
**Structure of the compound :**
Since the compound is aromatic, we can write its formula as $C_6H_5CH_2NO$ or $C_6H_5CH{=}NOH$ (benzaldoxime). It can exist in following two isomeric structures :

$$C_6H_5{-}\overset{\displaystyle H}{\underset{\displaystyle N{-}OH}{C}} \qquad C_6H_5{-}\overset{\displaystyle H}{\underset{\displaystyle HO{-}N}{C}}$$
$\quad\quad$ *syn*-Benzaldoxime $\qquad$ *anti*-Benzaldoxime
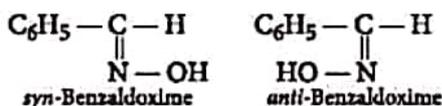
**8.** Total weight of AgCl obtained = 2.567 g
NaCl does not decompose on heating to 300°C. Therefore, amount of AgCl formed due to $MCl$ = 1.341 g
$\therefore$ Weight of AgCl formed due to NaCl
$= 2.567 - 1.341$ g = 1.226 g

$$\underset{\substack{23 + 35.5 \\ = 58.5}}{\text{NaCl}} \equiv \underset{\substack{108 + 35.5 \\ = 143.5}}{\text{AgCl}} \equiv MCl$$

143.5 g of AgCl is obtained from NaCl = 58.5 g
$\therefore$ 1.226 g of AgCl is obtained from NaCl
$\qquad\qquad = \dfrac{58.5}{143.5} \times 1.226$ g = 0.4998 g
$\therefore$ Weight of $MCl$ in 1 g of mixture = 1.000 – 0.4948 g
$\qquad\qquad\qquad\qquad\qquad = 0.5002$ g
1.341 g AgCl is obtained from $MCl$ = 0.5052 g
143.5 g AgCl is obtained from $MCl = \dfrac{0.5002}{1.341} \times 143.5$ g
$\qquad\qquad\qquad\qquad\qquad = 53.53$
Hence, molecular weight of $MCl$ = 53.53 g.

**9.** Let the number of moles of sodium propionate = $x$
$\therefore$ $pH = pK_a + \log \dfrac{[\text{Salt}]}{[\text{Acid}]} = -\log(1.34 \times 10^{-5}) + \log\left[\dfrac{x}{0.02}\right]$
or $4.75 = -\log(1.34 \times 10^{-5}) + \log\left[\dfrac{x}{0.02}\right]$
or $4.75 = 4.8729 + \log\left[\dfrac{x}{0.02}\right]$
or $\log \dfrac{x}{0.02} = 4.75 - 4.8729 = -0.1229$
or $x = 1.5 \times 10^{-2}$ moles
$\therefore$ Amount of sodium propionate = $1.5 \times 10^{-2}$ moles
When 0.01 moles of HCl is added, 0.03 moles (0.01 + 0.02) propionic acid and 0.005 moles (0.015 – 0.010) of sodium propionate are formed.
$\therefore$ $pH = -\log(1.34 \times 10^{-5}) + \log \dfrac{0.005}{0.03}$
$\qquad = 4.87 - 0.78 = 4.09$

**10.** $NH_{3(g)} + HCl_{(g)} \longrightarrow NH_4Cl_{(s)} ; \Delta H = -43.0$ kJ

| | $\dfrac{2 \times 1}{0.08 \times 200}$ | $\dfrac{8 \times 0.8}{0.08 \times 200}$ | |
|---|---|---|---|
| Initial mole | 0.125 | 0.4 | 0 |
| Final mole | 0 | 0.275 | 0.125 |

$\therefore$ Heat produced = $0.125 \times 43 = 5.375$ kJ
The heat produced is used to increase the temperature of HCl left in flask since heat capacity of flask and $NH_4Cl = 0$
$\therefore$ $Q = n \times C_v \times \Delta T$
$5.375 \times 10^3 = 0.275 \times 20 \times \Delta T \Rightarrow \Delta T = 977.27$ K
$\therefore$ Final temperature = 200 + 977.27 = 1177.27 K

◆ ◆

# GET SET GO for NEET

## with exclusive and brain storming MCQs

Practicing these MCQs help to strengthen your concepts and give you extra edge in your NEET preparation

1. Consider the following reaction,

$$CH_3-\underset{\underset{Br}{|}}{\overset{\overset{CH_3}{|}}{C}}-CH_2CH_3 \xrightarrow[base]{Heat}$$

$$\underset{CH_3}{\overset{CH_3}{>}}C=C\underset{H}{\overset{CH_3}{<}} + CH_2=C\underset{CH_3}{\overset{CH_2CH_3}{<}}$$

I           II

Which of the following base will give the best yield of the alkene II as the major product?
(a) $CH_3O^-$       (b) $C_2H_5O^-$
(c) $(CH_3)_3CO^-$    (d) $(C_2H_5)_3CO^-$

2. If $10^{21}$ molecules are removed from 200 mg of $CO_2$, then the number of moles of $CO_2$ left are
(a) $2.87 \times 10^{-3}$      (b) $28.8 \times 10^{-3}$
(c) $0.288 \times 10^{-3}$     (d) $1.68 \times 10^{-2}$

3. On addition of increasing amount of $AgNO_3$ to 0.1 M each of NaCl and NaBr in a solution, what % of $Br^-$ ion get precipitated when $Cl^-$ ion starts precipitating?
$[K_{sp}(AgCl) = 1.0 \times 10^{-10}, K_{sp}(AgBr) = 1 \times 10^{-13}]$
(a) 0.11           (b) 99.9
(c) 0.01           (d) 9.99

4. In a measurement of quantum efficiency of photosynthesis in green plants, it was found that 10 quanta of red light of wavelength 6850 Å were needed to release one molecule of $O_2$. The average energy storage in this process for 1 mole $O_2$ evolved is 112 kcal. What is the energy conversion efficiency in this experiment?
(Given : 1 cal = 4.18 J; $N_A = 6 \times 10^{23}$, $h = 6.63 \times 10^{-34}\, m^2\, kg\, s^{-1}$)
(a) 23.5    (b) 26.9    (c) 66.37   (d) 73.1

5. Which of the following statements about polar stratospheric clouds (PSCs) is not correct?
(a) PSCs are formed over Antarctica during summer season.
(b) Type I clouds are formed at about –77°C and contain solid $HNO_3\text{-}3H_2O$.
(c) Type II clouds are formed at about – 85°C and contain some ice.
(d) A tight whirlpool of wind called Polar Vortex is formed which surrounds Antarctica.

6. The C—C single bond length is 1.54 Å and that of Cl—Cl is 1.98 Å. If the electronegativity of Cl and C are 3.0 and 2.5 respectively, the C—Cl bond length will be equal to
(a) 3.12 Å   (b) 1.67 Å   (c) 1.71 Å   (d) 2.12 Å

7. $\Delta H_f^{\circ}$ of $NF_3$ is $-113$ kJ mol$^{-1}$ and N—F bond energy is 273.0 kJ mol$^{-1}$. If $N \equiv N$ and F—F bond energies are in the ratio of 6 : 1 then their magnitudes will be respectively
    (a) 780.0 kJ mol$^{-1}$ and 130.0 kJ mol$^{-1}$
    (b) 840.0 kJ mol$^{-1}$ and 140.0 kJ mol$^{-1}$
    (c) 950.0 kJ mol$^{-1}$ and 158.3 kJ mol$^{-1}$
    (d) 941.3 kJ mol$^{-1}$ and 156.9 kJ mol$^{-1}$.

8. $n$-factors for $Cu_2S$ and $CuS$ when they react with $KMnO_4$ in acidic medium are (neglecting the further oxidation of released $SO_2$.)
    (a) 7, 7    (b) 6, 6    (c) 6, 8    (d) 8, 6

9. Let the most probable velocity of hydrogen molecules at a temperature of $t°C$ be $V_0$. When the temperature is raised to $(2t + 273)°C$ the new $rms$ velocity is (suppose all the molecules dissociate into atoms at later temperature.)
    (a) $2\sqrt{3}\,V_0$
    (b) $\sqrt{6}\,V_0$
    (c) $\sqrt{3\left(2+\dfrac{273}{t}\right)}\,V_0$
    (d) $\sqrt{\dfrac{2}{3}}\,V_0$

10. Which method is best for the synthesis of the following compound?
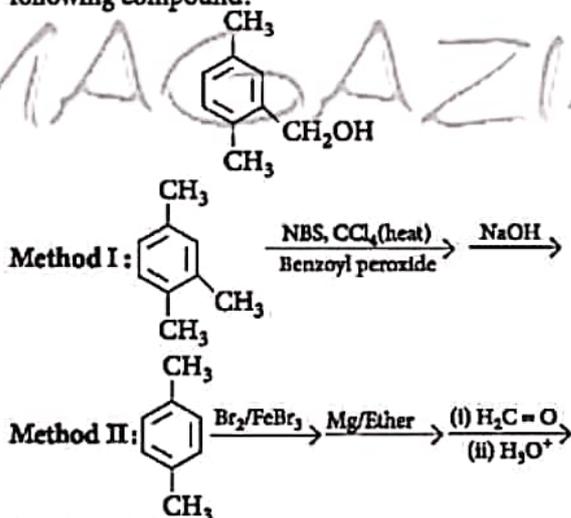


(a) Method I
(b) Method II
(c) Both methods (I) and (II) are equally good.
(d) Neither method (I) nor method (II).

11. Which one of the following statement is wrong for the following reaction sequence?

$$[A] + NaCr(OH)_4 \xrightarrow[\text{Boil}]{H_2O_2} (B) \xrightarrow{H_2SO_4} (C)$$
                        Yellow      Orange
                        colour      colour
                        sol.       comp.

(a) $[A]$ is NaOH.
(b) $[B]$ is $Na_2CrO_3$.
(c) $[B]$ is $Na_2CrO_4$.
(d) $[C]$ is $Na_2Cr_2O_7$.

12. Which of the following is not a resonance form of the enolate ion formed in the following acid-base equilibrium?
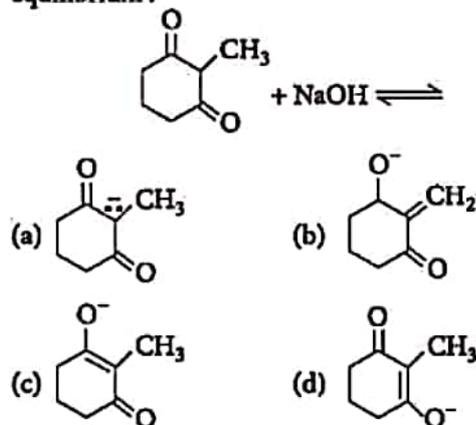


13. Which of the following is not correct from the viewpoint of molecular orbital?
    (a) $Be_2$ is not a stable molecule.
    (b) $He_2$ is not stable but $He^+$ is expected to exist.
    (c) Bond strength of $N_2$ is maximum amongst the homonuclear diatomic molecules.
    (d) The order of energies of molecular orbitals in $F_2$ molecule is $KK\,\sigma 2s^2 < \sigma^*2s^2 < \pi 2p_x^2 = \pi 2p_y^2 < \sigma 2p_z^2 < \pi^*2p_x^2 = \pi^*2p_y^2$

14. A mixture of $Na_2CO_3$ and $K_2CO_3$ is used as fusion mixture because
    (a) it has lower m.pt than $Na_2CO_3$ and converts metal salts to carbonates which decompose to metal oxides
    (b) it has higher m.pt than $K_2CO_3$ and converts metal salts to carbonates, which decompose to metal oxides
    (c) it has lower m.pt. than both $Na_2CO_3$ and $K_2CO_3$ and converts the metal salts to carbonates, which decompose to metal oxides
    (d) it has higher m.pt. than both $Na_2CO_3$ and $K_2CO_3$ and converts the metal salts to carbonates which decompose to metal oxide.

15. In the following reaction, $B_2H_6 + NH_3 \xrightarrow{120°C} X$, $X$ is
    (a) $[BH_2(NH_3)_2]^+[BH_4]^-$
    (b) $[BH_2(NH_3)_2]^+[BH_3]^-$
    (c) $(BH_4)^+[BH_2(NH_3)_2]^-$
    (d) $(BH_3)^+[BH_3(NH_3)_2]^-$

1. **(d):** Alkene II is less substituted means Hofmann's product. Bulky base gives Hofmann's product.

2. **(a):** 200 mg of $CO_2 = 200 \times 10^{-3} = 0.2$ g
44 g of $CO_2 = 6.023 \times 10^{23}$ molecules
$$0.2 \text{ g of } CO_2 = \frac{6.023 \times 10^{23}}{44} \times 0.2 = 0.0273 \times 10^{23}$$
$$= 2.73 \times 10^{21} \text{ molecules}$$
Now, as $10^{21}$ molecules are removed, so remaining molecules $= 2.73 \times 10^{21} - 10^{21}$
$= 10^{21} (2.73 - 1) = 1.73 \times 10^{21}$ molecules
Now, $6.023 \times 10^{23}$ molecules = 1 mole
$$\therefore 1.73 \times 10^{21} \text{ molecules} = \frac{1 \times 1.73 \times 10^{21}}{6.023 \times 10^{23}} = 0.287 \times 10^{-2}$$
$$= 2.87 \times 10^{-3} \text{ moles}$$

3. **(b):** To precipitate the AgCl,
$$[Ag^+] \text{ required} = \frac{K_{sp}(AgCl)}{[Cl^-]} = \frac{1.0 \times 10^{-10}}{0.1} = 1.0 \times 10^{-9} M$$
$$[Br^-] \text{ left at this stage} = \frac{K_{sp}(AgBr)}{[Ag^+]} = \frac{1.0 \times 10^{-13}}{1.0 \times 10^{-9}}$$
$$= 1.0 \times 10^{-4} M$$
$$\% \text{ of remaining } [Br^-] = \frac{1.0 \times 10^{-4}}{0.1} \times 100 = 0.1$$
% of $[Br^-]$ to be precipitated = 100 − 0.1 = 99.9

4. **(b):** $E = \dfrac{hc}{\lambda} = 2.9 \times 10^{-19}$ J
Total energy of 10 quanta $= 10 \times 2.9 \times 10^{-19} = 29 \times 10^{-19}$ J
$$\text{Energy stored for process} = \frac{112 \times 4.18 \times 10^3}{6 \times 10^{23}}$$
$$= 7.80 \times 10^{-19} \text{ J}$$
$$\% \text{ efficiency} = \frac{7.80 \times 10^{-19}}{29 \times 10^{-19}} \times 100 = 26.9$$

5. **(a)**

6. **(c):** For a diatomic hetero molecule,
$d_{A-B} = r_A + r_B - 0.09(\chi_A - \chi_B)$
Where, $\chi_A$ = Electronegativity of more electronegative atom
$\chi_B$ = Electronegativity of less electronegative atom
Thus, $r_C = \dfrac{1.54}{2} = 0.77$ Å, $r_{Cl} = \dfrac{1.98}{2} = 0.99$ Å
$\chi_{Cl} - \chi_C = 3.0 - 2.5 = 0.5$
$d_{C-Cl} = 0.77 + 0.99 - 0.09 \times 0.5 = 1.71$ Å
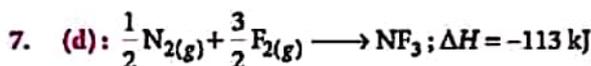
7. **(d):** $\dfrac{1}{2} N_{2(g)} + \dfrac{3}{2} F_{2(g)} \longrightarrow NF_3 ; \Delta H = -113$ kJ
or $\dfrac{1}{2} \Delta H_{N \equiv N} + \dfrac{3}{2} \Delta H_{F-F} - 3\Delta H_{N-F} = -113$ kJ

Let $x$ kJ mol$^{-1}$ be the bond energy of F—F bond then bond energy of N ≡ N bond will be $6x$.
$$\therefore \frac{1}{2} \times 6x + \frac{3}{2} \times x - 3 \times 273 = -113 \text{ kJ}$$
On solving, $x = 156.9$ kJ mol$^{-1}$
Therefore, N≡N bond energy $= 6 \times 156.9$
$$= 941.3 \text{ kJ mol}^{-1}$$
and F—F bond energy = 156.9 kJ mol$^{-1}$
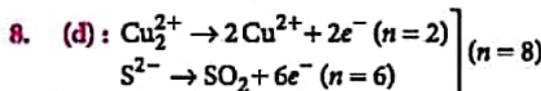
8. **(d):** $\left. \begin{array}{l} Cu_2^+ \rightarrow 2Cu^{2+} + 2e^- \ (n=2) \\ S^{2-} \rightarrow SO_2 + 6e^- \ (n=6) \end{array} \right] (n=8)$
$Cu^{2+}$ does not change only $S^{2-}$ changes to $SO_2$ hence, $n = 6$

9. **(b):** $V_0 = \sqrt{\dfrac{2RT}{M}} = \sqrt{R(273 + t)}$
$$V_{rms} = \sqrt{\frac{3(2t + 273 + 273)R}{1}} = \sqrt{6(t + 273)R} = \sqrt{6}V_0$$

10. **(b):**

11. **(b):** $2NaCr(OH)_4 + 2NaOH + 3H_2O_2 \xrightarrow{\text{Boil}}$
$\qquad\qquad (A)$
$8H_2O + 2Na_2CrO_4 \xrightarrow{H_2SO_4} Na_2Cr_2O_7$
$\qquad (B) \qquad\qquad\qquad (C)$
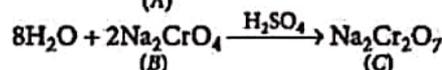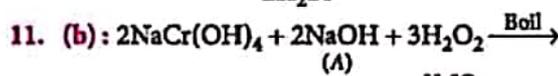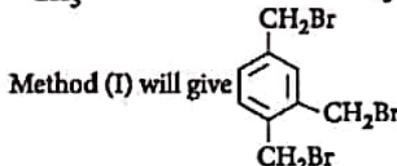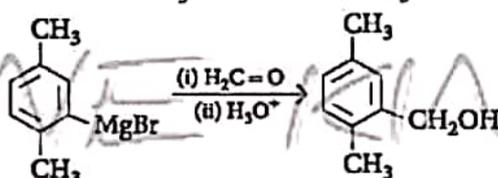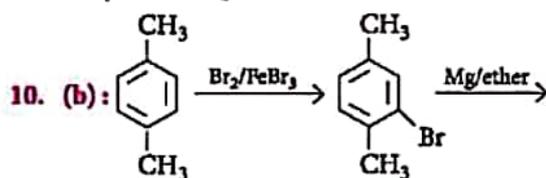
12. **(b):** (a), (c) and (d) are resonating structures.
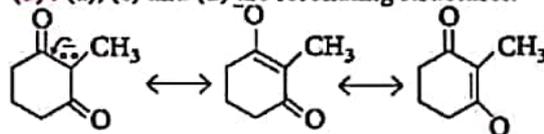
13. **(d):** The molecular orbital electronic configuration of $F_2$ molecule is $\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma^* 2s^2 < \sigma 2p_z^2 < \pi 2p_x^2$ $= \pi 2p_y^2 < \pi^* 2p_x^2 = \pi^* 2p_y^2$

14. **(c)**
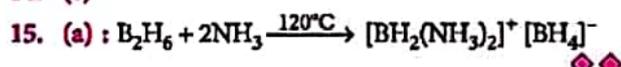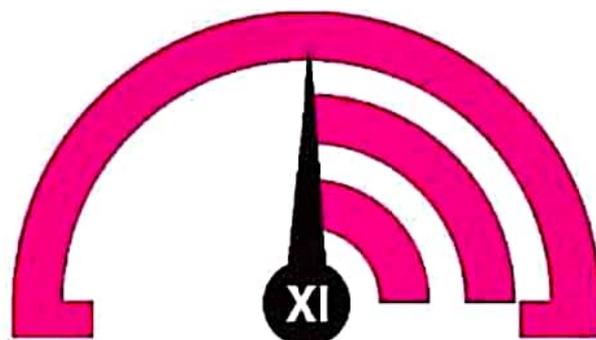
15. **(a):** $B_2H_6 + 2NH_3 \xrightarrow{120°C} [BH_2(NH_3)_2]^+ [BH_4]^-$

❖❖

# MONTHLY TEST DRIVE

**XI**

This specially designed column enables students to self analyse their extent of understanding of all chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

**Total Marks : 120**

## PRACTICE PAPER

**Time Taken : 60 Min.**

### NEET
#### Only One Option Correct Type

1. If H-atom is supplied with 12.1 eV energy and electron returns to the ground state after excitation then number of spectral lines in Balmer series would be
   (Use energy of ground state of H-atom = –13.6 eV)
   (a) 1   (b) 2   (c) 3   (d) 4

2. $n_1$ and $n_2$ moles of two ideal gases having molecular weights $M_1$ and $M_2$ respectively at temperatures $T_1$ K and $T_2$ K are mixed. Assuming no loss of energy, the temperature of mixture will become
   (a) $n_1 T_1 + n_2 T_2$
   (b) $\dfrac{n_1 T_1 + n_2 T_2}{T_1 + T_2}$
   (c) $\dfrac{n_1 T_1 + n_2 T_2}{n_1 + n_2}$
   (d) $\dfrac{T_1 \times T_2}{n_1 \times n_2}$

3. The formation of the oxide ion, $O^{2-}_{(g)}$, from oxygen atom requires first an exothermic and then an endothermic step as shown below :
   $$O_{(g)} + e^- \longrightarrow O^-_{(g)} ; \Delta H^\circ = -141 \text{ kJ mol}^{-1}$$
   $$O^-_{(g)} + e^- \longrightarrow O^{2-}_{(g)} ; \Delta H^\circ = +780 \text{ kJ mol}^{-1}$$
   Thus, process of formation of $O^{2-}$ in gas phase is unfavourable even though $O^{2-}$ is isoelectronic with neon. It is due to the fact that
   (a) oxygen is more electronegative
   (b) addition of electron in oxygen results in larger size of the ion
   (c) electron repulsion outweighs the stability gained by achieving noble gas configuration
   (d) $O^-$ ion has comparatively smaller size than oxygen atom.
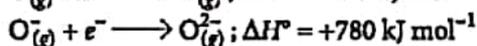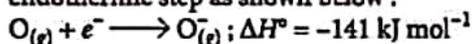
4. Ethanol can undergoes decomposition to form two sets of products.

$$C_2H_5OH_{(g)} \begin{cases} \xrightarrow{1} C_2H_{4(g)} + H_2O_{(g)}; \Delta H^\circ = 45.54 \text{ kJ} \\ \xrightarrow{2} CH_3CHO_{(g)} + H_{2(g)}; \Delta H^\circ = 68.91 \text{ kJ} \end{cases}$$
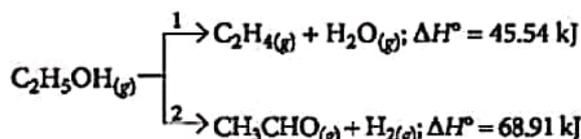
   If the molar ratio of $C_2H_4$ to $CH_3CHO$ is 8 : 1 in a set of product gases, then the energy involved in the decomposition of 1 mole of ethanol is
   (a) 114.45 kJ   (b) 48.137 kJ
   (c) 23.37 kJ   (d) 57.22 kJ

5. When $KMnO_4$ acts as an oxidising agent and ultimately forms $[MnO_4]^{2-}$, $MnO_2$, $Mn_2O_3$, $Mn^{2+}$ then the number of electrons transferred in each case respectively is
   (a) 4, 3, 1, 5   (b) 1, 5, 3, 7
   (c) 1, 3, 4, 5   (d) 3, 5, 7, 1

6. When cyclohexane is poured on water, it floats, because
   (a) cyclohexane is in 'boat' form
   (b) cyclohexane is in 'chair' form
   (c) cyclohexane is in 'crown' form
   (d) cyclohexane is less denser than water.

7. X and Y are metal nitrates. X on heating liberates $O_2$ but Y on heating liberates $NO_2$ and $O_2$. X and Y are respectively
   (a) $NaNO_3$, $KNO_3$   (b) $LiNO_3$, $Mg(NO_3)_2$
   (c) $NaNO_3$, $Mg(NO_3)_2$   (d) $Mg(NO_3)_2$, $NaNO_3$

8. Main pollutants release from iron and steel industry are
   (a) only $SO_2$   (b) only $CO_2$
   (c) only $CO$   (d) all of these.

9. The standard heat of combustion of Al is –837.8 kJ mol$^{-1}$ at 25°C. If Al reacts with $O_2$ at 25°C, which of the following releases 250 kJ of heat?

(a) The reaction of 0.624 mol of Al.
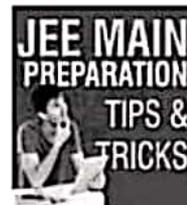(b) The formation of 0.624 mol of $Al_2O_3$.
(c) The reaction of 0.312 mol of Al.
(d) The formation of 0.150 mol of $Al_2O_3$.

10. The dipole moment of chlorobenzene,  is 1.5 D.
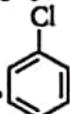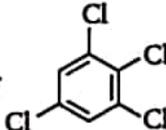
The dipole moment of  is

(a) 2.86 D   (b) 2.25 D   (c) 1.5 D   (d) 0 D

11. The major organic products A and B in the given reactions are respectively
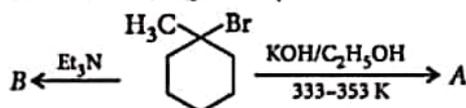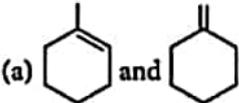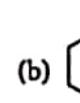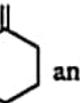


(a)  and    (b)  and 
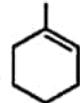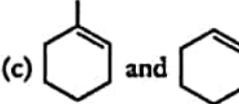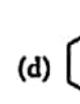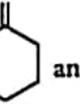
(c)  and    (d)  and 
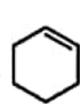
12. How can the given reaction is made to proceed in forward direction?
$$2B(OH)_3 + 2NaOH \rightleftharpoons NaBO_2 + Na[B(OH)_4] + 2H_2O$$
(a) Addition of cis-1, 2-diol
(b) Addition of borax
(c) Addition of trans-1, 2-diol
(d) Addition of $Na_2HPO_4$

### Assertion & Reason Type

Directions : In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as :
(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

13. Assertion : Buffer system of carbonic acid and sodium bicarbonate is used for the precipitation of hydroxides of third group elements.
Reason : It maintains the pH to a constant value, about 7.4.

14. Assertion : In $BrF_3$, axial fluorine atoms are bent towards the equatorial fluorine.
Reason : Repulsion of lone pairs on equatorial fluorine is stronger as compared to on axial fluorine.

15. Assertion : Hydrogen and deuterium are both present in ordinary dihydrogen.
Reason : Heavy hydrogen or deuterium was separated from liquid hydrogen by fractional distillation by H.C. Urey.

### JEE MAIN / ADVANCED
#### Only One Option Correct Type

16. When sulphur in the form of $S_8$ is heated at 900 K, the initial pressure of 1 atm falls by 29% at equilibrium. This is because of conversion of some $S_8$ into $S_2$. The value of equilibrium constant for this reaction is
(a) 2.55                     (b) $9.9 \times 10^{-3}$
(c) $11 \times 10^{-2}$       (d) 1.89

17. For a 3s-orbital, $\psi(3s) = \dfrac{1}{9\sqrt{3}}\left(\dfrac{1}{a_0}\right)^{1/2}$
$(6 - 6\sigma + \sigma^2)e^{-\sigma/2}$ where, $\sigma = \dfrac{2Zr}{3a_0}$. What is the maximum radial distance of node from nucleus?
(a) $\dfrac{2}{3}\dfrac{(3+\sqrt{3})a_0}{Z}$     (b) $\dfrac{3}{2}\dfrac{(3+\sqrt{3})a_0}{Z}$
(c) $\dfrac{3}{2}\dfrac{(3-3\sqrt{3})a_0}{Z}$     (d) $\dfrac{3}{2}\dfrac{(3-\sqrt{3})a_0}{Z}$

18. A flask of 1 L having $NH_{3(g)}$ at 2.0 atm and 200 K is connected with another flask of volume 800 mL having $HCl_{(g)}$ at 8 atm and 200 K through a narrow tube of negligible volume. The two gases react to form $NH_4Cl_{(s)}$ with evolution of 43 kJ mol$^{-1}$ of heat. If heat capacity of $HCl_{(g)}$ at constant volume is 20 J K$^{-1}$ mol$^{-1}$ and neglecting heat capacity of flask, and volume of solid $NH_4Cl$ formed, then final temperature in flask is
(Assume $R = 0.08$ L atm K$^{-1}$ mol$^{-1}$)
(a) 977.27 K                 (b) 1177.27 K
(c) 1077.27 K                (d) 1277.27 K

## At least half of Earth's Oxygen Comes from the Ocean

Microscopic, single celled photosynthetic micro-organisms called phytoplankton live near the surface of the water, drift with the currents, and generally do what plants do-make oxygen as a by-product by taking in sunlight and carbon dioxide.

**19.** The compounds in which the $-CH_3$ group causing decrease in acid strength and increase in basic strength are respectively

(1) $CH_3-COOH$

(2) HOOC—⟨benzene ring⟩—$CH_3$

(3) ⟨benzene ring with HOOC and $CH_3$⟩

(4) ⟨benzene ring with $H_3C$ and $NH_2$⟩

(5) ⟨benzene ring with $CH_3$ and $NH_2$⟩
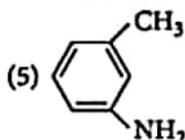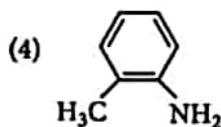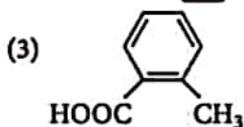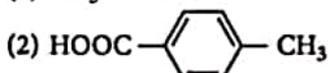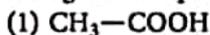
(a) 3 and 5      (b) 1 and 5

(c) 3 and 4      (d) 2 and 5

### More than One Options Correct Type

**20.** The values of two lattice energies are given below :
NaF – 915 kJ mol$^{-1}$; MgO – 3933 kJ mol$^{-1}$
Which of the following correct statements help to explain the difference between these two values?

(a) In each of these compounds, the ions are isoelectronic.

(b) The attraction between doubly charged ions is about four times than that between singly charged ions.

(c) The interionic distance in NaF is greater than that in MgO.

(d) The interionic distance in NaF is smaller than that in MgO.

**21.** Which of the following reactions will give both gases ($X$) and ($Y$)?

$$Na_2C_2O_4 + H_2SO_4 \longrightarrow (A) + Na_2SO_4$$
$$\downarrow \Delta$$
$$H_2O + (X) \quad + \quad (Y)$$

Burns with yellow flame     Turns lime water milky

(a) $H_2C_2O_4 \xrightarrow{\Delta}$     (b) $FeC_2O_4 \xrightarrow{\Delta}$

(c) $HCOONa \xrightarrow{\Delta}$     (d) $HCOOAg \xrightarrow{\Delta}$
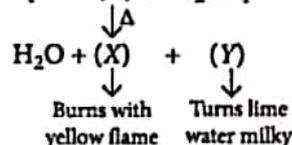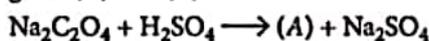
**22.** The van der Waals' parameters $a$ and $b$ for two gases are given as,

| Gas A | Gas B |
|---|---|
| $a = 6.5$ dm$^6$ bar/mole$^2$ | $a = 18.0$ dm$^6$ bar/mole$^2$ |
| $b = 0.056$ dm$^3$ mole$^{-1}$ | $b = 0.011$ dm$^3$ mole$^{-1}$ |

Which of the following options are incorrect?

(a) $(V_c)_A > (V_c)_B$     (b) $(P_c)_A > (P_c)_B$

(c) $(T_c)_A > (T_c)_B$     (d) $(P_c)_A = (P_c)_B$

**23.** Which of the following statements are correct about the electrophilic substitution reactions in given compounds A and B?
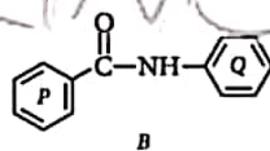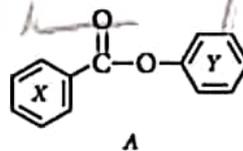
⟨structure A: benzene ring X with $-C(=O)-O-$ Y ring⟩     ⟨structure B: benzene ring P with $-C(=O)-NH-$ Q ring⟩

A          B
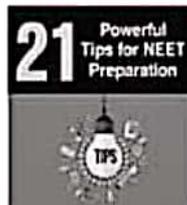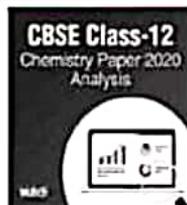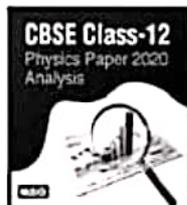
(a) Compound *A* is more reactive than compound *B*.
(b) In *A*, ring *Y* will take part in electrophilic substitution reaction.
(c) In *B*, ring *Q* will take part in electrophilic substitution reaction.
(d) Compound *B* is more reactive than compound *A*.

### Numerical Value Type

24. In 1 L saturated solution of AgCl [$K_{sp}$(AgCl) = $1.6 \times 10^{-10}$], 0.1 mol of CuCl [$K_{sp}$(CuCl) = $1.0 \times 10^{-6}$] is added. The resultant concentration of $Ag^+$ in the solution is $1.6 \times 10^{-x}$. The value of $x$ is _____.

25. From the given species, the number of aromatic species is _____.



(I)     (II)     (III)     (IV)



(V)     (VI)     (VII)     (VIII)
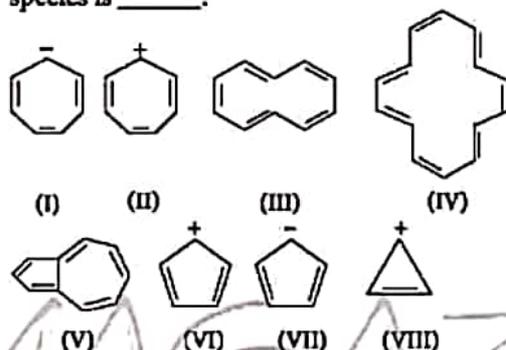
26. To an evacuated vessel with movable piston under external pressure of 1 atm, 0.1 mol of He and 1.0 mol of an unknown compound (vapour pressure = 0.68 atm at 0°C) are introduced. Considering the ideal gas behaviour, the total volume (in litres) of the gases at 0°C is _____.

### Matrix Match Type

Answer the following questions (27 and 28) by appropriately matching the columns based on the information given in the passage :
Columns 1, 2 and 3 contain number of moles, volumes at STP and number of atoms, respectively.

| Column 1 | Column 2 | Column 3 |
| --- | --- | --- |
| (I) 0.125 | (i) 7840 mL | (P) $13.25 \times 10^{23}$ |
| (II) 0.35 | (ii) 11.2 dm³ | (Q) $6.32 \times 10^{23}$ |
| (III) 1.1 | (iii) 2.8 L | (R) $6.023 \times 10^{23}$ |
| (IV) 0.50 | (iv) 24640 cc | (S) $3.011 \times 10^{23}$ |

27. The correct combination for 16 g of $NO_2$ is
(a) (I) → (ii) → (R)     (b) (II) → (iii) → (S)
(c) (II) → (i) → (Q)     (d) (IV) → (iii) → (P)

28. For 32 g of sulphur, correct combination will be
(a) (I) → (ii) → (P)     (b) (I) → (iii) → (R)
(c) (II) → (iii) → (Q)     (d) (III) → (iv) → (S)

Answer the following questions (29 and 30) by appropriately matching the columns based on the information given in the passage :
Columns 1, 2 and 3 contain reactants, products and type of reactions, respectively.

| Column 1 | Column 2 | Column 3 |
| --- | --- | --- |
| (A) $2CH_2{=}CH_2 \xrightarrow{HF}$ | (p) $CH_3CH_2CH{=}CH_2$ | (w) Dimerisation |
| (B)  $\xrightarrow[470\text{-}570\ K]{Al_2(SO_4)_3}$ | (q)  | (x) Interconversion |
| (C)  $\xrightarrow{U.V.}$ | (r)  | (y) Isomerisation |
| (D)  | (s)  | (z) Alkylation |

29. Which of the following has the correct combination considering column-I, column-II and column-III ?
(a) A → p, w     (b) B → s, w
(c) C → q, y     (d) D → r, x

30. Which of the following has the correct combination considering column-I, column-II and column-III ?
(a) D → q, z     (b) C → s, y
(c) B → r, y     (d) A → s, w     ◆◆

*Keys are published in this issue. Search now!* ☺

## CHECK YOUR PERFORMANCE ✏

| | If your score is | |
| --- | --- | --- |
| No. of questions attempted ...... | > 80% | Your preparation is going good, keep it up to get high score. |
| No. of questions correct ...... | 60-80% | Need more practice, try hard to score more next time. |
| Marks scored in percentage ...... | <60% | Stress more on concepts and revise thoroughly. |

# CONCEPT BOOSTER

Hello dear students! Hope you all are fine. Those who have appeared for the board examinations, I believe that you did your best. Now it's hard time that you start identifying your weak areas. I would suggest you to study topicwise and not chapterwise as of now. Keeping this in mind I have present this article with some intricate and conceptual topics. Hope you will like it. All the best!

*Arunava Sarkar

## WHAT YOU KNOW?
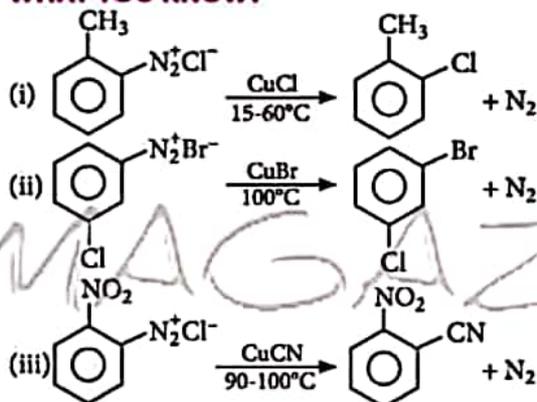


## Do you know?
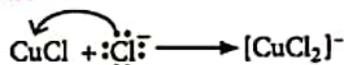


(Cuprous salts have a special affinity for diazonium salts.)

$$ArN_2^+ + [Cl-Cu-Cl]^- \xrightarrow{slow} \overset{\bullet}{Ar} + N_2 \xrightarrow{CuCl_2} Ar-Cl + CuCl$$
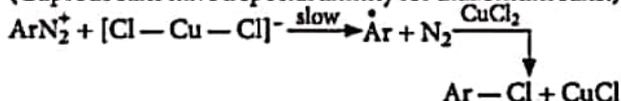
## What you must know?

The above reactions are Sandmeyer reactions. If you take Cu powder then it will be named as Gattermann reaction.

## WHAT YOU KNOW?

$$C_6H_5N_2^+Cl^- + H_3PO_2 + H_2O \xrightarrow{0°C} C_6H_6 + H_3PO_3 + HCl + N_2\uparrow$$
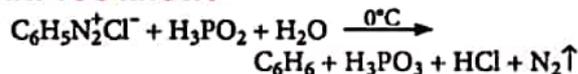
This is deamination process.

## Do you know?

The above reaction takes place via free radical mechanism.

Chain initiation :

$$PhN_2^+Cl^- + H_2P(O)OH$$
$$\rightarrow HCl + Ph-N=N-PH(O)OH$$
$$\rightarrow \overset{\bullet}{Ph} + N_2 + \overset{\bullet}{P}H(O)OH$$

Chain propagation :

$$\overset{\bullet}{Ph} + H_2P(O)OH \rightarrow PhH + \overset{\bullet}{P}H(O)OH$$
$$PhN_2^+ + \overset{\bullet}{P}H(O)OH \rightarrow \overset{\bullet}{Ph}N_2 + \overset{+}{P}H(O)OH$$
$$\overset{\bullet}{Ph} + N_2 \qquad \downarrow H_2O$$
$$H_3PO_3 + H^+$$
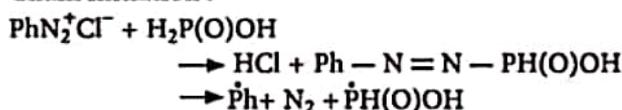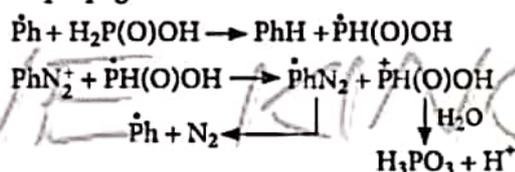
## What you must know?

$NaBH_4$/ethanol can also be used for replacement of diazonium group by hydrogen.

*Institute of Chemistry (IOC)- Asansol, Durgapur, Dhanbad, Burdwan, Kolkata, Jamshedpur, Bokaro, Patna

## WHAT YOU KNOW?

$$Br-\underset{}{\bigcirc}-N_2^+Cl^- + C_6H_6 \xrightarrow{NaOH}$$

$$Br-\bigcirc-\bigcirc + N_2 + NaCl + H_2O$$

$$\bigcirc-N_2^+Cl^- + \bigcirc-NO_2 \xrightarrow{NaOH}$$

$$\bigcirc-\bigcirc-NO_2 + N_2 + NaCl + H_2O$$

### Do you know?

$$PhN_2^+Cl^- \xrightarrow{\bar{O}H} Ph-N=N-OH \rightarrow \overset{\cdot}{P}h + N_2 + \overset{\cdot}{O}H$$
$$O \leftarrow N = O$$

$$\overset{\cdot}{P}h \longrightarrow$$
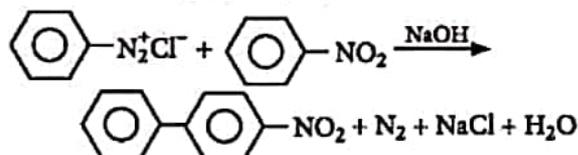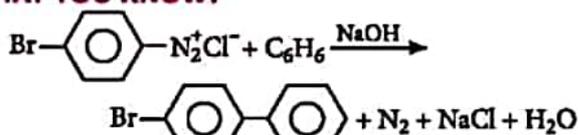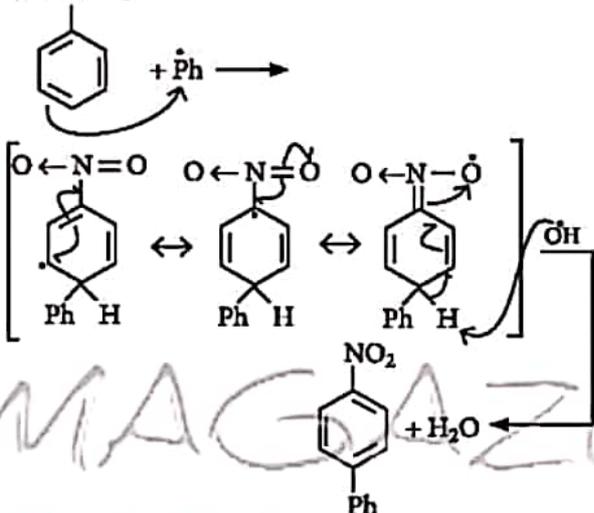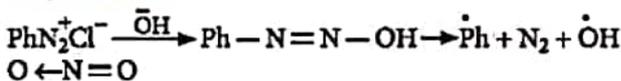
### What you must know?

The above reactions are Gomberg reactions. It is to be remembered that whatever becomes the nature of a substituent in the second component, *ortho* or *para* substitution always occurs predominantly.

**Q.** Identify the product.

$$CH_3CH=NOH \xrightarrow[\Delta]{Ac_2O} ?$$
(oxime)

**Sol.:**

Z-oxime
$$\xrightarrow{\Delta} CH_3-C\equiv N + CH_3COOH$$

or

E-oxime
$$\xrightarrow{\Delta} CH_3-C\equiv N + CH_3COOH$$
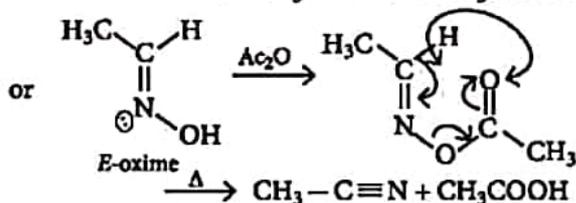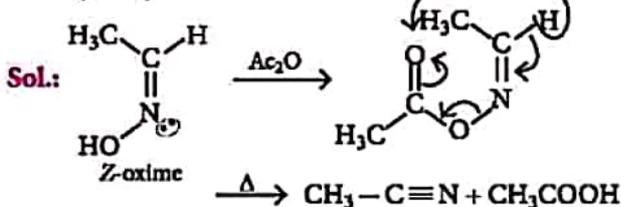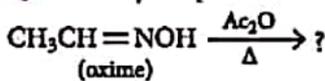
### Do you know?
### Thorpe nitrile condensation or Thorpe reaction :

Base catalysed condensation between two cyanide molecules where α-carbon of one molecule combines to the cyano carbon of the other is popularly known as Thorpe nitrile condensation or Thorpe reaction. Take the following example :

$$CH_3CH_2C\equiv N + CH_3CH_2CN \xrightarrow[EtOH]{NaOEt}$$

$$\underset{\text{imino-nitrile}}{CH_3CH_2\overset{\overset{NH}{\|}}{C}-\overset{\overset{CH_3}{|}}{CH}-CN} \rightleftharpoons \underset{\text{(enamino-nitrile)}}{CH_3CH_2\overset{\overset{NH_2}{|}}{C}=\overset{\overset{CH_3}{|}}{C}-CN}$$
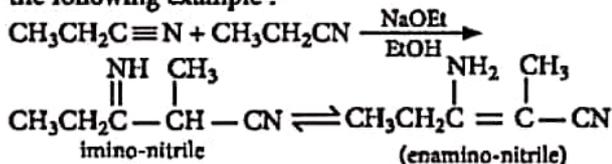
Enamino-nitrile is more stabilised than imino-nitrile. Hence, the tautomerism takes place.

**Mechanism :**

$$\underset{\text{imino-nitrile}}{CH_3-\overset{\overset{NH}{\|}}{C}-\overset{\overset{}{|}}{CH}-CH_2CH_3} \xrightarrow{\text{tautomerism}}$$
$$\underset{CN}{\quad}$$

$$\underset{\text{enamino-nitrile}}{CH_3-\overset{\overset{}{|}}{C}=\overset{\overset{NH_2}{|}}{C}-CH_2CH_3}$$
$$\underset{CN}{\quad}$$
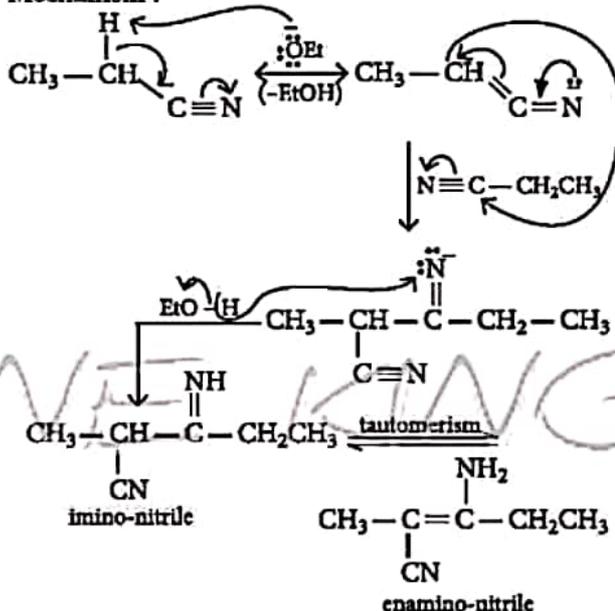
Do remember that this reaction is carried out intramolecularly also, and in that case this reaction is called Thorpe-Ziegler reaction and this is a useful method for preparing 5 to 8 large membered ring.

❖❖
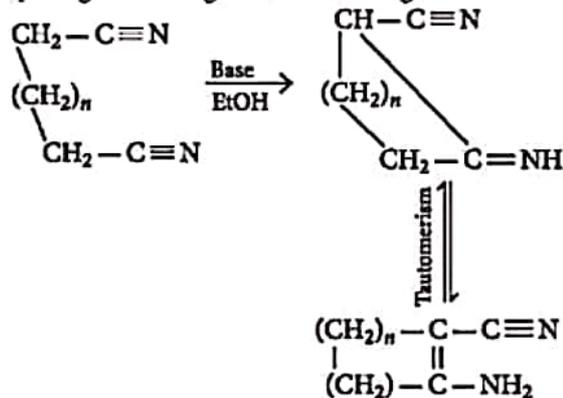
# GET SET GO for JEE

## with exclusive and brain storming MCQs

### Only One Option Correct Type

**1.** Consider the following,
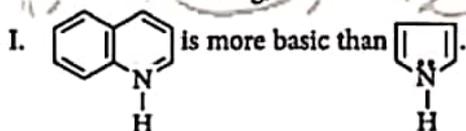
I.  is more basic than .

II. Order of basic nature is
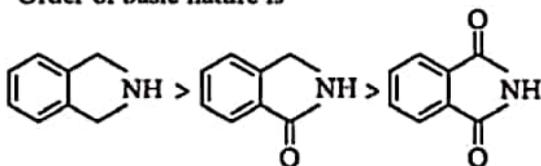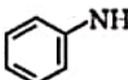


III.  is more basic than ammonia.

(a) All statements are correct.
(b) II is wrong while I and III are correct statements.
(c) I and III are wrong while II is correct statement.
(d) Statements I and II are correct while III is wrong.

**2.** In a given set of the reactions, acetic acid yielded a product C.

$$CH_3COOH \xrightarrow{PCl_5} A \xrightarrow[AlCl_3]{C_6H_6} B \xrightarrow{C_2H_5MgBr/H_3O^+} C$$
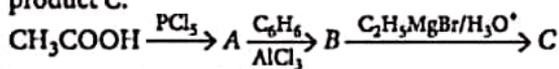
The product C would be

(a) $CH_3CH(OH)C_2H_5$
(b) $CH_3COC_6H_5$
(c) $CH_3CH(OH)C_6H_5$
(d) $CH_3-\overset{\underset{\displaystyle C_2H_5}{|}}{C}(OH)C_6H_5$

**3.** Which resonance form is not possible in the nucleophilic addition of $OH^-$ ion to *para*-fluoronitrobenzene?

(a) 
(b) 
(c) 
(d) 
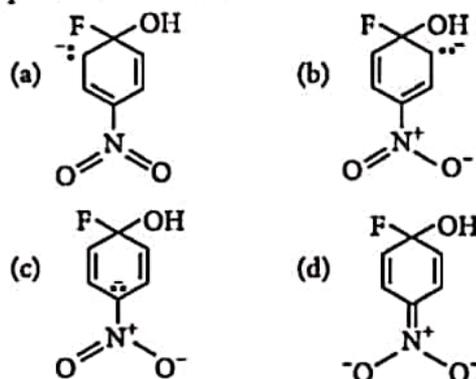
**4.** The emf of a Daniell cell at 298 K is $E_1$,

Zn | ZnSO$_4$(0.01 M) || CuSO$_4$ (1.0 M) | Cu

When the concentration of ZnSO$_4$ is 1.0 M and that of CuSO$_4$ is 0.01 M, the emf is changed to $E_2$. What is the relationship between $E_1$ and $E_2$?

(a) $E_2 = 0 \approx E_1$      (b) $E_1 > E_2$
(c) $E_1 < E_2$      (d) $E_1 = E_2$

5. $P_4S_3$ is used with $KClO_3$ in "strike any-where" matches. The number of 'P—P' bonds and 'S—P' bonds in $P_4S_3$ are respectively

| | 'P—P' bond | 'S—P' bond |
|---|---|---|
| (a) | 6 | 3 |
| (b) | 3 | 6 |
| (c) | 1 | 2 |
| (d) | 0 | 6 |

6. Which of the following statements is incorrect?
(a) Natural starch has approximately 10-20% of amylose and 80-90% of amylopectin.
(b) Amylose is water soluble and gives blue colour with iodine.
(c) Amylopectin is a branched chain polysaccharides insoluble in water and does not give blue colour with iodine.
(d) Starch is not hydrolysed by enzyme amylase present in saliva.

7. I. $[MnCl_6]^{3-}$, $[FeF_6]^{3-}$ and $[CoF_6]^{3-}$ are paramagnetic having four, five and four unpaired electrons respectively.
II. Valence bond theory gives a quantitative interpretation of the thermodynamic stabilities of coordination compounds.
III. The crystal field splitting $\Delta_o$, depends upon the field produced by the ligand and charge on the metal ion.
Among the following correct statements are
(a) only I and II      (b) only I and III
(c) I, II and III      (d) only II and III.

8. Which of the following relations is/are correct according to Freundlich adsorption isotherm?
(i) $x/m$ = constant
(ii) $x/m$ = constant $\times p^{1/n}$ $(n > 1)$
(iii) $x/m$ = constant $\times p^n$ $(n > 1)$
(a) All are correct.      (b) Only (i) and (ii)
(c) Only (ii)      (d) Only (iii)

9. Which of the following expressions is correct for packing fraction of NaCl if the ions along the face are diagonally removed ?

(a) $\dfrac{\frac{13}{3}\pi r_-^3 + \frac{16}{3}\pi r_+^3}{8(r_+ + r_-)^3}$    (b) $\dfrac{\frac{13}{3}\pi r_-^3 + \frac{4}{3}\pi r_+^3}{8(r_+ + r_-)^3}$

(c) $\dfrac{\frac{16}{3}\pi r_-^3 + \frac{13}{3}\pi r_+^3}{8(r_+ + r_-)^3}$    (d) $\dfrac{\frac{4}{3}\pi r_-^3 + \frac{13}{3}\pi r_+^3}{8(r_+ + r_-)^3}$

10. Consider the following isolation/purification processes.
I. Heating impure metal with $I_2$ at 150–200°C and passing the resulting volatile iodide on hot tungsten filament at 1400°C to get the pure metal.
II. Heating the sulphide ore in air until a part is converted to oxide and then further heating in the absence of air to let the oxide react with unchanged metal sulphide to get the metal.
III. Electrolysis of the molten electrolyte containing metal oxide and cryolite or fluorspar to obtain the metal.
The processes used for obtaining aluminium, titanium and lead are respectively
(a) I, II and III      (b) II, III and I
(c) III, I and II      (d) II, I and III.

## More Than One Options Correct Type

11. Which is not correct about $X$?

OHC—[cyclohexane ring with COOH, COOH, and O (ketone)] $\xrightarrow{\Delta}$ $X$
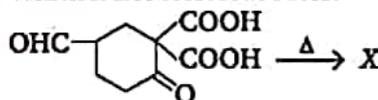
(a) $X$ can show haloform test.
(b) $X$ can give brisk effervescence with $NaHCO_3$.
(c) $X$ cannot show Fehling's test.
(d) $X$ contains one —CHO, one $>C=O$ group and one —COOH group.

12. The vapour pressure of an ideal solution of benzene and toluene is 550 torr at 80°C then what would be the correct statement about same solution at 100°C?
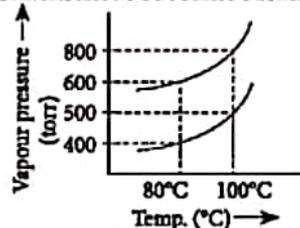


(a) Vapour pressure of solution = 725 torr.
(b) At 725 torr pressure and 90°C, no vapour will form.

(c) Composition of vapours is $\frac{2}{11}$ and $\frac{9}{11}$.

(d) Composition of liquid remain same at equilibrium condition at any temperature.

13. Fenton's reagent is, $X + H_2O_2$. $X$ combines readily with $Y$ and $H_2O$ to form crystals of Mohr's salt. $X$ can be made in laboratory from Kipp's waste. When Kipp's waste is heated in the presence of $O_2$ and water, $Z$ is also produced along with $X$. The reaction of $X$ with $KMnO_4$ in the presence of $H_2SO_4$ also gives $Z$. Identify the correct match.

(a) $X = FeSO_4$      (b) $Z = Fe_2(SO_4)_3$
(c) $Y = (NH_4)_2SO_4$      (d) $Z = FeSO_4$

14. Which of the following statements is false regarding given reaction?
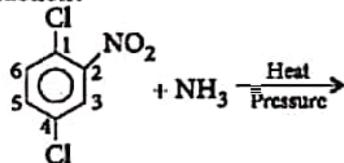


(a) No reaction is possible because —Cl is present on benzene ring.

(b) A nucleophilic substitution will take place in which both —Cl will be replaced by two —$NH_2$ groups.

(c) A nucleophilic substitution will take place in which only —Cl attached on $C_1$ will be replaced by —$NH_2$.

(d) A nucleophilic substitution will take place in which only —Cl attached on $C_4$ will be replaced by —$NH_2$.

15. When the temperature of a reaction is changed from $T_1$ to $T_2$, half-life is found to decrease. Thus,

(a) $T_2 > T_1$
(b) the reaction is exothermic
(c) the reaction is endothermic
(d) the reaction can be exothermic or endothermic.

## SOLUTIONS

1. (d)

2. (d):
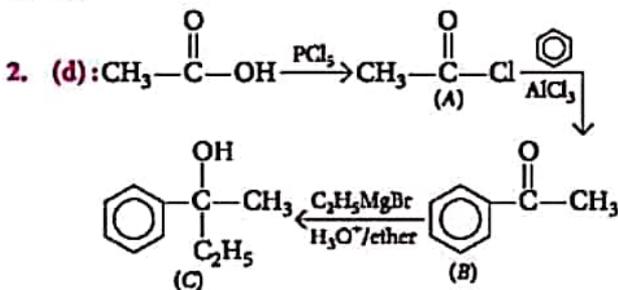


3. (a)

4. (b) : Daniell cell reaction :
$Cu^{2+} + Zn \rightarrow Zn^{2+} + Cu$ ; $n = 2$

$$E_{cell} = E_{cell}^\circ - \frac{0.0591}{2} \log \frac{[Zn^{2+}]}{[Cu^{2+}]}$$

$$E_1 = E_{cell}^\circ - \frac{0.0591}{2} \log \frac{0.01}{1.0}$$

$$E_2 = E_{cell}^\circ - \frac{0.0591}{2} \log \frac{1.0}{0.01}$$

On increasing $[Zn^{2+}]$ and decreasing $[Cu^{2+}]$, $E_2$ becomes less than $E_1$ i.e., $E_1 > E_2$.

5. (b) :
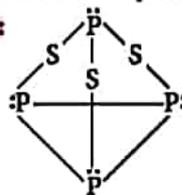


Tetraphosphorus trisulphide, $P_4S_3$

"S—P" bonds = 6   "P—P" bonds = 3

6. (d)

7. (b) : Valence bond theory does not give a quantitative interpretation of the thermodynamic or kinetic stabilities of coordination compounds.

8. (c)

9. (a) : Effective number of remaining $Cl^-$
$$= 4 - \left( 2 \times \frac{1}{8} + \frac{1}{2} \right) = \frac{13}{4}$$

Effective number of $Na^+ = 4$

$$\text{Packing fraction} = \frac{\text{Occupied volume}}{\text{Total volume}}$$

$$= \frac{\frac{13}{4} \times \frac{4}{3} \pi r_-^3 + 4 \times \frac{4}{3} \pi r_+^3}{8(r_+ + r_-)^3} = \frac{\frac{13}{3} \pi r_-^3 + \frac{16}{3} \pi r_+^3}{8(r_+ + r_-)^3}$$

10. (c) : I. $Ti_{(s)} (\text{impure}) + 2I_{2(g)} \xrightarrow{150-250°C} TiI_4$

$TiI_4 (\text{volatile}) \xrightarrow[\text{tungsten filament}]{1400°C} Ti_{(s)} (\text{pure}) + 2I_{2(g)}$

II. $2PbS + 3O_2 \xrightarrow{\Delta} 2PbO + 2SO_2$

$PbS + 2PbO \xrightarrow[\text{temp.}]{\text{high}} 3Pb + SO_2$

III. Cathode : $Al^{3+} (\text{melt}) + 3e^- \longrightarrow Al_{(l)}$

Anode : $C_{(s)} + O^{2-} (\text{melt}) \longrightarrow CO_{(g)} + 2e^-$

$C_{(s)} + 2O^{2-} (\text{melt}) \longrightarrow CO_{2(g)} + 4e^-$

## 11. (a,b,c,d):
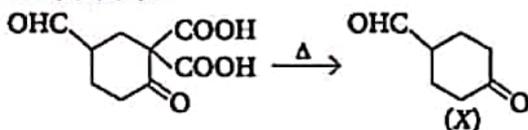


## 12. (a,b): $p = p_A^o x_A + p_B^o x_B$    ($x_B$ = mole fraction of benzene)

$550 = 400 \times (1 - x_B) + 600(x_B)$

$150 = (600 - 400)x_B$

$\dfrac{150}{200} = \dfrac{3}{4} = x_B \; ; x_A = \dfrac{1}{4}$

At 100 °C mole fraction will be same initially but get changed at equilibrium.

$P = \dfrac{1}{4} \times 500 + \dfrac{3}{4} \times 800 = 125 + 600 = 725 \text{ torr}$

$x_A p_A^o = y_A P$

$\dfrac{1}{4} \times 500 = y_A \times 725 \Rightarrow y_A = \dfrac{125}{725}$

So, $y_A = \dfrac{5}{29}$ and $y_B = \dfrac{24}{29}$

At 90°C, mole fraction will be same initially but get changed at equilibrium.

$500 < P < 725$

So, at $P = 725$ only liquid state exists.

## 13. (a,b,c) : Fenton's reagent is, $FeSO_4 + H_2O_2$.

$\underset{(X)}{FeSO_4} + \underset{(Y)}{(NH_4)_2SO_4} + 6H_2O \rightarrow FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$

$\underset{(X)}{FeS_2} + O_2 + H_2O \rightarrow \underset{(Z)}{FeSO_4} + Fe_2(SO_4)_3 + H_2SO_4$

$\underset{(X)}{10FeSO_4} + 2KMnO_4 + 8H_2SO_4 \rightarrow 5Fe_2(SO_4)_3 + \underset{(Z)}{2MnSO_4} + 8H_2O$
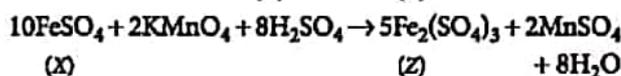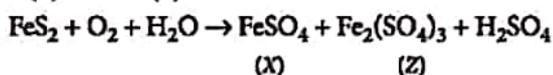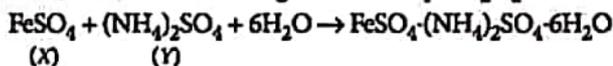
## 14. (a,b,d) : The —Cl group present in the o- and p-positions to the electron withdrawing group is activated towards nucleophilic substitution, hence, only —Cl present on the o- and/or p-position to the —NO₂ group will be replaced.

## 15. (a, d) : Half-life of a reaction will decrease only when rate constant increases. Rate constants of all reactions (endothermic or exothermic) increase on increasing temperature (except for the reaction, $2NO + O_2 \rightarrow 2NO_2$).

#########

# UNSCRAMBLE ME

Unscramble the words given in column I and match them with their explanations in column II.

| Column I | Column II |
|---|---|
| 1. HANESPLIC | (a) A hydrated Mg-Al-Fe silicate clay. Used as a catalyst, thermal insulator and in agriculture as a rooting medium and soil additive. |
| 2. OPTHYRIXTO | (b) It is a term applied to solids e.g., during the process of magnetization of iron. |
| 3. ITEREVUICML | (c) It is an impure $Al_2O_3$ (corundum) containing some iron oxide. It is used as a polishing agent and abrasive. |
| 4. YRRME | (d) The isothermal gel-sol transformation brought about by shaking or other mechanical means. It may be regarded as a packing phenomenon. |
| 5. ANDBL | (e) Phospholipids similar to lecithins except that ethanolamine or serine replaces choline in the molecule. They are found in all animals and vegetable tissues. |
| 6. AIMOERXLAHTP | (f) Disease which is caused due to the deficiency of vitamin A. |
| 7. SYHSITREES | (g) It is a white crystalline substance which turns red when exposed to air. It is used in analytical detection of carbohydrates. |
| 8. OLIRONC | (h) It refers to any non-irritating chemical such as olive oil. |

*Readers can send their responses at editor@mtg.in or post us with complete address by 10th of every month.*
*Names of solution senders will be published in next issue.*

# CBSE BOARD
# BOARD
## SOLVED PAPER 2020*
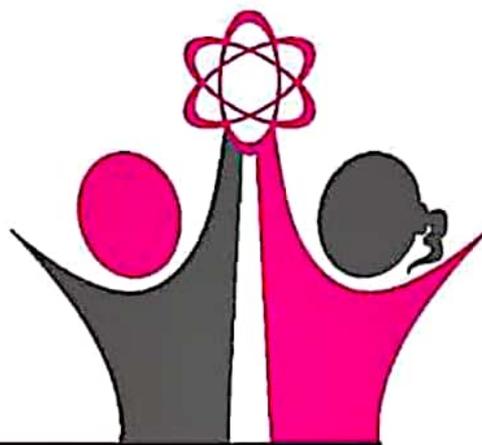
### GENERAL INSTRUCTIONS

(a) All questions are compulsory.
(b) Section A: Q.no. 1 to 20 are very short answer questions (objective type) and carry 1 mark each.
(c) Section B: Q.no. 21 to 27 are short answer questions and carry 2 marks each.
(d) Section C: Q.no. 28 to 34 are long answer questions and carry 3 marks each.
(e) Section D: Q.no. 35 to 37 are also long answer questions and carry 5 marks each.
(f) There is no overall choice. However an internal choice has been provided in two questions of two marks, two questions of three marks and all the three questions of five marks weightage. You have to attempt only one of the choices in such questions.
(g) Use log tables if necessary, use of calculators is not allowed.

Time Allowed : 3 hours                                              Maximum Marks : 70

## SECTION A

Read the given passage and answer the questions number 1 to 5 that follow :

The substitution reaction of alkyl halide mainly occurs by $S_N1$ or $S_N2$ mechanism. Whatever mechanism alkyl halides follow for the substitution reaction to occur, the polarity of the carbon halogen bond is responsible for these substitution reactions. The rate of $S_N1$ reactions are governed by the stability of carbocation whereas for $S_N2$ reactions steric factor is the deciding factor. If the starting material is a chiral compound, we may end up with an inverted product or racemic mixture depending upon the type of mechanism followed by alkyl halide. Cleavage of ethers with HI is also governed by steric factor and stability of carbocation, which indicates that in organic chemistry, these two major factors help us in deciding the kind of product formed.

1. Predict the stereochemistry of the product formed if an optically active alkyl halide undergoes substitution reaction by $S_N1$ mechanism.

2. Name the instrument used for measuring the angle by which the plane polarised light is rotated.

3. Predict the major product formed when 2-bromopentane reacts with alcoholic KOH.

4. Give one use of $CHI_3$.

5. Write the structures of the products formed when anisole is treated with HI.

Questions number 6 to 10 are one word answers :

6. Identify which liquid will have a higher vapour pressure at 90°C if the boiling points of two liquids A and B are 140°C and 180°C, respectively.

7. Out of zinc and tin, whose coating is better to protect iron objects?

8. Will the rate constant of the reaction depend upon $T$ if the $E_{act}$ (activation energy) of the reaction is zero?

9. Give the structure of the monomer of PVC.

10. Which structural unit present in a detergent makes it non-biodegradable?

Questions number 11 to 15 are multiple choice questions :

11. Out of the following, the strongest base in aqueous solution is

(a) methylamine  (b) dimethylamine
(c) trimethylamine (d) aniline.

12. Iodoform test is not given by
    (a) ethanol        (b) ethanal
    (c) pentan-2-one  (d) pentan-3-one.

13. Out of the following transition elements, the maximum number of oxidation states are shown by
    (a) Sc $(Z = 21)$  (b) Cr $(Z = 24)$
    (c) Mn $(Z = 25)$  (d) Fe $(Z = 26)$.

14. Hardening of leather in tanning industry is based on
    (a) electrophoresis    (b) electro-osmosis
    (c) mutual coagulation (d) Tyndall effect.

15. What is the correct IUPAC name of the given compound?

$$CH_3 - \overset{\overset{\displaystyle CH_3}{|}}{\underset{\underset{\displaystyle COOH}{|}}{C}} - CH_2 - CH_3$$
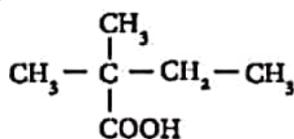
    (a) 2,2-Dimethylbutanoic acid
    (b) 2-Carboxyl-2-methylbutane
    (c) 2-Ethyl-2-methylpropanoic acid
    (d) 3-Methylbutanecarboxylic acid

For questions number 16 to 20, two statements are given—one labelled Assertion (A) and the other labelled Reason(R). Select the correct answer to these questions from the codes (i), (ii), (iii) and (iv) as given below :
(i) Both Assertion (A) and Reason (R) are correct statements, and Reason (R) is the correct explanation of the Assertion (A).
(ii) Both Assertion (A) and Reason (R) are correct statements, but Reason (R) is not the correct explanation of the Assertion (A).
(iii) Assertion (A) is correct, but Reason (R) is incorrect statement.
(iv) Assertion (A) is incorrect, but Reason (R) is correct statement.

16. Assertion (A) : Au and Ag are extracted by leaching their ores with a dil. solution of NaCN.
    Reason (R) : Impurities associated with these ores dissolve in NaCN.

17. Assertion (A) : F — F bond in $F_2$ molecule is weak.
    Reason (R) : F atom is small in size.

18. Assertion (A) : Linkage isomerism arises in coordination compounds because of ambidentate ligand.
    Reason (R) : Ambidentate ligand like $NO_2$ has two different donor atoms i.e., N and O.

19. Assertion (A) : Sucrose is a non-reducing sugar.
    Reason (R) : Sucrose has glycosidic linkage.

20. Assertion (A) : The molecularity of the reaction $H_2 + Br_2 \longrightarrow 2HBr$ appears to be 2.
    Reason (R) : Two molecules of the reactants are involved in the given elementary reaction.

## SECTION B

21. Define the following terms :
    (a) Tranquilizers
    (b) Antiseptic

    OR

    Explain the cleansing action of soaps.

22. For a 5% solution of urea (Molar mass = 60 g/mol), calculate the osmotic pressure at 300 K.
    [$R = 0.0821$ L atm K$^{-1}$ mol$^{-1}$]

    OR

    Visha took two aqueous solutions – one containing 7.5 g of urea (Molar mass = 60 g/mol) and the other containing 42.75 g of substance Z in 100 g of water, respectively. It was observed that both the solutions froze at the same temperature. Calculate the molar mass of Z.

23. Analyse the given graph, drawn between concentration of reactant vs. time.
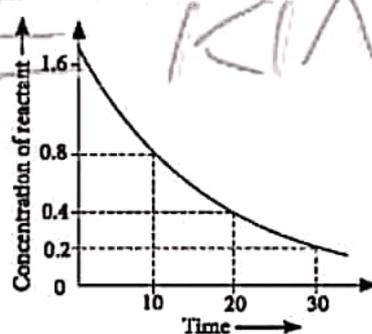


    (a) Predict the order of reaction.
    (b) Theoretically, can the concentration of the reactant reduce to zero after infinite time. Explain.

24. Draw the shape of the following molecules :
    (a) $XeOF_4$
    (b) $BrF_3$

25. Give the formulae of the following compounds :
    (a) Potassium tetrahydroxidozincate(II)
    (b) Hexaammineplatinum(IV) chloride

26. What happens when
    (a) propanone is treated with methylmagnesium iodide and then hydrolysed, and

(b) benzene is treated with $CH_3COCl$ in presence of anhydrous $AlCl_3$?

27. Write the names and structures of monomers in the following polymers :
    (a) Bakelite    (b) Neoprene

## SECTION C

28. Give the structures of $A$ and $B$ in the following sequence of reactions :

    (a) $CH_3COOH \xrightarrow[\Delta]{NH_3} A \xrightarrow{Na_2OBr} B$

    (b) $C_6H_5NO_2 \xrightarrow{Fe/HCl} A \xrightarrow[0°-5°C]{NaNO_2+HCl} B$

    (c) $C_6H_5N_2^+Cl^- \xrightarrow[\Delta]{CuCN} A \xrightarrow{H_2O/H^+} B$
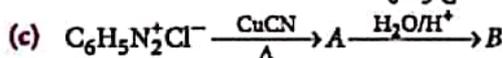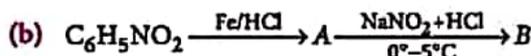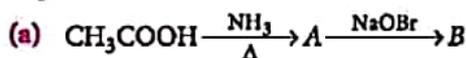
    **OR**

    (a) How will you distinguish between the following pairs of compounds :
    (i) Aniline and ethanamine
    (ii) Aniline and $N$-methylaniline

    (b) Arrange the following compounds in decreasing order of their boiling points :
    Butanol, Butanamine, Butane

29. Give the plausible explanation for the following :
    (a) Glucose doesn't give 2,4-DNP test.
    (b) The two strands in DNA are not identical but are complementary.
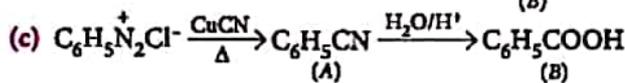    (c) Starch and cellulose both contain glucose unit as monomer, yet they are structurally different.

30. Account for the following :
    (a) Sulphurous acid is a reducing agent.
    (b) Fluorine forms only one oxoacid.
    (c) Boiling point of noble gases increases from He to Rn.

    **OR**

    Complete the following chemical reactions :
    (a) $MnO_2 + 4HCl \longrightarrow$
    (b) $XeF_6 + KF \longrightarrow$
    (c) $I^-_{(aq)} + H^+_{(aq)} + O_{2(g)} \longrightarrow$
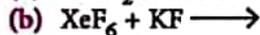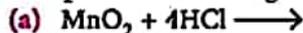
31. Explain the role of the following :
    (a) NaCN in the separation of ZnS and PbS.
    (b) $SiO_2$ in the metallurgy of Cu containing Fe as impurity.
    (c) Iodine in the refining of Ti.

32. Give three points of difference between physisorption and chemisorption.

33. How will the rate of the reaction be affected when
    (a) surface area of the reactant is reduced,
    (b) catalyst is added in a reversible reaction, and
    (c) temperature of the reaction is increased?

34. Calculate the mass of ascorbic acid (Molar mass = 176 g $mol^{-1}$) to be dissolved in 75 g of acetic acid, to lower its freezing point by 1.5°C.
    ($K_f$ = 3.9 K kg $mol^{-1}$)

## SECTION D

35. (a) Calculate $\Delta G°$ for the reaction,
    $Zn_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$
    Given : $E°$ for $Zn^{2+}/Zn$ = –0.76 V and
    $E°$ for $Cu^{2+}/Cu$ = +0.34 V
    $R$ = 8.314 J $K^{-1}$ $mol^{-1}$, $F$ = 96500 C $mol^{-1}$.
    (b) Give two advantages of fuel cells.

    **OR**

    (a) Out of the following pairs, predict with reason which pair will allow greater conduction of electricity.
    (i) Silver wire at 30°C or silver wire at 60°C.
    (ii) 0.1 M $CH_3COOH$ solution or 1 M $CH_3COOH$ solution.
    (iii) KCl solution at 20°C or KCl solution at 50°C.

    (b) Give two points of differences between electrochemical and electrolytic cells.

36. (a) Account for the following :
    (i) Copper(I) compounds are white whereas copper(II) compounds are coloured.
    (ii) Chromates change their colour when kept in an acidic solution.
    (iii) Zn, Cd, Hg are considered as $d$-block elements but not as transition elements.

    (b) Calculate the spin-only moment of $Co^{2+}$ ($Z$ = 27) by writing the electronic configuration of Co and $Co^{2+}$.

    **OR**

    (a) Give three points of difference between lanthanoids and actinoids.

    (b) Give reason and select one atom/ion which will exhibit asked property :
    (i) $Sc^{3+}$ or $Cr^{3+}$ (exhibit diamagnetic behaviour)
    (ii) Cr or Cu (high melting and boiling point)

37. (a) Out of $t$-butyl alcohol and $n$-butanol, which one will undergo acid catalysed dehydration faster and why?

    (b) Carry out the following conversions :
    (i) Phenol to salicylaldehyde
    (ii) $t$-Butyl chloride to $t$-butyl ethyl ether
    (iii) Propene to propanol

(a) Give the mechanism for the formation of ethanol from ethene.

(b) Predict the reagent for carrying out the following conversions :
   (i) Phenol to benzoquinone
   (ii) Anisole to *p*-bromoanisole
   (iii) Phenol to 2,4,6-tribromophenol

## SOLUTIONS

1. Stereochemical aspects of nucleophilic substitution reaction in $S_N1$ proceeds with racemisation.

2. Polarimeter is used for measuring the angle by which the plane polarised light is rotated.

3.
$$CH_3-CH_2-CH_2-\underset{\underset{\text{2-Bromopentane}}{|}}{\overset{\overset{Br}{|}}{CH}}-CH_3 + KOH_{(alc)} \longrightarrow$$
$$\underset{\underset{\text{(Major)}}{\text{Pent-2-ene}}}{CH_3-CH_2-CH=CH-CH_3} + \underset{\underset{\text{(Minor)}}{\text{Pent-1-ene}}}{CH_3-CH_2-CH_2-CH=CH_2}$$
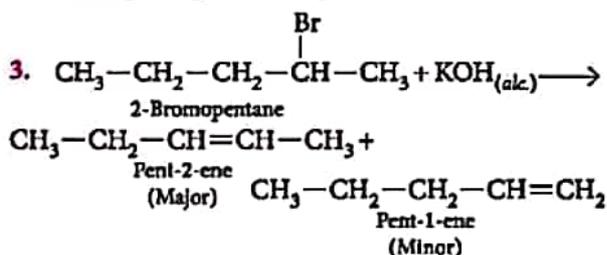
4. Iodoform ($CHI_3$) is used as a mild antiseptic.

5.

Anisole + HI → Phenol + $CH_3I$

6. Liquid *A*   7. Zinc   8. No

9. $CH_3-\underset{\overset{|}{}}{\overset{\overset{Cl}{|}}{CH_2}}$
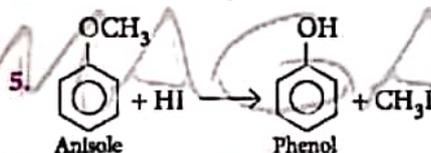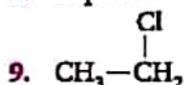
10. Branched hydrocarbon chain

11. (b) : The increasing order of basicity of the given compounds are $(CH_3)_2NH > CH_3NH_2 > (CH_3)_3N > C_6H_5NH_2$.
There is a subtle interplay of the inductive effect, solvation effect and steric hindrance of alkyl groups which decides the basic strength of alkyl amines in the aqueous state.

12. (d) : Iodoform test is given by only those carbonyl compounds which have $CH_3-\overset{\overset{O}{||}}{C}-$ group or alcohols which have $CH_3-\underset{\overset{|}{OH}}{CH}-$ in their structure.

13. (c)

14. (c) : Hardening of leather in tanning industry is based on mutual coagulation.

15. (a)

16. (c) : Au and Ag dissolve in NaCN solution to form their soluble complexes while the impurities remain unaffected which are filtered off.

17. (b) : Due to small size, the lone pairs of electrons on F-atoms repel the bond pair between F-atoms. Therefore, F—F bond in $F_2$ molecule is weak.

18. (a)

19. (a) : Sucrose is disaccharide and its two monosaccharides are held together by a glycosidic linkage. Since the reducing groups of glucose and fructose are involved in glycosidic bond formation, therefore, sucrose is a non-reducing sugar.

20. (a) : Molecularity is two because two molecules of the reactants are involved in the given elementary reaction.

21. (a) *Refer to answer 8, Page no. 267 (MTG CBSE Champion Chemistry Class 12).*
(b) *Refer to answer 6, Page no. 267 (MTG CBSE Champion Chemistry Class 12).*

OR

Soap has a hydrophobic part (hydrocarbon) that attracts dirt, grease oil, etc. whereas hydrophilic part (— COONa) attracts water that take oil, dirt and grease. Soaps do not work well with hard water because $Mg^{2+}$ and $Ca^{2+}$ ions of hard water react with soap to form magnesium and calcium salts of fatty acids which are insoluble in water and form scum.
$$\underset{\text{Soap}}{2C_{17}H_{35}COONa} + CaCl_2 \rightarrow 2NaCl + \underset{\substack{\text{Insoluble calcium}\\\text{stearate (soap)}}}{(C_{17}H_{35}COO)_2Ca}$$
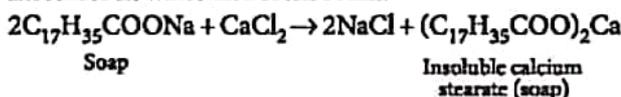
22. Molality (*m*) of urea solution
$$= \frac{w \times 1000}{M \times \text{Mass of solvent}} = \frac{5 \times 1000}{60 \times 95} = 0.877\ m$$

Osmotic pressure ($\pi$) = CRT
$$= 0.877 \times 0.0821 \times 300 = 21.6\ atm$$

OR

Molality (*m*) of urea $= \dfrac{75 \times 1000}{60 \times 100} = 1.25\ m$   ...(i)

Molality of substance, $Z = \dfrac{42.75 \times 1000}{\text{Molar mass} \times 100}$
$$= \frac{427.5}{\text{Mol. mass}} \quad ...(ii)$$

As both the solutions have same depression in freezing point so they have same molality.

From eqn. (i) and (ii), we get

$$1.25 = \frac{427.5}{\text{Molar mass}}$$

Molar mass of $Z$ = 342 g/mol

**23. (a)** The reaction is of first order.

**(b)** Rate = $k[A]$ for first order reaction.

$$k = \frac{2.303}{t} \log \frac{[A]_0}{[A]_t}$$

At infinite time

$$t_\infty = \frac{2.303}{k} \log \frac{0}{[A]_t}$$

**24. (a)**



XeOF$_4$

**(b)**



BrF$_3$
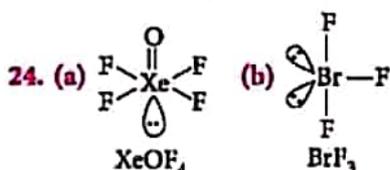
**25. (a)** K$_2$[Zn(OH)$_4$]
Potassium tetrahydroxidozincate(II)

**(b)** [Pt(NH$_3$)$_6$]Cl$_4$
Hexaammineplatinum(IV) chloride

**26. (a)**



2-Methylpropan-2-ol

**(b)**



Benzene → Acetophenone
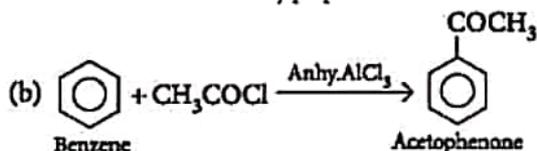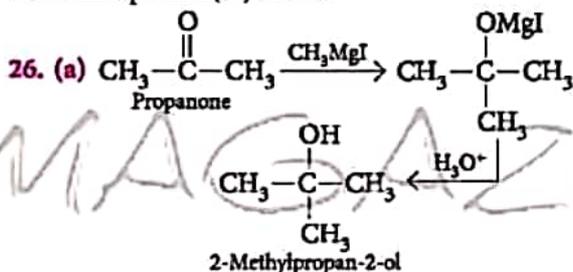
**27. (a) Bakelite:** Monomers are phenol and formaldehyde.



Formaldehyde    Phenol
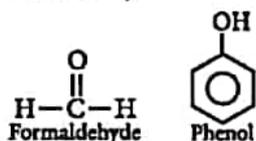
**(b) Neoprene :** Neoprene or polychloroprene is formed by the polymerisation of chloroprene.



Chloroprene
(2-Chloro-1,3-butadiene)

**28. (a)** $CH_3COOH \xrightarrow[\Delta]{NH_3} CH_3CONH_2 \xrightarrow{NaOBr} CH_3NH_2$
                                        (A)                                    (B)

**(b)** $C_6H_5NO_2 \xrightarrow{Fe + HCl} C_6H_5NH_2 \xrightarrow[0-5°C]{NaNO_2 + HCl} C_6H_5N_2^+Cl^-$
                                        (A)                                                        (B)

**(c)** $C_6H_5\overset{+}{N}_2Cl^- \xrightarrow[\Delta]{CuCN} C_6H_5CN \xrightarrow{H_2O/H^+} C_6H_5COOH$
                                        (A)                                    (B)
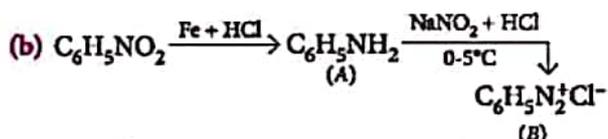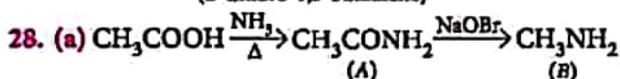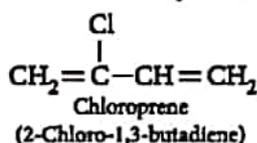
**OR**

**(a) (i)** *Refer to answer 42, Page no. 228 (MTG CBSE Champion Chemistry Class 12).*

**(ii)** *Refer to answer 60 (ii), Page no. 230 (MTG CBSE Champion Chemistry Class 12).*

**(b)** Decreasing order of boiling points of given compounds :

Butanol > Butanamine > Butane

**29. (a)** Actually, glucose exists in the cyclic hemiacetal form with only a small amount (< 0.05%) of the open chain form. Since, the concentration of the open chain form is low and its reaction with 2,4-DNP is reversible, therefore, formation of 2,4-DNP derivative cannot disturb the equilibrium to regenerate more of the open chain form from the cyclic hemiacetal form and hence, does not give this test.

**(b)** The two strands in DNA molecule are held together by the hydrogen bonds between purine base of one strand and pyrimidine base of the other and *vice versa.* Because of different sizes and geometries of the bases, the only possible pairing in DNA are G (guanine) and C (cytosine) through three H-bonds, *i.e.*, (C ≡ G) and between A (adenine) and T (thymine) through two H-bonds (*i.e.*, A ≡ T). Due to this base-pairing principle, the sequence of bases in one strand automatically fixes the sequence of bases in the other strand. Thus, the two strands are complementary and not identical.

**(c)** The basic structural difference between starch and cellulose is of linkage between the glucose units. In starch, there is α-D-glycosidic linkage. Both the components of starch-amylose and amylopectin are polymers of α-D-glucose. On the other hand, cellulose is a linear polymer of β-D-glucose in which C1 of one glucose unit is connected to C4 of the other through β-D-glycosidic linkage.

**30. (a)** Due to the presence of a lone pair of electrons on the sulphur atom, sulphurous acid can be easily oxidised to sulphuric acid therefore, it acts as a reducing agent.

$$H_2O + Br_2 + H_2SO_3 \longrightarrow 2HBr + H_2SO_4$$
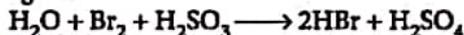
**(b)** *Refer to answer 88, Page no. 110 (MTG CBSE Champion Chemistry Class 12).*

**(c)** As the size of noble gases increases, van der Waals' forces of attraction increase accordingly and hence, the boiling point increases from He to Rn.

**OR**

(a) $MnO_2 + 4HCl \longrightarrow MnCl_2 + 2H_2O + Cl_2$

(b) $XeF_6 + KF \longrightarrow K^+ [XeF_7]^-$

(c) $4I^-_{(aq)} + 4H^+_{(aq)} + O_{2(g)} \longrightarrow 2H_2O + 2I_2$
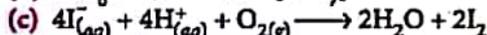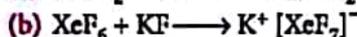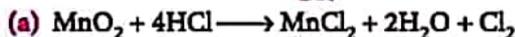
**31. (a)** NaCN is used as a depressant in froth floatation process which selectively prevents ZnS from coming to the froth but allows PbS to come with the froth.

**(b)** During the metallurgy of copper from copper pyrites, $CuFeS_2$, its roasting gives FeO besides $Cu_2O$ and $SO_2$.

$$4CuFeS_{2(s)} + 11O_{2(g)} \rightarrow 4FeO_{(s)} + 2Cu_2O_{(s)} + 8SO_{2(g)}$$
(Copper pyrites)
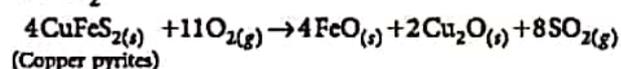
To remove FeO, $SiO_2$ is added to form slag.

$$\underset{\text{(Basic oxide)}}{FeO} + \underset{\text{(Acidic oxide)}}{SiO_2} \rightarrow \underset{\text{Slag}}{FeSiO_3}$$
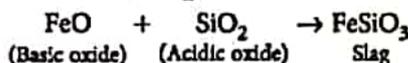
**(c)** *Refer to answer 86, Page no. 93 (MTG CBSE Champion Chemistry Class 12).*

**32.**

| Property | Physisorption | Chemisorption |
|---|---|---|
| Enthalpy | Low enthalpy, is the order of 20-40 kJ mol⁻¹. | High enthalpy, is the order of 80-240 kJ mol⁻¹. |
| Reversibility | Reversible process. | Irreversible process. |
| Effect of temperature | With the increase in temperature, extent of adsorption decreases because adsorption is a exothermic process and kinetic energy of gas molecules increases with temperature. | Chemisorption first increases with temperature upto a certain extent and then decreases. A gas adsorbed at low temperature by physical adsorption may change into chemisorption at high temperature. |

**33. (a)** For a reaction involving a solid reactant or catalyst, the smaller is the particle size *i.e.*, greater is the surface area, the faster is the reaction. therefore, on reducing the surface area, rate of reaction is reduced.

**(b)** A catalyst generally increases the speed of a reaction without itself being consumed in the reaction. In case of reversible reactions, a catalyst helps to attain the equilibrium quickly without disturbing the state of equilibrium.

**(c)** The rate of reaction increases with increase of temperature. In most of the cases, the rate of reaction becomes nearly double for 10° rise of temperature. In some cases, reactions do not take place at room temperature but takes place at higher temperature.

**34.** Given, $M_2 = 176$ g mol⁻¹, $\Delta T_f = 1.5°C$
$w_1 = 75$ g, $K_f = 3.9$ K kg mol⁻¹, $w_2 = ?$

$$\Delta T_f = \frac{K_f \times w_2 \times 1000}{M_2 \times w_1}$$

$$w_2 = \frac{\Delta T_f \times M_2 \times w_1}{K_f \times 1000} = \frac{1.5 \times 176 \times 75}{3.9 \times 1000} = 5.077 \text{ g}$$

**35. (a)** $Zn_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$

Here, $n = 2$

$E°_{cell} = E°_{cathode} - E°_{anode}$
$= 0.34 - (-0.76) = 1.1$ V

$F = 96500$ C mol⁻¹

$\Delta_r G° = -nFE°_{cell} = -2 \times 1.1 \times 96500 = -212300$ J mol⁻¹
$= -212.3$ kJ mol⁻¹

**(b)** The two advantages of fuel cells are :

**(i)** They produce electricity with an efficiency of about 70% compared to thermal plants whose efficiency is about 40%.

**(ii)** They are pollution free.

**OR**

**(a) (i)** Silver wire at 30°C allows greater conduction of electricity than 60°C because with increase in temperature metallic conduction decreases due to vibration of kernels.

**(ii)** 0.1 M acetic acid solution allows greater conduction of electricity because with dilution degree of dissociation increases and hence, number of ions increases.

**(iii)** KCl solution at 50°C will have greater conductance. This is because ionic mobilities increases with increase in temperature.

**(b)**

| S.No. | Electrochemical cell | Electrolytic cell |
|---|---|---|
| 1. | It is a device to convert chemical energy into electrical energy, *i.e.*, electrical energy is produced as a result of the redox reaction. | It is a device to convert electrical energy into chemical energy, *i.e.*, electrical energy is supplied to the electrolytic solution to bring about the redox reaction. |
| 2. | It is based upon the redox reaction which is spontaneous *i.e.*, $\Delta G = -ve$ | The redox reaction is non-spontaneous and takes place only when electrical energy is supplied *i.e.*, $\Delta G = +ve$. |

**36. (a) (i)** Cu(I) compounds have completely filled *d*-orbitals and there are no vacant *d*-orbitals for

promotion of electrons whereas in Cu(II) compounds have one unpaired electron which is responsible for colour formation.

(ii) In aqueous solution,

$$Cr_2O_7^{2-} + H_2O \rightleftharpoons 2CrO_4^{2-} + 2H^+$$

Dichromate ion (Orange red)    Chromate ion (Yellow)
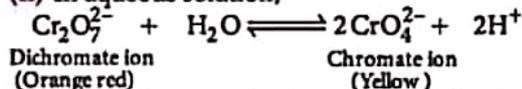
When an acid is added (i.e., pH of solution decreased), the concentration of $H^+$ ions is increased and the reaction proceeds in the backward direction producing an orange red dichromate solution.

(iii) Zn, Cd, Hg are considered as d-block elements but not as transition elements because they do not have partly filled d-orbitals in their atomic state or their common oxidation states (i.e., $Zn^{2+}$, $Cd^{2+}$, $Hg^{2+}$).

(b) $Co = [Ar]3d^7 4s^2$

$Co^{2+} = [Ar]3d^7$
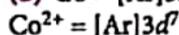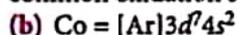
i.e., there are three unpaired electrons (n = 3).

Hence, $\mu = \sqrt{n(n+2)}$ B.M. $= \sqrt{3(3+2)} = 3.87$ B.M.

**OR**

(a) (i) Difference between lanthanoids and actinoids are following :

(i) **Electronic configuration :** The general electronic configuration of lanthanoids is $[Xe]4f^{1-14} 5d^{0-1} 6s^2$ whereas, that of actinoids is $[Rn] 5f^{1-14} 6d^{0-1} 7s^2$. Thus, lanthanoids involve the filling of 4f-orbitals whereas, actinoids involve the filling of 5f-orbitals.

(ii) **Oxidation states :** Lanthanoids have principal oxidation state of +3. In addition, the lanthanoids show limited oxidation states such as +2, +3 and +4 because of large energy gap between 4f and 5d subshells. On the other hand, actinoids show a large number of oxidation states because of small energy gap between 5f and 6d subshells.

(iii) **Chemical reactivity :** First few members of lanthanoids are quite reactive almost like calcium, whereas, actinoids are highly reactive metals especially in the finely divided state. Lanthanoids react with dilute acids to liberate $H_2$ gas whereas actinoids react with boiling water to give a mixture of oxide and hydride.

(b) (i) $Sc^{3+}$ has $3d^0$ outer electronic configuration, therefore it is diamagnetic in nature whereas $Cr^{3+}$ has $3d^3$ outer electronic configuration. So, it is paramagnetic due to presence of unpaired electrons.

(ii) In a particular series, the metallic strength increases upto middle with increasing number of unpaired electrons, i.e., upto $d^5$ configuration. After Cr, the number of unpaired electrons goes on decreasing. Accordingly, the m.pt and b.pt. decrease after middle (Cr) because of increasing pairing of electrons.

37. (a) *Refer to answer 73, Page no. 188 (MTG CBSE Champion Chemistry Class 12).*

(b) (i)



Salicylaldehyde
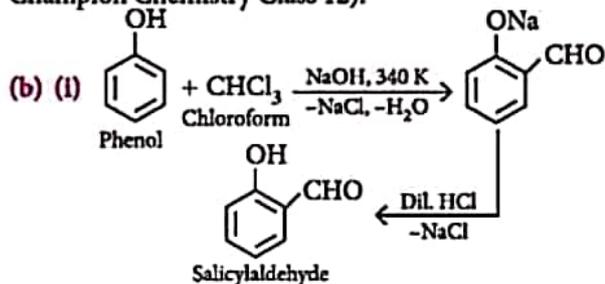
(ii) The given conversion is not possible by treating sodium ethoxide with t-butyl chloride or bromide since, under these conditions an alkene i.e., isobutylene (2-methylpropene) is the main product.

(iii)
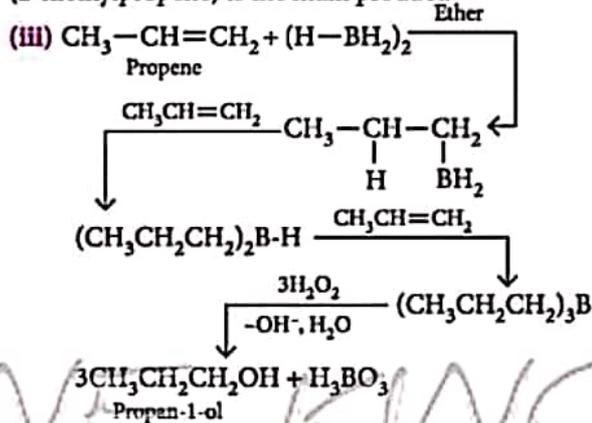


**OR**

(a) *Refer to answer 53, Page no. 186 (MTG CBSE Champion Chemistry Class 12).*

(b) (i) *Refer to answer 58 (i), Page no. 186 (MTG CBSE Champion Chemistry Class 12).*

(ii) *Refer to answer 83, Page no. 189 (MTG CBSE Champion Chemistry Class 12).*

(iii) *Refer to answer 51 (ii), Page no. 186 (MTG CBSE Champion Chemistry Class 12).*

# Essentials of

▶ Redox Reactions
▶ The *s*-Block Elements
▶ The *p*-Block Elements

## REDOX REACTIONS

- Redox reaction (Oxidation-reduction)

$$\underset{\substack{\text{Reducing}\\\text{agent}}}{Sn^{2+}} + \underset{\substack{\text{Oxidising}\\\text{agent}}}{2Fe^{3+}} \longrightarrow 2Fe^{2+} + Sn^{4+}$$

(with Reduction arrow above, Oxidation arrow below)
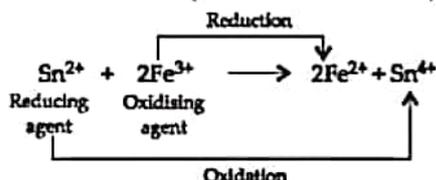
- Types of redox reactions :
  - **Combination reaction :**

    $$\overset{0}{3Mg} + \overset{0}{N_2} \overset{\Delta}{\longrightarrow} \overset{+2 \ -3}{Mg_3N_2}$$
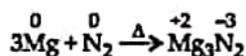
  - **Decomposition reaction :**

    $$\overset{+1 \ +5 \ -2}{2KClO_3} \overset{\Delta}{\longrightarrow} \overset{+1 \ -1}{2KCl} + \overset{0}{3O_2}$$
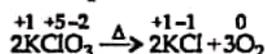
  - **Displacement reaction :**
    (a) Metal displacement :

    $$\overset{+2 \ +6 \ -2}{CuSO_4} + \overset{0}{Zn} \longrightarrow \overset{0}{Cu} + \overset{+2 \ +6 \ -2}{ZnSO_4}$$

    (b) Non-metal displacement :

    $$\overset{0}{2Fe} + \overset{+1 \ -2}{3H_2O} \overset{\Delta}{\longrightarrow} \overset{+3 \ -2}{Fe_2O_3} + \overset{0}{3H_2}$$

  - **Disproportionation reaction :**

    $$\overset{+1 \ -1}{2H_2O_2} \longrightarrow \overset{+1 \ -2}{2H_2O} + \overset{0}{O_2}$$
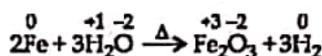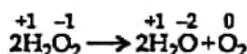
- In $C_3O_2$, oxidation number of carbon is 4/3.
- In $Br_3O_8$, oxidation number of bromine is 16/3.
- In $Na_2S_4O_6$, oxidation number of sulphur is 2.5.
- The element having fractional oxidation state is realised to present in different oxidation states.

$$\overset{+2}{O}=\overset{0}{C}=\overset{+2}{C}=\overset{}{C}=O$$

$C_3O_2$ (Carbon suboxide)

$Br_3O_8$
(Tribromooctaoxide)

$S_4O_6^{2-}$
(Tetrathionate ion)
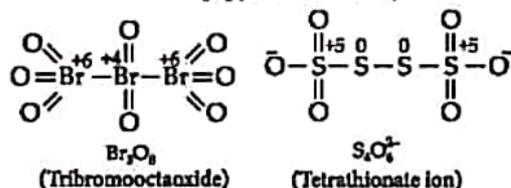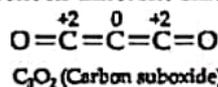
- In redox systems, the titration method can be adopted to determine the strength of a reductant/oxidant using a redox sensitive indicator.
- $MnO_4^-$ acts as the self-indicator.
- $Cr_2O_7^{2-}$, which is not a self-indicator but oxidises the indicator substance diphenylamine just after the equivalence point to produce an intense blue colour thus signalling the end point.
- Iodine itself gives an intense blue colour with starch and has a very specific reaction with thiosulphate ions ($S_2O_3^{2-}$), which is a redox reaction.
- $2Cu^{2+} + 4I^- \rightarrow Cu_2I_2 + I_2$
- $I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$

## THE *s*-BLOCK ELEMENTS

- Alkali metals : [noble gas]$ns^1$
- Alkaline earth metals : [noble gas]$ns^2$
- Chemical properties of alkali metals :

$4Li + O_2 \rightarrow 2Li_2O$ (Oxide)

$2Na + O_2 \rightarrow Na_2O_2$ (Peroxide)

$M + O_2 \rightarrow MO_2$ (Superoxide) (where, $M$ = K, Rb, Cs)

$2M + 2H_2O \rightarrow 2M^+ + 2OH^- + H_2$ [$M$ = an alkali metal]

$2M + H_2 \overset{\Delta}{\longrightarrow} 2M^+H^-$

$2M + X_2 \rightarrow 2M^+X^-$

$M + (x+y)NH_3 \rightarrow \underset{\substack{\text{ammoniated cation}\\\text{causes conductivity}}}{[M(NH_3)_x]^+} + \underset{\substack{\text{ammoniated}\\\text{electron}\\\text{responsible for}\\\text{blue colour and}\\\text{paramagnetism}}}{[e(NH_3)_y]^-}$

$M_2O + H_2O \rightarrow 2M^+ + 2OH^-$

$M_2O_2 + 2H_2O \rightarrow 2M^+ + 2OH^- + H_2O_2$

$2MO_2 + 2H_2O \rightarrow 2M^+ + 2OH^- + H_2O_2 + O_2$

$4LiNO_3 \rightarrow 2Li_2O + 4NO_2 + O_2$

$2NaNO_3 \rightarrow 2NaNO_2 + O_2$
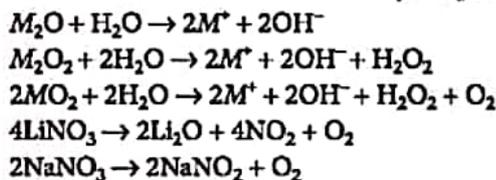
- Some important reactions :

$2NH_3 + H_2O + CO_2 \rightarrow (NH_4)_2CO_3$

$(NH_4)_2CO_3 + H_2O + CO_2 \rightarrow 2NH_4HCO_3$

$NH_4HCO_3 + NaCl \rightarrow NH_4Cl + NaHCO_3$

$2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$

$$2NH_4Cl + Ca(OH)_2 \rightarrow 2NH_3 + CaCl_2 + 2H_2O$$
$$Na_2CO_3 \cdot 10H_2O \xrightarrow{375\,K} Na_2CO_3 \cdot H_2O + 9H_2O$$
$$Na_2CO_3 \cdot H_2O \xrightarrow{>373\,K} Na_2CO_3 + H_2O$$
$$Na_2CO_3 + H_2O + CO_2 \rightarrow 2NaHCO_3$$
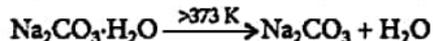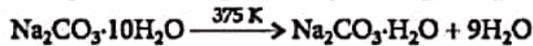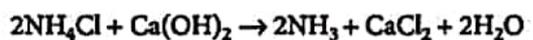
- **Chemical properties of alkaline earth metals :**

$$M + X_2 \rightarrow MX_2 \qquad (X = F, Cl, Br, I)$$
$$BeO + C + Cl_2 \xrightleftharpoons{600-800\,K} BeCl_2 + CO$$
$$2BeCl_2 + LiAlH_4 \rightarrow 2BeH_2 + LiCl + AlCl_3$$
$$M + 2HCl \rightarrow MCl_2 + H_2$$
$$M + (x + y)NH_3 \rightarrow [M(NH_3)_x]^{2+} + 2[e(NH_3)_y]^-$$
$$MO + H_2O \rightarrow M(OH)_2$$
$$Be(OH)_2 + 2OH^- \rightarrow [Be(OH)_4]^{2-}$$
<div align="center">Beryllate ion</div>
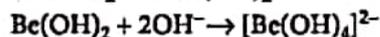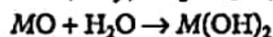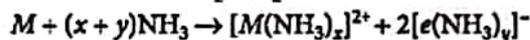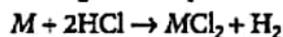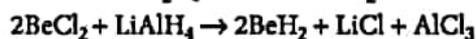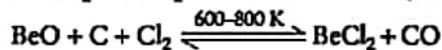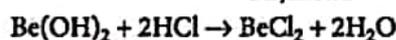
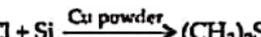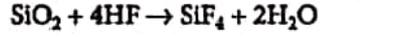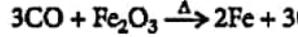$$Be(OH)_2 + 2HCl \rightarrow BeCl_2 + 2H_2O$$
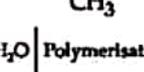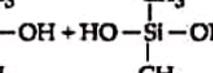$$2M(NO_3)_2 \rightarrow 2MO + 4NO_2 + O_2$$
$$[M = Be, Mg, Ca, Sr, Ba)$$

- **Important reactions :**

$$CaCO_3 \xrightleftharpoons{heat} CaO + CO_2$$
$$CaO + H_2O \rightarrow Ca(OH)_2$$
$$CaO + CO_2 \rightarrow CaCO_3$$
$$CaO + SiO_2 \rightarrow CaSiO_3$$
$$6CaO + P_4O_{10} \rightarrow 2Ca_3(PO_4)_2$$
$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$
$$CaCO_3 + CO_2 + H_2O \rightarrow Ca(HCO_3)_2$$
$$2Ca(OH)_2 + 2Cl_2 \rightarrow CaCl_2 + Ca(OCl_2) + 2H_2O$$
<div align="center">Bleaching powder</div>

$$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaCl$$
$$CaCO_3 \xrightarrow{1200\,K} CaO + CO_2$$
$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$$
$$CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + H_2O + CO_2$$
$$2(CaSO_4 \cdot 2H_2O) \rightarrow 2(CaSO_4) \cdot H_2O + 3H_2O$$
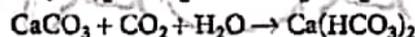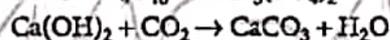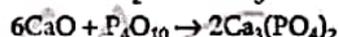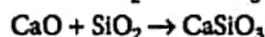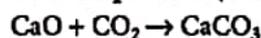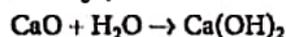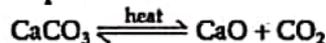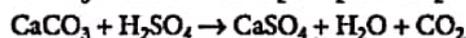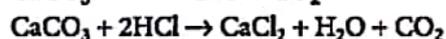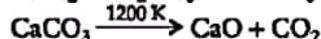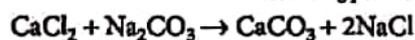
<div align="center" style="background:magenta;color:white;"><b>THE p-BLOCK ELEMENTS</b></div>

- **Electronic configuration :** $ns^2 np^{1-6}$ (except for He)
- **Chemical properties :**
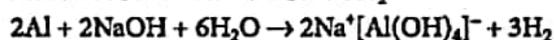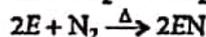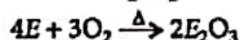
$$4E + 3O_2 \xrightarrow{\Delta} 2E_2O_3$$
$$2E + N_2 \xrightarrow{\Delta} 2EN$$
$$2Al + 6HCl \rightarrow 2Al^{3+} + 6Cl^- + 3H_2$$
$$2Al + 2NaOH + 6H_2O \rightarrow 2Na^+[Al(OH)_4]^- + 3H_2$$
<div align="center">Sodium<br>tetrahydroxoaluminate(III)</div>

$$2E + 3X_2 \rightarrow 2EX_3 \qquad (X = F, Cl, Br, I)$$
$$F_3B + :NH_3 \longrightarrow F_3B \leftarrow NH_3$$
$$Na_2B_4O_7 + 7H_2O \rightarrow 2NaOH + 4H_3BO_3$$
<div align="center">Orthoboric acid</div>

$$Na_2B_4O_7 \cdot 10H_2O \xrightarrow{\Delta} Na_2B_4O_7 \xrightarrow{\Delta} 2NaBO_2 + B_2O_3$$
<div align="center">Sodium        Boric<br>metaborate     enhydride</div>
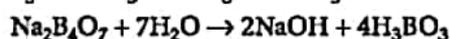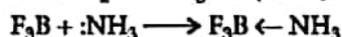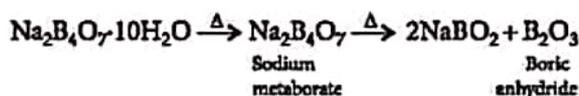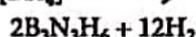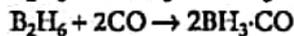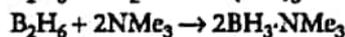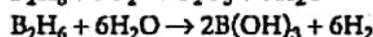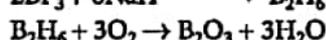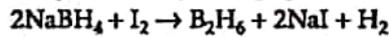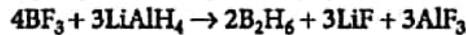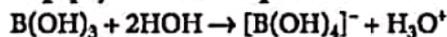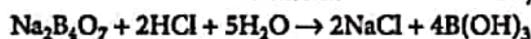
$$Na_2B_4O_7 + 2HCl + 5H_2O \rightarrow 2NaCl + 4B(OH)_3$$
$$B(OH)_3 + 2HOH \rightarrow [B(OH)_4]^- + H_3O^+$$
$$H_3BO_3 \xrightarrow{\Delta} HBO_2 \xrightarrow{\Delta} B_2O_3$$
$$4BF_3 + 3LiAlH_4 \rightarrow 2B_2H_6 + 3LiF + 3AlF_3$$
$$2NaBH_4 + I_2 \rightarrow B_2H_6 + 2NaI + H_2$$
$$2BF_3 + 6NaH \xrightarrow{450\,K} B_2H_6 + 6NaF$$
$$B_2H_6 + 3O_2 \rightarrow B_2O_3 + 3H_2O$$
$$B_2H_6 + 6H_2O \rightarrow 2B(OH)_3 + 6H_2$$
$$B_2H_6 + 2NMe_3 \rightarrow 2BH_3 \cdot NMe_3$$
$$B_2H_6 + 2CO \rightarrow 2BH_3 \cdot CO$$
$$3B_2H_6 + 6NH_3 \rightarrow 3[BH_2(NH_3)_2]^+[BH_4]^- \xrightarrow{Heat}$$
$$2B_3N_3H_6 + 12H_2$$
<div align="center">Borazine<br>(Inorganic benzene)</div>
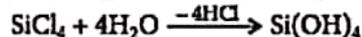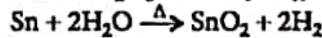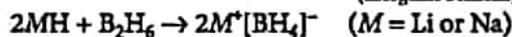
$$2MH + B_2H_6 \rightarrow 2M^+[BH_4]^- \qquad (M = Li \text{ or } Na)$$
$$Sn + 2H_2O \xrightarrow{\Delta} SnO_2 + 2H_2$$
$$SiCl_4 + 4H_2O \xrightarrow{-4HCl} Si(OH)_4$$
<div align="center">Silicic acid</div>

- **Important reactions :**

$$2C + O_2 \xrightarrow{\Delta} 2CO$$
$$HCOOH \xrightarrow[conc.\ H_2SO_4]{373\,K} H_2O + CO$$
$$C + H_2O \xrightarrow{473-1273\,K} \underbrace{CO + H_2}_{Water\ gas}$$
$$2C + O_2 + 4N_2 \xrightarrow{1273\,K} \underbrace{2CO + 4N_2}_{Producer\ gas}$$
$$3CO + Fe_2O_3 \xrightarrow{\Delta} 2Fe + 3CO_2$$
$$CO + ZnO \xrightarrow{\Delta} Zn + CO_2$$
$$SiO_2 + 2NaOH \rightarrow Na_2SiO_3 + H_2O$$
$$SiO_2 + 4HF \rightarrow SiF_4 + 2H_2O$$
$$2CH_3Cl + Si \xrightarrow[570\,K]{Cu\ powder} (CH_3)_2SiCl_2$$
$$(CH_3)_2Si(OH)_2 \xleftarrow[-2HCl]{+2H_2O}$$

$$HO-\underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{Si}}-OH + HO-\underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{Si}}-OH + HO-\underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{Si}}-OH$$
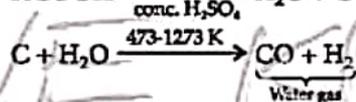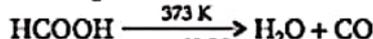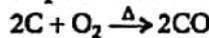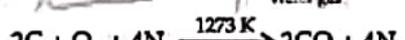
<div align="center">$-H_2O$ | Polymerisation</div>
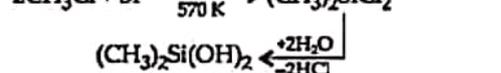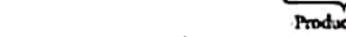
$$-O\left(\!\!\begin{array}{c}CH_3\\|\\Si-O\\|\\CH_3\end{array}\!\!\right)_n \begin{array}{c}CH_3\\|\\Si-\\|\\CH_3\end{array}$$
<div align="center">Silicone</div>

This specially designed column enables students to self analyse their extent of understanding of all chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

## PRACTICE PAPER

Total Marks : 120      Time Taken : 60 Min.

**NEET**

**Only One Option Correct Type**

1. The volume of a colloidal particle, $V_c$ as compared to the volume of a solute particle in a true solution $V_s$ approximately could be
   (a) 1   (b) $10^{23}$   (c) $10^{-3}$   (d) $10^3$

2. On the basis of following reactions and conditions,
   $PbO_2 \rightarrow PbO$;     $\Delta G_{298\,K} < 0$
   $SnO_2 \rightarrow SnO$;     $\Delta G_{298\,K} > 0$
   most probable oxidation state of Pb and Sn will be
   (a) $Pb^{4+}, Sn^{4+}$    (b) $Pb^{4+}, Sn^{2+}$
   (c) $Pb^{2+}, Sn^{2+}$    (d) $Pb^{2+}, Sn^{4+}$

3. The pair in which both species have same magnetic moment (spin only value) is
   (a) $[Cr(H_2O)_6]^{2+}, [CoCl_4]^{2-}$
   (b) $[Cr(H_2O)_6]^{2+}, [Fe(H_2O)_6]^{2+}$
   (c) $[Mn(H_2O)_6]^{2+}, [Cr(H_2O)_6]^{2+}$
   (d) $[CoCl_4]^{2-}, [Fe(H_2O)_6]^{2+}$

4. In a solid $AB$ having the NaCl structure, $A$ atoms occupy the corners of the cubic unit cell. If all the face-centred atoms along one of the axes are removed, then the resultant stoichiometry of the solid is
   (a) $AB_2$   (b) $A_2B$   (c) $A_4B_3$   (d) $A_3B_4$

5. The correct IUPAC name of compound $[Pt(en)_2Cl(ONO)]^{2+}$ is
   (a) chloridodiethylenediaminenitritoplatinum(IV) ion
   (b) *bis*(ethylenediamine)chloridonitro-O-platinum(IV) ion
   (c) chlorido*bis*(ethylenediamine)nitrito-O-platinum(IV) ion
   (d) chloridodiethylenediaminenitro-O-platinum (IV) ion.

6. The radioactive isotope, $^{60}_{27}Co$ which is used in the treatment of cancer can be made by $(n, p)$ reaction. For this reaction the target nucleus is
   (a) $^{60}_{27}Co$      (b) $^{59}_{28}Ni$
   (c) $^{59}_{27}Co$      (d) $^{60}_{28}Ni$

7. Identify $X$ and $Y$.
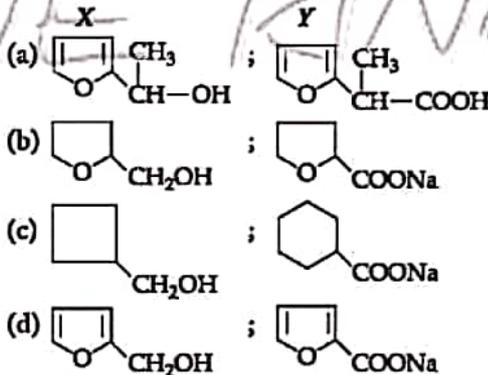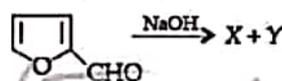


8. The major product of the following reaction is
   $C_6H_5CH_2CH(OH)CH(CH_3)_2 \xrightarrow{conc.\ H_2SO_4}$ ?
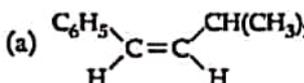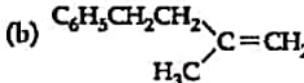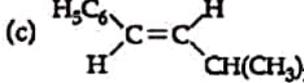

   (d) none of these.

9. Which one of the following is a non-steroidal hormone?
   (a) Estradiol
   (b) Prostaglandin
   (c) Progesterone
   (d) Estrone

10. Which of the following statements indicates the cyclic structure of glucose?
    (a) Glucose gets oxidised to gluconic acid on reaction with bromine water.
    (b) Glucose on heating with HI forms $n$-hexane.
    (c) Glucose does not give 2, 4-DNP test.
    (d) All of the above.

11. Which of the following reactions takes place in fusion zone in the blast furnace during the extraction of iron?
    (a) $CaCO_3 \longrightarrow CaO + CO_2$
    (b) $CO_2 + C \longrightarrow 2CO$
    (c) $C + O_2 \longrightarrow CO_2$
    (d) $Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$

12. The monomer unit for the following polymer is

$$\left( CH_2 - \underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{C}} \right)_n$$

    (a) 
    (b) 
    (c) 
    (d) 

# Some Facts Behind the Chemistry of Insect Repellents

Insect repellents are used to repel mosquitoes, ticks, flies and other biting insects. These repellents affect an insect senses such as smell and taste to prevent it from finding a human or animal host.

**WHAT ATTRACTS INSECTS?**

1-Octen-3-ol

MOLECULAR FORMULA

$C_8H_{16}O$
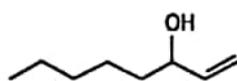


This chemical is present in human sweat and breath, and is thought to attract biting insects such as mosquitoes. It is often used in combination with $CO_2$ in mosquitoes traps. It is also known as mushroom alcohol because it is found in mushrooms.

## COMMON INGREDIENTS IN INSECT REPELLENTS

**DEET**
N, N-Diethyl-meta-toluamide
MOLECULAR FORMULA
$C_{12}H_{17}NO$
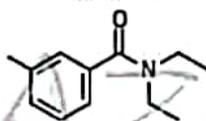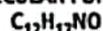


- It is the most common active ingredient.
- 2-8 hours protection (20-30% solution).
- 10-30% solution safe for adults. <10% recommended for children up to 12.
- Effective for mosquitoes, ticks, flies and other biting insects.

**CITRIODIOL**
p-Menthane-3, 8-diol
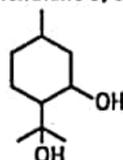


MOLECULAR FORMULA
$C_{10}H_{20}O_2$
- It is obtained from citriodora of the lemon eucalyptus tree.
- Approximately 6 hours protection (10-20% solution).
- No adverse effects - irritation possible if contact with eyes occurs.
- Mosquitoes, flies and gnat repellent; also a miticide, killing insects and mites.

**ICARIDIN OR PICARIDIN**
MOLECULAR FORMULA
$C_{12}H_{23}NO_3$
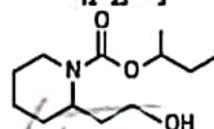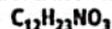


- It is odourless and doesn't damage plastics.
- 2-8 hours protection (20% solution.)
- Used on human skin or clothing. These products may be pumps sprays, liquids, aerosols or wipes.
- Not a skin irritant, but can cause mild eye irritation on contact.
- Repels mosquitoes, ticks and chiggers.

**IR3535**
Ethyl butylacetylamino propionate
MOLECULAR FORMULA
$C_{11}H_{21}NO_3$
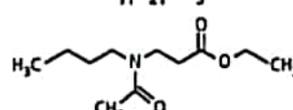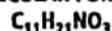


- It is odourless and highly stable.
- 7 hours protection (10-20% solution.)
- Not harmful when ingested or inhaled, although can irritate eyes on contact.
- Repels mosquitoes, ticks, body lice and biting flies.

## HOW DO INSECT REPELLENTS WORK?



Unpleasent odour of repellents confuses insects by jamming their olfactory receptors which produces repellent effect. Recent studies suggest that, after initially being exposed to the repellent DEET, insects can temporarily overcome or develop resistance to its repellent effect. This could have future implications for how the efficacy of repellents is determined.

**AN INVISIBLE BUT A BUILT IN DEFENCE?**
1-Methylpiperazine
MOLECULAR FORMULA :
$C_5H_{12}N_2$
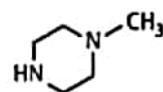


Researchers showed that bacteria on human skin form 1-methylpiperazine that prevents mosquitoes from recognising presence of human.

**Directions :** In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as :

(a) If both assertion and reason are true and reason is the correct explanation of assertion.

(b) If both assertion and reason are true but reason is not the correct explanation of assertion.

(c) If assertion is true but reason is false.

(d) If both assertion and reason are false.

13. **Assertion :** The size of the heavier lanthanoid ions $Dy^{3+}$ and $Ho^{3+}$ are similar to that of $Y^{3+}$.

    **Reason :** The lanthanoid contraction reduces the radii of the last four elements in the series below that of $Y^{3+}$ in the preceding transition series.

14. **Assertion :** Decrease in the vapour pressure of water by adding 1.0 mol of sucrose to one kg of water is nearly similar to that produced by adding 1.0 mol of urea to the same quantity of water at the same temperature.

    **Reason :** Decrease in the vapour pressure of solvent depends on the quantity of non-volatile solute present in the fixed amount of solvent, irrespective of its nature.

15. **Statement-1 :** The gross mobility of elastomer chain is due to its special characteristics.

    **Statement-2 :** It contains a linear chain.

## JEE MAIN / ADVANCED

### Only One Option Correct Type

16. The standard electrode potential of $Cu/Cu^{2+}$ couple is –0.34 volt. At what concentration of $Cu^{2+}$ ions will this electrode potential be zero?

    (a) $3.12 \times 10^{12}$     (b) $3.02 \times 10^{-12}$

    (c) $5.66 \times 10^{-5}$     (d) $5.66 \times 10^{5}$

17. What would be the $Y$ and $Z$ in the following reaction sequence?
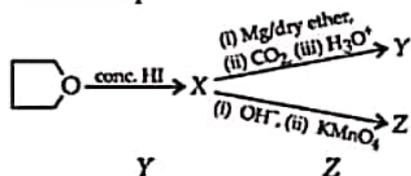
    

    | | $Y$ | $Z$ |
    |---|---|---|
    | (a) | Succinic acid | Adipic acid |
    | (b) | Oxalic acid | Malonic acid |
    | (c) | Glutaric acid | Adipic acid |
    | (d) | Adipic acid | Succinic acid |

18. The total vapour pressure of a 4 mole % solution of $NH_3$ in water at 293 K is 50.0 torr and the vapour pressure of pure water is 17.0 torr at this temperature. Applying Henry's law and Raoult's law, the total vapour pressure for a 5 mole % solution is

    (a) 58.42 torr     (b) 33 torr

    (c) 42.1 torr     (d) 52.25 torr.

19. Final product of the given reaction sequence is
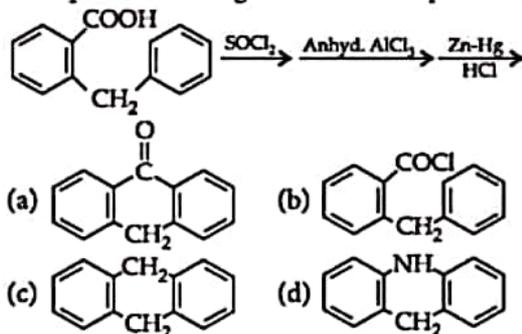
    

### More than One Options Correct Type

20. Protons accelerate the hydrolysis of esters. This is an example of

    (a) a promoter

    (b) a heterogeneous catalyst

    (c) an acid base catalyst (d) an auto catalyst.

21. Which of the following statements are correct?

    (a) $TeO_2$ is almost insoluble in water so that tellurous acid has not been characterised.

    (b) $BrF_3$ is pyramidal in shape.

    (c) Except $CCl_4$, other tetrahalides of group 14 are easily hydrolysed by water.

    (d) There are only 12 bonding electrons available in diborane.

22. If same quantity of electricity is passed through three electrolytic cells containing $FeSO_4$, $Fe_2(SO_4)_3$ and $Fe(NO_3)_3$, then

    (a) the amount of iron deposited in $FeSO_4$ and $Fe_2(SO_4)_3$ are equal

    (b) the amount of iron deposited in $FeSO_4$ is 1.5 times the amount of iron deposited in $Fe(NO_3)_3$

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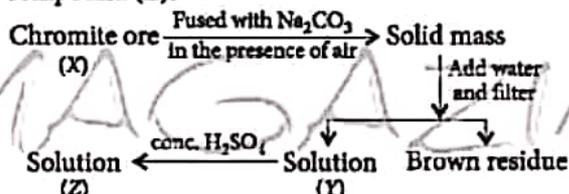"The pessimist sees difficulty in every opportunity. The optimist sees the opportunity in every difficulty."

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(c) the amount of iron deposited in $Fe_2(SO_4)_3$ and $Fe(NO_3)_3$ are equal
(d) the same amount of gas is evolved in all three cases at the anode.

23. If the radius of $Na^+$ is 95 pm and that of $Cl^-$ ion is 181 pm then
(a) co-ordination no. of $Na^+$ is 6
(b) co-ordination no. of $Na^+$ is 8
(c) length of the unit cell is 552 pm
(d) length of the unit cell is 380 pm.

### Numerical Value Type

24. The number of monochlorinated products possible for free radical chlorination of 2, 2-dimethylbutane is _____.

25. Among the complex ions, $[Co(NH_2CH_2CH_2NH_2)_2Cl_2]^+$, $[CrCl_2(C_2O_4)_2]^{3-}$, $[Fe(H_2O)_4(OH)_2]^+$, $[Fe(NH_3)_2(CN)_4]^-$, $[Co(NH_2CH_2CH_2NH_2)_2(NH_3)Cl]^{2+}$ and $[Co(NH_3)_4(H_2O)Cl]^{2+}$, the number of complex ions that show cis-trans isomerism is _____.

26. Following steps are involved in manufacturing of compound (Z).

Chromite ore $\xrightarrow[\text{In the presence of air}]{\text{Fused with Na}_2\text{CO}_3}$ Solid mass (X)

Add water and filter

Solution (Z) $\xleftarrow{\text{conc. H}_2\text{SO}_4}$ Solution (Y) Brown residue

The difference in the oxidation number of Cr in (X) and (Z) is _____.

### Matrix Match Type

**Questions 27-28 :**

Drugs are chemical substances of low molecular mass. These interact with macromolecular targets to produce biological response. If biological response is therapeutic and useful then these chemicals are called medicines which are used for treatment, diagnosis and prevention of disease.

| Column I | | Column II | |
|---|---|---|---|
| P. | Naproxen | I. | Antifertility drug |
| Q. | Meprobamate | II. | Analgesic |
| R. | Terfenadine | III. | Neurological active drug |
| S. | Norethindrone | IV. | Antihistamines |

27. Which of the following has correct combination considering column-I and column-II?
(a) P → II   (b) Q → IV
(c) R → I   (d) S → III

28. Which of the following has correct combination considering column-I and column-II?
(a) P → III   (b) Q → I
(c) R → IV   (d) S → II

**Questions 29-30 :**

Haloalkanes undergoes nucleophilic substitution reactions and elimination reactions. Reactions in which a stronger nucleophile displaces a weaker nucleophile are called nucleophilic substitution reactions. Elimination reactions occur when a strong base approaches to haloalkanes and tends to loose proton from β-carbon atom.

| | Column I | | Column II |
|---|---|---|---|
| P. | Reactions are concerted. | I. | $S_N1$ |
| Q. | Carbocation is formed in the reaction. | II. | Both $S_N2$ and E2 |
| R. | Polar protic solvent is used in the reaction. | III. | E2 |
| S. | Reaction occurs at high temperature. | IV. | Both E2 and E1 |

29. Which of the following has correct combination considering column-I and column-II?
(a) P → II   (b) Q → III
(c) R → IV   (d) S → I

30. Which of the following has correct combination considering column-I and column-II?
(a) P → I   (b) Q → II
(c) R → III   (d) S → IV   ◆◆

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**SELF CHECK** ✓

**Check your score! If your score is**

No. of questions attempted ......
No. of questions correct ......
Marks scored in percentage ......

| > 90% | EXCELLENT WORK ! | You are well prepared to take the challenge of final exam. |
| 90-75% | GOOD WORK ! | You can score good in the final exam. |
| 74-60% | SATISFACTORY ! | You need to score more next time. |
| < 60% | NOT SATISFACTORY! | Revise thoroughly and strengthen your concepts. |