Sample Paper 9 Solutions

Class XII 2023-24

Chemistry

Time: 3 Hours **Max. Marks: 70**

General Instructions:

1. There are 33 questions in this question paper with internal choice.
2. SECTION A consists of 16 multiple-choice questions carrying 1 mark each.
3. SECTION B consists of 5 very short answer questions carrying 2 marks each.
4. SECTION C consists of 7 short answer questions carrying 3 marks each.
5. SECTION D consists of 2 case-based questions carrying 4 marks each.
6. SECTION E consists of 3 long answer questions carrying 5 marks each.
7. All questions are compulsory.
8. Use of log tables and calculators is not allowed.

SECTION-A

Directions (Q. Nos. 1-16) : The following questions are multiple-choice questions with one correct answer. Each question carries 1 mark. There is no internal choice in this section.

1. Which of the following reactions is an example of nucleophilic substitution reaction ?

(a) $2RX + 2NA \rightarrow R - R + 2NaX$

(b) $RX + H_2 \rightarrow RH + HX$

(c) $RX + Mg \rightarrow RH + HX$

(d) $RX + KOH \rightarrow ROH + KX$

Ans : (d) $RX + KOH \rightarrow ROH + KX$

In nucleophillic substitution, a nucleophile provides an electron pair to the substrate and the leaving group departs with an electron pair.

$$Nu: + R-X \longrightarrow R-Nu + X:^{\ominus}$$

These are usually written as S_N(S stands for substitution and N for nucleophilic) and are common in aliphatic compounds especially in alkyl halides and acyl halides.

2. Which enzyme converts glucose and fructose both into ethanol ?

(a) Diastase (b) Invertase

(c) Zymase (d) Maltase

Ans : (c) Zymase

Glucose and fructose obtained by hydrolysis of sucrose, are converted into alcohol by enzyme zymase.

$$C_6H_{12}O_6 \xrightarrow{\text{zymase}} 2C_2H_5OH + 2CO_2$$

3. Faraday's law of electrolysis is related to :

(a) Atomic number of cation

(b) Speed of cation

(c) Speed of anion

(d) Equivalent weight of element

Ans : (d) Equivalent weight of element

According to Faraday's law,
Mass of any element, w, $\propto$ Charge Q.
i.e., for 1 mol of charge, if given to any element, 1 equivalent weight of that substance is obtained.
Hence Faraday's law of electrolysis is related with the equivalent weight of electrolytes.

4. The green residue (B) has the formula :

(a) CrO_2 (b) Cr_2O_2

(c) Cr_2O_3 (d) CrO_5

Ans : (c) Cr_2O_3

Chromic oxide (Cr_2O_3) is known as one of the most desirable Green pigments due to its high thermal stability, migration resistance and excellent light fastness. Colour performance is the most important requirement for Cr_2O_3 pigments.

$$\underset{(A)}{4K_2Cr_2O_7} \xrightarrow{\Delta} 4K_2Cr_2O_4 + \underset{(B)}{2Cr_2O_3} + \underset{(C)}{3O_2}$$

5. The compound having tetrahedral geometry is –

(a) $[NiCl_4]^{2-}$

(b) $[Ni(CN)_4]^{2-}$

(c) $[PdCl_4]^{2-}$

(d) $[NiCl_4]^{2-}$ and $[PdCl_4]^{2-}$ both

Ans : (a) $[NiCl_4]^{2-}$

The molecule $[Ni(CN)_4]^{2-}$ Geometry is square planar and it has a coordination number of 4, shouldn't its geometry be tetrahedral as it is coordinately bonded with the strong field ligand (i.e., CN^-)

The molecule $[PdCl_4]^{2-}$ is diamagnetic, which indicates a square planar geometry as all eight d electrons are paired in the lower-energy orbitals.

However, $[NiCl_4]^{2-}$ It has two unpaired electrons, indicating a tetrahedral geometry, as it is bonded with weak ligand $[CN^-]$.

6. In test for primary amines, the amine is treated with $CHCl_3$ and KOH and a bad smelling compound is formed. If the primary amine used is ethylamine, identify the bad smelling compound formed?

(a) CH_3CN (b) CH_3CNO

(c) CH_3CH_2NC (d) CH_3NCO

Ans : (c) CH_3CH_2NC

When ethyl amine reacts with chloroform in the presence of alcoholic potash, then ethylisocynide is formed. This reaction is known as carbyl amine reaction.

$C_2H_5-NH_2+CHCl_3+3KOH \longrightarrow$

Ethylamine Chloroform $C_2H_5-NC+3KCl+3H_2O$

7. During osmosis, flow of water through a semi-permeable membrane is:

(a) from both sides of semi-permeable with equal flow rates

(b) from both sides of semi-permeable membrane with unequal flow rates

(c) from solution having lower concentration only

(d) from solution having higher concentration only

Ans : (c) from solution having lower concentration only

During osmosis water flows through semi-permeable membrane from lower concentration to higher concentration.

8. In a first-order reaction $A \longrightarrow B$, if k is the rate constant and initial concentration of the reactant A is 0.5 M, then the half-life is

(a) $\frac{\log 2}{k}$ (b) $\frac{\log 2}{k\sqrt{0.5}}$

(c) $\frac{\ln 2}{k}$ (d) $\frac{0.693}{0.5k}$

Ans : (c) $\frac{\ln 2}{k}$

For a first order reaction

$$k = \frac{2.303}{t}\log_{10}\frac{a}{a-x}$$

When $t = t_{1/2}$

$$k = \frac{2.303}{t_{1/2}}\log_{10}\frac{a}{a-\frac{a}{2}}$$

or $$t_{1/2} = \frac{2.303}{k}\log_{10}2 = \frac{\ln 2}{k}$$

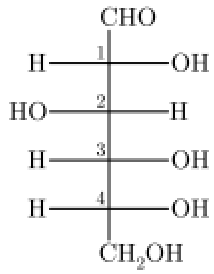
9. The number of chiral carbon is glucose is

(a) 4 (b) 5

(c) 3 (d) 1

Ans : (b) 5

The formula and structure of glucose is $C_6H_{12}O_6$ and



It is clear from the structure, that glucose has four asymmetric (chiral) carbon atoms.

10. In the Haber process for the manufacture of ammonia the following catalyst is used

(a) platinized asbestos

(b) iron with molybdenum as promoter

(c) copper oxide

(d) alumina

Ans : (b) iron with molybdenum as promoter

In Haber's process, ammonia is manufactured from N_2 and H_2 using iron as catalyst with molybdenum as promoter at high temperature and pressure $N_2+3H_2 \xrightarrow[\text{MO(catalytic promoter)}]{Fe_2O_3\text{(catalyst)}} 2NH_3$

Directions (Q. No. 13-16) : Each of the following questions consists of two statements, one is Assertion and the other is Reason. Give answer :

11. **Assertion :** Cyanide (CN^-) is a strong nucleophile.
Reason : Benzonitrilie is prepared by the reaction of chlorobenzene with potassium cyanide.

(a) Both Assertion and Reason are correct and Reason is a correct explanation of the Assertion.

(b) Both Assertion and Reason are correct but Reason is not the a correct explanation of the Assertion.

(c) Assertion is correct but Reason is incorrect.

(d) Both the Assertion and Reason are incorrect.

Ans : (c) Assertion is correct but Reason is incorrect.

Aryl halides (chlorobenzene) do not undergo nucleophilic substitution with KCN because of the low reactivity of the Cl atom, which is because of the low reactivity of the Cl atom, which is because of resonance in chlorobenzene. So assertion is true. Reason is false.

12. **Assertion :** Haemoglobin is an oxygen carrier.
Reason : Oxygen binds as O_2^- to Fe of haemoglobin.

(a) Both Assertion and Reason are correct and Reason is a correct explanation of the Assertion.

(b) Both Assertion and Reason are correct but Reason is not the a correct explanation of the Assertion.

(c) Assertion is correct but Reason is incorrect.

(d) Both the Assertion and Reason are incorrect.

Ans : (c) Assertion is correct but Reason is incorrect.

The assertion is correct that haemoglobin is an oxygen carrier, but the reason that oxygen binds a O_2^- to Fe is false because oxygen binds O_2 to Fe of heme part to form oxyhaemoglobin.

13. **Assertion :** If the activation energy of a reaction is zero, temperature will have no effect on the rate constant.
Reason : Lower the activation energy, faster is the reaction.

(a) Both Assertion and Reason are correct and Reason is a correct explanation of the Assertion.

(b) Both Assertion and Reason are correct but Reason is not the a correct explanation of the Assertion.

(c) Assertion is correct but Reason is incorrect.

(d) Both the Assertion and Reason are incorrect.

Ans : (b) Both Assertion and Reason are correct but Reason is not the a correct explanation of the Assertion.

According to Arrhenius equation, $k = \mathrm{A}e^{-} = E_a/RT$

When, $E_a = 0$

$k = A$

14. **Assertion :** Proteins are made up of α-amino acids.
Reason : During denaturation, secondary and tertiary structures of proteins are destroyed.

(a) Both Assertion and Reason are correct and Reason is a correct explanation of the Assertion.

(b) Both Assertion and Reason are correct but Reason is not the a correct explanation of the Assertion.

(c) Assertion is correct but Reason is incorrect.

(d) Both the Assertion and Reason are incorrect.

Ans : (c) Assertion is correct but Reason is incorrect.

During formation of proteins, $-NH_2$ group of one amino acid condenses with $-CO_2H$ of the other with elimination of a water molecule to form a peptide bond.

SECTION-B

Directions (Q. Nos. 17-21) : This section contains 5 questions with internal choice in one question. The following questions are very short answer type and carry 2 marks each.

15. What is the effect of temperature on solubility of a gas in a liquid?

Ans :

Solubility of a gas in a liquid decreases with increases in temperature. This is because dissolution of a gas in a liquid is an exothermic process (i.e. $\Delta \mathrm{H}$ is negative).

16. In what way is the electronic configuration of transition metals different from non-transition metals?

Ans :

Transition elements contain partially filled *d*-subshell whereas non-transition elements have ns^{1-2} or np^{1-6} in their valence shells, they have no *d*-subshell or their *d*-subshell is completely filled.

17. The decomposition of dimethyl ether leads to formation of CH_4, H_2 and CO and the reaction rate is given by Rate $= K[P_{CH_3OCH_3}]^{3/2}$. If the pressure is measured in bar and time in minutes then what are the units of the rate and rate constants ?

Ans :

In terms of pressure,

$$\text{Units of rate} = \text{bar min} -1$$

$$\text{Units of } K = \frac{\text{Rate}}{[P_{CH_3OCH_3}]^{3/2}}$$

$$= \frac{\text{bar min}^{-1}}{\text{bar}^{3/2}} = \text{bar}^{\frac{1}{2}}\text{min}^{-1}$$

18. What are secondary alcohols ?

Ans :

In secondary alcohols, two carbon atoms are directly bonded to the carbon carrying the –OH group.

```
                  H
                  |
Example : CH3 – C – CH3  (Propan-2-ol)
                  |
                 OH
```

or

What are tertiary alcohols?

Ans :

In tertiary alcohols, three carbon atoms are directly bonded to the carbon carrying the –OH group.

```
                 CH3
                  |
Example : CH3 – C – OH  (2-Methylpropan-2-ol
                  |
                 CH3
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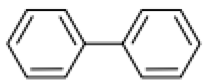
19. Write the structure of diphenyl. How is it prepared from chlorobenzene?

Ans :



Diphenyl

Diphenyl

SECTION-C

Directions (Q. Nos. 22-28) : This section contains 7 questions with internal choice in one question. The following questions are short answer type and carry 3 marks each.

20. Discuss Raoult's law of relative lowering of vapour pressure.

Ans :

When a non-volatile solute is added to a solvent, the vapour pressure is lowered. So, vapour pressure of a solution (p) is always less than the vapour pressure of pure solvent (p°) at the given temperature. $(p^\circ - p)$ is called the lowering in vapour pressure and the ratio $\left(\frac{p^\circ - p}{p^\circ}\right)$ is known as the relative lowering in vapour pressure. According to Raoult's law, the relative lowering in vapour pressure of a dilute solution is equal to the mole fraction of the solute present in the solution. i.e.,

$$\frac{p^\circ - p}{p^\circ} = \chi_B$$

Where, χ_B = mole fraction of solute

21. What is specific conductance and molar conductance?

Ans :

Conductivity or specific conductance of an electrolyte solution is a measure of its ability to conduct electricity.
SI Unit of specific conductance

= Slemers per meter (S/m)

Conductivity is also temperature-dependent.
The molar conductance is defined as the conductance of all the ions produced by ionization of 1g mole of an electrolyte when present in Vml of solution.
Units of molar conductance

$$= \Omega^{-1}\text{cm}^{-2}\text{mol}^{-1}$$

22. Why is the E° value for the Mn^{3+}/Mn^{2+} couple much more positive than that of Cr^{3+}/Cr^{2+} or Fe^{3+}/Fe^{2+}? Explain.

Ans :

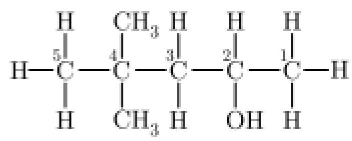
Much more positive E° value for Mn^{3+}/Mn^{2+} means than Mn^{2+} is more sable than Mn^{3+} , because configuration of Mn^{2+} is $3d^5$ (half filled) which is stable than configuration of Mn^{3+} i.e. d^4. Hence the 3rd I.E. of Mn is very high. This also explain why the +3 state of Mn is of little importance.

23. Write the structural formulae of the following:

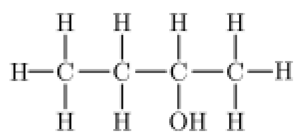
1. 4, 4 dimethyl-2-pentanol
2. 2-butanol

Ans :

1. Structural formula of 4, 4 dimethyl-2-pentanol is,



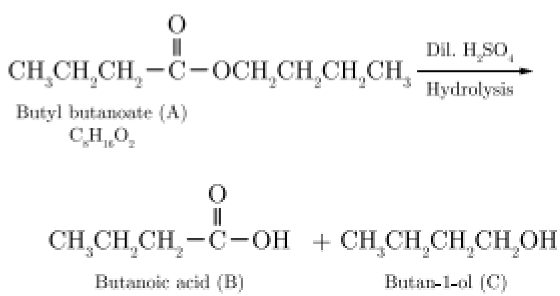
2. Structural formula of 2-butanol is,

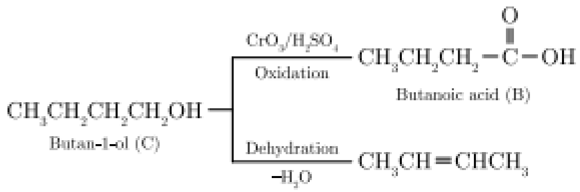


24. An organic compound (A) (molecular formula ($C_8H_{16}O_2$) was hydrolysed with dilute sulphuric acid to give a carboxylic acid (B) and an alcohol (C) Oxidation of (C) with chromic acid produced (B). (C) on dehydration gives but-2-ene as the major product. Write equation for the reaction involved.

Ans :

The organic compound (A) upon hydrolysis with dil. H_2SO_4 gives carboxylic acid (B) and the alcohol (C), therefore (A) is an ester.
Since oxidation of (C) with chromic acid produces the acid (B) therefore, both the carboxylic acid (B) and the alcohol (C) contain four carbon atoms each. Becasue the alcohol (C) on dehydration gives but-1-ene therefore (C) must be a straight chain alcohol i.e., butan-1-ol, the acid (B) which it gives on oxidation must butanoic acid and the ester (A) must be butyl butanoate.
Reactions are as follows :





or

Write difference between aldehyde and ketone.

Ans :

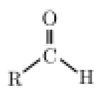
Difference between aldehydes and ketone are as follows :

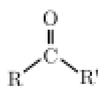
	Aldehyde	Ketone
1.	Aldehyde gives silver mirror test with Tollen's reagent.	Ketone does not give silver mirror test.
2.	Aldehyde gives red ppt. of Cu_2O with Fehling's solution.	Ketone does not give red ppt. with Fehling's solution.
3.	On reduction with $LiAlH_4$ aldehyde from primary alcohol.	Ketone forms sec-alcohol.
4.	Aldehyde forms acetal with alcohol easily.	Ketone does not form ketal easily.
5.	Aldehyde restore pink colour of Schiff's reagent.	Ketones do not react.

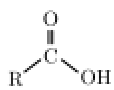
25. What are aldehydes, ketones, carboxylic acid?

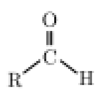
Ans :

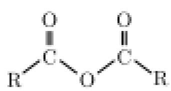
In aldehydes, the carbonyl group is bonded to a carbon and hydrogen while in the ketones, it is bonded to two carbon atoms. The carbonyl compounds in which carbonyl group is bonded to oxygen are known as carboxylic acids, and their derivaties (e.g. esters, anhydrides) while in compounds where carbon is attaced to nitrogen and to halogens are called amides and acyl halides respectively. The general formula of these classes of compounds are given below:

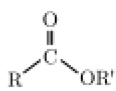

Aldehyde

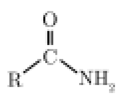

ketone


Carboxylic acid


Acyl halide : X = (Halogen)


Acid anhydride


Ester


Amide

26. Define Collision frequency.

Ans :

The number of collisions per second per unit volume of the reaction mixture is known as collision frequency (Z)

SECTION-D

Directions (Q. Nos. 29-30) : The following questions are case-based questions. Each question has an internal choice and carries 4 marks each. Read the passage carefully and answer the questions that follow.

27. In a reaction, the rates of disappearance of different reactants or rates of formation of different products may not be equal but rate of reaction at any instant of time has the same value expressed in terms of any reactant or product. Further, the rate of reaction may not depend upon the stoichiometric coefficients of the balanced chemical equation. The exact powers of molar concentrations of reactants on which rate depends are found experimentally and expressed in terms of 'order of reaction: Each reaction has a characteristic rate constant depends upon temperature. The units of the rate constant depend upon the order of reaction.

Answer the following questions :

(a) The rate constant of a reaction is found to be $3\times10^{-3}\,mol^{-2}L^2\,sec^{-1}$. What is the order of the reaction?

(b) Rate of a reaction can be expressed by following rate expression, Rate $= k[A]^2[B]$, if concentration of A is increased by 3 times and concentration of B is increased by 2 times, how many times rate of reaction increases?

(c) The rate of a certain reaction is given by, rate $= k[H^+]^n$. The rate increases 100 times when the pH changes from 3 to 1. What is the order (n) of the reaction ?

or

(d) In a chemical reaction $A+2B\rightarrow$ products, when concentration of A is doubled, rate of the reaction increases 4 times and when concentration of B alone is doubled rate continues to be the same. What is the order of the reaction ?

Ans :

(a) Unit of k for n^{th} order

$$= (mol\,L^{-1})^{1-n}\,sec^{-1} \qquad ...(1)$$

Here, $k = 3\times10^{-3}\,mol^{-2}\,L^2\,sec^{-1}$

Unit of $k = mol^{-2}\,L^2\,sec^{-1}$

$$= (mol\,L^{-1})^{-2}\,sec^{-1} \qquad ...(2)$$

Comparing (i) and (ii) we get,

$$1-n = -2$$

$$n = 3$$

(b) Given,

$$R_1 = k[A]^2[B]$$

According to question,

$$R_2 = k[3A]^2[2B]$$

$$= k\times9[A]^2\times2[B]$$

$$= 18 \times k[A]^2[B] = 18R_1$$

(c) Rate, $r = k[H^+]^n$

When, $pH = 3; [H^+] = 10^{-3}$

and when, $pH = 1; [H^+] = 10^{-1}$

$$\frac{r_1}{r_2} = \frac{k(10^{-3})^n}{k(10^{-1})^n}$$

$$\frac{1}{100} = \left(\frac{10^{-3}}{10^{-1}}\right)^n \qquad (r_2 = 100r_1)$$

$$(10^{-2})^1 = (10^{-2})^n$$

$$n = 1$$

or

(d) Let the order of reaction w.r.t. A is x and w.r.t. B is y

$$r_1 = k[A]^x[B]^y \qquad ...(1)$$

$$r_2 = k[2A]^x[B]^y \qquad ...(2)$$

$$r_3 = k[A]^x[2B]^y \qquad ...(3)$$

$$\frac{r_1}{r_2} = \frac{k[A]^x[B]^y}{k[2A]^x[B]^y}$$

$$\frac{1}{4} = \left(\frac{1}{2}\right)^x$$

$$\left(\frac{1}{2}\right)^2 = \left(\frac{1}{2}\right)^x$$

$$x = 2$$

Similarly, $$\frac{r_1}{r_3} = \frac{k[A]^x[B]^y}{= k[A]^x[2B]^y}$$

$$1 = \left(\frac{1}{2}\right)^y$$

$$\left(\frac{1}{2}\right)^0 = \left(\frac{1}{2}\right)^y$$

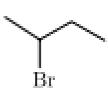
$$y = 0$$

28. When haloalkanes with (β-hydrogen atom are boiled with alcoholic solution of KOH, they undergo elimination of hydrogen halide resulting in the formation of alkenes. These reactions are called (β-elimination reactions or dehydrohalogenation reactions. These reactions follow Saytzeff's rule. Substitution and elimination reactions often compete with each other. Mostly bases behave as nucleophiles and therefore can engage in substitution or elimination reactions depending upon the alkyl halide and the reaction conditions.

Answer the following questions :

(a) Which alkyl halide from the following pair is chiral and undergoes faster S_N2 reaction ?

(i) 

(ii) 

(b) What happens when ethyl chloride is treated with aqueous KOH?

(c) Out of 2-bromopentane, 2-bromo-2-methylbutane, and 1-bromopentane, which compound is most reactive towards elimination reaction and why?

or

(d) Write the mechanism of the following S_N1 reaction.

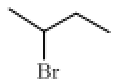
$$(CH_3)_3C - Br \xrightarrow{\text{aq. NaOH}} C - OH + NaBr$$

Ans :

(a)

(i) 

Undergoes faster S_N2 reaction.

(ii) 

is chiral.

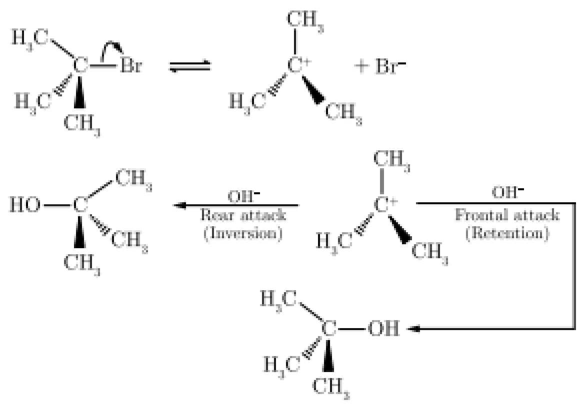
(b) When ethyl chloride is treated with aqueous KOH, ethanol is formed,

$$CH_3CH_2Cl + KOH_{(aq)} \rightarrow CH_3CH_2OH + KCl$$

(c) 2-Bromo-2-methylbutane will give fastest elimination reaction because it is a tert-halides prefer elimination reaction

or

(d)



SECTION-E

Directions (Q. Nos. 31-33) : The following questions are long answer type and carry 5 marks each. Two questions have an internal choice.

29. Arrange the following :

(i) In decreasing order of pk_b values :

$C_2N_5NH_2, C_6H_5NHCH, (C_2H_5)_2NH$ and $C_6H_5NH_2$

(ii) In increasing order of basic strength (or basicity) :

$C_6H_5NH_2, C_6H_5N(CH_3)_2, (C_2H_5)_2NH$ and CH_3NH_2

(iii) increasing order of basic strength or (basicity) :

(a) Aniline, p-nitroaniline and p-toluidine

(b) $C_6H_5NH_2, C_6H_5NHCH_3, C_6H_5CH_2NH_2$

(c) $C_6H_5NH_2, C_6H_5NHCH_3, C_6H_5N(CH_3)_2$

(iv) Decreasing order of basic strength in the gas phase :

$C_2H_5NH_2, (C_2H_5)_2NH, (C_2H_5)_2N$ and NH_3.

(v) Decreasing order of basic strength :

$C_2H_5NH_2$, $C_2H_5NH_2$, $(C_2H_5)_2NH$, NH_3

Ans :

(i) Due +I effect of CH_3 group $C_6H_5NHCH_3$ is more basic than $C_6H_5NH_2$ but both are less basic than $(C_2H_5)_2NH$ and CH_3NH_2 beause of resonance, among $C_2H_5NH_2$ and $(C_2H_5)_2NH$, $(C_2H_5)_2NH$ is more basic due to combined effect of +I effect and H-bonding. The overall basic strength of these four amines is

$(C_2H_5)_2NH > C_2H_5NH_2 > C_6H_5NHCH_3 > C_6H_5NH_2$.

Since a stronger base has a lower pk_b value, therefore order of pk_b value is $C_6H_5NH_2 > C_6H_5NHCH_3 > C_2H_5NH_2 > (C_2H_5)_2NH$

Basic strength

(ii) Due to resonance :

$(C_2H_5)_2NH$ and $CH_3NH_2 > C_6H_5NH_2$ and $C_6H_5N(CH_3)_2$ Due to +I effect :

$(C_2H_5)_2NH > CH_3NH_2$

$C_6H_5N(CH_3)_2 > C_6H_5NH_2$

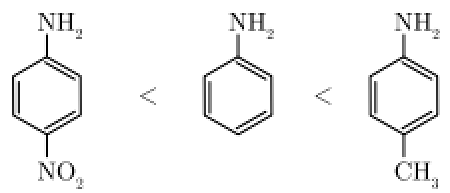
Hence the overall increasing order of basic stringth is

$C_6H_5NH_2 < C_6H_5N(CH_3)_2 < CH_3NH_2 < (C_2H_5)_2NH$

(iii)

(a) The electron donating group $(-CH_3)$ increases the basicity and electron with drawing group $(-NO_2)$ decrease the basicity. Therefore basicity increases in the order

p-nitroaniline < aniline < p-toluidine.



(b) **Basic strength :** $C_6H_5NH_2$ and $C_6H_5NHCH_3 < C_6H_5CH_2NH_2$ because in $C_6H_5NH_2$ and $C_6H_5NHCH_3$, N is directly attached to the benzene ring, the lone pair of electrons on the N-atom is less available due to delocalization ove the benzene ring. Due to +I effect of $-CH_3$ group

$C_6H_5NH_2 < C_6H_5NHCH_3$

Hence the overall increasing order of basic strength is

$C_6H_5NH_2 < C_6H_5NHCH_3 < C_6H_5CH_2NH_2$

(c) Basicity increases with increase in +I effect of $-CH_3$ group.

Hence increasing order of basicity is:

$C_6H_5NH_2 < C_6H_5NHCH_3 < C_6H_5N(CH_3)_2$

(iv) In the gas phase basic strength mainly depends upon +I effect of the alkyl groups, therefore decreasing order of basic strength is :

$(C_2H_5)_3N > (C_2H_5)_2NH > C_2H_5NH_2 > NH_3$

(v) Due to delcoalization of lone pair of electrons present on nitrogen over the benzene ring $C_6H_5NH_2$ is a weaker base than aliphatic amines and ammonia, further due to +I effect aliphatic amines are stronger base than ammonia. Hence decrasing order of basic strength is :

$(C_2H_5)_2NH > C_2H_5NH_2 > C_6H_5NH_2$

30. Give the reactions occurring at two electrodes during electrolysis of aqueous sodium chloride solution.

Ans :

During the electrolysis of aqueous sodium chloride solution, the products are NaOH, Cl_2 and H_2. In this case besides Na^+ and Cl^- ions we also have H^+ and OH^- ions along with the solvent molecules H_2O.

At the cathode there is competition between the following reduction reactions :

$$Na^+(aq) + e^- \rightarrow Na(aq)$$
$$E^\circ_{cell} = -2.71 \text{ Volt}$$
$$H^+(aq) + e^- \rightarrow \frac{1}{2}H_2(g)$$
$$E^\circ_{cell} = 0.00 \text{ Volt}$$

The reaction with higher value of E° is preferred and therefore, the reaction at the cathode during electrolysis is :

$$H^+(aq) + e^- \rightarrow \frac{1}{2}H_2(g) \qquad ...(1)$$

But $H^+(aq)$ is produced by the dissociation of H_2O i.e.,

$$H_2O(l) \rightarrow H^+(aq) + OH^-(aq) \qquad ...(2)$$

Therefore the net reaction at the cathode may be written as the sum of (1) and (2) and we have

$$H_2O(l) + e^- \rightarrow \frac{1}{2}H_2(g) + OH^- \qquad ...(3)$$

At the anode the following oxidation reaction are possible :

$$Cl^-(aq) \rightarrow \frac{1}{2}Cl_2(g) + e^-$$
$$E^\circ_{cell} = 1.36 \text{ Volt} \qquad ...(4)$$
$$2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$$
$$E^\circ_{cell} = 1.23 \text{ Volt} \qquad ...(5)$$

The reaction at anode with lower value of E° is preferred and therefore, water should get oxidised in preference to $Cl^-(aq)$. However on account of over potential of oxygen reaction (iv) is preferred. Thus, the net reaction may be summarised as :

$$NaCl(aq) \xrightarrow{H_2O} Na^+(aq) + Cl^-(aq)$$

Cathode : $H_2O(l) + e^- \rightarrow \frac{1}{2}H_2(g) + OH^-(aq)$

Anode : $Cl^-(aq) \rightarrow \frac{1}{2}Cl_2(g) + e^-$

Net reaction :

$$NaCl(aq) + H_2O(l) \rightarrow Na^+(aq) + OH^-(aq) + \frac{1}{2}H_2(g) + \frac{1}{2}Cl_2(g)$$

or

What are fuel cells? Discuss $H_2 - O_2$ fuel cell. List some advantages of fuel cells over other cells?

Ans :

Fuel Cell : Galvanic cells that are designed to convert the energy of combustion of fuels like hydrogen, methane, methanol etc directly into electrical energy are called fuel cells.

$H_2 - O_2$ **fuel Cell :** It is one of the most successful fuel cells uses the reaction of hydrogen and oxygen to form water. The cell was used for providing electrical power in the Apollo space program. The water vapour produced during the reaction were condensed and added to the drinking water supply for the astronauts.

Construction and working : Hydrogen and oxygen are bubbled through porous carbon electrodes into concentrated aqueous sodium hydrozide solution.

Catalyst like finely divided platinum or palladium metal are incorporated into the electrodes for increasing the rate of electrode reactions. The electrode reactions are :

Anode : $2H_2(g) + 4OH^-(aq) \rightarrow 4H_2O(l) + 4e^-$

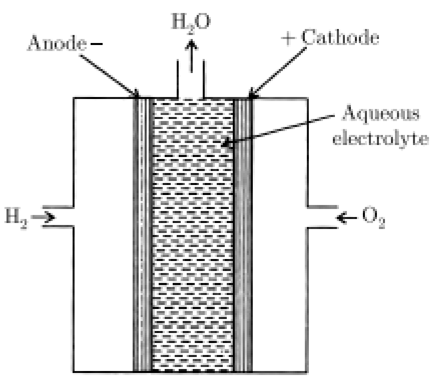
Cathode : $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-(aq)$

Overall reaction :

$$2H_2(g) + O_2(g)\ 2H_2O(l)$$

Advantage (Characteristics) of fuel cells :

1. The fuel runs continuously as long as the reactants are supplied.
2. Fuel cells produced electricity with an efficiency of about 70% compared to thermal plants whose efficiency is about 40%.
3. Fuel cells are pollution free.



31. Explain IUPAC system of Nomenclature of coordination compounds.

Ans :

Following rules are followed for naming of coordination compounds:

1. **Order of Naming Ions :** In ionic complex the cation is named firs then the anion.
2. **Naming of Coordination Sphere :** Ligands are named first and then the central metal ion.
3. **Naming of Ligands :** Names of negative ligands end in $-$o and names of positive ligands end in $-$ium.

List of Negative Ligands

Formula	Name	Formula	Name
F^-	fluorido	Cl^-	chlorido
Br^-	bromido	I^-	iodido
NO_2^-	nitrito-N	NO_3^-	nitrato
ON^-	nitrito-O	CN^-	cyanido or cyano
SCN^-	thiocyanato	NCS^-	isothiocyanato
SO_4^{2-}	sulphato	O^{2-}	oxo
CO_3^{2-}	carbonato		
NH_2^-	amido	NH^{2-}	imido
H^-	hydrido	COO^- | $COO-$ or ox	oxalato
OH^-	hydroxo or hydroxido	$CH_2\langle^{NH_2}_{COO^-}$ gly	glycinato

List of Positive Ligands

Formula	Name	Formula	Name
NO^+	nitrosonium	NO_2^+	nitronium
$NH_2{-}NH_3^+$	hydrazinium		

List of Neutral Ligands

Formula	Name	Formula	Name
NH_3	ammine	H_2O	aqua or aquo
CH_3NH_2	methylamine or methanamine	NO	nitrosyl
CO	carbonyl	PH_3	phosphine
$(C_6H_5)_3P$	triphenyl phosphine	C_5H_5N or (py)	pyridine
CH_2-NH_2 | CH_2-NH_2 or (en)	ethylen-ediamine or ethane-1, 2-diamine		

4. **Order of Naming Ligands :** Ligands are named in alphabetical order.
5. **Numerical Prefixes to Indicate Number of One Kind of Ligand :** To indicate the number of ligands of the same

type prefix di, tri, tetra, penta or hexa is used when the name of a complex ligand already has di, tri etc. then the prefix used are bis, tris, tetrakis, pentakis etc. instead of di, tri, tetra, penta.

6. **Ending the Name of Metal Ion or Atom :** When the complex ion is anionic, the name of central metal atom ends in −ate and in cationic or neutral complexes, the name of metal is written as such.
7. **Oxidation State of Central Metal Ion :** Oxidation state is indicated by a Roman numeral and written after metal in brackets.

Example

	Complex Compound	Name
1.	$K_4[Fe(CN)_6]$	potassium hexacyanoferrate (II)
2.	$K_3[Fe(CN)_6]$	potassium hexacyanoferrate (III)
3.	$[Co(NH_3)_6]Cl_3$	hexaammine cobalt (III) chloride
4.	$K_3[Co(CN)_5(NO)]$	potassium pentacyanonitrosyl cobaltate (II)
5.	$K[Pt(NH_3)Cl_3]$	potassium amminetri-chloridoplatinate (II)
6.	$[Pt(NH_3)_2Cl(NO_2)]$	diammine-chloridonitrito-N-platinum (II)
7.	$[Ni(CO)_4]$	tetracarbonyl nickel (O)
8.	$K_3[Cr(C_2O_4)_3]$	potassium trioxalatochromate (III)
9.	$[Co(NH_3)_4(H_2O)(Cl)]Cl_2$	tetraammineaquachlorido cobalt (III) chloride
10.	$K_2[Zn(OH)_4]$	potassium tetrahydroxozincate (II)
11.	$[Ag(NH_3)_2][Ag(CN)_2]$	diamminesilver (I) dicyanoargentate (I)
12.	$K_3[Al(C_2O_4)_3]$	potassium trioxalato aluminate (III)
13.	$Hg[Co(SCN)_4]$	mercury tetrathiocyanatocobaltate (III)
14.	$[Co(NH_3)_5(CO_3)]Cl$	pentaammine carbonatocobalt (III) chloride
15.	$K_3[Fe(C_2O_4)_3]$	potassium trioxalatoferrate (III)
16.	$[Pt(NH_3)_2Cl(NH_2CH_3)]Cl$	diamminechlorido-methanamine platinum (II) chloride
17.	$[Cr(NH_3)_3(H_2O)_3]Cl_3$	triammine triaquachromium (III) chloride
18.	$[Co(en)_3]_2(SO_4)_3$	tris (ethylenediammine) cobalt (III) sulphate
19.	$[CoCl_2(en)_2]Cl$	dichloridobis (ethane-1, 2-diamine) cobalt (III) chloride
20.	$K_2[PdCl_4]$	potassium tetrachloridopalladate (II)
21.	$[Ti(H_2O)_6]^{3+}$	hexaaquatitanium (III) ion
22.	$[Co(en)_3]^{3+}$	tris (ethane-1, 2-diamine) cobalt (III) ion
23.	$[Co(NH_3)_4Cl(NO_2)]Cl$	tetraammine-chloridonitrito-N-cobalt (III) chloride
24.	$[NiCl_4]^{2-}$	tetrachloridonickelate (II) ion
25.	$[Ni(NH_3)_6]Cl_2$	hexaamminenickel (II) chloride
26.	$[Mn(H_2O)_6]^{2+}$	hexaaqua manganese (II) ion

or

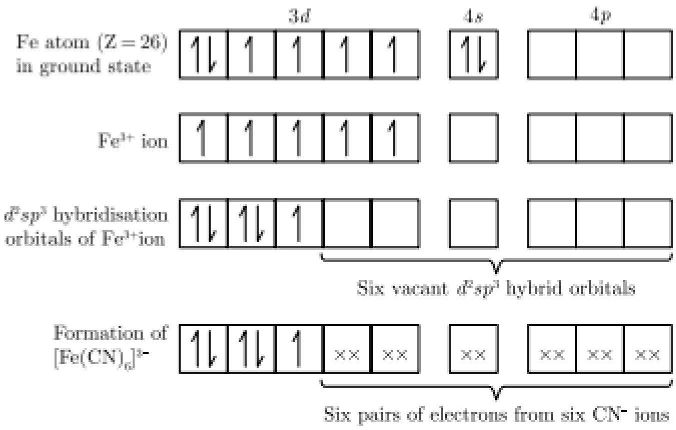
Explain bonding in co-ordination compounds with the help of valence bond theory.

Ans :

The main postulates of valence bond theory are:

1. Metal-ligand bond is formed by the donation of pairs of electron by ligand to the metal atom.
2. Metal atom must possess vacant orbitals to accommodate these electrons. These orbitals are obtained by hybridisation.
3. Some times the unpaired $(n-1)$d electrons pair up prior to hybridisation for making some $(n-1)$ d orbitals vacant.
4. Metal-ligand bonds are formed by the overlap of these orbitals with ligand orbitals, these bonds are of equal strength and directional in nature.
5. Octahedral complexes are formed by d^2sp^3 (or sp^3d^2) hybridisation.
   Square planar complexes are formed by dsp^2 hybridisation, tetrahedral complexes are formed by sp^3 hybridisation.

Examples : formation of ferricyanide ion $[Fe(CN)_6]^{3-}$


3d
4s
4p
Fe atom (Z = 26) in ground state
Fe3+ ion
d2sp3 hybridisation orbitals of Fe3+ion
Six vacant d2sp3 hybrid orbitals
Formation of [Fe(CN)6]3-
Six pairs of electrons from six CN- ions

□□□□□□□