ISC SEMESTER 2 EXAMINATION
SAMPLE PAPER - 2
CHEMISTRY PAPER 1 (THEORY)

Maximum Marks: 35

Time allowed: One and a half hour

Candidates are allowed an additional ***10 minutes*** *for* **only** *reading the paper.*

They must ***NOT*** *start writing during this time.*

All questions are compulsory

All working, including rough work, should be done on the same sheet as, and adjacent to the rest of the answer.

Balanced equations must be given wherever possible and diagrams where they are helpful.

When solving numerical problems, all essential working must be shown.

In working out problems, use the following data:

Gas constant $R = 1{\cdot}987$ cal deg^{-1} mol^{-1} $= 8{\cdot}314$ JK^{-1} mol^{-1} $= 0{\cdot}0821$ dm^3 atm K^{-1}mol^{-1}

1 l atm $= 1$ dm^3 atm $= 101{\cdot}3$ J. 1 Faraday $= 96500$ coulombs.

Avogadro's number $= 6{\cdot}023 \cdot 10^{23}$.

Section-A

Question 1.

Fill in the blanks by choosing the appropriate word(s) from those given in the brackets:

(order, Galena, molecularity, azurite, malachite, Wolf-Kishner reduction, single, hydrazine, KOH, double)

(i) _______ of a reaction is sum of number of molecules of reactant taking part in _______ step of the reaction.

(ii) _______ and _______ are ores of copper.

(iii) Acetaldehyde is converted to ethane by _______ using _______ as reducing agent.

Question 2.

Select and write the correct alternative from the choices given below.

(i) The tetrahedral crystal field splitting is only _______ of the octahedral splitting.

(a) $\frac{1}{9}$ (b) $\frac{2}{9}$ (c) $\frac{4}{9}$ (d) $\frac{5}{9}$

(ii) Formation of cyanohydrin with an aldehyde is an example of:

(a) Electrophilic substitution
(c) Nucleophilic addition
(b) Nucleophilic substitution
(d) Electrophilic addition

(iii) Ethyl nitrite on reduction with Sn/HCl gives:

(a) $C_2H_5NH_2 + HNO_2$
(c) $C_2H_5OH + NH_4OH$
(b) $C_2H_5NH_2 + H_2O$
(d) $C_2H_5OH + NaNO_2$

(iv) **Assertion:** A colloidal sol scatters light but a true solution does not.

Reason: The particles in a colloidal sol move slowly than in a true solution.

(a) Both assertion and reason are true and reason is the correct explanation of assertion.
(b) Both assertion and reason are true but reason is not the correct explanation for assertion.
(c) Assertion is true but reason is false.
(d) Assertion is false but reason is true.

Section-B

Question 3.

Write IUPAC name of:

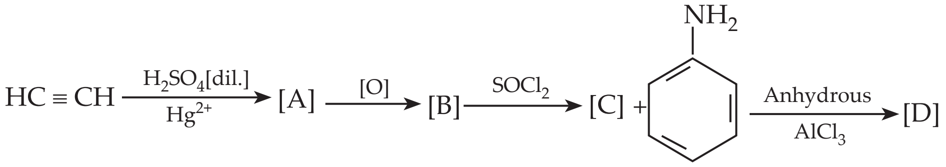
(i) $K[Cr(H_2O)_2(C_2O_4)_2].3H_2O$.
(ii) $[Pt(NH_3)_4(NO_2)Cl]SO_4$
(iii) $[Cr(NH_3)_5CO_3]Cl$
(iv) $[Cr(NH_3)_5(NCS)][ZnCl_4]$

Question 4.

(i) A hydrocarbon with molecular formula C_7H_8 on oxidation with CrO_2Cl_2 in CCl_4 followed by hydrolysis yields compound 'A'. 'A' on treatment with dil. NaOH forms two compounds 'B' and 'C'. 'B' on acid hydrolysis gives white crystalline solid 'D'. 'B' and 'D' both on being heated with soda lime yields a liquid hydrocarbon with empirical formula CH.

OR

(ii) Identify A, B, C and D.

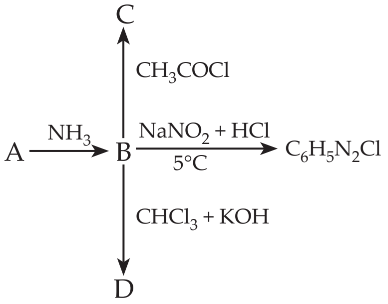


Question 5.

(i) Define a peptide linkage.
(ii) What is glycosidic linkage? Give name of a biomolecule having glycosidic linkage.

Question 6.

(i) Give name and formula of A, B, C, D.



(ii) Describe Gabriel phthalimide synthesis. (Give reaction)

Question 7.

(i) Name the type of bonding stabilise the α-helix structure of proteins.

(ii) The K_a and K_b value of alpha-amino acid are very low. Why?

Question 8.

Consider the following data for the reaction:

$$A + B \longrightarrow \text{Product}$$

Experiment Number	[A] mol L^{-1}	[B] mol L^{-1}	Rate mol sec^{-1}
1.	0.10 M	1.0	2.1×10^{-3}
2.	0.20 M	2.0	8.4×10^{-3}
3.	0.30 M	3.0	8.4×10^{-3}

Determine the order of reaction with respect to A and with respect to B and the overall order of reaction.

Question 9.

Complete and write chemical equations for the following reactions :

(i) Benzenesulphonyl chloride reacts with ethanamine.

(ii) 2-Bromo-4-nitrotoluene reacts with tin and hydrochloric acid.

Question 10.

(i) Compound (A) $C_6H_{12}O$, forms a derivative with hydrazine and gives yellow ppt. with iodine and sodium hydroxide solution. It does not react with Tollen's reagent. What is the structure of A ?

(ii) How will you convert toluene to benzaldehyde ?

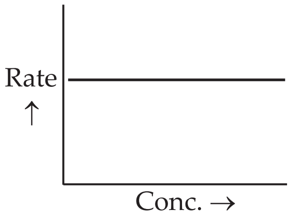
Section-C

Question 11.

(i) **Answer the following:**

(a) The rate constant for a reaction of zero order in A is 0.0030 mol L^{-1} s^{-1}. How long will it take for the initial concentration of A to fall from 0.10 M to 0.075M.

(b) For a chemical reaction, the rate with concentration is shown. What is the order of reaction ?



OR

(ii) **Answer the following:**

For the reaction:

$$2NO(g) + Cl_2(g) \longrightarrow 2NOCl(g)$$

The following data were collected. All the measurement were taken at 263 K.

Experiment	**Initial [NO] (M)**	**Initial [Cl_2] (M)**	**Initial rate of disappearance of Cl_2 (M) min.**
1	0.15	0.15	0.60
2	0.15	0.30	1.20
3	0.30	0.15	2.40
4	0.25	0.25	?

(a) Write the expression for rate law.

(b) Calculate the value of rate constant and specify its units.

(c) What is the initial rate of disappearance of Cl_2 in experiment 4?

Question 12.

(i) Predict the stable oxidation states of transition elements having following ground state *d*-orbital electronic configurations :

(a) $3d^3$ (b) d^8

What could be the names of these element?

(ii) Based on the data, arrange Fe^{2+}, Mn^{2+} and Cr^{2+} in the increasing order of stability of +2 oxidation state:

$$E^\circ_{Cr^{3+}/Cr^{2+}} = -0.4\ V,$$
$$E^\circ_{Mn^{3+}/Mn^{2+}} = 1.5\ V,$$
$$E^\circ_{Fe^{3+}/Fe^{2+}} = 0.8\ V$$

Question 13.

(i) The CFSE for octahedral $[CoCl_6]^{-4}$ is 18,000 cm^{-1}. What will be the CFSE for tetrahedral $[CoCl_3]^{-2}$?

(ii) Write the hybridisation and geometry of following compounds:

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

Question 14.

Give reason for each of the following:

(i) Alum is added to water containing suspended impurities.

(ii) Why is gelatin mixed with gold sol.

(iii) When KI solution is added to $AgNO_3$ solution, positively charged sol results.

Answers

Section-A

Answer 1.

(i) Molecularity, single

Explanation:

For a single-step reaction, the molecularity of reaction is given by the sum of number of reactants that are taking part in the reaction.

For example-

$A + B \rightarrow C + D$

It is a single step reaction and total 2 molecules are taking part in the reaction, so the molecularity of reaction is 2.

(ii) Azurite, malachite

Explanation:

Main ores of copper are:

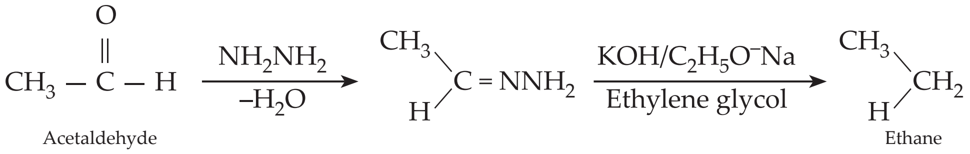
1. Copper pyrite $CuFeS_2$
2. Malachite $CuCO_3.Cu(OH)_2$
3. Cuprite Cu_2O
4. Copper glance Cu_2S
5. Azurite: $2CuCO_3.Cu(OH)_2$

(iii) Wolf- Kishner reduction, hydrazine

Explanation:

In the Wolf-Kishner reaction,

The carbonyl group of aldehydes and ketones is reduced to CH_2 group on treatment with hydrazine followed by heating with NaOH/KOH in high boiling solvent such as ethylene Glycol.



Answer 2.

(i) (c) $\frac{4}{9}$

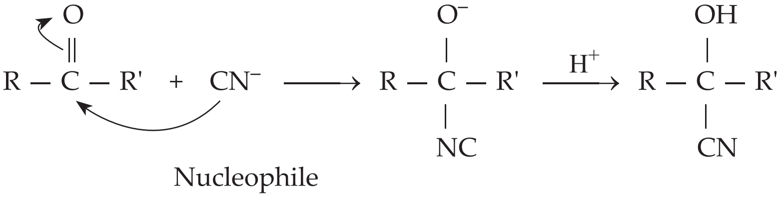
Explanation:

$$\Delta_t = \frac{4}{9}\Delta_0 \text{ (where } t = \text{tetrahedral, O = octahedral)}$$

(ii) (c) Nucleophilic addition

Explanation:

The formation of cyanohydrin from a ketone is an example of nucleophilic addition reaction because the initial attack is by CN^- which is a nucleophile.



(iii) (c) $C_2H_5OH + NH_4OH$

Explanation:

Ethylnitrile on reduction with Sn/HCl gives ethanol and ammonium hydroxide. The reaction can be represented as follows:

$$CH_3-CH_2-O-N=O \xrightarrow[6[H]]{Sn/HCl} CH_3-\underset{\text{Ethanol}}{CH_2OH} + NH_4OH$$

(iv) (b) Both assertion and reason are true but reason is not the correct explanation for assertion.

Explanation:

Colloid solution is heterogeneous solution and shows tyndall effect, while the true Solution is homogeneous and don't show tyndall effect. Thus, both assertion and reason are true but reason is not the correct explanation of assertion.

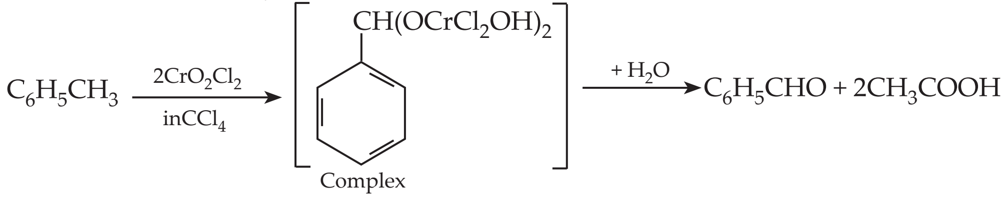
Section-B

Answer 3.

(i) Potassium diaquadioxalato chromate (III) trihydrate
(ii) Tetraamminechloronitrito-n-platinum(IV) sulphate
(iii) Pentaamminecarbonatochromium (III) chloride
(iv) Pentaammineisothiocyanatochromium (III) tetrachlorozincate (II)

Answer 4.

(i) Compound 'A' is benzaldehyde



Compound 'B' is sodium benzoate and 'C' is benzyl alcohol

$$\underset{(A)}{2C_6H_5CHO} + NaOH \xrightarrow[\text{reaction}]{\text{Cannizzaro's}} \underset{(B)}{C_6H_5COONa} + \underset{(C)}{C_6H_6CH_2OH}$$

Compound 'D' is benzoic acid

$$\underset{(B)}{C_6H_5COONa} + HCl \longrightarrow \underset{(D)}{C_6H_5COOH} + NaCl$$

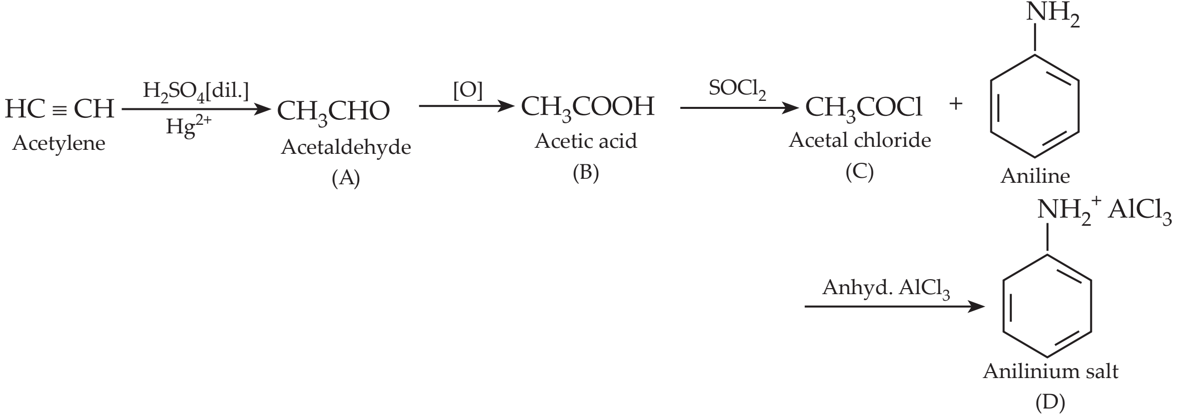
$$\underset{(B)}{C_6H_5COONa} + NaOH \xrightarrow[\Delta]{CaO} C_6H_6 + Na_2CO_3 + H_2O$$

$$\underset{(D)}{C_6H_5COOH} + 2NaOH \xrightarrow[\Delta]{CaO} C_6H_6 + Na_2CO_3 + H_2O$$

C_6H_6 is a hydrocarbon benzene with empirical formula CH.

OR

(ii) The above reaction sequence gives the following compounds, Acetaldehyde (A), Acetic acid (B), Acetyl chloride (C). But, aniline does not gives Friedel-Crafts reaction due to the formation of strongly deactivating anilinium ion (D) in the reaction conditions.

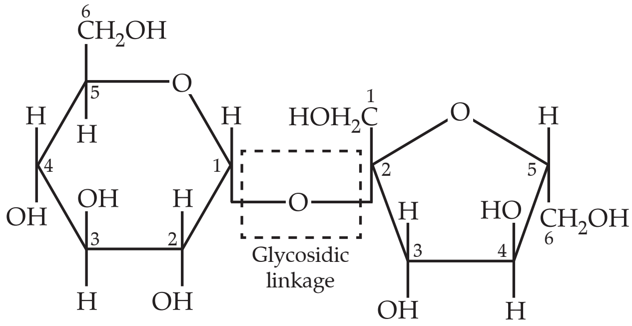


Answer 5.

(i) Peptide linkage is an amide formed between a –COOH group and an $-NH_2$ group.

(ii) The two monosaccharides are joined together by an oxide linkage formed by the loss of a water molecule. Since the reducing groups of glucose and fructose are involved in glycosidic bond formation, between two monosaccharide units through oxygen atom, it is called as glycosidic linkage.

Sucrose is a biomolecule with glycosidic linkage.



Sucrose

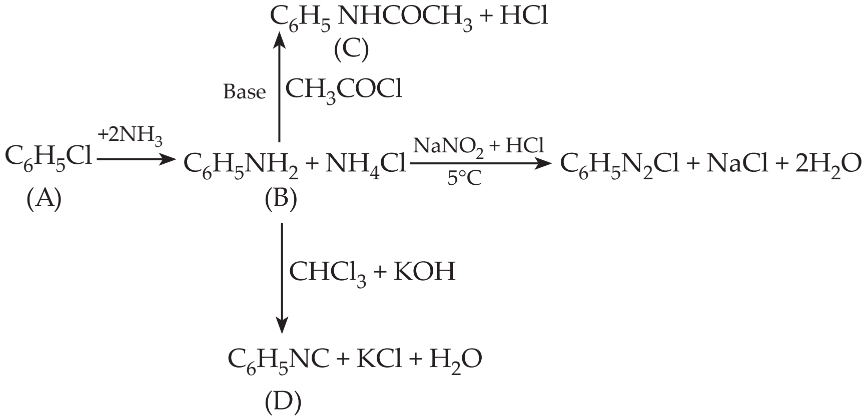
Answer 6.

(i) A ⟶ Chlorobenzene C_6H_5Cl

B ⟶ Aniline $C_6H_5NH_2$

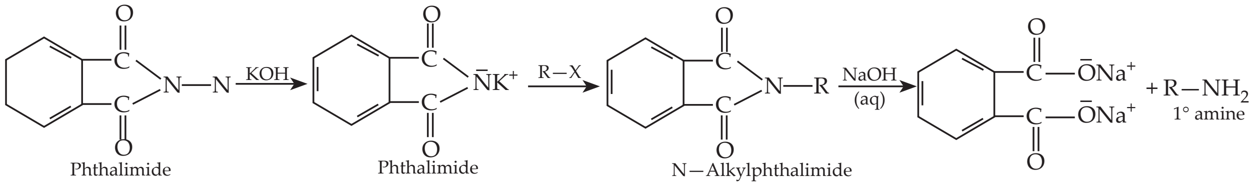
C ⟶ Acetanilide $C_6H_5NHCOCH_3$

D ⟶ Phenyl isocyanide C_6H_5NC



$$\begin{tikzcd}
& \underset{(C)}{C_6H_5\,NHCOCH_3 + HCl} & \\
\underset{(A)}{C_6H_5Cl} \arrow[r, "+2NH_3"] & \underset{(B)}{C_6H_5NH_2} + NH_4Cl \arrow[u, "\text{Base}", "CH_3COCl"'] \arrow[d, "CHCl_3 + KOH"] \arrow[r, "NaNO_2 + HCl", "5^\circ C"'] & C_6H_5N_2Cl + NaCl + 2H_2O \\
& \underset{(D)}{C_6H_5NC + KCl + H_2O} &
\end{tikzcd}$$

(ii) A nucleophile in the form of an imide ion is formed the reaction of KOH with phthalimide. The nucleophilic imide ion attacks the electrophilic carbon of the alkyl halide. The nitrogen atom subsequently replaces the halogen (Fluorine, Chlorine, Bromine or Iodine) in the alkyl halide and bonds with the carbon itself. This results in the formation of an N-Alkyl Phthalimide.



Hydrolysis of this phthalimide yields a primary alkyl amine. In other words, in the process of hydrolysis of pthalamide, the hydroxide ion attacks the carbon atom bonded to the nitrogen atom, cleaving the N-Alkyl phthalimide and the cation in the base attaches itself to the oxygen atom as well. However, Aryl amines cannot be prepared via Gabriel synthesis as aryl halides do not undergo simple nucleophilic substitution.

Answer 7.

(i) Hydrogen bonds between —CO— and —NH— group of amino acids stabilize the α-helix structure of proteins.

(ii) The K_a value of α-aminoacids are very low because in α-aminoacids, the acidic group is $-NH_3^+$ instead of $-COOH$ group in a carboxylic acids, similarly the K_b values of α-amino acids are very low because the basic group is $-COO$ instead of $-NH_2$ group in aliphatic amines.

Answer 8.

The rate law may be expressed as

Rate = $k[A]^p [B]^q$

Comparing experiments 2 and 3

$(\text{Rate})_2 = k[0.2]^p [1.0]^q = 8.4 \times 10^{-3}$ ...(i)

$(\text{Rate})_3 = k[0.2]^p [2.0]^q = 8.4 \times 10^{-3}$ ...(ii)

Dividing eq^n. by (ii) by (i),

$$\frac{(\text{Rate})_3}{(\text{Rate})_2} = \frac{k[0.2]^p [2.0]^q}{k[0.2]^p [1.0]^q} = \frac{8.4 \times 10^{-3}}{8.4 \times 10^{-3}}$$

$[2]^q = [2]^0$ or $q = 0$.

Comparing experiments (i) and (ii)

$(\text{Rate})_2 = k[0.20]^p [1.0]^q = 8.4 \times 10^{-3}$ ...(iii)

$(\text{Rate})_1 = k[0.10]^p [1.0]^q = 2.1 \times 10^{-3}$ ...(iv)

Dividing eq^n. (iii) by (iv),

$$\frac{(\text{Rate})_2}{(\text{Rate})_1} = \frac{k[0.20]^p [1.0]^q}{k[0.10]^p [1.0]^q} = \frac{8.4 \times 10^{-3}}{2.7 \times 10^{-3}} = 4$$

$[2]^q = [2]^2$ or $q = 2$.

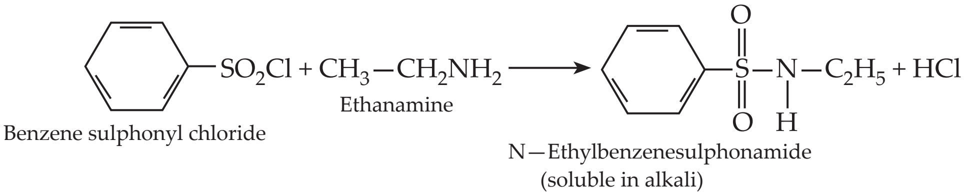
order with respect to A = 2.

order with respect to B = 0.

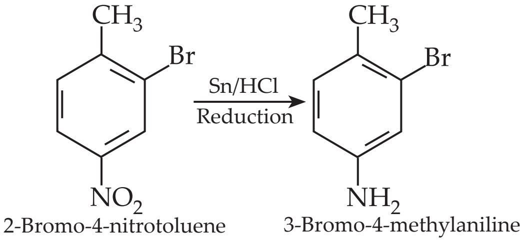
overall order of reaction = 2.

Answer 9.

(i)



(ii)

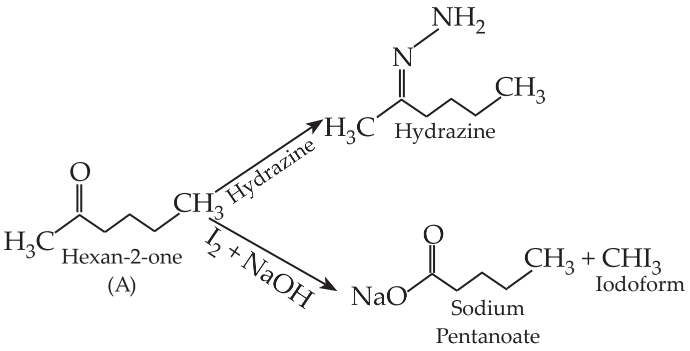


Answer 10.

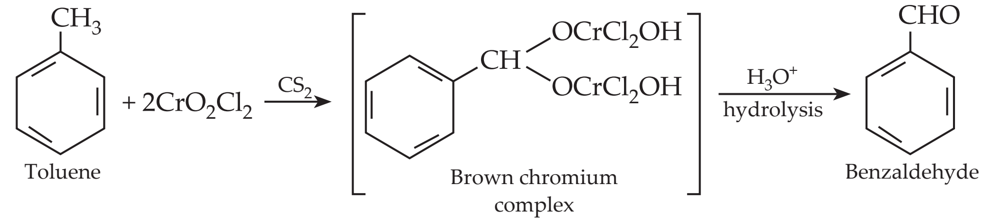
(i) The compound A forms a derivative with hydrazine means it contains a carbonyl group and as the compound A does not give reaction with Tollen's reagent, it does not have an aldehyde group. So, the compound A is a ketone.

Also, the compound A gives the iodoform reaction with iodine and sodium hydroxide. It contains a methyl group next to the carbonyl group. So, the structure of compound A is $CH_3CO(CH_2)_3CH_3$, *i.e.*, Hexan-2-one.

The reactions can be explained as follows :



(ii)



Section-C

Answer 11.

(i) (a) For a zero order reaction $k = 0.0030 \text{ mol L}^{-1} \text{ s}^{-1}$

$$[A]_0 = 0.10\text{M}, [A] = 0.075\text{M}$$

$$K_0 = \frac{[A]_0 - [A]}{t}$$

$$t = \frac{[A]_0 - [A]}{K_0} = \frac{0.10 - 0.075}{0.0030} = 8.33\text{s}$$

(b) Order of the reaction is zero because the rate of reaction is independent of the concentration of reactants.

OR

(ii) (a) Rate law may be written as

Rate = $k[\text{NO}]^p\,[\text{Cl}_2]^q$

The initial rate becomes

$(\text{Rate})_0 = k[\text{NO}]^p\,[\text{Cl}_2]^q$

Comparing experiment 1 and 2

$(\text{Rate})_1 = k(0.15)^p\,(0.15)^q = 0.60$ ...(i)

$(\text{Rate})_2 = k(0.15)^p\,(0.30)^q = 1.20$ ...(ii)

Dividing equation (ii) by (i)

$$\frac{(\text{Rate})_2}{(\text{Rate})_1} = \frac{k(0.15)^p\,(0.30)^q}{k(0.15)^p\,(0.15)^q} = \frac{1.20}{0.60}$$

or

$2^q = 2^1$

$q = 1$

Order with respect to $\text{Cl}_2 = 1$

comparing experiment (i) and (iii)

$(\text{Rate})_1 = k(0.15)^p\ (0.15)^q = 0.60$ ...(i)

$(\text{Rate})_2 = k(0.30)^p\ (0.15)^q = 2.40$ ...(iii)

Dividing equation (ii) by (i)

$$\frac{(\text{Rate})_3}{(\text{Rate})_1} = \frac{k(0.30)^p\ (0.15)^q}{k(0.15)^p\ (0.15)^q} = \frac{2.40}{0.60}$$

or

$2^p = 4$

$2^p = 2^2$

$p = 2$

Thus order with respect to NO is 2.

(b) The rate law for the reaction Rate = $k[\text{NO}]^2\ [\text{Cl}_2]^1$

Rate constant can be calculated by substituting the value of rate, [NO] and $[\text{Cl}_2]$ for any experiment

$$k = \frac{\text{Rate}}{[\text{NO}]^2[\text{Cl}]} = \frac{0.60}{(0.15)^2\ (0.15)}$$

$$= \frac{0.60}{0.003375} = 177.77\ \text{mol}^{-2}\ \text{L}^{-2}\ \text{min}^{-}$$

(c) Let initial rate of disappearance of Cl_2 in exp. 4 is r_4.

Therefore,

$r_4 = k[\text{NO}]^2\ [\text{Cl}_2]$

$= 177.77 \times (0.25)^2\ (0.25)$

$= 2.78$ M/min

Answer 12.

(i) (a) $3d^3$ (Vanadium) : + 2, + 3, + 4 and + 5

(b) $3d^8$ (Nickel) : + 2 + 3 (in complexes)

(ii) As the value of reduction potential increase, the stability of + 2 oxidation state increases. Therefore, correct order of stability is

$$\text{Cr}^{3+}\ |\ \text{Cr}^{2+} < \text{Fe}^{3+}\ |\ \text{Fe}^{2+} < \text{Mn}^{3+}\ |\ \text{Mn}^{2+}$$

Answer 13.

(i) CFSE for tetrahedral complex = $\frac{4}{9}$ CFSE of octahedral complex

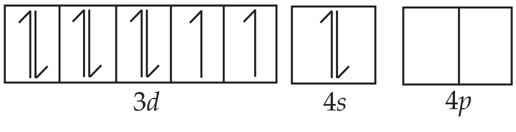
$$= \frac{4}{9} \times 18{,}000 = 8000\ \text{cm}^{-1}$$

(ii) (a) Tetrahedral, sp^3

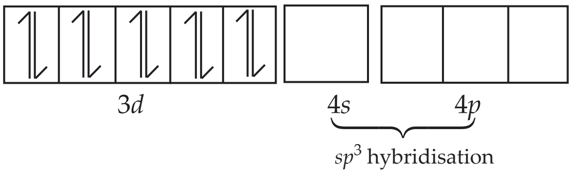
The valence shell electronic configuration of ground state Ni atom is $3d^8\ 4s^2$.

All of these 10 electrons are pushed into $3d$ orbitals and get paired up when strong field CO ligands approach Ni atom. The empty $4s$ and three $4p$ orbitals undergo sp^3 hybridization and form bonds with CO ligands to give Ni(CO)_4. Thus Ni(CO)_4 is diamagnetic. Thus, according to VBT sp^3 hybridization have tetrahedral geometry.

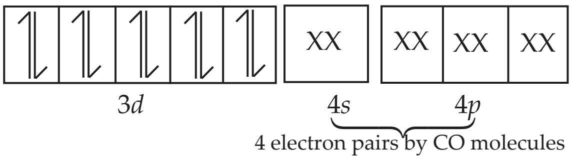
Ni (Z = 28)



Hybridised sp^3 orbitals of Ni



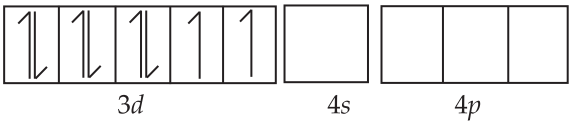
Formation of $[NiCO)_4]$



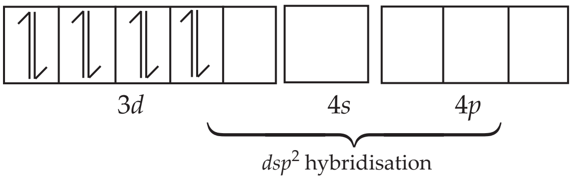
(b) Square planar, dsp^2

In $[Ni(CN)_4]^{2-}$, there is Ni^{2+} ion for which the electronic configuration in the valence shell is $3d^8\ 4s^0$. In presence of strong field CN^- ions, all the electrons are paired up. The empty $4d$, $3s$ and two $4p$ orbitals undergo dsp^2 hybridization to make bonds with CN^- ligands in square planar geometry. Thus $[Ni(CN)_4]^{2-}$ is diamagnetic.

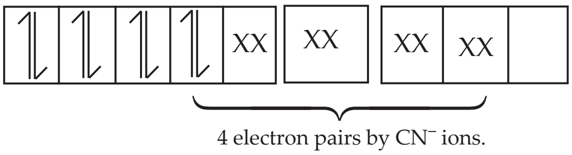
Ni^{2+} ion



dsp^2 hybridised orbitals of Ni^{2+} ion



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



Answer 14.

(i) The water obtained from natural sources often contain suspended impurities. Alum is added to such water to coagulate the suspended impurities and make water fit for drinking purposes.

(ii) Gelatin is a lyophilic sol. Gold sol is a lyophobic sol. When gelatin is added to gold sol, it acts as a stabilizing agent as it protects the gold sol by forming a layer of gelatin particles around each gold particle. Due to this, the gold colloidal particles cannot come in contact with electrolytes.

(iii) When KI solution is added to $AgNO_3$ solution, positively charged sol results due to adsorption of Ag^+ ions from dispersion medium.

❑❑