Maharashtra State Board
Chemistry
Sample Question Paper - 2
Academic Year: 2024-2025

General Instructions: The question paper is divided into four sections.

1. **Section A**: Q.No.1 contains Ten multiple-choice types of questions carrying One mark each. Q.No.2 contains Eight very short answer type of questions carrying One mark each.
2. **Section B**: Q.No.3 to Q.No.14 are Twelve short answer type questions carrying Two marks each. (Attempt any Eight).
3. **Section C:** Q.No.15 to Q.No.26 are Twelve short answer type questions carrying Three marks each. (Attempt any Eight).
4. **Section D**: Q.No.27 to Q.No.31 are Five Long answer-type questions carrying Four marks each. (Attempt any Three).
5. Use of Log table is allowed. Use of calculator is not allowed.
6. Figures to the right indicate full marks.
7. For each multiple-choice type question, it is mandatory to write the correct answer along with its alphabet. e.g., (a) .... /(b) .... /(c) .... /(d) .... ,etc. No mark(s) shall be given if ONLY the correct answer or the alphabet of the correct answer is written.
   Only the first attempt will be considered for evaluation.

SECTION - A

Q1. Select and write the correct answer for the following multiple-choice type of questions:

1.1. Choose the most correct option.

Components of Nichrome alloy are _______.

1. Ni, Cr, Fe
2. Ni, Cr, Fe, C
3. Ni, Cr

4. Cu, Fe

Solution

Components of Nichrome alloy are **Ni, Cr**.

Explanation:

This alloy is typically made up of 80% nickel and 20% chromium. It can also be found in other ratios.

1.2. Choose the most correct option.

Pressure cooker reduces cooking time for food because _______.

1. **boiling point of water involved in cooking is increased**
2. heat is more evenly distributed in the cooking space
3. the higher pressure inside the cooker crushes the food material
4. cooking involves chemical changes helped by a rise temperature

Solution

Pressure cooker reduces cooking time for food because **boiling point of water involved in cooking is increased**.

Explanation:

The boiling point of a substance is the temperature at which the vapour pressure of a liquid equals the pressure surrounding the liquid and the liquid changes to vapour.

Normally, when we cook food, the temperature inside rises until the water begins to boil. The temperature of the system will not rise at boiling point because heat is utilised to boil the water.

However, when we cook food in a pressure cooker, the temperature at which water boils rises as the pressure within the pressure cooker rises.

As the surrounding pressure rises, so does the boiling point temperature. As a result, instead of boiling the water, the heat will raise the temperature of the system. Food cooks faster at higher temperatures because cooking reactions speed up.

1.3. Choose the most correct option.

A living cell contains a solution which is isotonic with 0.3 M sugar solution. What osmotic pressure develops when the cell is placed in 0.1 M KCl solution at body temperature?

1. 5.08 atm
2. 2.54 atm
3. 4.92 atm
4. 2.46 atm

Solution

2.54 atm

Explanation:

$\pi = i_1M_1RT - i_2M_2RT$

$= [(1 \times 0.3 \text{ mol dm}^{-3}) - (2 \times 0.1 \text{ mol dm}^{-3})] \times 0.08205 \text{ atm dm}^3 \text{ K}^{-1} \text{ mol}^{-1} \times 310 \text{ K}$

$= 2.54$ atm

1.4. Choose the most correct option.

Which of the following is not correct?

1. Gibbs energy is an extensive property
2. Electrode potential or cell potential is an intensive property
3. Electrical work = – ΔG
4. If half-reaction is multiplied by a numerical factor, the corresponding E° value is also multiplied by the same factor.

Solution

If half-reaction is multiplied by a numerical factor, the corresponding E° value is also multiplied by the same factor.

1.5. Choose the correct option from the given alternatives.

The number of carbon atoms present in the ring of ε-caprolactam is ______.

1. Five
2. Two

3. Seven
4. Six

Solution

The number of carbon atoms present in the ring of ε-caprolactam is **six**.

1.6. In which reaction mechanism carbocation is formed?

1. SN_1
2. SN_2
3. Both SN_1 and SN_2
4. None of them

Solution

SN_1

1.7. Select appropriate answers for the following.

Which of the following has highest electron gain enthalpy?

1. Fluorine
2. Chlorine
3. Bromine
4. Iodine

Solution

Chlorine

Explanation:

Chlorine is larger in size and has a lower electronegativity value than fluorine. As a result, it readily accepts an electron and has the highest electron gain enthalpy value.

1.8. Isobutylamine is an example of ______.

1. 2° amine
2. 3° amine
3. 1° amine

4. quaternary ammonium salt

Solution

Isobutylamine is an example of **1° amine**.

Explanation:

The general formula for isobutylamine is $(CH_3)_2-CH-CH_2-NH_2$. It is an ammonia derivative where the ammonia's solitary hydrogen atom is replaced with an isobutyl group. Therefore, in addition to the two **N−H** bonds that are present and belong to a primary amine, isobutylamine also contains a secondary carbon atom.

1.9. The molecule of glucose is also called ______.

1. Glucopyranose
2. Pyranose
3. Rabinose
4. None of them

Solution

The molecule of glucose is also called **glucopyranose**.

1.10. Choose the most correct answer :

For pH > 7 the hydronium ion concentration would be _________.

1. 10^{-7}M
2. $< 10^{-7}$M
3. $> 10^{-7}$M
4. $\geq 10^{-7}$M

Solution

For pH > 7 the hydronium ion concentration would be $\mathbf{< 10^{-7}M}$.

Q2. Answer the following questions:

2.1. Answer the following in one sentence.

Write examples of addition polymers and condensation polymers.

Solution

1. **Addition polymers:** Polythene, Teflon, Polyacrylonitrile, Polyvinylchloride (PVC), etc.
2. **Condensation polymers:** Terylene, Nylon-6,6, Bakelite, Novolac, etc.

2.2. Why tryptophan is an essential amino acid?

Solution

Tryptophan is on essential amino acid because it cannot be synthesised by human body.

2.3. Answer in one sentence.

Which amide does produce ethanamine by Hofmann bromamide degradation reaction?

Solution

Propanamide ($C_2H_5CONH_2$) produces ethanamine by Hofmann bromamide degradation reaction.

2.4. Answer in one sentence/ word.

Write the name of the electrophile used in Kolbe's Reaction.

Solution

Carbon dioxide

2.5. Answer the following in one or two sentences.

What is the relationship between coefficients of reactants in a balanced equation for an overall reaction and exponents in the rate law? In what case the coefficients are the exponents?

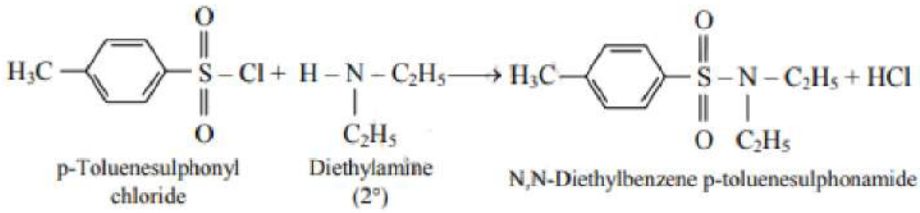
Solution

Coefficients of reactants in a balanced chemical equation may or may not be the same as the exponents in rate law for the same reaction. For elementary reaction, coefficients in a balanced chemical equation are the same as the exponents in the rate law.

2.6. Answer in one sentence.

Write the reaction of p-toluenesulphonyl chloride with diethylamine.

Solution



2.7. Answer the following in brief.

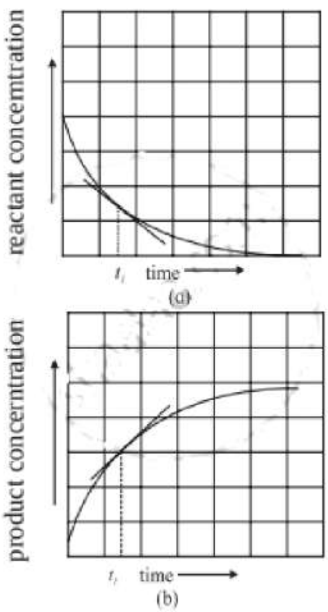
How instantaneous rate of reaction is determined?

Solution

To determine the instantaneous rate of a reaction the progress of a reaction is followed by measuring the concentrations of a reactant or product for different time intervals.

ii. The concentration of a reactant or a product is plotted against time.

iii. A tangent drawn to the curve at time t_1 gives the rate of the reaction. The slope thus obtained gives the instantaneous rate of the reaction at time t_1.



Determination of instantaneous rate

iv. Mathematically the instantaneous rate is expressed by replacing Δ by derivative dc/dt in the expression of the average rate.

Instantaneous rate = $\frac{d[C]}{dt}$

v. For a reaction A ⟶ B

Instantaneous rate of consumption of A at time t = $-\frac{d[A]}{dt}$

Instantaneous rate of the formation of B at time t = $\frac{d[B]}{dt}$

Therefore, instantaneous rate of the reaction at time t = $-\frac{d[A]}{dt} = \frac{d[B]}{dt}$

2.8. Name a compound where Frenkel defect is found.

Solution

AgCl

SECTION – B

Attempt any EIGHT of the following questions:

Q3. Why alkyl halides though polar are immiscible with water?

Solution

Alkyl halides are polar molecules, therefore, their molecules are held together by dipole-dipole attraction. The molecules of H_2O are held together by H-bonds. Since the new forces of attraction between water and alkyl halide molecules are weaker than the force of attraction already existing between alkyl halide - alkyl halide molecules and water - water molecules therefore alkyl halides are immiscible (not soluble) in water. Alkyl halide are neither able to form H-bonds with water nor able to break the H-bonding network of water.

Q4. Answer in brief.

What are ionization isomers ? Give an example.

Solution

Isomers that involve the exchange of ligands between coordination and ionization spheres are called ionization isomers.

e.g. $[Co(NH_3)_5SO_4]Br$ and $[Co(NH_3)_5Br]SO_4$

Q5. What is Henry's law?

Solution

It states that the solubility of a gas in a liquid is directly proportional to the pressure of the gas over the solution. Thus, S α P or $S = K_HP$. Where, S is the solubility of the gas in mol L^{-1}, P is the pressure of the gas in bar over the solution. K_H, the proportionality constant is called Henry's law constant.

Q6. Answer the following.

What are isotonic and hypertonic solutions?

Solution

i. **Isotonic solutions:** Two or more solutions having the same osmotic pressure are said to be isotonic solutions.
e.g. For example, 0.1 M urea solution and 0.1 M sucrose solution are isotonic because their osmotic pressures are equal. Such solutions have the same molar concentrations but different concentrations in g/L. If these solutions are separated by a semipermeable membrane, there is no flow of solvent in either direction.

ii. **Hypertonic solution:** If two solutions have unequal osmotic pressures, the more concentrated solution with higher osmotic pressure is said to be the hypertonic solution.
e.g. For example, if osmotic pressure of sucrose solution is higher than that of urea solution, the sucrose solution is hypertonic to urea solution.

Q7. Give scientific reasons:

α-Amino acids have high melting points compared to the corresponding amines or carboxylic acids of comparable molecular mass.

Why α-amino acids have high melting points compared to the corresponding amines or carboxylic acids of comparable molecular mass?

Solution

i. This is due to the peculiar structure called zwitter ion structure of α -amino acids.

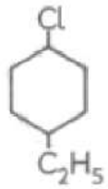
ii. α-Amino acid molecule contains both acidic carboxyl (–COOH) group as well as basic amino ($-NH_2$) group.

iii. Proton transfer from the acidic group to the basic group of amino acid forms a salt, which is a dipolar ion called zwitter ion.

Thus, α-amino acids have high melting points compared to the corresponding amines or carboxylic acids of comparable molecular mass.

Q8.

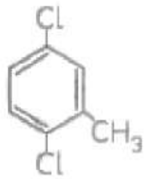
8.1. Write IUPAC names of following compounds.



Solution

1-Chloro-4-ethylcyclohexane

8.2. Write IUPAC names of following compounds.



Solution

1, 4-Dichloro-2-methylbenzene

Q9. Answer the following in brief.

Construct a galvanic cell from the electrodes Co^{3+} | Co and Mn^{2+}/Mn. E°_{Co} = 1.82 V, E°_{Mn} = –1.18 V. Calculate E°_{cell}

Solution

Given:

E°_{Co} = 1.82 V,

E°_{Mn} = –1.18 V.

To find: E°_{cell} and cell representation

Formulae: $E^{\circ}_{cell} = E^{\circ}_{Cathode} - E^{\circ}_{anode}$

Calculation: Electrode reactions are

At anode: $3\left(Mn_{(s)} \rightarrow Mn^{2+}_{(aq)} + 2e^-\right)$

At cathode: $2\left(Co^{3+}_{(aq)} + 3e^- \rightarrow Co_{(s)}\right)$

The cell is composed of Mn (anode),

$Mn_{(s)} \left| Mn^{2+}_{(aq)} \right.$ and $Co(cathode), Co^{3+}_{(aq)} \left| Co_{(s)} \right.$

The cell is represented as:

$Mn_{(s)} \left| Mn^{2+}_{(aq)} \right| \left| Co^{3+}_{(aq)} \right| Co_{(s)}$

The standard electrode potential is given by

$E^\circ_{cell} = E^\circ_{Cathode} - E^\circ_{anode}$

= 1.82 V – (–1.18 V)

= 3.00 V

The standard cell potential is 3.00 V.

Q10. Answer the following in one or two sentences.

Write Nernst equation. What part of it represents the correction factor for nonstandard state conditions?

Solution

1) For any general reaction, aA + bB ⟶ cC + dD

Nernst equation is given by

$$E_{cell} = E^\circ_{cell} - \frac{RT}{nF} \ln \frac{[C]^c [D]^d}{[A]^a [B]^b} \text{ OR}$$

$$E_{cell} = E^\circ_{cell} - \frac{2.303RT}{nF} \log_{10} \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

where n = moles of electrons used in the reaction, F = Faraday = 96500 C,

T = temperature in kelvin,

R = gas constant = 8.314 J K^{-1} mol^{-1}

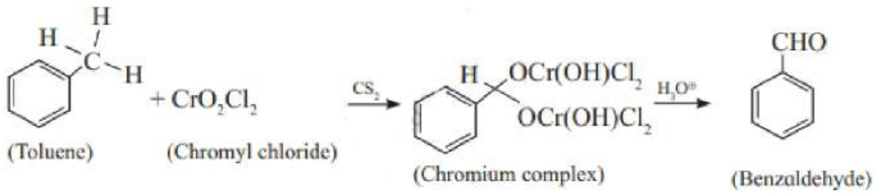
2) The second term in the Nernst equation is the correction for nonstandard state conditions.

Correction factor is $\frac{2.303RT}{nF} \log_{10} \frac{[C]^c [D]^d}{[A]^a [B]^b}$

Q11. Give the reactions involved in the Etard's reaction.

Solution

The reactions involved in the Etard's reaction are:



Q12. Answer the following in brief :

What are acids and bases according to Arrhenius theory?

Solution

According to Arrhenius theory, acids and bases are defined as follows:

i. Acid: An acid is a substance that contains hydrogen and gives H^+ ions in an aqueous solution.

e.g.

$$HCl_{(aq)} \xrightarrow{water} H^+_{(aq)} + Cl^-_{(aq)};$$

$$CH_3COOH_{(aq)} \overset{water}{\rightleftharpoons} H^+_{(aq)} + CH_3COO^-_{(aq)}$$

ii. Base: A base is a substance that contains the OH group and produces hydroxide ions (OH^- ions) in aqueous solution.

e.g.

$$NaOH_{(aq)} \xrightarrow{water} Na^+_{(aq)} + OH^-_{(aq)};$$

$$NH_4OH_{(aq)} \overset{water}{\rightleftharpoons} NH^+_{4(aq)} + OH^-_{(aq)}$$

Q13. Give reason:

Alkyl halides are generally not prepared by free radical halogenation of alkanes.

Solution

Free radical halogenation of alkanes leads to the formation of a mixture of mono and poly halogen compounds. Hence, free radical halogenation of alkanes is not suitable for the preparation of alkyl halides.

Q14.

14.1. Answer the following

Give the full form (long form) of the name for following instrument.

XRD

Solution

X-ray diffraction

14.2. Answer the following

Give the full form (long form) of the name for the following instrument.

TEM

Solution

Transmission Electron Microscope

SECTION – C

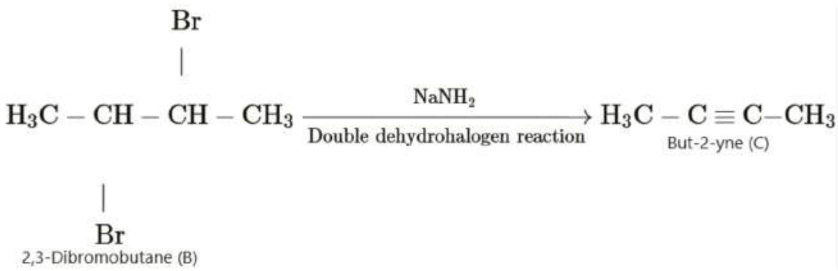
Attempt any EIGHT of the following questions:

Q15. Complete the following reaction sequence by writing the structural formulae of the organic compound 'A', 'B' and 'C'.

$$\text{2-Bromobutane} \xrightarrow{\text{Alc} \cdot \text{KOH}} \text{A} \xrightarrow[\text{Br}_2]{} \text{B} \xrightarrow[\text{NaNH}_2]{} \text{C}$$

Solution

$$\underset{\text{2-Bromobutane}}{\mathrm{H_3C - \overset{\displaystyle Br \atop |}{C}H - CH_2CH_3}} \xrightarrow[-\text{KBr}]{\text{Alc} \cdot \text{KOH}} \underset{\substack{\text{But-2-ene} \\ \text{(Major) (A)}}}{\mathrm{H_3C - CH = CH - CH_3}} \xrightarrow{\text{Br}_2}$$



Q16. The vapour pressure of water at 20°C is 17 mm Hg. What is the vapour pressure of solution containing 2.8 g urea in 50 g of water?

Solution

Given: Vapour pressure of pure water = P_1^0 = 17 mm Hg

Mass of urea (W_2) = 2.8 g

Mass of water (W_1) = 50 g

To find: Vapour pressure of the solution (P_1)

Formula: $\frac{P_1^0 - P_1}{P_1^0} = \frac{W_2 M_1}{M_2 W_1}$

Calculation:

Molar mass of urea (NH_2CONH_2) = 14 + 2 + 12 + 16 + 14 + 2 = 60 g mol^{-1}

Molar mass of water = 18 g mol^{-1}

Now, using formula,

$$\frac{P_1^0 - P_1}{P_1^0} = \frac{W_2 M_1}{M_2 W_1}$$

$$= \frac{17\text{mm Hg} - P_1}{17\text{mm Hg}} = \frac{2.8g \times 18g\,mol^{-1}}{50g \times 60g\,mol^{-1}}$$

$$\therefore \frac{17\text{mm Hg} - P_1}{17\text{mm Hg}} = 0.0168$$

∴ 17 mm Hg – P_1 = 0.0168 × 17 mm Hg

∴ 17 mm Hg – P_1 = 0.2856 mm Hg

∴ P_1 = 17 mm Hg – 0.2856 mm Hg = 16.71 mm Hg

Vapour pressure of the given solution is 16.71 mm Hg.

Q17.

17.1. What are pseudo-first-order reactions?

Solution

Certain reactions that are expected to be of higher order follow the first-order kinetics. Such reactions are said to be pseudo-first-order reactions.

17.2. Answer the following in brief.

Give one example and explain why it is pseudo-first-order.

Solution

Example: Consider the hydrolysis of methyl acetate.

$CH_3COOCH_{3(aq)} + H_2O_{(l)} \longrightarrow CH_3COOH_{(aq)} + CH_3OH_{(aq)}$

The rate law is rate = k' $[CH_3COOCH_3][H_2O]$

Explanation: The reaction was expected to follow the second-order kinetics, however, obeys the first order. The reason is that solvent water is present in such large excess that the change in its concentration is negligible compared to the initial one or its concentration remains constant. Thus $[H_2O]$ = constant = k''. The rate law becomes rate = k' $[CH_3COOCH_3]$k'' = k $[CH_3COOCH_3]$

where, k = k'k''

The reaction is thus of first order.

Q18. Attempt the following:

Write preparation, properties and uses of Teflon.

Solution

Preparation of teflon:

i. The monomer used in preparation of teflon is tetrafluoroethylene, ($CF_2 = CF_2$), which is a gas at room temperature.

ii. Tetrafluoroethylene is polymerized by using free-radical initiators such as hydrogen peroxide or ammonium persulphate at high pressure to produce polytetrafluoroethylene (teflon).

$$\underset{\text{Tetrafluoroethylene}}{n\,CF_2 = CF_2} \xrightarrow[\text{Peroxide}]{\text{Polymerization}} \underset{\text{Teflon}}{[-CF_2 - CF_2 -]_n}$$

Properties of teflon:

i. Teflon is tough, chemically inert and resistant to heat and attack by corrosive reagents.

ii. C – F bond is very difficult to break and remains unaffected by corrosive alkali, organic solvents.

Uses: Teflon is used in making non-stick cookware, oil seals, gaskets, etc.

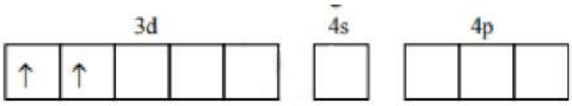
Q19. Answer the following question.

Give valence bond description for the bonding in the complex $[VCl_4]^-$. Draw box diagrams for the free metal ion. Which hybrid orbitals are used by the metal? State the number of unpaired electrons.

Solution

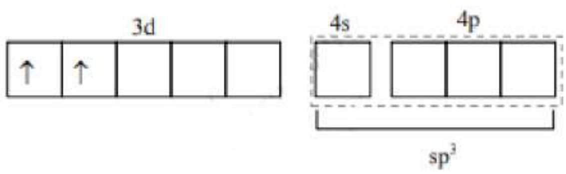
i. The oxidation state of vanadium is +3

ii. Valence shell electronic configuration of free metal ion, V^{3+}



iii. The number of Cl^- ligands is 4. Therefore, the number of vacant metal ion orbitals required for bonding with ligands must be four.

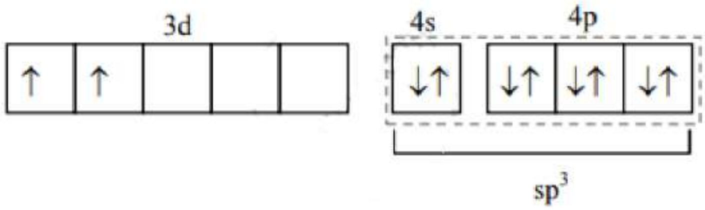
iv. Four orbitals on metal available for hybridisation are one s and three 4p. The complex is tetrahedral.



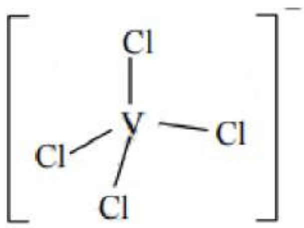
v. The four metal ion orbitals for bonding with Cl^- ligands are derived from the sp^3 hybridization.

vi. Four vacant sp^3 hybrid orbitals of V^{3+} overlap with four orbitals of Cl^- ions.

vii. Configuration after complex formation would be



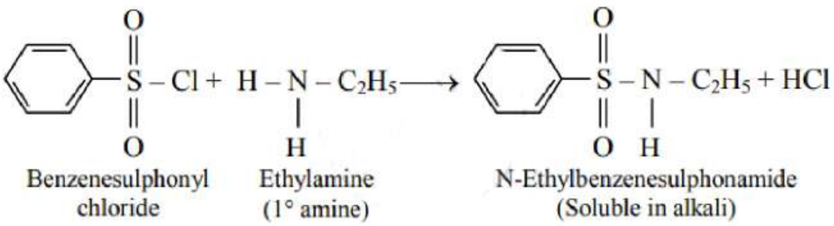
viii. The complex has two unpaired electrons. The structure of $[VCl_4]^-$ is



Q20. Distinguish between ethylamine, diethylamine, and triethylamine by using Hinsberg's reagent?

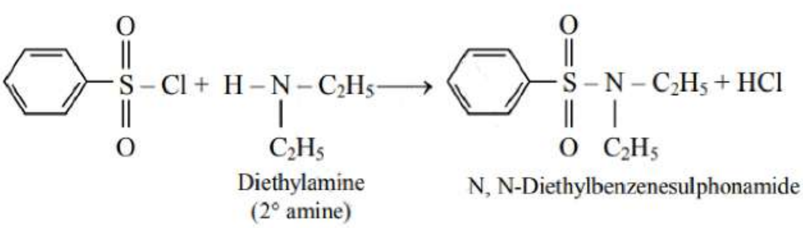
Solution

i. Ethylamine (primary amine) reacts with benzenesulphonyl chloride to form N-ethylbenzenesulphonyl amide.



The hydrogen attached to nitrogen in N-ethylbenzene sulphonamide is strongly acidic. Hence it is soluble in alkali.

ii. Diethylamine reacts with benzene-sulphonyl chloride to give N, N-diethyl benzene sulphonamide.



N, N-diethylbenzenesulphonamide does not contain any H-atom attached to the nitrogen atom. Hence it is not acidic and does not dissolve in alkali.

iii. Triethylamine does not react with benzenesulphonyl chloride (i.e., Hinsberg's reagent) as it does not contain any H-atom attached to the nitrogen atom.

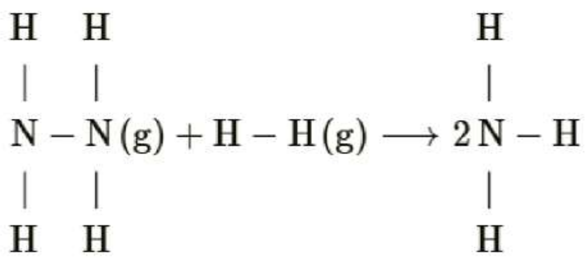
Q21.

21.1. Calculate the standard enthalpy of:

$N_2H_{4(g)} + H_{2(g)} \longrightarrow 2NH_{3(g)}$

If $\Delta H^0(N - H) = 389\ kJ\ mol^{-1}$, $\Delta H^0(H - H) = 435\ kJ\ mol^{-1}$, $\Delta H^0(N - N) = 159\ kJ\ mol^{-1}$.

Solution



$\Delta_r H^0 = \sum \Delta H^0(\text{reactant}) - \sum \Delta H^0(\text{product})$

$= [4\Delta H^0(N - H) + \Delta H^0(N - N) + \Delta H^0(H - H)] - [6\Delta H^0(N - H)]$

$= \Delta H^0(N - N) + \Delta H^0(H - H) - 2\Delta H^0(N - H)$

$= 1 \times 159 + 1\ mol \times 435 - 2 \times 389$

$= -184\ kJ$

21.2. The enthalpy change of the following reaction:

$CH_{4(g)} + Cl_{2(g)} \longrightarrow CH_3Cl_{(g)} + HCl_{(g)} \Delta H^0 = -104 kJ$

Calculate C – Cl bond enthalpy. The bond enthalpies are:

Bond	C – H	Cl – Cl	H – Cl
$\Delta H°/kJ\ mol^{-1}$	414	243	431

Solution

Given: $\Delta_r H^0 = -104\ kJ$

ΔH^0 (C – H) = 414 kJ mol^{-1}

ΔH^0 (Cl – Cl) = 243 kJ mol^{-1}

ΔH^0 (H – Cl) = 431 kJ mol^{-1}

To find: C – Cl bond enthalpy, ΔH^0 (C – Cl)

Formula: $\Delta_r H^0 = \sum \Delta H^\circ$(reactant bonds) − $\sum \Delta H^0$ (product bonds)

Calculation: $\Delta_r H^0 = \Sigma\ \Delta H^0$ (reactant bonds) – $\Sigma\ \Delta H^0$ (product bonds)

$= [4\ \Delta H^0(C - H) + \Delta H^\circ(Cl - Cl)] - [3\ \Delta H^0(C - H) + \Delta H^0(C - Cl) + \Delta H^0(H - Cl)]$

$= \Delta H^0(C - H) + \Delta H^0(Cl - Cl) - \Delta H^0(C - Cl) - \Delta H^0(H - Cl)$ −104 kJ

$\therefore$ = 1 mol × (414 kJ mol^{-1}) + 1 mol × (243 kJ mol^{-1}) – $\Delta H^0(C - Cl)$ – 1 mol × (431 kJ mol^{-1})

$\therefore$ −104 kJ = 226 kJ – $\Delta H^\circ(C - Cl)$

$\therefore\ \Delta H^0(C - Cl)$ = 226 kJ + 104 kJ

$\therefore\ \Delta H^0(C - Cl)$ = 330 kJ mol^{-1}

C – Cl bond enthalpy is 330 kJ mol^{-1}.

Q22. Write a note on Stephen reaction.

Solution

Nitriles are reduced to imine hydrochloride by stannous chloride in presence of hydrochloric acid which on acid hydrolysis give corresponding aldehydes. This reaction is called Stephen reaction.

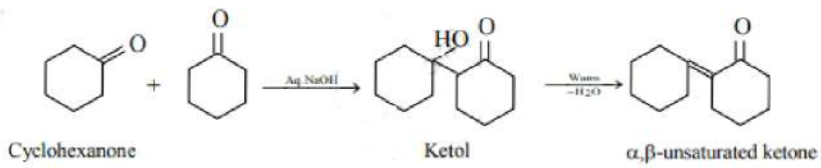
$$\underset{\text{(Alkane nitrile)}}{R - C \equiv N} + 2\,[H] \xrightarrow{SnCl_2,\ HCl} \underset{\text{(Imine hydrochloride)}}{R - HC = NH \cdot HCl} \xrightarrow{H_3O^+} \underset{\text{(Aldehyde)}}{R - CHO} + NH_4Cl$$

e.g. $$\underset{\text{(Ethanenitrile)}}{H_3C - C \equiv N} + 2\,[H] \xrightarrow[\text{(reduction)}]{SnCl_2,\ HCl} \underset{\text{(Ethanimine hydrochloride)}}{CH_3 - HC = NH \cdot HCl} \xrightarrow{H_3O^+} \underset{\text{(Ethanal)}}{CH_3 - CHO} + NH_4Cl$$

Q23.

23.1. Write reaction showing aldol condensation of cyclohexanone.

Solution



23.2. How acetone is converted into propane.

Solution

$$\underset{\text{(Acetone)}}{H_3C - \overset{\overset{\displaystyle CH_3}{|}}{C} = O} + 4\,[H] \xrightarrow[\Delta]{\text{Zn–Hg, conc}\cdot\text{HCl}} \underset{\text{(propane)}}{H_3C - \overset{\overset{\displaystyle CH_3}{|}}{CH_2}} + H_2O$$

23.3. How propanal is converted into propane.

Solution

$$\underset{\text{(Propanal)}}{CH_3 - CH_2 - CHO} + 4\,[H] \xrightarrow[\Delta]{\text{Zn–Hg, conc}\cdot\text{HCl}} \underset{\text{(Propane)}}{CH_3 - CH_2 - CH_3} + H_2O$$

Q24. Aluminium crystallises in a cubic close-packed structure with a unit cell edge length of 353.6 pm. What is the radius of Al atom? How many unit cells are there in 1.00 cm^3 of Al?

Solution

Using the formula (i),

r = 0.3535 a

∴ r = 0.3535 × 353.6 = 125 pm

Using the formula (ii),

$$\text{Number of unit cells in volume (V) of metal} = \frac{V}{a^3}$$

$$\therefore \text{Number of unit cells in 1.00 cm}^3\text{ of Al} = \frac{1.00}{(3.536 \times 10^{-8})^3}$$

$= 2.26 \times 10^{22}$

a. Radius of Al atom (r) is 125 pm.

b. Number of unit cells in 1.00 cm^3 of Al is 2.26×10^{22}.

Q25. Answer the following

What is meant by diamagnetic and paramagnetic? Give one example of diamagnetic and paramagnetic transition metal and lanthanoid metal.

Solution

The substances with all electrons paired are weakly repelled by magnetic fields. Such substances are called diamagnetic substances.

The substances with unpaired electrons are weakly attracted by the magnetic field. Such substances are called paramagnetic substances.

Examples:

	Transition metal	**Lanthanoid metal**
Diamagnetic	Zinc	Ytterbium
Paramagnetic	Titanium	Cerium

Q26. Answer the following question.

State Hess's law of constant heat summation. Illustrate with an example. State its applications.

Solution

1. Hess's law of constant heat summation:

Hess's law of constant heat summation states that "Overall the enthalpy change for a reaction is equal to the sum of enthalpy changes of individual steps in the reaction".

2. Illustration:

- The enthalpy change for a chemical reaction is the same regardless of the path by which the reaction occurs. Hess's law is a direct consequence of the fact that enthalpy is a state function. The enthalpy change of a reaction depends only on the initial and final states and not on the path by which the reaction occurs.
- To determine the overall equation of the reaction, reactants and products in the individual steps are added or subtracted like algebraic entities.
- Consider the synthesis of NH_3,

1. $2\,H_{2(g)} + N_{2(g)} \longrightarrow N_2H_{4(g)},\ \Delta_r\,H_1^0 = +95.4\,kJ$
2. $N_2H_{4(g)} + H_{2(g)} \longrightarrow 2\,NH_{3(g)},\ \Delta_r\,H_2^0 = -187.6\,kJ$

$$H_{2(g)} + N_{2(g)} \longrightarrow 2\,NH_{3(g)},\ \Delta_r H^0 = -92.2\,kJ$$

The sum of the enthalpy changes for steps (1) and (2) is equal to the enthalpy change for the overall reaction.

3. Application of Hess's law:

The Hess's law has been useful to calculate the enthalpy changes for the reactions with their enthalpies being not known experimentally. To calculate heat of formation, combustion, neutralization, ionization, etc.

SECTION – D

Attempt any THREE of the following questions:

Q27. Give the properties of Lanthanoids.

Solution

The properties of lanthanoids are:

i. Soft metals with silvery white colour and moderate densities of 7 g cm^{-3}. Colour and brightness reduces on exposure to air.

ii. Good conductors of heat and electricity.

iii. Except for promethium (Pm), all are non-radioactive in nature.

iv. The atomic and ionic radii decrease from lanthanum (La) to lutetium (Lu). This is known as lanthanoid contraction.

v. Binding to water is common (i.e.,) such that H_2O is often found in products when isolated from aqueous solutions.

vi. Coordination numbers usually are greater than 6, typically 8, 9.... (up to 12 found).

vii. The Lonthonoides are strongly paramagnetic. Gadolinium becomes ferromagnetic below 16°C (Curie point). The other heavier Lothonoids terbium, dysprosium, holmium, erbium, thulium, and ytterbium become ferromagnetic at much lower temperatures.

viii. Magnetic and optical properties are Largely independent of environment (similar spectra in gas/solution/solid).

Q28.

28.1. Answer the following.

Give two reactions showing the oxidising property of concentrated H_2SO_4.

Answer the following.

Give two chemical reactions to explain oxidizing property of concentrated H_2SO_4.

Solution

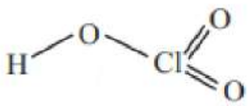
Metals and nonmetals both are oxidized by hot, concentrated sulfuric acid which itself gets reduced to SO_2.

1. $\underset{\text{Copper}}{\mathrm{Cu}} + \underset{\substack{\text{Sulfuric} \\ \text{acid (Conc}\cdot)}}{2\,\mathrm{H_2SO_4}} \longrightarrow \underset{\substack{\text{Copper} \\ \text{sulphate}}}{\mathrm{CuSO_4}} + \underset{\substack{\text{Sulfur} \\ \text{dioxide}}}{\mathrm{SO_2}} + 2\,\mathrm{H_2O}$
2. $\underset{\text{Sulphuric}}{\mathrm{S}} + \underset{\substack{\text{Sulfuric} \\ \text{acid (Conc}\cdot)}}{2\,\mathrm{H_2SO_4}} \longrightarrow \underset{\substack{\text{Sulfur} \\ \text{dioxide}}}{3\,\mathrm{SO_2}} + 2\,\mathrm{H_2O}$

28.2. Draw the structures of the $HClO_3$.

Solution

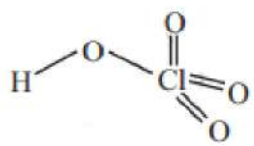
Chloric acid, $HClO_3$



28.3. Write the structure of $HClO_4$.

Solution

Perchloric acid, $HClO_4$



Q29. Describe the manufacturing of H_2SO_4 by the contact process.

Write chemical reactions in the manufacture of sulfuric acid by contact process.

Solution

Sulfuric acid is manufactured by the contact process, which involves the following three steps.

1) Roasting in air:

Sulfur or sulfide ore (iron pyrites) on burning or roasting in air produces sulfur dioxide.

i) $\underset{\text{Sulfur}}{S_{(s)}} + O_{2(g)} \xrightarrow{\Delta} \underset{\text{Sulfur dioxide}}{SO_{2(g)}}$

ii) $\underset{\text{Iron sulfide}}{4\,FeS_{2(s)}} + 11\,O_{2(g)} \xrightarrow{\Delta} 2\,Fe_2O_{3(s)} + \underset{\text{Sulfur dioxide}}{8\,SO_{2(g)}}$

2) Catalytic oxidation of sulfur dioxide:

i) Sulfur dioxide is oxidised catalytically with oxygen to sulfur trioxide, in the presence of V_2O_5 catalyst.

$$\underset{\text{Sulfur dioxide}}{2\,SO_{2(g)}} + O_{2(g)} \xrightarrow{V_2O_5} \underset{\text{Sulfur trioxide}}{2\,SO_{3(g)}}$$

ii) The reaction is exothermic and reversible and the forward reaction leads to decrease in volume. Therefore, low temperature (720K) and high pressure (2 bar) are favourable conditions for maximum yield of SO_3.

3) Absorption, followed by dilution of sulfur trioxide gas:

i) Sulfur trioxide gas (from the catalytic converter) is absorbed in concentrated H_2SO_4 to produce oleum.

$$\underset{\text{Sulfur trioxide}}{SO_3} + H_2SO_4 \longrightarrow \underset{\text{Oleum}}{H_2S_2O_7}$$

ii) Dilution of oleum with water gives sulfuric acid of desired concentration.

$$\underset{\text{Oleum}}{H_2S_2O_7} + H_2O \longrightarrow \underset{\text{Sulfuric acid}}{2\,H_2SO_4}$$

iii) The sulfuric acid obtained by contact process is 96-98 % pure.

Q30. The density of iridium is 22.4 g/cm^3. The unit cell of iridium is fcc. Calculate the radius of iridium atom. Molar mass of iridium is 192.2 g/mol.

Solution

Given: Type of unit cell is fcc.

Density of iridium (ρ) = 22.4 g/cm^3

Molar mass of iridium = 192.2 g/mol

To find: Radius of iridium atom (r)

Formula used:

1. Density (ρ) = $\frac{M\,n}{a^3 N_A}$

2. For fcc unit cell, r = 0.3535 a

Calculation: For fcc unit cell, n = 4, using formula (i)

$$\text{Density } (\rho) = \frac{M\,n}{a^3 N_A}$$

$$22.4\text{g cm}^{-3} = \frac{192.2\text{g mol}^{-1} \times 4 \text{ atom}}{a^3 \times 6.022 \times 10^{23}\text{atom mol}^{-1}}$$

$$a^3 = \frac{192.2 \times 4}{22.4 \times 6.022 \times 10^{23}}$$

$$a = \sqrt[3]{\frac{192.2 \times 4}{22.4 \times 6.022 \times 10^{23}}}$$

$$= \sqrt[3]{\frac{192.2 \times 4 \times 10^{-23}}{22.4 \times 6.022}}$$

$$= \sqrt[3]{\frac{192.2 \times 40 \times 10^{-24}}{22.4 \times 6.022}}$$

$$= \sqrt[3]{\frac{192.2 \times 40 \times (10^{-8})^3}{22.4 \times 6.022}}$$

$$= \sqrt[3]{\frac{192.2 \times 40}{22.4 \times 6.022}} \times 10^{-8}$$

= 3.849×10^{-8} cm

= 384.9 pm

Using formula (ii)

r = 0.3535 a

r = 0.3535 × 384.9 pm

= 135.7 pm ≈ 136 pm

Radius of iridium atom (r) is 136 pm.

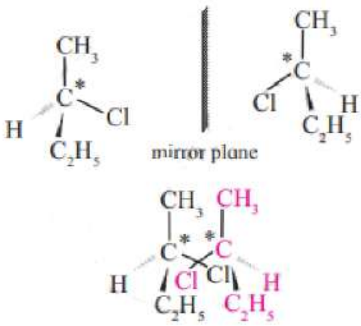
Q31. Explain optical isomerism in 2-chlorobutane.

Solution

i. The stereoisomerism in which the isomers have different spatial arrangements of groups/atoms around a chiral atom is called optical isomerism.

ii. 2-chlorobutane has one chiral carbon atom. The spatial arrangement of the four different groups around the chiral atom is different.

iii. Structure of 2-chlorobutane and its mirror image can be represented as:



iv. 2-Chlorobutane cannot superimpose perfectly on its mirror image as shown in the figure. Hence, 2-chlorobutane exhibits optical isomerism.