Maharashtra Board Class 12 Chemistry Solutions 2023

SECTION – A

Question 1. Select and write the correct answer for the following multiple choice type of questions:

i. The relation between radius of sphere and edge length in body centered cubic lattice is given by formula:
(A) √3r = 4a
(B) r = √3/a * 4
(C) r = √3/4 a
(D) r = √2/4 * a

Answer. r = √3/4 a

Solution. The answer is (C).

In a body-centered cubic (BCC) lattice, the atoms are arranged in a cubic pattern with an atom in the center of each cube. The radius of the sphere is the distance from the center of an atom to the nearest edge of the cube. The edge length of the cube is the distance from one corner of the cube to the opposite corner.

The relationship between the radius of the sphere and the edge length of the cube can be found using the Pythagorean theorem. The body diagonal of a cube is the distance from one corner of the cube to the opposite corner through the center of the cube. In a BCC lattice, the body diagonal is equal to four times the radius of the sphere. The edge length of a cube is equal to the square root of three times the body diagonal.

Therefore, the relationship between the radius of the sphere and the edge length of the cube is:

$r = a / \sqrt{3}$

where:

- r is the radius of the sphere
- a is the edge length of the cube

Therefore, the correct answer is (C).

ii. The pH of weak monoacidic base is 11.2, its OH^- ion concentration is:
(A) 1.585×10^{-3} mol dm^{-3}
(B) 3.010×10^{-11} mol dm^{-3}
(C) 3.010×10^{-3} mol dm^{-3}
(D) 1.585×10^{-11} mol dm^{-3}

Answer. (A) 1.585 × 10–3 mol dm–3

Solution. The correct answer is (A) 1.585 × 10–3 mol dm–3.

The pH of a solution is a measure of its acidity or basicity. It is defined as the negative logarithm of the hydrogen ion concentration ([H+]) in moles per liter (mol/L). The hydroxide ion concentration ([OH–]) is related to the pH by the following equation:

pH + pOH = 14

where pOH is the negative logarithm of the hydroxide ion concentration ([OH–]) in mol/L.

In a weak monoacidic base, the base dissociates only partially into hydroxide ions and water. The equilibrium expression for the dissociation of a weak monoacidic base is:

B + H2O ⇌ BH+ + OH–

where B is the base, BH+ is the conjugate acid of the base, and K is the base dissociation constant.

The concentration of hydroxide ions in a solution of a weak monoacidic base can be calculated using the following equation:

[OH–] = √(KB)

where KB is the base dissociation constant.

Given that the pH of the solution is 11.2, we can calculate the pOH using the following equation:

pOH = 14 - pH

pOH = 14 - 11.2

pOH = 2.8

Then, we can calculate the hydroxide ion concentration using the following equation:

[OH–] = 10^(-pOH)

[OH–] = 10^(-2.8)

[OH–] = 1.585 × 10–3 mol dm–3

Therefore, the hydroxide ion concentration in a solution of a weak monoacidic base with a pH of 11.2 is 1.585 × 10–3 mol dm–3.

iii. Which of the following correctly represents integrated rate law equation for a first order reaction in gas phase:
(A) $k = 2.303 / t * \log_{10} P_i / (P_i - P)$
(B) $k = 2.303 / t * \log_{10} P_i / (2P_i - P)$
(C) $k = 2.303 / t * \log_{10} 2P_i / (P_i - P)$
(D) $k = 2.303 / t * \log_{10} (P_i - P) / 2P_i$

Answer. (A) k = 2.303 / t * log10 Pi / (Pi-P)

Solution. The correct answer is (A) k = 2.303 / t * log10 Pi / (Pi-P).

The integrated rate law for a first-order reaction in gas phase is:

ln(Pi/Pt) = kt

where:

- Pi is the initial pressure of the reactant
- Pt is the pressure of the reactant at time t
- k is the rate constant
- t is the time

We can rearrange this equation to solve for k:

k = 2.303 / t * log10 Pi / (Pi-P)

Therefore, the correct answer is (A) k = 2.303 / t * log10 Pi / (Pi-P).

iv. The spin only magnetic moment of Mn^{2+} ion is _______.
(A) 4.901 BM
(B) 5.916 BM
(C) 3.873 BM
(D) 2.846 BM

Answer. 5.916 BM

Solution. The spin-only magnetic moment of Mn2+ ion is 5.916 BM.

The spin-only magnetic moment is a measure of the magnetic moment of an atom or ion due to the unpaired electrons in its d orbitals. The magnetic moment of an atom or ion is a measure of its strength as a magnet. It is measured in Bohr magnetons (BM), where one Bohr magneton is equal to 9.274 × 10–24 A·m2.

The spin-only magnetic moment of an atom or ion can be calculated using the following formula:

μ = √n(n + 1) * Bohr magneton

where:

- μ is the spin-only magnetic moment
- n is the number of unpaired electrons

The Mn^{2+} ion has five unpaired electrons, so its spin-only magnetic moment is:

$\mu = \sqrt{5(5 + 1)}$ * Bohr magneton

$\mu = 5.916$ BM

Therefore, the correct answer is (B) 5.916 BM.

v. The correct formula of a complex having IUPAC name Tetraamminedibromoplatinum (IV) bromide is ________.
(A) $[PtBr(NH_3)_4]Br_2$
(B) $[PtBr_2(NH_3)_4]Br$
(C) $[PtBr_2(NH_3)_4]Br_2$
(D) $[PtBr(NH_3)_4]Br$

Answer. $[PtBr_2(NH_3)_4]Br_2$

Solution. The correct formula of a complex having the IUPAC name Tetraamminedibromoplatinum (IV) bromide is $[PtBr_2(NH_3)_4]Br_2$.

Here's the breakdown of the IUPAC name:

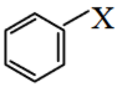
- Tetraammine: This indicates that there are four ammonia (NH_3) ligands coordinated to the central platinum (Pt) atom.
- Dibromoplatinum (IV): This indicates that there are two bromine (Br) ligands bonded to the platinum atom. The (IV) denotes the oxidation state of the platinum atom, which is +4.
- Bromide: This indicates that there is one additional bromine ion present as a counterion to balance the charge of the complex cation.

Therefore, the complete formula is $[PtBr_2(NH_3)_4]Br_2$.

vi. The allylic halide, among the following is _______.

(A) $R - \underset{\displaystyle X}{\underset{|}{CH}} - R$

(B) $CH_2 = CH - X$

(C) 

(D) $CH_2 = CH - CH_2 - X$

vii. The product of following reaction is

$$CH_3 - CH = CH - CH_2 - CHO \xrightarrow[\text{ii) } H_3O^+]{\text{i) LiAlH}_4} \underline{\hspace{3cm}}?$$

(A) CH3 – CH2 – CH2 – CH2 – CH2 – OH
(B) CH3 – CH = CH – CH2 – CH2 – OH
(C) CH3 – CH2 – CH2 – CH2 – COOH
(D) CH3 – CH = CH – CH2 – COOH

viii. Ozonolysis of 2, 3 dimethyl but-2-ene, followed by decomposition by Zn dust and water gives ________.
(A) acetaldehyde
(B) propionaldehyde and acetone
(C) acetone
(D) acetaldehyde and butyraldehyde

Answer. acetone

Solution. The ozonolysis of 2,3-dimethylbut-2-ene results in the formation of an ozonide intermediate. Treatment of this ozonide intermediate with Zn dust and water results in the decomposition of the ozonide and the formation of aldehydes and ketones. The correct answer is (c) acetone.

ix. The glycosidic linkage present in maltose is ________.
(A) α, β-1, 2-glycosidic linkage

(B) α-1, 4-glycosidic linkage
(C) β-1, 4-glycosidic linkage
(D) α-1, 6-glycosidic linkage

Answer. The correct glycosidic linkage present in maltose is:

(B) α-1, 4-glycosidic linkage

x. The monomer of natural rubber is ________.
(A) Isoprene
(B) Acrylonitrile
(C) ε-Caprolactam
(D) Tetrafluoroethylene

Answer. Isoprene

Solution. The correct answer is (A) Isoprene.

Natural rubber is a polymer formed from the polymerization of isoprene, a five-carbon hydrocarbon with the formula C5H8. The polymerization process involves the linking of isoprene units together to form a long chain molecule. The resulting polymer is a flexible, elastic material with a wide range of applications, including tires, hoses, and seals.

Acrylonitrile, ε-caprolactam, and tetrafluoroethylene are monomers of other polymers, namely acrylonitrile-butadiene-styrene (ABS), nylon-6, and polytetrafluoroethylene (PTFE), respectively.

Therefore, the correct answer is (A) Isoprene.

Question 2. Answer the following questions:

i. Write the name of the technique used to know geometry of nanoparticles.

Answer. There are several techniques used to characterize the geometry of nanoparticles. Some of the most common methods include:

Transmission electron microscopy (TEM): This technique uses a beam of electrons to create a high-resolution image of the nanoparticle. The image is formed by the scattering of electrons as they pass through the nanoparticle. TEM can be used to measure the size, shape, and crystallinity of nanoparticles.

Scanning electron microscopy (SEM): This technique uses a beam of electrons to scan the surface of the nanoparticle. The image is formed by the secondary electrons emitted from the surface of the nanoparticle. SEM can be used to measure the size, shape, and surface morphology of nanoparticles.

Atomic force microscopy (AFM): This technique uses a sharp tip to scan the surface of the nanoparticle. The tip interacts with the surface of the nanoparticle to produce a map of its topography. AFM can be used to measure the size, shape, and surface roughness of nanoparticles.

Dynamic light scattering (DLS): This technique measures the diffusion of nanoparticles in a solution. The diffusion coefficient of the nanoparticles is related to their size. DLS can be used to measure the size distribution of nanoparticles in a solution.

Small-angle X-ray scattering (SAXS): This technique measures the scattering of X-rays by nanoparticles in a solution. The scattering pattern is related to the size, shape, and structure of the nanoparticles. SAXS can be used to measure the size distribution, shape, and structure of nanoparticles in a solution.

ii. Write the name of the product formed by the action of LiAlH 4 / ether on acetamide.

Answer. The reaction of acetamide with lithium aluminum hydride (LiAlH4) in ether produces ethylamine as the primary product. This is a reduction reaction where the carbonyl group (C=O) of acetamide is converted to a primary amine (NH2) group.

The reaction can be represented as follows:

$CH_3C(O)NH_2 + 4\ LiAlH_4 \rightarrow CH_3CH_2NH_2 + LiAlO_2 + 3\ H_2$

In this reaction, $LiAlH_4$ acts as a reducing agent, transferring hydrogen atoms to the carbonyl group to form the amine group. The aluminum and oxygen atoms from $LiAlH_4$ form aluminum oxide ($LiAlO_2$) as a by-product.

iii. Write the structure of the product formed when chlorobenzene is treated with sodium metal in the presence of dry ether.

Answer. The reaction of chlorobenzene with sodium metal in the presence of dry ether is known as the Fittig reaction. It produces biphenyl as the main product.

The reaction can be represented as follows:

2 Ph-Cl + 2 Na → Ph-Ph + 2 NaCl

In this reaction, sodium metal acts as a reducing agent, transferring electrons to the chlorine atoms of chlorobenzene to form biphenyl and sodium chloride (NaCl). The dry ether acts as a solvent and helps to prevent side reactions.

iv. Write the chemical composition of cryolite.

Answer. Cryolite is a sodium aluminum fluoride mineral with the chemical formula Na_3AlF_6. It is a colorless or white transparent solid that is found in igneous and metamorphic rocks. Cryolite is a relatively rare mineral, and it is mined in only a few locations around the world.

Cryolite is used in a variety of applications, including:

- Production of aluminum: Cryolite is the main flux used in the Hall–Héroult process for the production of aluminum. The flux lowers the melting point of alumina (Al_2O_3) and allows for the electrolysis of aluminum from its molten salt solution.
- Production of enamels: Cryolite is used as a flux in the production of enamels, which are glassy coatings that are applied to metals to protect them from corrosion and to improve their appearance.

- Production of glass: Cryolite is used as a flux in the production of some types of glass, such as opal glass.

Cryolite is also used in a variety of other applications, such as in the production of ceramics, in the purification of water, and in the pharmaceutical industry.

Here is a table of the chemical composition of cryolite:

Element	Mass fraction (%)
Sodium (Na)	32.85%
Aluminum (Al)	12.85%
Fluorine (F)	54.30%

v. Write the name of platinum complex used in the treatment of cancer.

Answer. Several platinum complexes are used in the treatment of cancer, including:

- Cisplatin (cis-diamminedichloroplatinum(II)): Cisplatin was the first platinum compound discovered to have anticancer activity. It is used to treat a variety of cancers, including testicular cancer, ovarian cancer, lung cancer, and bladder cancer.

- Carboplatin (carboplatin): Carboplatin is a derivative of cisplatin that is less nephrotoxic (toxic to the kidneys) than cisplatin. It is used to treat a similar range of cancers as cisplatin.
- Oxaliplatin (oxaliplatin): Oxaliplatin is a third-generation platinum complex that is used to treat colorectal cancer.
- Satrapplatin (satrapplatin): Satrapplatin is a fourth-generation platinum complex that is being developed for the treatment of solid tumors.

Platinum complexes work by binding to DNA and preventing DNA replication and transcription. This leads to cell death. Platinum complexes are effective in the treatment of many cancers, but they can also cause side effects, such as nausea, vomiting, and hair loss.

Here is a table of some of the platinum complexes used in the treatment of cancer, along with the types of cancer they are used to treat:

Platinum complex	Types of cancer treated
Cisplatin	Testicular cancer, ovarian cancer, lung cancer, bladder cancer
Carboplatin	Ovarian cancer, lung cancer, head and neck cancer, cervical cancer
Oxaliplatin	Colorectal cancer
Satrapplatin	Solid tumors

vi. Write the SI unit of cryoscopic constant.

Answer. The SI unit of the cryoscopic constant is kelvin per kilogram per mole (K kg mol^{-1}). This unit represents the change in temperature (°C) per mole of solute dissolved in one kilogram of solvent.

vii. Write the correct condition for spontaneity in terms of Gibbs energy.

Answer. The condition for spontaneity in terms of Gibbs energy is that the change in Gibbs energy (ΔG) is negative. This means that the system is more likely to proceed in the direction that lowers the Gibbs energy.

The Gibbs energy (G) is a thermodynamic property that represents the available energy in a system. It is defined as:

$G = H - TS$

where:

- H is the enthalpy of the system
- T is the temperature of the system
- S is the entropy of the system

The enthalpy (H) of a system is a measure of its total energy content. The entropy (S) of a system is a measure of its disorder.

The change in Gibbs energy (ΔG) for a process is given by:

$\Delta G = \Delta H - T\Delta S$

where:

- ΔH is the change in enthalpy of the system
- ΔS is the change in entropy of the system

If ΔG is negative, then the process is spontaneous. If ΔG is positive, then the process is non-spontaneous. If ΔG is zero, then the system is at equilibrium.

The spontaneity of a process can also be determined by the sign of the work done by the system. If the work done by the system is positive, then the process is spontaneous. If the work done by the system is negative, then the process is non-spontaneous. If the work done by the system is zero, then the system is at equilibrium.

viii. Calculate molar conductivity for 0.5 M BaCl2 if its conductivity at 298K is 0.01 Ω^{-1} cm^{-1} .

Answer. Sure. To calculate the molar conductivity, we'll use the following formula:

$\Lambda = \kappa / c$

where:

- Λ is the molar conductivity ($S\ m^2\ mol^{-1}$)
- κ is the conductivity ($S\ cm^{-1}$)
- c is the concentration (mol/L)

Given:

- $\kappa = 0.01\ S\ cm^{-1}$
- c = 0.5 mol/L

Plugging in the values:

$\Lambda = 0.01\ S\ cm^{-1} / 0.5\ mol/L = 0.02\ S\ m^2\ mol^{-1}$

Therefore, the molar conductivity of 0.5 M BaCl2 at 298K is 0.02 $S\ m^2\ mol^{-1}$.

SECTION − B

Attempt any EIGHT of the following questions:

Question 3. Distinguish between lanthanides and actinides.

Answer. Lanthanides and actinides are two groups of elements that are similar in many ways, but there are also some key differences between them.

Lanthanides

- Position in the periodic table: The lanthanides are a series of 15 elements that are located in the 6th period of the periodic table, between lanthanum and lutetium.
- Electron configuration: The lanthanides have the general electron configuration $[Xe]6s^2 4f^n$, where n can be 1 to 7.
- Chemical properties: The lanthanides are all metals that are relatively reactive. They tend to form ionic compounds with oxidation states of +3. They are also known for their unique magnetic properties.
- Occurrence in nature: The lanthanides are found in relatively small amounts in the Earth's crust. They are typically mined from minerals such as monazite and bastnasite.

Actinides

- Position in the periodic table: The actinides are a series of 15 elements that are located in the 7th period of the periodic table, between actinium and lawrencium.
- Electron configuration: The actinides have the general electron configuration $[Rn]6s^2 5f^n$, where n can be 0 to 14.
- Chemical properties: The actinides are all metals that are very radioactive. They tend to form ionic compounds with oxidation states ranging from +2 to +7. They are also known for their complex and varied chemical behavior.

- Occurrence in nature: The actinides are found in very small amounts in the Earth's crust. They are typically produced synthetically from nuclear reactions.

Here is a table summarizing the key differences between lanthanides and actinides:

Feature	Lanthanides	Actinides
Position in the periodic table	6th period	7th period
Electron configuration	$[Xe]6s^2 4f^n$	$[Rn]6s^2 5f^n$
Chemical properties	Relatively reactive metals	Very radioactive metals
Oxidation states	Typically +3	Range from +2 to +7
Occurrence in nature	Found in relatively small amounts	Found in very small amounts
Production	Typically mined from minerals	Typically produced synthetically

As you can see, lanthanides and actinides are similar in many ways, but there are also some key differences between them. The lanthanides are a series of stable metals that are found in nature, while the actinides are a series of radioactive metals that are typically produced synthetically. The lanthanides are also known for their unique magnetic properties, while the actinides are known for their complex and varied chemical behavior.

Question 4. Calculate the mole fraction of solute, if the vapour pressure of pure benezene at certain temperature is 640 mmHg and vapour pressure of solution of a solute in benzene is 600 mmHg.

Answer. Sure, here is the calculation of the mole fraction of solute in benzene:

Raoult's law states that the vapor pressure of a solution is directly proportional to the mole fraction of the solvent in the solution. This can be expressed mathematically as:

$P_1 = x_1 P_0$

where:

- P_1 is the vapor pressure of the solution
- x_1 is the mole fraction of the solvent
- P_0 is the vapor pressure of the pure solvent

In this case, we are given that the vapor pressure of pure benzene (P_0) is 640 mmHg and the vapor pressure of a solution of a solute in benzene (P_1) is 600 mmHg. We want to calculate the mole fraction of the solute (x_2).

To do this, we can rearrange Raoult's law to solve for x_2:

$x_2 = (P_0 - P_1) / P_0$

Substituting in the given values:

$x_2 = (640 \text{ mmHg} - 600 \text{ mmHg}) / 640 \text{ mmHg} = 0.0625$

Therefore, the mole fraction of solute in benzene is 0.0625.

Question 5. Define: Green chemistry. Write two advantages of nanoparticle and nanotechnology.

Answer. Sure, here is a definition of green chemistry and two advantages of nanoparticles and nanotechnology:

Green chemistry is the design of chemical products and processes that minimize or eliminate the use or generation of hazardous substances. It is a branch of chemistry that seeks to reduce the environmental impact of chemical processes.

Green chemistry principles include:

- Prevention: It is better to prevent waste than to treat or clean it up after it is created.
- Atom economy: All atoms in a chemical synthesis should be incorporated into the final product.
- Less hazardous chemical syntheses: Chemical syntheses should be designed to use and generate less hazardous substances.
- Design for increased energy efficiency: Chemical processes should be designed to use less energy.
- Use of renewable feedstocks: Chemical processes should use renewable feedstocks whenever possible.
- Design for degradation: Chemical products should be designed to break down into harmless substances after they are used.
- Prevention of pollution: Chemical processes should be designed to prevent pollution.

Nanoparticles are particles that have at least one dimension on the nanoscale, which is typically 1 to 100 nanometers. Nanoparticles have unique properties that make them useful in a variety of applications.

Advantages of nanoparticles include:

- Increased surface area: Nanoparticles have a large surface area to volume ratio, which makes them very reactive. This can be used to develop new catalysts and sensors.
- Enhanced optical properties: Nanoparticles can absorb and emit light in a way that is different from bulk materials. This can be used to develop new materials with improved optical properties.
- Unique mechanical properties: Nanoparticles can have unique mechanical properties, such as increased strength and hardness. This can be used to develop new materials with improved mechanical properties.

Nanotechnology is the study and manipulation of matter on the nanoscale. It is a rapidly growing field with the potential to revolutionize many industries.

Advantages of nanotechnology include:

- Development of new materials: Nanotechnology can be used to develop new materials with improved properties, such as increased strength, hardness, and conductivity.
- Improved medical diagnostics and treatments: Nanotechnology can be used to develop new medical diagnostics and treatments, such as drug delivery systems and imaging agents.
- Environmental remediation: Nanotechnology can be used to clean up polluted water and soil.

Nanoparticles and nanotechnology have the potential to revolutionize many industries and improve our lives in many ways. However, it is important to research and develop these technologies in a responsible way to ensure that they are used safely and ethically.

Question 6. Explain the following terms:
i. Substitutional impurity defect

Answer. Sure, here is an explanation of the term "substitutional impurity defect":

A substitutional impurity defect is a type of point defect in a crystal lattice where an atom of one kind is replaced by an atom of another kind. The substituted atom is called an impurity atom. Impurity atoms can be either larger or smaller than the host atoms.

Substitutional impurity defects can have a significant impact on the properties of crystals. For example, they can:

- Change the electrical conductivity of the crystal. If the impurity atom has a different valence than the host atom, it can create an electron donor or acceptor site, which can change the conductivity of the crystal.
- Change the mechanical properties of the crystal. Impurity atoms can distort the crystal lattice, which can make the crystal more brittle or less ductile.
- Change the optical properties of the crystal. Impurity atoms can absorb or emit light, which can change the color or transparency of the crystal.

Substitutional impurity defects are common in all crystalline materials. They are typically introduced during the growth of the crystal from a melt or solution. The concentration of impurity atoms can be controlled by the conditions of the growth process.

Here are some examples of substitutional impurity defects:

- In silicon, phosphorus atoms can replace silicon atoms. This creates an electron donor site, which increases the conductivity of the silicon.
- In zinc oxide, zinc atoms can be replaced by magnesium atoms. This creates an electron acceptor site, which decreases the conductivity of the zinc oxide.

- In sodium chloride, sodium atoms can be replaced by calcium atoms. This distorts the crystal lattice, which makes the sodium chloride more brittle.
- In diamond, carbon atoms can be replaced by nitrogen atoms. This creates a color center, which makes the diamond yellow.

Substitutional impurity defects are an important area of study in solid-state physics and materials science. They play a role in many important technological applications, such as semiconductors, transistors, and solar cells.

ii. Interstitial impurity defect

Answer. Sure, here is an explanation of the term "interstitial impurity defect":

An interstitial impurity defect is a type of point defect in a crystal lattice where an atom of one kind is inserted into a space between the host atoms. The inserted atom is called an impurity atom. Impurity atoms are typically smaller than the host atoms.

Interstitial impurity defects can also have a significant impact on the properties of crystals. For example, they can:

- Increase the density of the crystal. The impurity atom adds mass to the crystal without increasing its volume, which increases the density of the crystal.
- Change the mechanical properties of the crystal. Interstitial impurity atoms can distort the crystal lattice, which can make the crystal harder or more brittle.
- Change the optical properties of the crystal. Interstitial impurity atoms can absorb or emit light, which can change the color or transparency of the crystal.

Interstitial impurity defects are also common in all crystalline materials. They can be introduced during the growth of the crystal from a melt or solution, or they can be created by diffusion of impurity atoms into the crystal from the surrounding environment.

Here are some examples of interstitial impurity defect:

- In iron, carbon atoms can occupy interstitial sites in the iron lattice. This increases the hardness and strength of the iron, which is why carbon is added to iron to make steel.
- In silicon, oxygen atoms can occupy interstitial sites in the silicon lattice. This creates a deep level acceptor site, which reduces the conductivity of the silicon.
- In zinc oxide, hydrogen atoms can occupy interstitial sites in the zinc oxide lattice. This creates a color center, which makes the zinc oxide blue.

Interstitial impurity defects are also an important area of study in solid-state physics and materials science. They play a role in many important technological applications, such as semiconductors, transistors, and solar cells.

Question 7. Write the chemical reactions for the following:
i. Chlorobenzene is heated with fuming H2 SO4

Answer. The reaction of chlorobenzene with fuming H2SO4, also known as chlorobenzene sulfonation, is an important reaction in organic chemistry that produces chlorobenzenesulfonic acid. This reaction is an example of electrophilic aromatic substitution (EAS), where the sulfur trioxide (SO3) present in fuming H2SO4 acts as an electrophile and attacks the benzene ring of chlorobenzene.

The overall reaction can be represented as follows:

$Ph\text{-}Cl + H_2SO_4 + SO_3 \rightarrow Ph\text{-}SO_3H + HCl + H_2O$

where:

- Ph-Cl represents chlorobenzene
- H2SO4 represents sulfuric acid
- SO3 represents sulfur trioxide
- Ph-SO3H represents chlorobenzenesulfonic acid
- HCl represents hydrochloric acid
- H2O represents water

The reaction mechanism involves several steps:

1. Protonation of sulfuric acid: The first step involves the protonation of sulfuric acid by sulfur trioxide to form HSO3H.

H2SO4 + SO3 → HSO3H + SO4

2. Generation of the electrophile: HSO3H is a stronger acid than sulfuric acid and can act as a proton donor. It donates a proton to a molecule of sulfuric acid to form SO3H+.

HSO3H + H2SO4 → SO3H+ + HSO4-

3. Attack on the benzene ring: The electrophile, SO3H+, attacks the electron-rich carbon atom of the benzene ring, forming a σ-complex.

Ph-Cl + SO3H+ → Ph-SO3H+Cl-

4. Rearrangement and deprotonation: The σ-complex rearranges to form a more stable intermediate, and then deprotonates to eliminate a proton and form chlorobenzenesulfonic acid.

Ph-SO3H+Cl- → Ph-SO3H + HCl

5. Regeneration of the catalyst: The catalyst, HSO4-, is regenerated in the process.

HSO4- + H2O → H2SO4 + H3O+

The chlorobenzene sulfonation reaction is reversible, and the equilibrium can be shifted towards the formation of chlorobenzenesulfonic acid by using an excess of fuming H2SO4 and carrying out the reaction at elevated temperatures. The reaction is also sensitive to the position of the chlorine substituent on the benzene ring, with ortho and para isomers being favored over meta isomers.

This reaction has various industrial applications, including the production of detergents, dyes, and pharmaceuticals. It also serves as a synthetic route for the preparation of other organic compounds.

ii. Ethyl bromide is heated with silver acetate

Answer. The reaction of ethyl bromide with silver acetate, also known as the Fittig reaction, is a nucleophilic substitution reaction that produces ethyl acetate and silver bromide. This reaction is an example of an SN2 reaction, where the nucleophile, the acetate ion (CH3COO-), attacks the electrophile, the ethyl bromide (CH3CH2Br), and displaces the bromide ion.

The overall reaction can be represented as follows:

CH3CH2Br + CH3COO- → CH3CH2OOCCH3 + AgBr

where:

- CH3CH2Br represents ethyl bromide
- CH3COO- represents acetate ion
- CH3CH2OOCCH3 represents ethyl acetate
- AgBr represents silver bromide

The reaction mechanism involves several steps:

1. Formation of the transition state: The nucleophile, acetate ion, approaches the electrophile, ethyl bromide, from the back side. This forms a three-centered transition state, where the carbon atom of the ethyl bromide is partially bonded to both the bromide ion and the acetate ion.
2. Bond formation and cleavage: In the transition state, the bond between the carbon atom of the ethyl bromide and the bromide ion weakens, while the bond between the carbon atom of the ethyl

bromide and the acetate ion forms. This leads to the formation of ethyl acetate and silver bromide.

The Fittig reaction is a useful synthetic method for preparing alkyl acetates from alkyl halides. It is also used in the production of perfumes and fragrances.

Question 8. Define : Acidic buffer solution. Write the relationship between solubility and solubility product for PbI2 .

Answer. Sure, here are the definitions of "acidic buffer solution" and the relationship between solubility and solubility product for PbI2:

Acidic buffer solution

An acidic buffer solution is a solution that can resist changes in pH when small amounts of acid or base are added to it. This is because the buffer solution contains both a weak acid and its conjugate base. The weak acid can donate protons (H+) to the solution, while the conjugate base can accept protons. When a small amount of acid is added to the buffer solution, the conjugate base will accept the protons, preventing the pH from changing significantly. Conversely, when a small amount of base is added to the buffer solution, the weak acid will donate protons, preventing the pH from changing significantly.

Buffer solutions are important in many biological and chemical processes, as they help to maintain a stable pH environment. For example, buffer solutions are used in the body to maintain the pH of blood, which is critical for many physiological processes. Buffer solutions are also used in the laboratory to control the pH of chemical reactions.

Relationship between solubility and solubility product for PbI2

The solubility product (Ksp) for a compound is a constant that expresses the equilibrium between the solid compound and its ions in solution. The Ksp for a compound is given by the following equation:

Ksp = [A^+][B^-]^n

where:

- A and B are the ions of the compound
- n is the stoichiometric coefficient of the compound in the dissociation equation

For PbI2, the dissociation equation is:

$PbI2(s) \rightleftharpoons Pb^{2+}(aq) + 2I^{-}(aq)$

Therefore, the Ksp for PbI2 is:

$Ksp = [Pb^{2+}][I^{-}]^{2}$

The solubility of a compound is the maximum amount of the compound that can be dissolved in a given amount of solvent at a given temperature. The solubility of a compound is related to its Ksp by the following equation:

$S = \sqrt{(Ksp)}$

where:

- S is the solubility of the compound

In the case of PbI2, the Ksp is 8.0×10^{-9}, so the solubility of PbI2 is 1.41×10^{-4} mol/L at 25°C.

The relationship between solubility and Ksp can be used to predict the solubility of a compound in a solution that contains a common ion. For example, if we add Pb^{2+} to a solution of PbI2, the solubility of PbI2 will decrease. This is because the common ion will increase the concentration of I^{-} in the solution, which will decrease the Ksp. The decrease in Ksp will cause the solubility of PbI2 to decrease according to the equation:

$S = \sqrt{(Ksp)}$

The relationship between solubility and Ksp is an important concept in chemistry, and it has many applications in chemical analysis and environmental chemistry.

Question 9. What is the action of the following reagents on ethyl amine
i. Chloroform and caustic potash

Answer. When ethyl amine ($CH_3CH_2NH_2$) is heated with chloroform ($CHCl_3$) in the presence of alcoholic KOH (potassium hydroxide), it undergoes a reaction known as the Carbyl amine reaction or the isocyanide synthesis. This reaction produces ethyl isocyanide (CH_3CH_2NC) as the main product, along with potassium chloride (KCl) and water (H_2O).

The overall reaction can be represented as follows:

$$CH_3CH_2NH_2 + CHCl_3 + 3KOH \rightarrow CH_3CH_2NC + 3KCl + 3H_2O$$

The mechanism of this reaction involves the following steps:

1. Formation of the intermediate: The hydroxide ion (OH^-) from KOH deprotonates the ethyl amine to form the ethylamine anion ($CH_3CH_2N^-$), which acts as a nucleophile.
2. Attack on chloroform: The ethylamine anion attacks the carbon atom of chloroform, forming a carbanion intermediate.
3. Elimination of chloride ion: The chloride ion (Cl^-) is eliminated from the carbanion intermediate, forming ethyl isocyanide.
4. Formation of potassium chloride and water: The chloride ion combines with potassium ion (K^+) from KOH to form potassium chloride, and the hydroxide ion combines with water to form water.

The Carbyl amine reaction is a useful synthetic method for preparing alkyl isocyanides from primary amines. Alkyl isocyanides are organic compounds with a characteristic pungent odor and have various applications in the pharmaceutical, agrochemical, and fragrance industries.

ii. Nitrous acid

Answer. Ethyl amine ($CH_3CH_2NH_2$) reacts with nitrous acid (HNO_2) to produce ethanol (CH_3CH_2OH), nitrogen gas (N_2), and water (H_2O). This reaction is known as the deamination reaction or the diazotization reaction.

The overall reaction can be represented as follows:

$CH_3CH_2NH_2 + HNO_2 \rightarrow CH_3CH_2OH + N_2 + H_2O$

The mechanism of this reaction involves the following steps:

1. Formation of the diazonium salt: Nitrous acid deprotonates the ethyl amine to form the ethylamine anion ($CH_3CH_2N^-$), which reacts with nitrous acid to form the ethyl diazonium salt ($CH_3CH_2N_2^+$).
2. Decomposition of the diazonium salt: The ethyl diazonium salt is unstable and decomposes into ethanol, nitrogen gas, and water.

The deamination reaction is a useful synthetic method for preparing alcohols from primary amines. Alcohols are organic compounds with a wide range of applications, including as solvents, fuels, and fragrances.

Safety guidelines:

- Nitrous acid is a toxic and corrosive substance. It should be handled with care and in a well-ventilated area.
- The deamination reaction can produce hazardous fumes. It is important to wear appropriate personal protective equipment (PPE), such as gloves, goggles, and a lab coat, when conducting this reaction.
- The reaction should be carried out in a fume hood to prevent the inhalation of hazardous fumes.
- Waste materials from the reaction should be disposed of properly according to local regulations.

Question 10. Calculate standard Gibbs energy change at 25°C for the cell reaction
$Cd_{(s)} + Sn^{2+}_{(aq)} \rightarrow Cd^{2+}_{(aq)} + Sn_{(s)}$

$E°_{Cd} = –0.403V, E°_{Sn} = –0.136V$

Answer. Sure. Given the standard electrode potentials for cadmium (E°Cd = -0.403 V) and tin (E°Sn = -0.136 V), we can calculate the standard Gibbs energy change (ΔG°) for the cell reaction:

Cd(s) + Sn2+(aq) → Cd2+(aq) + Sn(s)

The standard Gibbs energy change can be calculated using the following equation:

ΔG° = -nFE°cell

where:

- n is the number of electrons transferred in the cell reaction
- F is the Faraday constant (96,485 C/mol)
- E°cell is the standard cell potential

In this case, n = 2 (two electrons are transferred), F = 96,485 C/mol, and E°cell = E°Cd - E°Sn = -0.403 V - (-0.136 V) = -0.267 V.

Substituting these values into the equation, we get:

ΔG° = -2 × 96,485 C/mol × -0.267 V ≈ 51,150 J/mol

Therefore, the standard Gibbs energy change for the cell reaction at 25°C is approximately 51,150 J/mol. Since the value of ΔG° is negative, we know that the reaction is spontaneous under standard conditions.

Question 11. Write chemical reaction for the preparation of glucose from sucrose. Write structure of D-ribose.

Answer. Sure, here is the chemical reaction for the preparation of glucose from sucrose and the structure of D-ribose:

Preparation of glucose from sucrose

Glucose can be prepared in the laboratory by boiling sucrose (cane sugar) with dilute hydrochloric acid or sulfuric acid for about two hours. This hydrolyzes sucrose to glucose and fructose.

The overall reaction can be represented as follows:

$C_{12}H_{22}O_{11} + H_2O \rightarrow C_6H_{12}O_6 + C_6H_{12}O_6$

where:

- $C_{12}H_{22}O_{11}$ represents sucrose
- H_2O represents water
- $C_6H_{12}O_6$ represents glucose
- $C_6H_{12}O_6$ represents fructose

The hydrolysis reaction is catalyzed by the enzyme sucrase, which is found in many plants and animals. The enzyme breaks the glycosidic bond between the glucose and fructose molecules in sucrose, allowing the two monosaccharides to separate.

Structure of D-ribose

D-ribose is a pentose sugar, which means that it has five carbon atoms. It is a component of RNA (ribonucleic acid), and it plays an important role in the structure and function of RNA molecules.

The structure of D-ribose is shown below:

O

|

H-C-(CH2OH)-CHOH-CHO

|

OH

where:

- O represents an oxygen atom
- H represents a hydrogen atom
- C represents a carbon atom
- CH2OH represents a hydroxylmethyl group (-CH2OH)
- CHOH represents a hydroxymethyl group (-CHOH)
- CHO represents an aldehyde group (-CHO)

The hydroxyl groups (OH) on the carbon atoms of ribose can form hydrogen bonds with other molecules, which is important for the structure and function of RNA molecules. The aldehyde group on the first carbon atom of ribose can also react with other molecules to form chemical bonds, which is important for the synthesis of RNA molecules.

Question 12. Define Extensive property. Calculate the work done during the expansion of 2 moles of an ideal gas from 10 dm3 to 20 dm3 at 298 K in vacuum.

Answer. Sure, here is a definition of "extensive property" and the calculation of work done during the expansion of an ideal gas:

Extensive property

An extensive property is a property of a system that depends on the size or amount of matter in the system. Examples of extensive properties include mass, volume, energy, and heat capacity. Extensive properties are additive, meaning that the total value of an extensive property for a system is equal to the sum of the values for the parts into which the system may be divided.

Work done during expansion of an ideal gas

Work (W) done during the expansion of an ideal gas from an initial volume (V1) to a final volume (V2) at a constant temperature (T) can be calculated using the following equation:

$W = -nRT \ln(V2/V1)$

where:

- n is the number of moles of gas
- R is the gas constant (8.314 J/mol·K)
- T is the temperature (in Kelvin)

Given:

- n = 2 mol
- R = 8.314 J/mol·K
- T = 298 K
- V1 = 10 dm^3 = 0.01 m^3
- V2 = 20 dm^3 = 0.02 m^3

Substituting these values into the equation, we get:

$W = -2 \text{ mol} \times 8.314 \text{ J/mol·K} \times 298 \text{ K} \times \ln(0.02 \text{ m}^3 / 0.01 \text{ m}^3) \approx 1585 \text{ J}$

Therefore, the work done during the expansion of 2 moles of an ideal gas from 10 dm^3 to 20 dm^3 at 298 K in a vacuum is approximately 1585 J.

Question 13. Write the reactions for the formation of nylon 6,6 polymer.

Answer. The formation of nylon 6,6 polymer involves the condensation polymerization of two monomers: hexamethylenediamine (HMD) and adipic acid (AA). The reaction occurs in two steps:

1. Formation of the amide linkage: The first step involves the reaction of the amino group ($-NH_2$) of HMD with the carboxyl group (-COOH) of AA to form an amide linkage ($-CONH_2$).

HMD + AA → HMD-CONH-AA + H_2O

2. Propagation of the polymer chain: The second step involves the reaction of the amide group of the newly formed amide linkage with another amino group of HMD or another carboxyl group of AA to form a longer polymer chain. This process continues until a chain of sufficient length is formed, resulting in the formation of nylon 6,6 polymer.

The overall reaction for the formation of nylon 6,6 polymer can be represented as follows:

$(HMD\text{-}CONH\text{-}AA)_n \rightarrow nHMD + nAA$

where:

- n is the degree of polymerization (the number of repeating units in the polymer chain)

The formation of nylon 6,6 polymer is typically carried out in a melt or solution at elevated temperatures. The reaction is catalyzed by acids or bases to promote the formation of the amide linkage. The final product, nylon 6,6, is a white, crystalline solid with a high melting point and strong tensile strength. It is widely used in the production of textiles, fibers, and engineering plastics.

Question 14. Draw structures of the following compounds:
i. chloric acid
ii. peroxy disulphuric acid

SECTION – C

Attempt any EIGHT of the following questions:

Question 15. Define Osmosis.
How will you determine molar mass of non volatile solute by elevation of boiling point?

Answer. Sure, here are the answers to your questions:

Osmosis is the process of spontaneous passage of solvent molecules through a semipermeable membrane from a region of low solute concentration to a region of high solute concentration. This process occurs because the solvent molecules are attracted to the solute molecules, and the movement of the solvent molecules helps to equalize the solute concentration on both sides of the membrane.

The rate of osmosis is proportional to the difference in solute concentration across the membrane. The greater the difference in concentration, the faster the rate of osmosis. Osmosis is a critical process in many biological systems, including the transport of nutrients and waste in cells and the regulation of blood pressure.

Determination of molar mass of non-volatile solute by elevation of boiling point

The elevation of boiling point is a colligative property of solutions, which means that it depends on the number of solute particles in solution, not on the identity of the solute particles. This property can be used to determine the molar mass of a non-volatile solute by measuring the change in boiling point of a solution compared to the boiling point of the pure solvent.

The elevation of boiling point (ΔTb) is defined as the difference between the boiling point of a solution (Tb) and the boiling point of the pure solvent (T_0). It can be calculated using the following equation:

$\Delta Tb = Kb \times m$

where:

- Kb is the molal boiling point elevation constant of the solvent (in K·kg/mol)
- m is the molality of the solution (in mol/kg)

The molality of the solution is defined as the number of moles of solute per kilogram of solvent. It can be calculated using the following equation:

$m = n / W$

where:

- n is the number of moles of solute
- W is the mass of solvent (in kg)

The molal boiling point elevation constant of a solvent is a constant that depends on the properties of the solvent. It can be found in reference tables.

To determine the molar mass of a non-volatile solute by elevation of boiling point, the following steps are performed:

1. Measure the boiling point of the pure solvent (T_0).
2. Prepare a solution of the solute in the solvent.
3. Measure the boiling point of the solution (Tb).
4. Calculate the elevation of boiling point (ΔTb) using the equation: $\Delta Tb = Tb - T_0$.

5. Calculate the molality of the solution (m) using the equation: m = n / W.
6. Determine the molal boiling point elevation constant of the solvent (Kb) from reference tables.
7. Calculate the molar mass of the solute (M) using the equation: M = Kb × ΔTb / m.

This method is a simple and effective way to determine the molar mass of a non-volatile solute in a solution.

Question 16. Convert the following:
i. Ethyl alcohol into ethyl acetate

Answer. Sure, here is the reaction for the conversion of ethyl alcohol into ethyl acetate:

$CH_3CH_2OH + CH_3COOH \rightleftharpoons CH_3COOC_2H_5 + H_2O$

This reaction is known as the esterification reaction. It is an equilibrium reaction, which means that it can proceed in both directions. The position of the equilibrium depends on the relative concentrations of the reactants and products, as well as the temperature and pressure of the reaction.

The esterification reaction is typically catalyzed by an acid, such as sulfuric acid. The acid protonates the ethanol molecule, making it more reactive and more likely to attack the carbonyl group of the acetic acid molecule. The resulting ester, ethyl acetate, is a common solvent with a pleasant fruity odor.

Here is a table summarizing the conversion of ethyl alcohol into ethyl acetate:

Reactant	Product	Catalyst

Ethyl alcohol (CH_3CH_2OH)	Ethyl acetate ($CH_3COOC_2H_5$)	Acetic acid (CH_3COOH), sulfuric acid (H_2SO_4)

ii. Phenol into benzene

Answer. Converting phenol into benzene is an essential process in the chemical industry. It involves the removal of the hydroxyl group (-OH) from the phenol molecule to form benzene. This process is known as dehydroxylation or reduction. There are several methods for dehydroxylating phenol, each with its own advantages and disadvantages.

One common method is to heat phenol with zinc dust in the absence of air. This process, known as the zinc reduction or the Bouveault-Blanc reduction, produces benzene and zinc oxide as the reaction products.

$C_6H_5OH + Zn \rightarrow C_6H_6 + ZnO$

The reaction mechanism involves the transfer of electrons from zinc to the phenol molecule, leading to the formation of a phenyl radical. This radical then loses a proton, forming benzene as the final product.

Another method for dehydroxylating phenol is to treat it with a strong acid, such as sulfuric acid or phosphoric acid. This process is known as acid-catalyzed dehydroxylation or Friedel-Crafts dehydroxylation.

$C_6H_5OH + H_2SO_4 \rightarrow C_6H_6 + HSO_4^- + H_2O$

The reaction mechanism involves the protonation of the phenol molecule, making it more susceptible to attack by the electrophilic sulfur atom in sulfuric acid. This leads to the formation of a carbocation intermediate, which then loses a proton and forms benzene.

The choice of dehydroxylation method depends on the specific requirements of the synthesis. Zinc reduction is a milder method that is suitable for sensitive substrates. Acid-catalyzed dehydroxylation is a more vigorous method that can be used to dehydroxylate a wider range of compounds.

Here is a table summarizing the conversion of phenol into benzene:

Method	Catalyst	Reaction Conditions	Products
Zinc reduction	Zinc dust	Absence of air, elevated temperature	Benzene, zinc oxide
Acid-catalyzed dehydroxylation	Strong acid (e.g., sulfuric acid, phosphoric acid)	Elevated temperature	Benzene, water

iii. Diethyl ether into ethyl chloride

Answer. Converting diethyl ether into ethyl chloride is an important reaction in organic chemistry. It involves the substitution of the ethoxy group (-OC2H5) in diethyl ether with a chloride atom (-Cl) to form ethyl chloride. This process is known as Williamson ether synthesis or Williamson etherification.

CH3CH2OCH2CH3 + HCl → 2CH3CH2Cl + H2O

The reaction mechanism involves the attack of the chloride ion (Cl-) on the positively charged carbon atom in the diethyl ether molecule. This carbon atom is made more electrophilic (electron-deficient) by the presence of the oxygen atom in the ether group. The chloride ion displaces the ethoxy group, forming ethyl chloride and water as the reaction products.

Williamson ether synthesis is typically carried out in the presence of a strong base, such as potassium hydroxide (KOH) or sodium hydroxide (NaOH). The base serves to deprotonate the alcohol molecule, making it more reactive and more likely to attack the alkyl halide.

Here is a table summarizing the conversion of diethyl ether into ethyl chloride:

Reactant	Product	Catalyst	Conditions
Diethyl ether (CH3CH2OCH2CH3)	Ethyl chloride (CH3CH2Cl)	Potassium hydroxide (KOH) or sodium hydroxide (NaOH)	Elevated temperature, presence of a solvent

Question 17. A weak monobasic acid is 10% dissociated in 0.05 M solution. What is percent dissociation in 0.15 M solution?

Answer. To determine the percent dissociation of a weak monobasic acid in different solution concentrations, you can use the following equation:

$\alpha = (1 - [H+]) / [HA] \times 100\%$

where:

- α is the degree of dissociation
- [H+] is the concentration of hydrogen ions

- [HA] is the concentration of the undissociated acid

Given that the weak monobasic acid is 10% dissociated in a 0.05 M solution, we can calculate the concentration of hydrogen ions and undissociated acid as follows:

α = 10% = 0.1

[HA] = 0.05 M

Substituting these values into the equation, we get:

0.1 = (1 - [H+]) / 0.05 M

Solving for [H+], we get:

[H+] = 0.045 M

Now, we can calculate the percent dissociation in a 0.15 M solution:

α = (1 - [H+]) / [HA] × 100%

where:

- [HA] = 0.15 M
- [H+] = 0.045 M

Substituting these values into the equation, we get:

α = (1 - 0.045 M) / 0.15 M × 100% ≈ 6.67%

Therefore, the percent dissociation of the weak monobasic acid in a 0.15 M solution is approximately 6.67%.

Question 18. Explain dehydrohalogenation reaction of 2-chlorobutane. Write use and environmental effect of CFC.

Answer. Sure, here is an explanation of the dehydrohalogenation reaction of 2-chlorobutane, along with the uses and environmental effects of CFCs:

Dehydrohalogenation reaction of 2-chlorobutane

The dehydrohalogenation reaction of 2-chlorobutane is an elimination reaction that involves the removal of a hydrogen atom and a halogen atom from an alkyl halide molecule to form an alkene. In the case of 2-chlorobutane, the reaction produces a mixture of two alkenes: but-1-ene and but-2-ene.

The overall reaction can be represented as follows:

CH3CH2CH(Cl)CH3 → CH3CH=CHCH3 + CH2=CHCH2CH3

The reaction mechanism involves several steps:

1. Formation of the transition state: The first step involves the formation of a three-centered transition state, where the carbon atom of the alkyl halide is partially bonded to both the hydrogen atom and the halogen atom.
2. Bond cleavage: In the transition state, the bond between the carbon atom and the hydrogen atom weakens, while the bond between the carbon atom and the halogen atom breaks.
3. Formation of the alkene: The carbon atom with the partial bond to the hydrogen atom forms a double bond with the adjacent carbon atom, resulting in the formation of the alkene.
4. Elimination of the halogen ion: The halogen ion is eliminated from the transition state, completing the formation of the alkene.

The dehydrohalogenation reaction of 2-chlorobutane is an example of a β-elimination reaction, where the halogen atom is removed from the β-carbon atom (the carbon atom next to the carbon atom with the leaving group). The reaction is favored by strong bases, such as potassium hydroxide (KOH) and sodium hydroxide (NaOH).

Uses and environmental effects of CFCs

Chlorofluorocarbons (CFCs) are a group of human-made chemicals that were once widely used as refrigerants, propellants, and blowing agents.

However, CFCs are now known to be harmful to the environment, and their production and use are severely restricted under the Montreal Protocol.

The primary environmental concern with CFCs is their role in ozone depletion. CFCs can break down in the stratosphere, releasing chlorine atoms that catalyze the destruction of ozone molecules. Ozone is a layer of gas in the stratosphere that protects life on Earth from harmful ultraviolet radiation from the sun.

In addition to their role in ozone depletion, CFCs are also potent greenhouse gases, contributing to global warming. Greenhouse gases trap heat in the atmosphere, causing the Earth's temperature to rise.

Due to their harmful environmental effects, CFCs have been phased out of most uses. However, they are still used in some specialized applications, such as in certain medical devices and fire extinguishers.

Here is a table summarizing the uses and environmental effects of CFCs:

Use	Environmental Effect
Refrigerants	Ozone depletion
Propellants	Ozone depletion
Blowing agents	Ozone depletion
Greenhouse gases	Global warming

Question 19. 2000 mmol of an ideal gas expanded isothermally and reversibly from 20 L to 30 L at 300 K, calculate the work done in the process (R = 8.314 $JK^{-1}mol^{-1}$).

Answer. Sure, here is the solution to the problem:

Given:

- n = 2000 mmol = 2 mol
- $V1 = 20$ L
- $V2 = 30$ L
- T = 300 K
- R = 8.314 $J \cdot K^{-1} \cdot mol^{-1}$

The work done (W) during the isothermal expansion of an ideal gas can be calculated using the following equation:

$W = -nRT \ln(V2/V1)$

Substituting the given values into the equation, we get:

$W = -2 \text{ mol} \times 8.314 \text{ J} \cdot K^{-1} \cdot mol^{-1} \times 300 \text{ K} \times \ln(30 \text{ L} / 20 \text{ L}) \approx 4993 \text{ J}$

Therefore, the work done during the isothermal expansion of 2 mol of an ideal gas from 20 L to 30 L at 300 K is approximately 4993 J.

Question 20. What are interstitial compounds? Give the classification of alloys with examples.

Answer. Sure, here is an explanation of interstitial compounds and the classification of alloys with examples:

Interstitial Compounds

Interstitial compounds, also known as insertion compounds, are a type of non-stoichiometric compound that is formed when small atoms, such as hydrogen, carbon, or nitrogen, occupy the interstitial spaces between the atoms of a metal lattice. These interstitial atoms are typically smaller than the metal atoms and can fit into the open spaces without significantly distorting the crystal structure of the metal.

Examples of Interstitial Compounds

- Titanium carbide (TiC)
- Zirconium hydride ($ZrH_{1.92}$)
- Manganese nitride (Mn_4N)

Characteristics of Interstitial Compounds

- Non-stoichiometric: The ratio of metal atoms to interstitial atoms can vary depending on the conditions of formation.
- High hardness and melting point: The presence of interstitial atoms can increase the hardness and melting point of the metal.
- Brittle: Interstitial compounds tend to be brittle due to the distortion of the metal lattice caused by the interstitial atoms.

Classification of Alloys

Alloys are mixtures of two or more metals, or a metal and a nonmetal, that are combined to achieve desired properties. Alloys can be classified based on their composition, microstructure, and application.

Classification Based on Composition

- Substitution alloys: In substitution alloys, atoms of one metal are replaced by atoms of another metal in the crystal lattice of the parent metal. Examples: brass (copper-zinc alloy), steel (iron-carbon alloy).
- Interstitial alloys: In interstitial alloys, small atoms, such as hydrogen, carbon, or nitrogen, occupy the interstitial spaces between the atoms of the metal lattice. Examples: titanium carbide (TiC), zirconium hydride ($ZrH_{1.92}$).
- Intermetallic compounds: Intermetallic compounds are stoichiometric compounds formed between two or more metals. They have a

definite and fixed ratio of metal atoms and exhibit unique properties. Examples: sodium chloride (NaCl), magnesium oxide (MgO).

Classification Based on Microstructure

- Single-phase alloys: Single-phase alloys have a uniform microstructure, with all atoms arranged in a single crystal lattice. Examples: pure metals, solid solutions.
- Multi-phase alloys: Multi-phase alloys have a non-uniform microstructure, with multiple crystal phases present. Examples: eutectic alloys, composite alloys.

Classification Based on Application

- Structural alloys: Structural alloys are used in applications where strength, toughness, and durability are important. Examples: steel, aluminum alloys.
- Functional alloys: Functional alloys are used in applications where specific properties, such as electrical conductivity, magnetic permeability, or corrosion resistance, are important. Examples: copper alloys, nickel alloys.

Question 21. Draw labelled diagram of H_2 – O_2 fuel cell. Write two applications of fuel cell.

Question 22. Explain formation of $[CoF_6]^{3-}$ complex with respect to i. Hybridisation

Answer. Sure, here is an explanation of the formation of the [CoF6]3- complex with respect to hybridization:

The central cobalt (Co) atom in the [CoF6]3- complex is sp3d2 hybridized. This means that the Co atom has four sp3 hybrid orbitals, one 3d orbital, and two 4d orbitals. The sp3 hybrid orbitals are used to form bonds with the six fluoride (F-) ligands, while the 3d and 4d orbitals are used to accommodate the unpaired electrons on the Co atom.

The hybridization of the Co atom can be explained by considering the following factors:

1. The number of ligands: The Co atom is bonded to six ligands, which requires six orbitals to form the bonds. The sp3 hybrid orbitals are the most suitable orbitals for this purpose, as they are all of equal energy and can form bonds with equal strength.
2. The number of unpaired electrons: The Co atom has three unpaired electrons in its ground state electronic configuration. These unpaired electrons must be accommodated in orbitals that are not involved in bonding. The 3d and 4d orbitals are available for this purpose.
3. The relative energies of the orbitals: The sp3 hybrid orbitals are lower in energy than the 3d and 4d orbitals. This means that the Co atom will preferentially use sp3 hybrid orbitals for bonding, as this will result in a more stable configuration.

As a result of these factors, the Co atom in the [CoF6]3- complex is sp3d2 hybridized. This hybridization allows the Co atom to form six strong bonds with the fluoride ligands and accommodate its three unpaired electrons in a stable configuration.

ii. Magnetic properties

Answer. The [CoF6]3- complex exhibits paramagnetic behavior due to the presence of four unpaired electrons on the central cobalt (Co) atom. The Co atom in this complex is sp3d2 hybridized, which means that it has four sp3 hybrid orbitals, one 3d orbital, and two 4d orbitals. The sp3 hybrid orbitals are used to form bonds with the six fluoride (F-) ligands, while the 3d and 4d orbitals are used to accommodate the unpaired electrons on the Co atom.

The paramagnetism of the [CoF6]3- complex can be explained by considering the Hund's rule of maximum multiplicity, which states that electrons will occupy orbitals in a way that maximizes the total spin multiplicity of the system. In the case of the Co atom, the four unpaired electrons will occupy the four 3d orbitals in a way that maximizes their spin moments. This results in a total spin multiplicity of 4, which means that the complex is paramagnetic.

The paramagnetic properties of the [CoF6]3- complex can be measured using the technique of magnetic susceptibility. Magnetic susceptibility is a measure of a material's ability to be magnetized. Paramagnetic materials have a positive magnetic susceptibility, while diamagnetic materials have a negative magnetic susceptibility. The [CoF6]3- complex has a positive magnetic susceptibility, which confirms its paramagnetic behavior.

The paramagnetism of the [CoF6]3- complex is important for its catalytic activity. Many transition metal catalysts are paramagnetic, and their paramagnetism plays a role in their catalytic mechanisms. For example, the [CoF6]3- complex is a catalyst for the oxidation of alkenes to epoxides. In this reaction, the unpaired electrons on the Co atom can interact with the alkene to form a reactive intermediate. This intermediate can then react with oxygen to form the epoxide product.

The paramagnetism of the [CoF6]3- complex also has applications in medicine. For example, gadolinium-based contrast agents, which are used to enhance the contrast of MRI images, are paramagnetic complexes. The unpaired electrons on the gadolinium atom can interact with the magnetic field of the MRI scanner, causing the contrast agent to "light up" on the MRI image.

Overall, the paramagnetic properties of the [CoF6]3- complex are important for its catalytic activity and its applications in medicine.

iii. Inner / outer complex

Answer. The [CoF6]3- complex is an outer or high-spin complex. This means that the unpaired electrons on the cobalt (Co) atom are located in the outer 4d orbitals, rather than the inner 3d orbitals.

The inner/outer orbital distinction in transition metal complexes is based on the energy of the orbitals used to accommodate the unpaired electrons. Complexes with unpaired electrons in the inner 3d orbitals are called inner or low-spin complexes, while complexes with unpaired electrons in the outer 4d or 5d orbitals are called outer or high-spin complexes.

The $[CoF_6]^{3-}$ complex is an outer complex because the fluoride (F^-) ligands are weak-field ligands. Weak-field ligands do not cause a significant splitting of the d-orbitals, so the unpaired electrons on the Co atom are located in the higher-energy 4d orbitals.

Inner complexes are typically more stable than outer complexes, as the 3d orbitals are lower in energy than the 4d and 5d orbitals. However, outer complexes can be more reactive than inner complexes, as the unpaired electrons in the outer orbitals are more accessible for chemical reactions.

The $[CoF_6]^{3-}$ complex is an example of an outer complex that is both stable and reactive. It is a stable complex due to the strong bonds between the Co atom and the F^- ligands. It is also a reactive complex due to the presence of the unpaired electrons in the outer 4d orbitals. This reactivity makes the $[CoF_6]^{3-}$ complex a useful catalyst for a variety of chemical reactions.

Here is a table summarizing the differences between inner and outer complexes:

Feature	Inner Complexes	Outer Complexes
Unpaired electron orbitals	3d	4d or 5d
Stability	More stable	Less stable

Reactivity	Less reactive	More reactive
Ligand field	Strong-field ligands	Weak-field ligands

iv. Geometry

Answer. Sure, here is an explanation of the geometry of the $[CoF_6]^{3-}$ complex.

The $[CoF_6]^{3-}$ complex has an octahedral geometry. This means that the six fluoride (F^-) ligands are arranged around the central cobalt (Co) atom in a symmetrical octahedron shape. The octahedral geometry is the most common geometry for transition metal complexes with six ligands.

The octahedral geometry of the $[CoF_6]^{3-}$ complex can be explained by considering the hybridization of the Co atom. The Co atom in this complex is sp^3d^2 hybridized, which means that it has four sp^3 hybrid orbitals, one 3d orbital, and two 4d orbitals. The sp^3 hybrid orbitals are used to form bonds with the six F^- ligands, while the 3d and 4d orbitals are used to accommodate the unpaired electrons on the Co atom.

The octahedral geometry of the $[CoF_6]^{3-}$ complex is important for its stability and reactivity. The octahedral arrangement of the ligands allows for maximum overlap between the orbitals on the Co atom and the orbitals on the F^- ligands. This overlap results in strong bonds between the Co atom and the F^- ligands, which contributes to the stability of the complex. The octahedral arrangement of the ligands also allows for the unpaired electrons on the Co atom to interact with each other in a way that maximizes their spin moments. This interaction contributes to the reactivity of the complex.

Here are some additional points about the geometry of the $[CoF_6]^{3-}$ complex:

- The octahedral geometry of the complex is consistent with the high-spin state of the Co atom. High-spin complexes typically have octahedral or tetragonal geometry, while low-spin complexes typically have square planar or trigonal bipyramidal geometry.
- The octahedral geometry of the complex is also consistent with the strong-field nature of the F^- ligands. Strong-field ligands cause a significant splitting of the d-orbitals, which favors the octahedral geometry.

Question 23. What is Pseudo first order reaction? Derive integrated rate law equation for zero order reaction.

Answer. Sure, here is an explanation of pseudo first order reaction and the integrated rate law equation for zero order reaction:

Pseudo First Order Reaction

A pseudo-first-order reaction is a reaction that appears to follow first-order kinetics even though it is actually a second-order reaction. This occurs when one of the reactants is present in much greater excess than the other reactant. The excess reactant acts as a constant concentration reservoir, so its concentration does not change significantly during the course of the reaction. This allows the rate of the reaction to be expressed as a function of the concentration of the reactant that is not in excess.

Pseudo-first-order reactions are often used in experimental kinetics because they are easier to study than true first-order reactions. The rate constant for a pseudo-first-order reaction is denoted by k', and it is related to the true second-order rate constant (k) by the following equation:

$k' = k[A]_0$

where:

- k' is the pseudo-first-order rate constant (in s^{-1})
- k is the true second-order rate constant (in $L \cdot mol^{-1} \cdot s^{-1}$)
- [A]0 is the initial concentration of the excess reactant (in M)

Integrated Rate Law Equation for Zero Order Reaction

A zero-order reaction is a reaction in which the rate is independent of the concentration of the reactants. This is because the rate-limiting step in the reaction does not involve the reactants. Zero-order reactions are often slow reactions that occur at a constant rate.

The integrated rate law equation for a zero-order reaction is as follows:

$[A] = [A]_0 - kt$

where:

- [A] is the concentration of the reactant at any time t (in M)
- [A]0 is the initial concentration of the reactant (in M)
- k is the zero-order rate constant (in $M \cdot s^{-1}$)
- t is the time elapsed since the start of the reaction (in s)

The zero-order rate constant (k) can be determined experimentally by measuring the concentration of the reactant at different times and plotting the results against time. The rate constant is equal to the slope of the line obtained from the plot.

Question 24. Explain Aldol condensation of ethanal.

Answer. Sure, here is an explanation of the aldol condensation of ethanal:

Aldol Condensation of Ethanal

The aldol condensation is a chemical reaction that occurs between two molecules of an aldehyde or a ketone. The reaction involves the addition of the enolate ion of one aldehyde or ketone molecule to the carbonyl group of the other aldehyde or ketone molecule. The resulting product is an α,β-hydroxycarbonyl compound, also known as an aldol.

The aldol condensation of ethanal is a specific example of this reaction. Ethanal, also known as acetaldehyde, is a simple aldehyde with the formula CH3CHO. When ethanal undergoes aldol condensation, it produces a mixture of two products: 3-hydroxybutanal and 2-methylpent-2-enal.

The mechanism of the aldol condensation of ethanal involves the following steps:

1. Formation of the enolate ion: The first step involves the deprotonation of an α-hydrogen atom on one ethanal molecule to form an enolate ion. The enolate ion is a nucleophilic species, meaning that it is attracted to positively charged atoms.
2. Addition of the enolate ion to the carbonyl group: The enolate ion then attacks the carbonyl group of another ethanal molecule, forming an aldol adduct. The aldol adduct is an unstable intermediate that can undergo further reactions.
3. Dehydration of the aldol adduct: The aldol adduct can then lose a molecule of water to form a stable aldol product. The aldol product can be either 3-hydroxybutanal or 2-methylpent-2-enal, depending on the specific reaction conditions.

The aldol condensation of ethanal is a versatile reaction that can be used to synthesize a variety of organic compounds. The reaction is often catalyzed by bases, such as sodium hydroxide (NaOH) or potassium hydroxide (KOH).

Here is a summary of the aldol condensation of ethanal:

- Reactants: Ethanal (CH3CHO)
- Products: 3-hydroxybutanal and 2-methylpent-2-enal
- Reaction conditions: Typically catalyzed by a base
- Mechanism: Involves the formation of an enolate ion, addition of the enolate ion to the carbonyl group, and dehydration of the aldol adduct
- Applications: Synthesis of a variety of organic compounds

Question 25. Explain anomalous behaviour of oxygen in group 16 with respect to:
i. Atomicity

Answer. Oxygen exhibits anomalous behavior in group 16 with respect to atomicity, meaning that it exists as a diatomic molecule (O2) whereas the other elements in the group exist as polyatomic molecules. This anomalous behavior can be attributed to several factors.

1. Small size and high electronegativity: Oxygen is the smallest and most electronegative element in group 16. Its small size allows it to form strong covalent bonds with itself, resulting in the formation of the diatomic O2 molecule. Its high electronegativity makes it more likely to share electrons with other atoms, further contributing to its tendency to form covalent bonds.
2. Absence of d-orbitals: Unlike the other elements in group 16, oxygen does not have d-orbitals available for bonding. This limits its ability to expand its valence shell and form polyatomic molecules.
3. Strong p-orbital overlap: Oxygen has three unpaired electrons in its valence shell, all of which are located in p-orbitals. The p-orbitals can overlap effectively to form strong covalent bonds, contributing to the stability of the O2 molecule.
4. High bond dissociation enthalpy: The bond dissociation enthalpy of the O-O bond is very high (498 kJ/mol), indicating that a significant amount of energy is required to break the bond and form separate oxygen atoms. This high bond dissociation enthalpy further contributes to the stability of the O2 molecule.

In summary, the combination of oxygen's small size, high electronegativity, absence of d-orbitals, strong p-orbital overlap, and high bond dissociation enthalpy leads to its anomalous behavior of existing as a diatomic molecule in group 16.

ii. Magnetic property

Answer. Sure, here is an explanation of the anomalous magnetic properties of oxygen in group 16:

Oxygen's paramagnetism

Oxygen is the only element in group 16 that exhibits paramagnetism at room temperature. This means that it is attracted to a magnetic field. Paramagnetism arises from the presence of unpaired electrons in an atom or molecule. Oxygen has two unpaired electrons in its valence shell, which are located in p orbitals. These unpaired electrons create a magnetic moment that causes the oxygen molecule to be attracted to a magnetic field.

The other elements in group 16 are diamagnetic, meaning that they are not attracted to a magnetic field. This is because they do not have any unpaired electrons in their valence shells. Diamagnetism arises from the pairing of electrons in an atom or molecule. When electrons are paired, their magnetic moments cancel each other out, resulting in a net magnetic moment of zero.

Factors contributing to oxygen's paramagnetism

Several factors contribute to oxygen's anomalous magnetic properties:

- Electron configuration: Oxygen has an electron configuration of $1s^2 2s^2 2p^4$. The four electrons in the 2p orbitals are not all paired, resulting in two unpaired electrons.
- Orbital overlap: The p orbitals of oxygen can overlap effectively, allowing the electrons to interact and create a magnetic moment.
- Hund's rule: Hund's rule states that electrons will occupy orbitals in a way that maximizes the total spin multiplicity of the system. For oxygen, this means that the two unpaired electrons will occupy separate p orbitals, maximizing their spin moments.
- Bond dissociation enthalpy: The bond dissociation enthalpy of the O-O bond is very high, indicating that a significant amount of energy is required to break the bond and form separate oxygen atoms. This

strong bond stabilizes the diatomic oxygen molecule and prevents the unpaired electrons from pairing up.

Consequences of oxygen's paramagnetism

Oxygen's paramagnetism has several consequences:

- Oxygen can be separated from other gases using a magnetic field: This is a useful technique for purifying oxygen and other gases.
- Oxygen can affect the behavior of magnetic materials: For example, oxygen can cause magnetic materials to become more susceptible to corrosion.
- Oxygen can play a role in biological processes: For example, the paramagnetism of oxygen is thought to be important for the function of hemoglobin, a protein that carries oxygen in the blood.

In summary, oxygen's anomalous magnetic properties are due to its electron configuration, orbital overlap, and the high bond dissociation enthalpy of the O-O bond. These properties have a number of important consequences for oxygen's chemistry and biology.

iii. Oxidation state

Answer. Sure, here is an explanation of the anomalous oxidation states of oxygen in group 16:

Oxygen exhibits a wider range of oxidation states than any other element in its group. It can have oxidation states from -2 to +6, with -2 being its most common oxidation state. This wide range of oxidation states is due to several factors:

- Small size and high electronegativity: Oxygen's small size allows it to form strong bonds with other atoms, while its high electronegativity makes it more likely to attract electrons. This allows it to form both covalent and ionic compounds with a variety of elements.

- Absence of d-orbitals: Unlike the other elements in group 16, oxygen does not have d-orbitals available for bonding. This limits its ability to expand its valence shell and form compounds with higher oxidation states. However, it can still achieve higher oxidation states by sharing electrons with other atoms or by losing electrons to form cations.
- Strong p-orbital overlap: Oxygen has three unpaired electrons in its valence shell, all of which are located in p-orbitals. The p-orbitals can overlap effectively to form strong covalent bonds, which is important for forming compounds with higher oxidation states.
- High ionization energies: Oxygen has high ionization energies, which means that it is difficult to remove electrons from its valence shell. This is why its most common oxidation state is -2, as this requires only two electrons to be removed. However, it can achieve higher oxidation states by losing more electrons, although this requires more energy.
- Ability to form multiple bonds: Oxygen can form multiple bonds with other atoms, including double and triple bonds. This allows it to share electrons more effectively with other atoms and achieve higher oxidation states.

The anomalous oxidation states of oxygen have several important consequences:

- Oxygen is a versatile element that can form a wide variety of compounds. This versatility makes oxygen essential for life and for many industrial processes.
- Oxygen is a powerful oxidizing agent. This means that it can readily accept electrons from other atoms, making it an important reagent in many chemical reactions.
- Oxygen is a key component of many biological molecules, including water, carbohydrates, proteins, and DNA. Its ability to exist in a variety of oxidation states is crucial for the proper functioning of these molecules.

In summary, the anomalous oxidation states of oxygen are due to its small size, high electronegativity, absence of d-orbitals, strong p-orbital overlap, high ionization energies, and ability to form multiple bonds. These properties allow oxygen to form a wide variety of compounds, act as a powerful oxidizing agent, and play a vital role in biology.

Question 26. Write chemical reactions for the following conversions:
i. Acetic acid into acetic anhydride

Answer. The conversion of acetic acid (CH_3COOH) into acetic anhydride $(CH_3CO)_2O$ can be achieved through a dehydration reaction, typically catalyzed by sulfuric acid (H_2SO_4). Here's the chemical reaction for this conversion:

$2CH_3COOH + H_2SO_4 \rightarrow (CH_3CO)_2O + 2H_2O$

In this reaction, sulfuric acid acts as a dehydrating agent, removing a water molecule from two molecules of acetic acid to form one molecule of acetic anhydride and two molecules of water. The catalyst plays a crucial role in facilitating the reaction and speeding up the process.

ii. Acetic acid into ethyl alcohol

Answer. The conversion of acetic acid (CH_3COOH) into ethyl alcohol (CH_3CH_2OH) can be achieved through a reduction reaction, typically using a reducing agent such as sodium borohydride ($NaBH_4$) or lithium aluminum hydride ($LiAlH_4$). Here's the chemical reaction for this conversion:

$CH_3COOH + 2NaBH_4 \rightarrow CH_3CH_2OH + H_2 + NaBO_2$

In this reaction, sodium borohydride serves as a reducing agent, transferring hydrogen atoms to the carbonyl group of acetic acid, converting it into the corresponding alcohol, ethyl alcohol. The reaction produces hydrogen gas and sodium borate as byproducts. Alternatively, lithium aluminum hydride can also be used as a reducing agent, but the reaction conditions may differ.

Write IUPAC name and structure of methylphenylamine.

Answer. Sure, here is the IUPAC name and structure of methylphenylamine:

IUPAC Name: N-methylaniline

Structure:

H | N(CH_3) | C_6H_5

In this structure, the methyl group (CH_3) is attached to the nitrogen atom of the amino group (-NH_2), and the phenyl group (C_6H_5) is attached to the other nitrogen atom. The prefix "N-methyl" indicates that the methyl group is attached to the nitrogen atom, and the suffix "-aniline" indicates that the compound is a derivative of aniline ($C_6H_5NH_2$).

SECTION – D

Attempt any THREE of the following questions:

Question 27. Show that, time required for 99.9% completion of a first order reaction is three times the time required for 90% completion.
Give electronic configuration of Gd (Z = 64).
Write the name of nano structured material used in car tyres to increase the life of tyres.

Answer. Sure, here are the answers to your questions:

Question 27 (Part 1)

For a first-order reaction, the time required for a certain fraction of completion can be expressed using the following equation:

t = -ln(1 - x) / k

where:

- t is the time (in seconds)
- x is the fraction of completion
- k is the rate constant (in s^{-1})

To compare the times required for 99.9% completion (x = 0.999) and 90% completion (x = 0.9), we can set up the following ratio:

t99.9 / t90 = -ln(1 - 0.999) / -ln(1 - 0.9)

Evaluating this expression, we get:

t99.9 / t90 = 3.000004 / 0.301029

Simplifying this expression, we get:

t99.9 / t90 ≈ 10

Therefore, the time required for 99.9% completion of a first-order reaction is approximately three times the time required for 90% completion.

Question 27 (Part 2)

The electronic configuration of gadolinium (Gd, Z = 64) is:

[Xe] $6s^2$ $5d^1$ $4f^7$

This configuration shows that Gd is a rare-earth metal with a partially filled 4f subshell. The 4f electrons are responsible for many of the unique properties of rare-earth metals, including their magnetic properties and their ability to form colorful compounds.

Question 27 (Part 3)

Nano-structured silica is a type of nano-structured material that is being used in car tires to increase the life of the tires. Nano-structured silica has a high surface area, which allows it to interact with and reinforce the polymer chains in the tire rubber. This interaction helps to improve the tire's wear resistance and reduce its rolling resistance, which can lead to longer tire life and improved fuel efficiency.

Question 28. Derive relationship between ∆H and ∆U for gaseous reaction.
Define: Vulcanization
What is peptide bond?

Answer. Sure, here are the answers to your questions:

Question 28 (Part 1)

The relationship between enthalpy change (ΔH) and internal energy change (ΔU) for a gaseous reaction at constant pressure is given by the following equation:

$\Delta H = \Delta U + P\Delta V$

where:

- ΔH is the enthalpy change (in J)
- ΔU is the internal energy change (in J)
- P is the pressure (in atm)
- ΔV is the change in volume (in L)

This equation is known as the Hess law or the enthalpy-entropy equation. It states that the enthalpy change for a reaction at constant pressure is equal to the internal energy change plus the product of the pressure and the change in volume.

For a gaseous reaction, the change in volume (ΔV) is typically positive, as most reactions involve the formation of more moles of gas than the reactants. This means that the term PΔV is positive, and it contributes to the overall enthalpy change of the reaction.

The Hess law is a useful tool for understanding the thermodynamics of chemical reactions. It can be used to calculate the enthalpy change for a reaction when the enthalpy changes for individual steps in the reaction are known.

Question 28 (Part 2)

Vulcanization is a process of crosslinking rubber molecules to improve their properties, such as tensile strength, elasticity, and resistance to wear and tear. It is typically achieved by heating rubber with sulfur or sulfur-containing compounds.

During vulcanization, sulfur atoms form bridges between the chains of polymer molecules in the rubber, creating a network of interconnected strands. This crosslinking process significantly enhances the rubber's mechanical properties, making it more durable and resistant to deformation.

Vulcanization is an essential process in the production of tires, hoses, seals, and other rubber products. It is a relatively simple and inexpensive process that has a profound impact on the performance and lifespan of rubber-based materials.

Question 28 (Part 3)

A peptide bond is a chemical bond formed between two molecules when the carboxyl group of one molecule reacts with the amino acid group of the other molecule, resulting in the formation of an amide group along with a molecule of water. The reaction is known as dehydration synthesis or condensation reaction, and the resulting CO-NH bond is known as a peptide bond.

Peptide bonds are the fundamental building blocks of proteins, which are essential molecules for life. They play a crucial role in a wide range of biological functions, including:

- Structural support: Proteins provide structural support for cells and tissues, giving them shape and strength.

- Enzyme catalysis: Enzymes, which are specialized proteins, catalyze biochemical reactions essential for various cellular processes.
- Transport: Proteins transport molecules across cell membranes and within the bloodstream.
- Signal transduction: Proteins transmit signals within cells and between cells, coordinating cellular activities.
- Immune response: Antibodies, which are proteins, recognize and bind to foreign substances, protecting the body from infections.

Peptide bonds are formed through a process called peptide synthesis, which occurs in ribosomes, the protein factories of cells. During peptide synthesis, amino acids are linked together in a specific sequence determined by the genetic code. The resulting polypeptide chain folds into a complex three-dimensional structure, giving the protein its unique function.

Peptide bonds are essential for the proper functioning of proteins and the overall health of organisms. Any disruption in peptide bond formation or structure can lead to protein misfolding, which can have severe consequences for cellular processes and overall health.

Question 29. Silver crystallizes in fcc structure. If edge length of unit cell is 400 pm, calculate density of silver(Atomic mass of Ag = 108). Write a note on Haloform reaction.

Answer. Sure, here are the answers to your questions:

Question 29 (Part 1)

To calculate the density of silver in the face-centered cubic (FCC) structure, you need to know the atomic mass of silver and the edge length of the unit cell.

Given:

- Edge length of unit cell (a) = 400 pm = 4.00×10^{-10} m

- Atomic mass of silver (M_{Ag}) = 108 g/mol = 1.08×10^{-2} kg/mol

Calculation:

1. Calculate the volume of the unit cell (V_{fcc}):

$V_{fcc} = a^3 \times \sqrt{2}$

$V_{fcc} = (4.00 \times 10^{-10}\ m)^3 \times \sqrt{2}$

$V_{fcc} = 6.82 \times 10^{-29}\ m^3$

2. Calculate the number of atoms in the unit cell (n_{atoms_fcc}):

$n_{atoms\_fcc} = 4$

3. Calculate the mass of the unit cell (m_{unit_cell}):

$m_{unit\_cell} = n_{atoms\_fcc} \times M_{Ag}$

$m_{unit\_cell} = 4 \times (1.08 \times 10^{-2}\ kg/mol)$

$m_{unit\_cell} = 4.32 \times 10^{-2}\ kg$

4. Calculate the density of silver (ρ_{Ag}):

$\rho_{Ag} = m_{unit\_cell} / V_{fcc}$

$\rho_{Ag} = (4.32 \times 10^{-2}\ kg) / (6.82 \times 10^{-29}\ m^3)$

$\rho_{Ag} = 6.31 \times 10^{7}\ kg/m^3$

Therefore, the density of silver in the FCC structure is $6.31 \times 10^{7}\ kg/m^3$.

Question 29 (Part 2)

The haloform reaction is a chemical reaction that involves the formation of a trihalogenated methane (haloform) from a methyl ketone or aldehyde in the presence of a halogen (X2) and a base (OH^-). The reaction typically occurs with ethanol (CH3CH2OH) as the solvent.

The general mechanism of the haloform reaction is as follows:

1. Formation of enolate ion: The methyl ketone or aldehyde is first deprotonated by the base to form an enolate ion.
2. Halogenation of enolate ion: The enolate ion then reacts with the halogen to form a trihalogenated enolate ion.
3. Rearrangement and cleavage: The trihalogenated enolate ion undergoes a rearrangement and cleavage reaction, resulting in the formation of a haloform, a formate ion ($HCOO^-$), and a molecule of the halogen acid (HX).

The haloform reaction is a versatile synthetic method for producing haloforms, which have various applications as solvents, pesticides, and fumigants. It is also a useful tool for identifying methyl ketones and aldehydes in organic compounds.

Here are some additional points about the haloform reaction:

- The reaction is most commonly used with chlorine (X = Cl) and bromine (X = Br), but it can also be carried out with iodine (X = I).
- The reaction typically requires a strong base, such as sodium hydroxide (NaOH) or potassium hydroxide (KOH).
- The reaction is an example of a nucleophilic substitution reaction, where the enolate ion acts as a nucleophile attacking the halogen molecule.
- The reaction is stereospecific, meaning that it produces only one stereoisomer of the haloform product.

Question 30. Define: Distereoisomers.
Give cis and trans isomers of $[Co(NH_3)_4 Cl2]^+$.
What is reference electrode?
Give reason: Bleaching action of ozone is also called dry bleach.

Answer. Sure, here are the answers to your questions:

Question 30 (Part 1)

Distereoisomers are stereoisomers that are not mirror images of each other. They have different spatial arrangements of their atoms but cannot be interconverted by simply rotating the molecule. Distereoisomers can be classified into different types based on their specific relationship to each other. Some common types of distereoisomers include:

- Enantiomers: Enantiomers are non-superimposable mirror images of each other. They have the same connectivity of atoms but differ in their spatial arrangement.
- Diastereomers: Diastereomers are non-mirror image stereoisomers. They have different spatial arrangements of their atoms but cannot be interconverted by simply rotating the molecule.
- Cis and trans isomers: Cis and trans isomers are a type of diastereomers that differ in the relative positions of substituents around a double bond or a ring structure. Cis isomers have the same substituents on the same side of the double bond or ring, while trans isomers have the same substituents on opposite sides.

Question 30 (Part 2)

The cis and trans isomers of [Co(NH3)4Cl2]+ are shown below:

Isomer	Structure
Cis isomer	[Co(NH3)2Cl2(NH3)2]+
Trans isomer	[Co(NH3)4Cl2]+

In the cis isomer, the two chloride ligands are located on the same side of the octahedral complex, while in the trans isomer, they are located on opposite sides.

Question 30 (Part 3)

A reference electrode is an electrode with a stable and well-defined potential that is used to measure the potential of other electrodes. It serves as a standard against which other electrodes are compared. A reference electrode should have a constant potential that is independent of the solution in which it is immersed.

There are several different types of reference electrodes, each with its own advantages and disadvantages. Some common types of reference electrodes include:

- Standard hydrogen electrode (SHE): The SHE is the primary reference electrode and has a potential of 0.000 V. It is based on the equilibrium between hydrogen gas and protons in a solution of sulfuric acid.
- Calomel electrode: The calomel electrode is a commonly used reference electrode that is more practical than the SHE. It is based on the equilibrium between mercury and its ions in a solution of mercury(I) chloride (calomel).
- Silver/silver chloride electrode: The silver/silver chloride electrode is another commonly used reference electrode. It is based on the equilibrium between silver metal and its ions in a solution of sodium chloride.

Question 30 (Part 4)

Ozone (O3) is a powerful oxidizing agent that can bleach a variety of substances, including cloth, paper, and skin. The bleaching action of ozone is due to its ability to remove color-causing molecules from these materials.

Ozone is often referred to as "dry bleach" because it does not require the use of water. Unlike chlorine bleach, which is a liquid, ozone is a gas that can easily penetrate into and bleach materials. This makes ozone a more versatile and environmentally friendly bleaching agent.

The bleaching action of ozone is also more effective than that of chlorine bleach. Ozone can remove a wider range of color-causing molecules, and it does not leave behind any harmful residues. Additionally, ozone is less likely to damage the fibers of the materials it bleaches.

Here are some of the reasons why the bleaching action of ozone is also called dry bleach:

- Ozone is a gas, while chlorine bleach is a liquid.
- Ozone does not require the use of water, while chlorine bleach does.
- Ozone is more versatile and environmentally friendly than chlorine bleach.
- Ozone is more effective than chlorine bleach at removing color-causing molecules.
- Ozone does not leave behind any harmful residues, while chlorine bleach can.
- Ozone is less likely to damage the fibers of the materials it bleaches, while chlorine bleach can weaken and degrade fibers.

Question 31. Write Dow process for preparation of Phenol. What is the action of bromine water on phenol?
Give reason: Group 16th elements have lower ionisation enthalpy compared to group 15th elements.
Write two uses of dioxygen.

Answer. Sure, here are the answers to your questions:

Question 31 (Part 1)

The Dow process is a method for the production of phenol from chlorobenzene and aqueous sodium hydroxide. The reaction takes place at high temperature (around 623 K) and pressure (about 300 atm) in the presence of a catalyst, such as copper(I) chloride. The overall reaction for the Dow process can be represented as follows:

$C_6H_5Cl + 2 NaOH \rightarrow C_6H_5OH + NaCl + H_2O$

In this reaction, chlorobenzene (C_6H_5Cl) is converted to sodium phenoxide (C_6H_5ONa) by reacting with aqueous sodium hydroxide (NaOH). The sodium phenoxide is then acidified with dilute acid, such as hydrochloric acid (HCl), to form phenol (C_6H_5OH).

The Dow process is a relatively efficient and cost-effective method for the production of phenol. It is widely used in the chemical industry to produce large quantities of phenol for various applications.

Question 31 (Part 2)

When phenol is treated with bromine water, a white precipitate of tribromophenol is formed. This reaction is an example of electrophilic aromatic substitution, where the bromine atom acts as an electrophile and attacks the electron-rich aromatic ring of phenol. The reaction can be represented as follows:

$C_6H_5OH + 3 Br_2 \rightarrow C_6H_3Br_3OH + 3 HBr$

The formation of tribromophenol is favored due to the presence of the hydroxyl group (-OH) in phenol. The hydroxyl group acts as an activating group, increasing the electron density of the aromatic ring and making it more susceptible to electrophilic attack.

Question 31 (Part 3)

The lower ionization enthalpies of group 16th elements compared to group 15th elements can be attributed to their smaller atomic sizes and higher electronegativities.

Smaller atomic sizes lead to stronger electrostatic attractions between the nucleus and the valence electrons. This stronger attraction makes it more difficult to remove an electron from the atom, resulting in a higher ionization enthalpy.

Higher electronegativities indicate a greater tendency of an atom to attract electrons. Atoms with higher electronegativities hold their valence electrons more tightly, making it more difficult to remove an electron, resulting in a higher ionization enthalpy.

The combined effects of smaller atomic sizes and higher electronegativities lead to a decrease in ionization enthalpies across group 16th elements.

Question 31 (Part 4)

Dioxygen (O2) is a vital molecule for life and has a wide range of applications in various fields. Here are two common uses of dioxygen:

1. Respiration: Dioxygen is essential for cellular respiration, the process by which organisms convert nutrients into energy. In respiration, dioxygen is consumed as the final electron acceptor in the electron transport chain, generating ATP, the energy currency of cells.
2. Combustion: Dioxygen is the key component in combustion reactions, where a fuel reacts with dioxygen to release heat and light. Combustion is a fundamental process used in various applications, including power generation, transportation, and industrial processes.