

BITSAT Chemistry Sample Paper – 15

Duration: 40 Minutes

Maximum Marks: 90

Instructions

- This paper contains **30** Multiple Choice Questions (Single Correct).
- Each correct answer carries **+3 marks**. Each incorrect answer carries **-1** mark. Unattempted questions carry **0** marks.
- Only **one** option is correct for each question.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

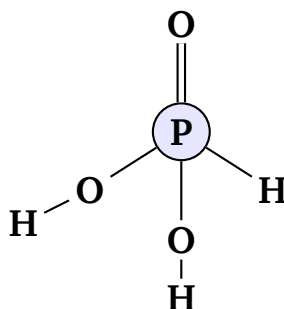
Q1. Which of the following species is diamagnetic?

- (A) O_2
- (B) NO
- (C) N_2
- (D) O_2^-

Q2. The hybridisation of carbon in CO_2 and in diamond respectively are:

- (A) sp^2 and sp^3
- (B) sp and sp^3
- (C) sp^3 and sp^2
- (D) sp and sp^2

Q3. In the structure of H_3PO_3 (phosphorous acid), the number of P–OH bonds is:

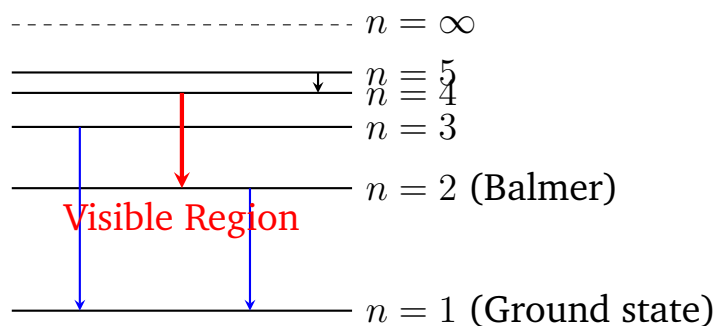


- (A) 3
- (B) 2
- (C) 1
- (D) 4

Q4. The energy of an electron in the n th Bohr orbit of hydrogen is given by $E_n = -13.6/n^2$ eV. The energy required to remove an electron from the second orbit ($n = 2$) to infinity is:

- (A) 13.6 eV
- (B) 6.8 eV
- (C) 3.4 eV
- (D) 1.51 eV

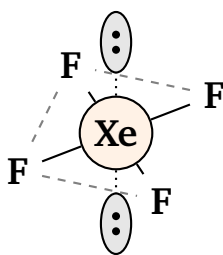
Q5. Which of the following transitions in the hydrogen spectrum falls in the visible region (Balmer series)?



- (A) $n = 3 \rightarrow n = 1$
- (B) $n = 4 \rightarrow n = 2$
- (C) $n = 2 \rightarrow n = 1$
- (D) $n = 5 \rightarrow n = 4$

Q6. Which of the following is a correct statement about XeF_4 ?





- (A) It is tetrahedral with no lone pairs on Xe
(B) It is square planar with two lone pairs on Xe
(C) It is pyramidal with one lone pair on Xe
(D) It is linear with four lone pairs on Xe
- Q7.** The correct decreasing order of first ionisation enthalpy among the elements N, O, F, and Ne is:
- (A) $\text{Ne} > \text{F} > \text{N} > \text{O}$
(B) $\text{Ne} > \text{F} > \text{O} > \text{N}$
(C) $\text{F} > \text{Ne} > \text{O} > \text{N}$
(D) $\text{Ne} > \text{N} > \text{F} > \text{O}$
- Q8.** The empirical formula of a compound is CH_2O . If its molar mass is 180 g mol^{-1} , the molecular formula is:
- (A) $\text{C}_3\text{H}_6\text{O}_3$
(B) $\text{C}_6\text{H}_{12}\text{O}_6$
(C) $\text{C}_4\text{H}_8\text{O}_4$
(D) $\text{C}_2\text{H}_4\text{O}_2$
- Q9.** 22 g of CO_2 (molar mass = 44 g mol^{-1}) contains how many molecules? (Avogadro number $N_A = 6.022 \times 10^{23}$)
- (A) 6.022×10^{23}
(B) 3.011×10^{23}
(C) 1.204×10^{24}
(D) 1.505×10^{23}



Q10. For the equilibrium $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$, increasing pressure at constant temperature will:

- (A) Shift equilibrium to the right (more products)
- (B) Shift equilibrium to the left (more PCl_5)
- (C) Have no effect since K_c depends only on temperature
- (D) Increase the value of K_c

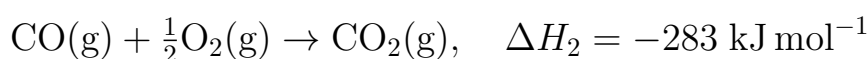
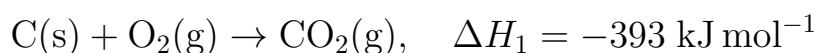
Q11. The pH of 0.001 M HCl solution is:

- (A) 1
- (B) 2
- (C) 3
- (D) 4

Q12. For the reaction $\text{C}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$, the change in entropy ΔS is expected to be:

- (A) Highly positive, since a solid reacts
- (B) Near zero or slightly negative, since 1 mol gas is consumed and 1 mol gas is produced
- (C) Highly negative, since the solid disappears
- (D) Positive, since combustion is always exothermic

Q13. From the following data, calculate $\Delta_f H^\circ$ of $\text{CO}(\text{g})$:



- (A) -676 kJ mol^{-1}
- (B) -110 kJ mol^{-1}
- (C) $+110 \text{ kJ mol}^{-1}$



(D) -393 kJ mol^{-1}

Q14. The conductance of a solution depends on which of the following?

- (A) Nature of the solvent only
- (B) Concentration of ions, their charges, and their mobilities
- (C) Temperature only
- (D) The electrode material alone

Q15. The Nernst equation for a cell reaction at 298 K is: $E_{\text{cell}} = E_{\text{cell}}^{\circ} - \frac{0.0592}{n} \log Q$. For the cell $\text{Zn} | \text{Zn}^{2+}(0.01 \text{ M}) || \text{Cu}^{2+}(1 \text{ M}) | \text{Cu}$, with $E_{\text{cell}}^{\circ} = 1.10 \text{ V}$ and $n = 2$, the cell EMF is approximately:

- (A) 1.16 V
- (B) 1.04 V
- (C) 0.54 V
- (D) 1.10 V

Q16. The rate constant of a reaction at 300 K is $1.6 \times 10^{-3} \text{ s}^{-1}$ and at 320 K is $6.4 \times 10^{-3} \text{ s}^{-1}$. The activation energy E_a (approximately) is: ($\ln 4 = 1.386$, $R = 8.314 \text{ J mol}^{-1}\text{K}^{-1}$)

- (A) 55.3 kJ mol^{-1}
- (B) 27.7 kJ mol^{-1}
- (C) $110.6 \text{ kJ mol}^{-1}$
- (D) 13.8 kJ mol^{-1}

Q17. Ozonolysis of 2-butene ($\text{CH}_3\text{CH} = \text{CHCH}_3$) followed by reductive workup gives:

- (A) Two molecules of acetaldehyde (CH_3CHO)
- (B) One molecule of formaldehyde and one of propionaldehyde
- (C) One molecule of acetone and one of formaldehyde



(D) One molecule of acetic acid and one of propanoic acid

Q18. Which reagent is used to convert benzene to nitrobenzene?

(A) HNO_3 alone

(B) Conc. HNO_3 + conc. H_2SO_4 (nitrating mixture)

(C) Dilute HNO_3 at room temperature

(D) NO_2 gas bubbled through benzene

Q19. Identify the compound that gives a yellow precipitate with iodine and NaOH (iodoform test):

(A) Methanol

(B) Ethanol

(C) Propan-1-ol

(D) Benzyl alcohol ($\text{C}_6\text{H}_5\text{CH}_2\text{OH}$)

Q20. Which of the following undergoes Cannizzaro reaction?

(A) Acetaldehyde (CH_3CHO)

(B) Benzaldehyde ($\text{C}_6\text{H}_5\text{CHO}$)

(C) Propanal ($\text{CH}_3\text{CH}_2\text{CHO}$)

(D) Butyraldehyde ($\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$)

Q21. The reaction of acetic acid with PCl_5 gives:

(A) Acetyl chloride (CH_3COCl) and POCl_3 and HCl

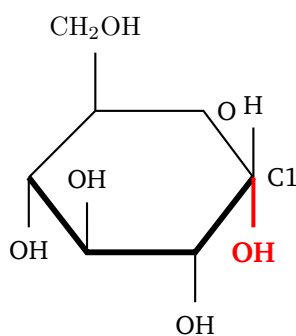
(B) Chloroacetic acid and HCl

(C) Acetaldehyde and POCl_3

(D) Ethyl chloride and POCl_3

Q22. The Haworth projection of α -D-glucose shows the $-\text{OH}$ group at C1 in which position?



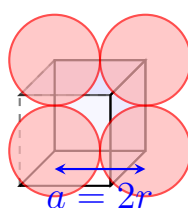


- (A) Axial (above the ring plane)
- (B) Equatorial (above the ring plane)
- (C) Below the ring plane (axial)
- (D) In the plane of the ring

Q23. Which of the following is a condensation polymer?

- (A) Polythene
- (B) Nylon-6,6
- (C) Teflon
- (D) Natural rubber

Q24. The packing efficiency of a simple cubic (SC) unit cell is approximately:



- (A) 52%
- (B) 68%
- (C) 74%
- (D) 100%

Q25. According to the IUPAC nomenclature rules, the correct name of $[\text{Fe}(\text{CN})_6]^{3-}$ is:

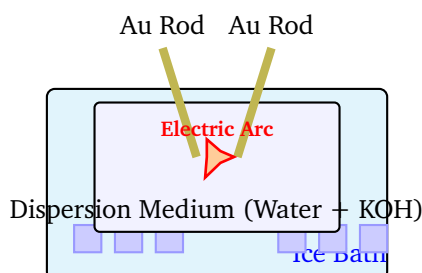


- (A) Hexacyanoferrate(II) ion
- (B) Hexacyanoferrate(III) ion
- (C) Hexacyanoiron(III) ion
- (D) Ferricyanide (no IUPAC name needed)

Q26. Which of the following alkaline earth metals does NOT form a stable bicarbonate in the solid state?

- (A) Calcium
- (B) Magnesium
- (C) Barium
- (D) None — all alkaline earth bicarbonates are stable in solution only

Q27. The colloidal solution of gold prepared by Bredig's arc method is an example of:



- (A) Chemical method of preparation
- (B) Mechanical dispersion method
- (C) Electrical dispersion method
- (D) Peptisation

Q28. Gabriel synthesis is used specifically for the preparation of:

- (A) Secondary amines
- (B) Tertiary amines
- (C) Primary amines
- (D) Quaternary ammonium salts



- Q29.** In the presence of anhydrous AlCl_3 , benzene reacts with CH_3Cl via:
- (A) Nucleophilic substitution ($\text{S}_{\text{N}}1$)
 - (B) Free radical substitution
 - (C) Electrophilic substitution (Friedel–Crafts alkylation)
 - (D) Electrophilic addition
- Q30.** The correct IUPAC name of the compound $\text{CH}_3 - \text{CO} - \text{CH}_2 - \text{CH}_2 - \text{COOH}$ is:
- (A) 4-oxopentanoic acid
 - (B) 2-acetylpropanoic acid
 - (C) 5-oxohexanoic acid
 - (D) Levulinic acid



Detailed Solutions

Q1.

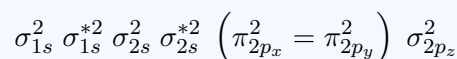
Solution

Concept: The magnetic behavior of homonuclear and heteronuclear diatomic molecules can be determined using Molecular Orbital (MO) Theory. A species is diamagnetic if all its electrons are paired, and it is paramagnetic if it contains one or more unpaired electrons.

Solution: Step 1: Write down the total number of electrons for each given species:

- For O_2 : Each oxygen atom has 8 electrons, so $8 + 8 = 16$ electrons.
- For NO: Nitrogen has 7 electrons and oxygen has 8 electrons, so $7 + 8 = 15$ electrons.
- For N_2 : Each nitrogen atom has 7 electrons, so $7 + 7 = 14$ electrons.
- For O_2^- : Superoxide ion has $16 + 1 = 17$ electrons.

Step 2: Write the molecular orbital electronic configuration for N_2 (14 electrons):



Counting the electrons in the configuration, we see that all 14 electrons are completely paired in their respective bonding and antibonding molecular orbitals. Since there are no unpaired electrons present, N_2 is strictly diamagnetic.

Step 3: Analyze the remaining options to confirm their paramagnetism:

- For O_2 (16 electrons), the configuration ends with $(\pi_{2p_x}^{*1} = \pi_{2p_y}^{*1})$, which contains two unpaired electrons, making it paramagnetic.
- For NO (15 electrons) and O_2^- (17 electrons), the total number of electrons is odd, which automatically means at least one electron must remain unpaired, making both species paramagnetic.

Final Answer:

The species that is diamagnetic is nitrogen gas because it contains a total of 14 electrons, all of which are completely paired within its molecular orbitals.

Answer: (C)

[Go Back to Question 1](#)



Q2.

Solution

Concept: The hybridisation of an atom in a molecule depends on its steric number, which is calculated as the sum of the number of σ bonds formed by the atom and the number of lone pairs on that atom. Single bonds are σ bonds, a double bond consists of one σ and one π bond, and a triple bond consists of one σ and two π bonds.

Solution: Step 1: Determine the hybridisation of carbon in carbon dioxide (CO_2):
The central carbon atom has 4 valence electrons and forms two double bonds with two oxygen atoms ($\text{O} = \text{C} = \text{O}$). Each double bond consists of one σ bond and one π bond. Therefore, the carbon atom forms 2 σ bonds and carries 0 lone pairs.

$$\text{Steric Number} = 2 \sigma \text{ bonds} + 0 \text{ lone pairs} = 2$$

A steric number of 2 corresponds to sp hybridisation, giving CO_2 a linear molecular geometry.

Step 2: Determine the hybridisation of carbon in diamond:

Diamond is a covalent network allotrope of carbon where each carbon atom is covalently bound to four other carbon atoms in a regular tetrahedral arrangement. Each bond is a single σ bond. Therefore, each carbon atom forms 4 σ bonds and has 0 lone pairs.

$$\text{Steric Number} = 4 \sigma \text{ bonds} + 0 \text{ lone pairs} = 4$$

A steric number of 4 corresponds to sp^3 hybridisation.

Step 3: Combine the results to match the options. The hybridisation states are sp and sp^3 respectively.

Final Answer:

The hybridisation of carbon in carbon dioxide is sp because it forms two sigma bonds, and in diamond it is sp^3 because each carbon atom is bonded to four other atoms tetrahedrally.

Answer: (B)

[Go Back to Question 2](#)



Q3.

Solution

Concept: Phosphorous acid (H_3PO_3) is a dibasic oxoacid of phosphorus. To determine the number of P – OH bonds, we must analyze its structural connectivity. In phosphorus oxoacids, the central phosphorus atom is always bonded to at least one oxygen atom via a coordinate/double bond ($\text{P} = \text{O}$) and at least one hydrogen atom directly ($\text{P} - \text{H}$) if it is a reducing acid, while the remaining acidic hydrogens are attached as P – OH groups.

Solution: Step 1: Identify the chemical formula and basicity of the acid. The formula is H_3PO_3 . Even though it contains three hydrogen atoms, it behaves as a dibasic acid because only the hydrogens attached to oxygen can ionize in aqueous solution.

Step 2: Analyze the structural diagram provided:

- The central atom is Phosphorus (P).
- There is 1 double bond to an oxygen atom ($\text{P} = \text{O}$) at the top.
- There is 1 direct bond to a hydrogen atom ($\text{P} - \text{H}$) on the bottom-right.
- There are 2 bonds linked to hydroxyl groups ($\text{P} - \text{O} - \text{H}$), one on the bottom-left and one pointing directly downwards.

Step 3: Count the specific bonds requested. The number of direct P – OH linkages present in this arrangement is exactly 2. These two hydroxyl groups are responsible for the di-protic nature of phosphorous acid.

Final Answer:

The number of P-OH bonds in the structure of phosphorous acid is 2, which corresponds to its property as a dibasic acid.

Answer: (B)

[Go Back to Question 3](#)



Q4.

Solution

Concept: The energy required to completely remove an electron from a specific orbit in a hydrogen atom to infinity ($n = \infty$) is known as the ionization or separation energy. This energy change can be calculated using Bohr's formula for the energy levels of a hydrogen atom:

$$E_n = -\frac{13.6}{n^2} \text{ eV}$$

The energy required for the transition is given by $\Delta E = E_\infty - E_n$.

Solution: Step 1: Identify the initial and final energy states of the electron:

- Initial orbit: $n = 2$
- Final orbit (removal to infinity): $n = \infty$

Step 2: Calculate the energy of the electron at the infinity orbit:

$$E_\infty = -\frac{13.6}{\infty^2} = 0 \text{ eV}$$

Step 3: Calculate the energy of the electron in the second Bohr orbit ($n = 2$):

$$E_2 = -\frac{13.6}{2^2} = -\frac{13.6}{4} = -3.4 \text{ eV}$$

Step 4: Determine the net energy required to remove the electron by finding the energy difference:

$$\Delta E = E_\infty - E_2 = 0 - (-3.4 \text{ eV}) = +3.4 \text{ eV}$$

Thus, an input energy of 3.4 eV must be provided to liberate the electron from the second orbit.

Final Answer:

The energy required to remove the electron from the second Bohr orbit of a hydrogen atom to infinity is equal to 3.4 eV.

Answer: (C)

[Go Back to Question 4](#)



Q5.

Solution

Concept: The spectral lines of the hydrogen atom are classified into different series based on the principal quantum number of the lower energy level (n_1) to which the electron drops. For the Lyman series, $n_1 = 1$ (ultraviolet region); for the Balmer series, $n_1 = 2$ (visible region); for the Paschen series, $n_1 = 3$ (infrared region), and so on.

Solution: Step 1: Identify the condition for a transition to fall within the visible spectrum of a hydrogen atom. The visible lines belong exclusively to the Balmer series.

Step 2: Apply the mathematical requirement for the Balmer series:

- The lower energy level must be $n_1 = 2$.
- The upper energy level from which the electron transitions down must be $n_2 = 3, 4, 5, 6, \dots$

Step 3: Evaluate the given options based on this criterion:

- Option (A) $n = 3 \rightarrow n = 1$: Since $n_1 = 1$, this line belongs to the Lyman series (Ultraviolet).
- Option (B) $n = 4 \rightarrow n = 2$: Since $n_1 = 2$, this line belongs to the Balmer series, which lies in the visible spectrum.
- Option (C) $n = 2 \rightarrow n = 1$: Since $n_1 = 1$, this line belongs to the Lyman series (Ultraviolet).
- Option (D) $n = 5 \rightarrow n = 4$: Since $n_1 = 4$, this line belongs to the Brackett series (Infrared).

Step 4: Therefore, the transition $n = 4 \rightarrow n = 2$ is the one that produces light in the visible region.

Final Answer:

The transition from $n = 4$ to $n = 2$ falls within the visible region of the hydrogen spectrum because all downward electronic transitions terminating at $n = 2$ constitute the Balmer series.

Answer: (B)

[Go Back to Question 5](#)



Q6.

Solution

Concept: The geometry and shape of a molecule can be determined using the Valence Shell Electron Pair Repulsion (VSEPR) theory. The steric number is found by adding the number of bonding atoms (sigma bonds) to the number of lone pairs on the central atom.

Solution: Step 1: Determine the total number of valence electrons for the central Xenon (Xe) atom. Xenon is a noble gas, so it possesses 8 valence electrons.

Step 2: Count the electrons involved in bonding with Fluorine (F) atoms. In XeF_4 , Xenon forms four single covalent bonds with four fluorine atoms, which utilizes 4 valence electrons.

Step 3: Calculate the remaining non-bonding valence electrons on Xenon:

$$\text{Remaining electrons} = 8 - 4 = 4 \text{ electrons}$$

These 4 non-bonding electrons organize into $4/2 = 2$ lone pairs on the Xenon atom.

Step 4: Find the total steric number of the central atom:

$$\text{Steric Number} = 4 \text{ bonding pairs} + 2 \text{ lone pairs} = 6$$

A steric number of 6 corresponds to an octahedral electronic geometry with sp^3d^2 hybridisation. To minimize electronic repulsion, the two lone pairs occupy positions opposite to each other (axial positions), leaving the four fluorine atoms arranged in a flat plane. Hence, the actual molecular shape is square planar.

Final Answer:

The correct statement about XeF_4 is that it has a square planar shape with two lone pairs residing on the central Xenon atom.

Answer: (B)

[Go Back to Question 6](#)

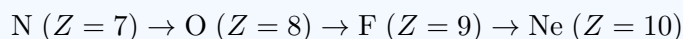


Q7.

Solution

Concept: First ionisation enthalpy generally increases across a period from left to right due to the increase in effective nuclear charge and a decrease in atomic size. However, stable electronic configurations (such as half-filled or fully filled subshells) create exceptions to this smooth trend.

Solution: Step 1: Write the general order of elements across the second period from left to right:

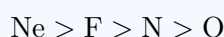


Step 2: Examine the electronic configurations of each element to check for stability factors:

- Neon (Ne): $1s^2 2s^2 2p^6$ (Inert gas with a completely filled stable octet; it has the highest ionisation enthalpy).
- Fluorine (F): $1s^2 2s^2 2p^5$ (High effective nuclear charge, highly electronegative, lacks a stable half-filled shell but is smaller than N and O).
- Nitrogen (N): $1s^2 2s^2 2p^3$ (Contains a stable, exactly half-filled $2p$ subshell).
- Oxygen (O): $1s^2 2s^2 2p^4$ (Removing one electron results in a stable $2p^3$ configuration).

Step 3: Identify the anomaly between Nitrogen and Oxygen. Because of the extra stability associated with the half-filled $2p^3$ subshell of Nitrogen, it requires more energy to remove an electron from a Nitrogen atom than from an Oxygen atom, despite Oxygen having a higher nuclear charge. Thus, $\text{N} > \text{O}$.

Step 4: Combine these trends into a final sequence of decreasing first ionisation enthalpy:



Final Answer:

The correct decreasing order of first ionisation enthalpy is $\text{Ne} > \text{F} > \text{N} > \text{O}$ due to the stable closed shell of Ne and the half-filled p-subshell stability of N over O.

Answer: (A)

[Go Back to Question 7](#)



Q8.

Solution

Concept: The empirical formula gives the simplest whole-number ratio of atoms of each element present in a compound, whereas the molecular formula gives the actual number of atoms of each element present. The relation between the two formulas is given by:

$$\text{Molecular Formula} = n \times (\text{Empirical Formula})$$

$$\text{where } n = \frac{\text{Molar Mass}}{\text{Empirical Formula Mass}}$$

Solution: Step 1: Identify the given information:

- Empirical formula: CH_2O
- Molar mass of the compound: 180 g mol^{-1}

Step 2: Compute the formula mass of the empirical unit (CH_2O):

- Atomic mass of Carbon (C) = 12 u
- Atomic mass of Hydrogen (H) = 1 u
- Atomic mass of Oxygen (O) = 16 u

$$\text{Empirical Formula Mass} = 12 + (2 \times 1) + 16 = 12 + 2 + 16 = 30 \text{ g mol}^{-1}$$

Step 3: Determine the multiplier factor n :

$$n = \frac{\text{Molar Mass}}{\text{Empirical Formula Mass}} = \frac{180}{30} = 6$$

Step 4: Calculate the molecular formula by multiplying each subscript in the empirical formula by $n = 6$:

$$\text{Molecular Formula} = (\text{CH}_2\text{O}) \times 6 = \text{C}_{1 \times 6}\text{H}_{2 \times 6}\text{O}_{1 \times 6} = \text{C}_6\text{H}_{12}\text{O}_6$$

Final Answer:

The molecular formula of the compound is $\text{C}_6\text{H}_{12}\text{O}_6$, obtained by multiplying the empirical formula components by the scaling factor of 6.

Answer: (B)

[Go Back to Question 8](#)



Q9.

Solution

Concept: According to the mole concept, one mole of any chemical substance contains an absolute number of structural units equal to the Avogadro constant ($N_A = 6.022 \times 10^{23}$ particles). The total number of molecules in a given sample mass can be determined using the formula:

$$\text{Number of moles } (n) = \frac{\text{Given Mass}}{\text{Molar Mass}}$$

$$\text{Total Molecules} = n \times N_A$$

Solution: Step 1: Extract the parameters provided in the problem statement:

- Given mass of carbon dioxide (CO_2) = 22 g
- Molar mass of carbon dioxide (CO_2) = 44 g mol⁻¹
- Avogadro constant (N_A) = 6.022×10^{23} molecules mol⁻¹

Step 2: Calculate the number of moles present in the sample:

$$\text{Number of moles } (n) = \frac{22 \text{ g}}{44 \text{ g mol}^{-1}} = 0.5 \text{ mol}$$

Step 3: Compute the absolute quantity of molecules by multiplying the moles by Avogadro's number:

$$\text{Total Molecules} = 0.5 \times 6.022 \times 10^{23}$$

$$\text{Total Molecules} = 3.011 \times 10^{23} \text{ molecules}$$

Final Answer:

The total number of molecules contained within 22 g of carbon dioxide gas is equal to 3.011×10^{23} molecules.

Answer: (B)

[Go Back to Question 9](#)



Q10.

Solution

Concept: Le Chatelier's Principle states that if a dynamic equilibrium system is subjected to a change in temperature, pressure, or concentration of reacting species, the system will shift its equilibrium position in a direction that counteracts or undoes the effect of that applied disturbance. For gas-phase equilibria, increasing the total pressure shifts the reaction toward the side with fewer total moles of gas.

Solution: Step 1: Analyze the stoichiometry of the given reversible gaseous reaction:



Step 2: Count the total moles of gas on both sides of the chemical equation:

- Reactant side (PCl_5): 1 mole of gaseous particles.
- Product side ($\text{PCl}_3 + \text{Cl}_2$): $1 + 1 = 2$ moles of gaseous particles.

Step 3: Deduce the effect of increasing the pressure. When the system's pressure is increased, it tries to relieve this stress by reducing the total volume or number of gas particles in space. Therefore, the equilibrium shifts toward the side with a lower number of gas moles.

Step 4: Compare the mole counts. Since the reactant side has fewer moles (1 mole) than the product side (2 moles), the system shifts backward to the left, resulting in the formation of more PCl_5 . Note that the equilibrium constant K_c itself remains completely unaltered because its value depends solely on temperature.

Final Answer:

Increasing the pressure at constant temperature will shift the equilibrium to the left, favoring the reactant side to produce more PCl_5 in accordance with Le Chatelier's Principle.

Answer: (B)

[Go Back to Question 10](#)



Q11.

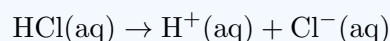
Solution

Concept: The pH of an aqueous solution measures its hydronium ion (H^+ or H_3O^+) concentration. It is defined as the negative logarithm (to the base 10) of the molar concentration of hydrogen ions:

$$\text{pH} = -\log_{10}[\text{H}^+]$$

For a strong monobasic acid like HCl, dissociation is complete in water, meaning the concentration of H^+ ions is exactly equal to the initial molarity of the acid.

Solution: Step 1: Identify the nature and concentration of the solute. Hydrochloric acid (HCl) is a strong mineral acid that undergoes complete ionization in water:



Step 2: Determine the concentration of H^+ ions. Since one mole of HCl releases one mole of H^+ ions upon dissociation, a 0.001 M solution of HCl yields:

$$[\text{H}^+] = 0.001 \text{ M} = 10^{-3} \text{ M}$$

Step 3: Substitute the value of hydrogen ion concentration into the standard pH formula:

$$\text{pH} = -\log_{10}(10^{-3})$$

Step 4: Solve the logarithmic expression using the exponent property $\log_{10}(10^x) = x$:

$$\text{pH} = -(-3) \cdot \log_{10}(10) = 3 \cdot 1 = 3$$

The solution has a pH value of 3, indicating its acidic character.

Final Answer:

The pH of a 0.001 M HCl solution is exactly 3 because the strong acid dissociates completely to yield 10^{-3} M hydrogen ions.

Answer: (C)

[Go Back to Question 11](#)



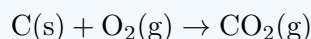
Q12.

Solution

Concept: Entropy (S) is a thermodynamic state function that serves as a measure of molecular disorder or randomness within a chemical system. The net change in reaction entropy (ΔS) can be qualitatively estimated by comparing the total number of moles of gaseous components present on the reactant side with those present on the product side:

$$\Delta S \approx \sum n_{\text{gas}}(\text{products}) - \sum n_{\text{gas}}(\text{reactants})$$

Solution: Step 1: Analyze the physical states of each chemical species involved in the given combustion reaction:



Step 2: Enumerate the number of moles of gas present before and after the chemical change:

- On the reactant side: Carbon (C) is a highly ordered crystalline solid, contributing negligibly to gaseous entropy. Oxygen (O_2) is a gas, and its coefficient is 1. Thus, $\sum n_{\text{gas}}(\text{reactants}) = 1 \text{ mol}$.
- On the product side: Carbon dioxide (CO_2) is a gas, and its stoichiometric coefficient is 1. Thus, $\sum n_{\text{gas}}(\text{products}) = 1 \text{ mol}$.

Step 3: Calculate the change in the total number of gaseous moles (Δn_g):

$$\Delta n_g = 1 - 1 = 0$$

Step 4: Interpret the result. Because the total number of highly disordered gaseous molecules remains identical throughout the progress of the reaction, the molecular chaos does not undergo any significant expansion or contraction. Consequently, the change in entropy (ΔS) is expected to be near zero or slightly negative due to minor structural differences.

Final Answer:

The change in entropy is expected to be near zero or slightly negative because exactly one mole of gas is consumed as a reactant and exactly one mole of gas is generated as a product.

Answer: (B)

[Go Back to Question 12](#)

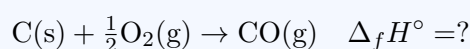


Q13.

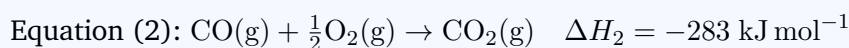
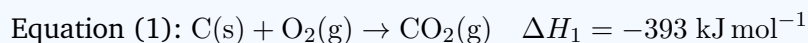
Solution

Concept: Hess's Law of Constant Heat Summation states that the total enthalpy change for a chemical reaction remains identical whether the process occurs in a single step or over multiple successive steps. The standard enthalpy of formation ($\Delta_f H^\circ$) of a compound is defined as the enthalpy change accompanying the synthesis of exactly one mole of that substance directly from its constituent elements in their most stable thermodynamic reference states.

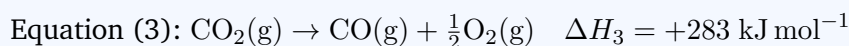
Solution: Step 1: Write down the target chemical equation that describes the standard formation of one mole of carbon monoxide gas (CO) from its elementary states:



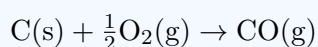
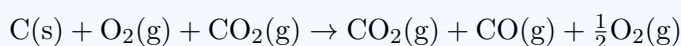
Step 2: Organize the given thermochemical data equations:



Step 3: Manipulate the given equations using algebraic operations to recreate the target synthesis. If we invert Equation (2), the reactant and product sides switch, which requires us to reverse the algebraic sign of its enthalpy change:



Step 4: Sum Equation (1) and Equation (3) together. The intermediate species carbon dioxide ($\text{CO}_2(\text{g})$) appears on opposite sides and cancels out completely. The oxygen terms simplify to $1 - \frac{1}{2} = \frac{1}{2}$ moles on the reactant side:



Step 5: Add the corresponding enthalpy values together to determine the target formation value:

$$\Delta_f H^\circ = \Delta H_1 + \Delta H_3 = -393 \text{ kJ mol}^{-1} + 283 \text{ kJ mol}^{-1} = -110 \text{ kJ mol}^{-1}$$

Final Answer: The standard enthalpy of formation of carbon monoxide gas is calculated to be -110 kJ mol^{-1} by applying Hess's Law to the provided combustion data.

Answer: (B)

[Go Back to Question 13](#)



Q14.

Solution

Concept: The electrical conductance (G) of an electrolytic solution represents the ease with which electric current can flow through it. Unlike metallic conduction, which depends on the movement of free electrons, electrolytic conduction relies on the physical migration of dissolved cations and anions toward their respective electrodes. Therefore, any factor that alters the concentration, charge, or movement speed of these ions will influence the total conductance.

Solution: Step 1: Identify the underlying mechanism of electrical transport in solutions. Solutions conduct electricity because mobile ions migrate under the influence of an applied external electric field.

Step 2: Analyze how different physical parameters affect this process:

- Concentration of ions: A higher number of ions per unit volume increases the quantity of charge carriers, leading to greater electrical conductance.
- Ionic charge: Ions carrying higher charges (e.g., Mg^{2+} compared to Na^+) transport more charge per ion, which increases the current flow.
- Ionic mobility: The velocity or speed at which ions migrate depends on their size, solvation level, and the viscosity of the solvent. Higher mobility results in higher conductance.

Step 3: Evaluate the comprehensive options. Conductance is not determined by temperature alone or by the solvent alone; instead, it depends on a combination of ionic concentration, charge magnitude, and ionic mobility.

Final Answer:

The conductance of an electrolytic solution depends on the total concentration of the ions, the magnitude of their electrical charges, and their individual transport mobilities through the medium.

Answer: (B)

[Go Back to Question 14](#)



Q15.

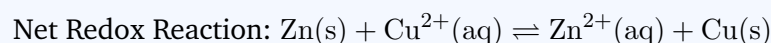
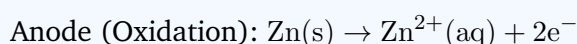
Solution

Concept: The electromotive force (EMF) of an electrochemical cell operating under non-standard concentration conditions can be determined using the Nernst Equation:

$$E_{\text{cell}} = E_{\text{cell}}^{\circ} - \frac{0.0592}{n} \log_{10} Q$$

where E_{cell}° is the standard cell potential, n is the total moles of electrons transferred in the balanced redox equation, and Q is the reaction quotient.

Solution: Step 1: Formulate the total balanced cell reaction from the provided notation:



The number of transferred electrons is verified as $n = 2$.

Step 2: Set up the mathematical expression for the reaction quotient (Q). Pure solids have an activity value of 1, so the expression depends only on the concentrations of the aqueous ions:

$$Q = \frac{[\text{Zn}^{2+}]}{[\text{Cu}^{2+}]} = \frac{0.01 \text{ M}}{1 \text{ M}} = 10^{-2}$$

Step 3: Substitute the known values ($E_{\text{cell}}^{\circ} = 1.10 \text{ V}$, $n = 2$, and $Q = 10^{-2}$) into the Nernst equation:

$$E_{\text{cell}} = 1.10 - \frac{0.0592}{2} \log_{10}(10^{-2})$$

Step 4: Evaluate the logarithmic term using the power property $\log_{10}(10^{-2}) = -2$:

$$E_{\text{cell}} = 1.10 - \left(\frac{0.0592}{2} \right) \cdot (-2)$$

The factor of 2 cancels out, and the two negative signs yield a positive term:

$$E_{\text{cell}} = 1.10 + 0.0592 = 1.1592 \text{ V} \approx 1.16 \text{ V}$$

Therefore, the operating cell potential increases to approximately 1.16 V.

Final Answer:

The non-standard electromotive force of the given galvanic cell is approximately equal to 1.16 V as calculated via the Nernst equation.

Answer: (A)

[Go Back to Question 15](#)



Q16.

Solution

Concept: The temperature dependence of chemical reaction rate constants is described by the Arrhenius Equation. When comparing rate constants (k_1 and k_2) at two different operational temperatures (T_1 and T_2), the integrated logarithmic version of the equation can be applied:

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

where E_a is the activation energy and R is the universal gas constant.

Solution: Step 1: Identify the values given in the problem statement:

- Initial temperature (T_1) = 300 K
- Final temperature (T_2) = 320 K
- Initial rate constant (k_1) = $1.6 \times 10^{-3} \text{ s}^{-1}$
- Final rate constant (k_2) = $6.4 \times 10^{-3} \text{ s}^{-1}$
- Logarithmic conversion factor: $\ln(4) = 1.386$
- Universal gas constant (R) = $8.314 \text{ J mol}^{-1}\text{K}^{-1}$

Step 2: Compute the ratio of the two rate constants:

$$\frac{k_2}{k_1} = \frac{6.4 \times 10^{-3}}{1.6 \times 10^{-3}} = 4$$

Step 3: Substitute these values into the integrated form of the Arrhenius equation:

$$\ln(4) = \frac{E_a}{8.314} \left(\frac{320 - 300}{300 \times 320}\right)$$

$$1.386 = \frac{E_a}{8.314} \left(\frac{20}{96000}\right)$$

$$1.386 = \frac{E_a}{8.314} \left(\frac{1}{4800}\right)$$

Step 4: Isolate the activation energy (E_a) variable to solve for its value in Joules:

$$E_a = 1.386 \times 8.314 \times 4800$$

$$E_a = 11.5232 \times 4800 = 55311.38 \text{ J mol}^{-1}$$

Step 5: Convert the final answer into kilojoules per mole (kJ mol^{-1}):

$$E_a = \frac{55311.38}{1000} \approx 55.3 \text{ kJ mol}^{-1}$$

Final Answer:

The activation energy for the given chemical process is approximately equal to 55.3 kJ mol^{-1} based on the temperature-dependent rate constants.

Answer: (A)

[Go Back to Question 16](#)

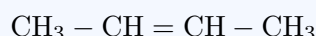


Q17.

Solution

Concept: Ozonolysis is an organic reaction where the unsaturated carbon-carbon double bond ($C = C$) of an alkene undergoes oxidative cleavage with ozone (O_3). This process initially forms a cyclic ozonide intermediate. When followed by reductive workup (using reagents like Zinc dust and water, Zn/H_2O , or dimethyl sulfide), the ozonide ring cleaves to yield carbonyl compounds (aldehydes or ketones) without further oxidation into carboxylic acids.

Solution: Step 1: Write out the structural structural layout of the starting material, 2-butene:



This is a symmetrical alkene containing an internal double bond located at the second carbon position.

Step 2: Predict the cleavage pattern during ozonolysis. A simple method to determine the products of reductive ozonolysis is to break the carbon-carbon double bond entirely and attach an oxygen atom to each of the two resulting fragments:



Step 3: Identify the resulting compounds. Both fragments are identical, and each forms a two-carbon aldehyde molecule known as acetaldehyde (CH_3CHO , or ethanal).

Step 4: Thus, the reductive ozonolysis of one mole of symmetrical 2-butene yields exactly two molecules of acetaldehyde.

Final Answer:

Reductive ozonolysis of 2-butene results in the complete cleavage of its double bond, yielding two separate molecules of acetaldehyde as the final carbonyl products.

Answer: (A)

[Go Back to Question 17](#)



Q18.

Solution

Concept: The conversion of benzene into nitrobenzene is a classic example of an Electrophilic Aromatic Substitution (S_{EAr}) reaction known as nitration. Because benzene possesses a stable aromatic π -electron cloud, it requires a powerful electrophile—specifically the nitronium ion (NO_2^+)—to disrupt its aromatic system and undergo substitution.

Solution: Step 1: Identify the electrophilic species needed for the reaction. The active electrophile required to attack the benzene ring is the nitronium ion (NO_2^+).

Step 2: Understand how the nitronium ion is generated in the reaction mixture. This species cannot be formed efficiently using nitric acid alone. Instead, a mixture of concentrated nitric acid (HNO_3) and concentrated sulfuric acid (H_2SO_4) is used, which is commonly referred to as the nitrating mixture.

Step 3: Analyze the chemical interaction within the nitrating mixture. In this combination, concentrated sulfuric acid acts as a strong Brønsted-Lowry acid, protonating the nitric acid molecule:



The protonated nitric acid subsequently loses a molecule of water to release the highly reactive nitronium ion (NO_2^+).

Step 4: The generated NO_2^+ electrophile then attacks the electron-dense benzene ring to form a sigma complex intermediate, which undergoes deprotonation to yield nitrobenzene ($\text{C}_6\text{H}_5\text{NO}_2$).

Final Answer:

The reagent used to convert benzene to nitrobenzene is a nitrating mixture consisting of concentrated nitric acid combined with concentrated sulfuric acid.

Answer: (B)[Go Back to Question 18](#)

Q19.

Solution

Concept: The iodoform test is a diagnostic organic reaction used to identify the presence of specific structural units in a compound, namely a methyl ketone group ($R - CO - CH_3$) or a secondary methyl alcohol group ($R - CH(OH) - CH_3$). When treated with iodine (I_2) in the presence of sodium hydroxide ($NaOH$), these specific groupings undergo oxidation and halogenation to form a bright yellow precipitate of iodoform (CHI_3).

Solution: Step 1: Identify the structural requirement for an alcohol to give a positive iodoform test. The alcohol must possess a methyl group directly bonded to the carbon atom that carries the hydroxyl group, forming a $-CH(OH) - CH_3$ unit. This structure is required because the reagent first oxidizes the alcohol into a carbonyl intermediate containing a reactive $-CO - CH_3$ group.

Step 2: Examine the chemical structures of the provided choices:

- Methanol: CH_3OH (Contains only a single carbon atom; lacks the required grouping).
- Ethanol: $CH_3 - CH_2 - OH$ (Can be rewritten as $H - CH(OH) - CH_3$. This fits the required structural unit).
- Propan-1-ol: $CH_3 - CH_2 - CH_2 - OH$ (A primary alcohol that oxidizes to propanal; lacks a methyl group directly attached to the C1 alcohol carbon).
- Benzyl alcohol: $C_6H_5 - CH_2 - OH$ (An aromatic primary alcohol; lacks the necessary methyl group connectivity).

Step 3: Confirm the reaction pathway for ethanol. When ethanol reacts with the alkaline iodine solution, it is first oxidized to acetaldehyde (CH_3CHO). The three alpha-hydrogen atoms on the methyl group are then replaced by iodine atoms to form triiodoacetaldehyde (CI_3CHO), which undergoes nucleophilic cleavage by OH^- to yield a yellow precipitate of iodoform (CHI_3) and sodium formate ($HCOONa$).

Final Answer:

Ethanol is the compound that gives a positive iodoform test because it contains the required methyl alcohol connectivity to form a yellow iodoform precipitate.

Answer: (B)[Go Back to Question 19](#)

Q20.

Solution

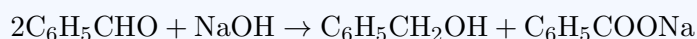
Concept: The Cannizzaro reaction is an organic redox reaction in which aldehydes that completely lack any alpha-hydrogen atoms (α -H) undergo a self-disproportionation reaction when exposed to a concentrated strong base (such as concentrated NaOH or KOH). In this process, one molecule of the aldehyde is reduced to its corresponding primary alcohol, while another molecule is simultaneously oxidized to the salt of its corresponding carboxylic acid. Aldehydes that possess α -H atoms will undergo Aldol condensation instead.

Solution: Step 1: Understand the structural requirement for the Cannizzaro reaction. The aldehyde must not contain any hydrogen atoms on the carbon atom directly adjacent to the carbonyl group (the α -carbon atom).

Step 2: Analyze the structures of the given aldehydes to determine the presence of α -hydrogens:

- Acetaldehyde (CH_3CHO): The α -carbon is a methyl group containing 3 α -hydrogen atoms. It undergoes Aldol condensation.
- Benzaldehyde ($\text{C}_6\text{H}_5\text{CHO}$): The carbonyl carbon is attached directly to a sp^2 hybridized carbon atom of the benzene ring. This carbon atom is bonded to three other carbon atoms within the aromatic ring and carries no hydrogen atoms. Therefore, it has 0 α -hydrogen atoms.
- Propanal ($\text{CH}_3\text{CH}_2\text{CHO}$): The α -carbon is a methylene group carrying 2 α -hydrogen atoms.
- Butyraldehyde ($\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$): The α -carbon has 2 α -hydrogen atoms.

Step 3: Since benzaldehyde completely lacks α -hydrogen atoms, it undergoes the Cannizzaro reaction when treated with concentrated alkali:



This reaction yields benzyl alcohol and sodium benzoate.

Final Answer:

Benzaldehyde undergoes the Cannizzaro reaction because it lacks alpha-hydrogen atoms, causing it to undergo disproportionation into benzyl alcohol and sodium benzoate in a concentrated basic medium.

Answer: (B)

[Go Back to Question 20](#)



Q21.

Solution

Concept: Carboxylic acids react with powerful halogenating agents such as phosphorus pentachloride (PCl_5), phosphorus trichloride (PCl_3), or thionyl chloride (SOCl_2) via a nucleophilic acyl substitution pathway. During this transformation, the hydroxyl group ($-\text{OH}$) attached to the acyl carbon is replaced by a chlorine atom ($-\text{Cl}$), converting the carboxylic acid into its corresponding acyl chloride (acid chloride).

Solution: Step 1: Write down the chemical formulas of the reactants. The starting materials are acetic acid (CH_3COOH) and phosphorus pentachloride (PCl_5).

Step 2: Trace the breaking and formation of chemical bonds. The $-\text{OH}$ group of the acetic acid molecule is cleaved from the carbonyl carbon. A chlorine atom from PCl_5 is transferred to the carbonyl carbon, forming acetyl chloride (CH_3COCl).

Step 3: Determine the nature of the inorganic by-products. The remaining parts of the cleaved hydroxyl group react with the remaining phosphorus tetrachloride fragment. The oxygen atom links with phosphorus via a strong double bond to form phosphorus oxychloride (POCl_3), while the hydrogen atom combines with another chlorine atom to release hydrogen chloride gas (HCl).

Step 4: Combine the individual components into a single balanced chemical equation:



This shows that the reaction forms acetyl chloride, phosphorus oxychloride, and hydrogen chloride gas.

Final Answer:

The reaction of acetic acid with PCl_5 yields acetyl chloride (CH_3COCl), phosphorus oxychloride (POCl_3), and hydrogen chloride (HCl) via nucleophilic acyl substitution.

Answer: (A)

[Go Back to Question 21](#)



Q22.

Solution

Concept: Monosaccharides like D-glucose exist predominantly in cyclic hemiacetal forms rather than open-chain structures. In aqueous solution, the hydroxyl group attached to the fifth carbon (C5) attacks the carbonyl carbon (C1), closing the ring to form a six-membered pyranose structure. This cyclization creates a new stereocenter at C1, known as the anomeric carbon. The two resulting stereoisomers are called the α and β anomers.

Solution: Step 1: Understand the conventions used in drawing a Haworth projection for a D-glucopyranose ring. The six-membered ring is depicted as a flat plane viewed from the edge, with the ring oxygen atom located at the upper right position.

Step 2: Number the carbon atoms in a clockwise direction, starting from the rightmost position, which corresponds to the anomeric carbon (C1).

Step 3: Apply the structural rules for designating α and β configurations in the Haworth representation of D-sugars:

- For the α -anomer, the hydroxyl group ($-\text{OH}$) attached to the anomeric carbon (C1) points downwards, which is below the plane of the ring (corresponding to an axial orientation in the stable chair conformation).
- For the β -anomer, the hydroxyl group ($-\text{OH}$) at C1 points upwards, which is above the plane of the ring (corresponding to an equatorial orientation in the chair conformation).

Step 4: According to the provided diagram and the structural rules for α -D-glucose, the $-\text{OH}$ group at the C1 position points downwards, placing it below the ring plane.

Final Answer:

The Haworth projection of α -D-glucose shows the $-\text{OH}$ group at C1 pointing below the ring plane, which corresponds to the axial position in its stable conformation.

Answer: (C)[Go Back to Question 22](#)

Q23.

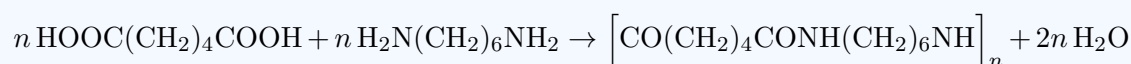
Solution

Concept: Polymers can be broadly classified into two major categories based on their mechanism of polymerization: addition polymers and condensation polymers. Addition polymers are formed by the direct linkage of unsaturated monomer units (containing double or triple bonds) without the loss of any small molecular fragments. Condensation polymers are formed through a series of step-growth reactions between bi-functional or poly-functional monomers, a process that is typically accompanied by the elimination of small stable molecules such as water (H_2O), ammonia (NH_3), or hydrogen chloride (HCl).

Solution: Step 1: Analyze the polymerization reactions for each of the given options:

- Polythene: Formed by the addition polymerization of ethene monomers ($\text{CH}_2 = \text{CH}_2$) under high pressure. No small molecules are eliminated during this process.
- Nylon-6,6: Prepared by the step-growth condensation copolymerization of two different bifunctional monomers: adipic acid ($\text{HOOC} - (\text{CH}_2)_4 - \text{COOH}$) and hexamethylenediamine ($\text{H}_2\text{N} - (\text{CH}_2)_6 - \text{NH}_2$).

Step 2: Examine the reaction mechanism of Nylon-6,6. When the carboxylic acid functional group ($-\text{COOH}$) of adipic acid reacts with the primary amine functional group ($-\text{NH}_2$) of hexamethylenediamine, a new amide linkage ($-\text{CONH}-$) is established. Each coupling step eliminates a molecule of water:



This systematic loss of water molecules defines it as a condensation polymer.

Step 3: Evaluate the remaining options:

- Teflon: Produced by the addition polymerization of tetrafluoroethene ($\text{CF}_2 = \text{CF}_2$).
- Natural rubber: A linear addition polymer of isoprene (2-methyl-1,3-butadiene).

Final Answer:

Nylon-6,6 is a condensation polymer formed via step-growth copolymerization between adipic acid and hexamethylenediamine with the elimination of water molecules.

Answer: (B)

[Go Back to Question 23](#)



Q24.

Solution

Concept: Packing efficiency represents the percentage of total space inside a crystal unit cell that is physically occupied by constituent particles (treated as hard spheres). It can be calculated using the formula:

$$\text{Packing Efficiency} = \frac{\text{Volume occupied by spheres in unit cell}}{\text{Total volume of the unit cell}} \times 100\%$$

$$\text{Packing Efficiency} = \frac{Z \times \left(\frac{4}{3}\pi r^3\right)}{V_{\text{cell}}} \times 100\%$$

where Z is the effective number of atoms per unit cell, r is the atomic radius, and V_{cell} is the total unit cell volume.

Solution: Step 1: Analyze the geometry of a Simple Cubic (SC) lattice:

- In a simple cubic structure, atoms are located only at the eight corners of the cube.
- Each corner atom is shared equally among 8 adjacent unit cells. Therefore, the effective number of atoms belonging to a single unit cell is:

$$Z = 8 \times \frac{1}{8} = 1$$

Step 2: Establish the geometric relationship between the cube edge length (a) and the atomic radius (r). In a simple cubic lattice, the spheres touch each other along the edges of the cell, as shown in the provided diagram:

$$a = 2r$$

Step 3: Express the total volume of the cubic unit cell (V_{cell}) in terms of the atomic radius (r):

$$V_{\text{cell}} = a^3 = (2r)^3 = 8r^3$$

Step 4: Substitute these values into the packing efficiency expression:

$$\text{Packing Efficiency} = \frac{1 \times \left(\frac{4}{3}\pi r^3\right)}{8r^3} \times 100\% = \frac{4\pi r^3}{3 \times 8r^3} \times 100\%$$

$$\text{Packing Efficiency} = \frac{\pi}{6} \times 100\% \approx \frac{3.14159}{6} \times 100\% \approx 52.4\%$$

Rounding this to the nearest whole integer yields approximately 52%.

Final Answer:

The packing efficiency of a simple cubic unit cell is approximately 52%, meaning that 52% of the total volume is occupied by atoms while the remaining 48% is empty space.

Answer: (A)

[Go Back to Question 24](#)



Q25.

Solution

Concept: According to standard IUPAC nomenclature rules for coordination compounds, the naming process follows a strict sequence: 1. Name the ligands first in alphabetical order, using Greek prefixes (such as di-, tri-, tetra-, penta-, hexa-) to indicate their quantities. 2. Name the central metal atom. If the entire coordination sphere carries a net negative charge (an anionic complex), the suffix of the metal atom must be modified to end in "-ate". For iron, the Latin root is used, transforming it into "ferrate". 3. Specify the formal oxidation state of the central metal atom as a Roman numeral enclosed in parentheses immediately following the metal's name.

Solution: Step 1: Identify the components inside the coordination sphere of the complex ion:



- The ligand is the cyanide ion (CN^-), which is named as "cyano" (or "cyanido") according to IUPAC guidelines.
- There are six cyanide ligands, which is designated by the prefix "hexa-", giving "hexacyano".

Step 2: Determine the formal oxidation state of the central iron atom (Fe). Let its oxidation state be represented by the variable x . Cyanide is an anionic ligand with a charge of -1 , and the total net charge of the complex is -3 :

$$x + 6(-1) = -3$$

$$x - 6 = -3 \implies x = +3$$

Thus, iron exists in the $+3$ oxidation state, which will be written as (III).

Step 3: Determine the name of the central metal. Because the coordination sphere carries a net negative charge (-3), the complex is anionic. Therefore, the name of the central iron atom must take the "-ate" suffix based on its Latin root, becoming "ferrate(III)".

Step 4: Combine the components. The complete IUPAC name of the complex anion is the hexacyanoferrate(III) ion.

Final Answer:

According to IUPAC rules, the correct name of $[\text{Fe}(\text{CN})_6]^{3-}$ is the hexacyanoferrate(III) ion because the complex is anionic and iron has an oxidation state of $+3$.

Answer: (B)

[Go Back to Question 25](#)



Q26.

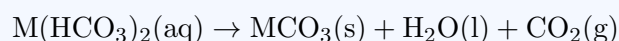
Solution

Concept: The hydrogen carbonates (bicarbonates) of Group 2 alkaline earth metals (Be, Mg, Ca, Sr, Baria) differ significantly in stability from those of Group 1 alkali metals. While several alkali metal bicarbonates (such as NaHCO_3 or KHCO_3) can be readily isolated as stable crystalline solids at room temperature, the bicarbonates of the alkaline earth metals are thermodynamically unstable in the solid state.

Solution: Step 1: Review the existence and physical properties of alkaline earth metal bicarbonates:

- Compounds like calcium bicarbonate [$\text{Ca}(\text{HCO}_3)_2$] and magnesium bicarbonate [$\text{Mg}(\text{HCO}_3)_2$] are well known for causing temporary hardness in water.
- However, these compounds exist and remain stable exclusively in aqueous solution.

Step 2: Analyze what happens when you attempt to isolate these compounds by heating or evaporating their solutions. As the water is removed, these dissolved bicarbonates undergo rapid thermal decomposition, breaking down into their corresponding insoluble carbonates, water, and carbon dioxide gas:



where $\text{M} = \text{Ca}, \text{Mg}, \text{Ba}, \text{etc.}$

Step 3: Due to this low thermal stability, it is impossible to isolate any alkaline earth metal bicarbonate as a stable solid substance at standard room conditions. They decompose before solidifying.

Step 4: Therefore, none of the listed alkaline earth metals can form a stable bicarbonate in the solid state, making Option (D) the correct choice.

Final Answer:

None of the alkaline earth metals form a stable bicarbonate in the solid state; all Group 2 bicarbonates exist and remain stable exclusively in aqueous solution.

Answer: (D)

[Go Back to Question 26](#)



Q27.

Solution

Concept: Colloidal solutions can be prepared using various techniques, which are broadly divided into two main classes: condensation (aggregation) methods and dispersion (fragmentation) methods. Dispersion methods involve breaking down large macroscopic pieces of a substance into smaller particles of colloidal dimensions (1 to 1000 nm). Bredig's Arc method (also known as the electrical disintegration or dispersion method) is a widely used technique for preparing colloidal sols of unreactive noble metals such as gold, silver, or platinum.

Solution: Step 1: Understand the experimental setup of Bredig's Arc method as illustrated in the provided schematic diagram:

- Two rods of the metal to be dispersed (gold rods in this case) are immersed in a cold dispersion medium (water containing a small amount of KOH as a stabilizer).
- The entire container is surrounded by an ice bath to maintain a very low temperature.
- An intense electrical arc is struck between the tips of the gold electrodes beneath the surface of the liquid.

Step 2: Analyze the physical processes occurring during the operation:

- The extreme heat generated by the electric arc instantly vaporizes a portion of the metallic gold rods.
- The intense cold provided by the surrounding ice bath immediately condenses these hot metal vapors into small particles of colloidal size.

Step 3: Characterize the method. Because the primary step involves breaking down macroscopic metal rods into colloidal particles using an electrical discharge, this technique is classified as an electrical dispersion method.

Final Answer:

Preparation of a gold sol by Bredig's arc method is an example of an electrical dispersion method, combining mechanical disintegration via an electric arc with rapid thermal condensation.

Answer: (C)

[Go Back to Question 27](#)



Q28.

Solution

Concept: Gabriel phthalimide synthesis is a classic laboratory method used for preparing pure primary aliphatic amines ($R - NH_2$) without contamination from secondary or tertiary amines. The reaction relies on the nucleophilic substitution (S_N2) of an alkyl halide by the phthalimide anion.

Solution: Step 1: Trace the sequence of steps involved in Gabriel synthesis:

- Phthalimide is first treated with ethanolic potassium hydroxide (KOH) to abstract its acidic imide proton, generating potassium phthalimide.
- The nucleophilic phthalimide anion then attacks an added primary alkyl halide ($R - X$) via a backside S_N2 mechanism, displacing the halide leaving group to form an *N*-alkylphthalimide intermediate.

Step 2: Complete the synthesis by liberating the amine. The *N*-alkylphthalimide is subsequently cleaved by alkaline hydrolysis (using aqueous NaOH) or hydrazinolysis (using hydrazine, N_2H_4). This breaks the cyclic imide linkages, releasing a pure primary aliphatic amine along with a phthalate byproduct:



Step 3: Understand the limitations of the reaction. Because the key step relies on an S_N2 displacement, this method cannot be used with aryl halides to prepare aniline, as aryl halides do not undergo nucleophilic attack under standard conditions. Crucially, the steric environment prevents the formation of secondary or tertiary amines, making it highly specific for synthesizing primary amines.

Final Answer:

Gabriel phthalimide synthesis is used specifically for the preparation of pure primary aliphatic amines because the reaction path prevents multi-alkylation from occurring.

Answer: (C)

[Go Back to Question 28](#)



Q29.

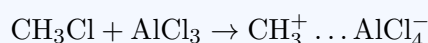
Solution

Concept: Benzene is an aromatic hydrocarbon that is stabilized by a delocalized cloud of π electrons. Because of this high electron density, benzene reacts primarily with strong electrophilic species that can temporarily disrupt its aromaticity. These reactions are classified as Electrophilic Aromatic Substitutions (S_EAr). Friedel–Crafts alkylation is a well-known example of this class of reactions.

Solution: Step 1: Identify the roles of the chemicals present in the reaction mixture:

- Benzene serves as the electron-rich aromatic substrate.
- Methyl chloride (CH_3Cl) provides the alkyl group source.
- Anhydrous aluminum chloride ($AlCl_3$) acts as a powerful Lewis acid catalyst.

Step 2: Trace the mechanism of electrophile generation. The anhydrous $AlCl_3$ catalyst attacks the chlorine atom of the methyl chloride molecule, abstracting it to form a complex. This polarizes the carbon-chlorine bond, generating a highly reactive methyl carbocation electrophile (CH_3^+):



Step 3: Describe the attack on the aromatic ring. The electron-dense benzene ring attacks the generated CH_3^+ electrophile, forming a resonance-stabilized carbocation intermediate known as an arenium ion (or sigma complex).

Step 4: Restore aromaticity. The $AlCl_4^-$ ion then acts as a weak base, abstracting a proton from the sp^3 hybridized carbon of the arenium ion. This restores the stable aromatic system, yielding toluene ($C_6H_5CH_3$) and regenerating the $AlCl_3$ catalyst. Because an electrophile replaces a hydrogen atom on the aromatic ring, the pathway is an electrophilic aromatic substitution.

Final Answer:

In the presence of anhydrous $AlCl_3$, benzene reacts with CH_3Cl via electrophilic aromatic substitution, a process commonly known as Friedel–Crafts alkylation.

Answer: (C)

[Go Back to Question 29](#)

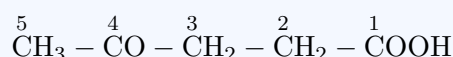


Q30.

Solution

Concept: To determine the correct IUPAC name of a polyfunctional organic compound, the principal functional group must first be identified according to the official IUPAC priority rules. The principal group defines the suffix of the parent chain name, while all other functional groups are treated as substituents and named using prefixes. The longest continuous carbon chain containing the principal group is numbered to give the lowest possible locants to the principal functional groups.

Solution: Step 1: Analyze the functional groups present in the given compound:



The compound contains two different functional groups: a carboxylic acid group ($-\text{COOH}$) and a ketone group ($-\text{CO}-$).

Step 2: Determine the priority ranking. According to IUPAC guidelines, carboxylic acids take priority over ketones, aldehydes, alcohols, and amines. Therefore, the $-\text{COOH}$ carbon defines the principal group and will take the suffix "-oic acid".

Step 3: Number the parent carbon chain. Numbering starts at the carboxylic acid carbon to give it the lowest possible locant: - C1 is the carboxylic acid carbon ($-\text{COOH}$).

- C2 and C3 are methylene groups ($-\text{CH}_2 - \text{CH}_2-$).
- C4 is the carbonyl carbon of the ketone ($-\text{CO}-$).
- C5 is the terminal methyl group ($-\text{CH}_3$).

The parent chain contains 5 carbons, which corresponds to "pentanoic acid".

Step 4: Name the remaining ketone group as a prefix substituent. When a ketone is treated as a substituent, its presence is indicated by the prefix "oxo-". Since it is located at the fourth carbon position, its full designation is "4-oxopentanoic acid". Note that while levulinic acid is a widely accepted common name, it is not the systematic IUPAC name.

Final Answer:

The correct systematic IUPAC name of the compound $\text{CH}_3 - \text{CO} - \text{CH}_2 - \text{CH}_2 - \text{COOH}$ is 4-oxopentanoic acid, as the carboxylic acid group takes priority over the ketone.

Answer: (A)

[Go Back to Question 30](#)



Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	B	3	B	4	C	5	B
6	B	7	A	8	B	9	B	10	B
11	C	12	B	13	B	14	B	15	A
16	A	17	A	18	B	19	B	20	B
21	A	22	C	23	B	24	A	25	B
26	D	27	C	28	C	29	C	30	A

