NIOS Class 12 Chemistry Sample Paper – 3

Duration: 180 Minutes **Maximum Marks: 80**

Instructions

- This paper contains **43** Questions. The paper is divided into two sections: **Section A – 40** marks, **Section B – 40** marks.
- **Section A** consists of
  - **Q.No. 1 to 16** – Multiple Choice type questions (MCQs) carrying 1 mark each. Select and write the most appropriate option out of the four options given in each of these questions. An internal choice has been provided in some of these questions. You have to attempt only one of the given choices in such questions.
  - **Q. No. 17 to 28** – Objective type questions. Q. No. 17 to 28 carry 02 marks each (with 2 sub- parts of 1 mark each). Attempt these questions as per the instructions given for each of the questions 17 –28.
- **Section B** consists of
  - **Q.No. 29 to 37** – Very Short questions carrying 02 marks each to be answered in the range of 30 to 50 words.
  - **Q.No. 38 to 41** – Short Answer type questions carrying 03 marks each to be answered in the range of 50 to 80 words.
  - **Q.No. 42 and 43** – Long Answer type questions carrying 05 marks each to be answered in the range of 80 to 120 words.
- There is **No Negative marking**.
- Use of mobile phones, smartwatches, calculators, or any electronic gadgets is strictly prohibited.

Section: A

Q1. The number of atoms present in 0.10 mol of ammonia (NH_3) is: **(1)**

(A) 6.022×10^{22}

(B) 2.408×10^{23}

(C) 1.806×10^{23}

(D) 1.204×10^{23}

Q2. The ground state electronic configuration of Chromium (Cr, $Z = 24$) is: **(1)**

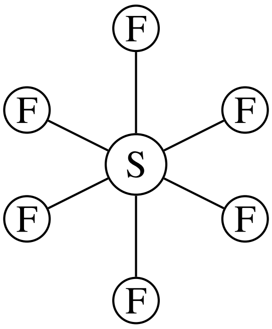
(A) $[\text{Ar}]4s^2 3d^4$

(B) $[\text{Ar}]4s^1 3d^5$

(C) $[\text{Ar}]4s^2 3d^5$

(D) $[\text{Ar}]4s^1 3d^4$

Q3. The molecular geometry of SF_6 as shown in the diagram is: **(1)**



(A) Tetrahedral

(B) Octahedral

(C) Trigonal bipyramidal

(D) Square planar

Q4. At constant temperature, the pressure of a fixed amount of gas is inversely proportional to its volume. This statement is known as: **(1)**

(A) Charles's law

(B) Boyle's law

(C) Avogadro's law

(D) Gay-Lussac's law

Q5. Which of the following conditions represents an ideal solution? **(1)**

(A) $\Delta H_{mix} > 0$

(B) $\Delta V_{mix} < 0$

(C) $\Delta H_{mix} = 0, \Delta V_{mix} = 0$

(D) Raoult's law is not obeyed

Q6. The entropy change for the melting of solid ice into liquid water is: **(1)**

(A) Negative

(B) Zero

(C) Positive

(D) Cannot be determined

Q7. The unit of the rate constant for a zero-order reaction is: **(1)**

(A) s^{-1}

(B) $\text{mol L}^{-1}\ \text{s}^{-1}$

(C) $\text{L mol}^{-1}\ \text{s}^{-1}$

(D) $\text{L}^2\ \text{mol}^{-2}\ \text{s}^{-1}$

Q8. According to Faraday's first law of electrolysis, the mass of a substance deposited at an electrode is: **(1)**

(A) Inversely proportional to the current

(B) Directly proportional to the quantity of electricity passed

(C) Independent of time

(D) Proportional to the square of the voltage

Q9. The conjugate base of the hydrogen sulphate ion (HSO_4^-) is: **(1)**

(A) H_2SO_4

(B) SO_4^{2-}

(C) $H_3SO_4^+$

(D) SO_3^{2-}

Q10. The oxidation state of phosphorus in phosphoric acid (H_3PO_4) is: **(1)**

(A) +3

(B) +5

(C) +4

(D) +1

Q11. The spin-only magnetic moment of Fe^{3+} ion (atomic number of Fe = 26) is approximately: **(1)**

(A) 1.73 BM

(B) 5.92 BM

(C) 4.90 BM

(D) 2.83 BM

Q12. Ethylenediaminetetraacetate (EDTA) is an example of a: **(1)**

(A) Monodentate ligand

(B) Bidentate ligand

(C) Hexadentate ligand

(D) Tridentate ligand

Q13. The IUPAC name of the compound $CH_3 - CH(CH_3) - CH_2 - OH$ is: **(1)**

(A) 2-Methylpropan-1-ol

(B) Butan-1-ol

(C) 2-Methylpropan-2-ol

(D) Butan-2-ol

Q14. The addition of HBr to propene yields mainly: **(1)**

(A) 1-Bromopropane

(B) 2-Bromopropane

(C) 1,2-Dibromopropane

(D) Propane

Q15. Which reagent is best used to convert a primary alcohol to an aldehyde without further oxidation? **(1)**

(A) Acidified $KMnO_4$

(B) Acidified $K_2Cr_2O_7$

(C) Pyridinium chlorochromate (PCC)

(D) $LiAlH_4$

Q16. Which of the following is commonly used as an artificial sweetening agent? **(1)**

(A) Sucrose

(B) Saccharin

(C) Fructose

(D) Maltose

Note: Q. No. 17 to 28 are the objective type questions of 2 marks each.

Q17. Read the passage given below and answer the following questions:

In a chemical reaction, the reactant that is entirely consumed when the reaction goes to completion is called the limiting reagent. It determines the maximum amount of product that can be formed. **(2)**

1. Define a limiting reagent in your own words.
2. In the reaction $2H_2 + O_2 \rightarrow 2H_2O$, if 2 moles of H_2 react with 2 moles of O_2, which is the limiting reagent?

Q18. Fill in the blanks: **(2)**

1. The energy of an electron in the n^{th} Bohr orbit of a hydrogen atom is inversely proportional to ....

2. The angular momentum of an electron in a stationary orbit is an integral multiple of . . . .

Q19. Write TRUE (T) for the correct statement and FALSE (F) for the incorrect statement: **(2)**

1. Hydrogen bonding is present in H_2S molecules.
2. London dispersion forces are the weakest intermolecular forces.

Q20. Complete the following by using the options given below:

(intensive, extensive, state, path) **(2)**

1. Enthalpy is an . . . . .property.
2. Temperature is an . . . . property.

Q21. Complete the following by using the options given below:

(zero, one, molecularity, order) **(2)**

1. The sum of powers of concentration terms in the experimental rate law is called the . . . . of the reaction.
2. The . . of an elementary reaction can never be zero or a fractional number.

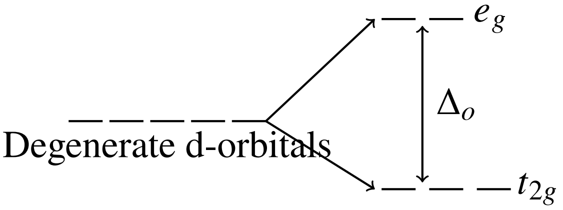
Q22. Read the passage given below and answer the following questions:

Ozone (O_3) is a thermodynamically unstable allotrope of oxygen. It readily decomposes into molecular oxygen and nascent oxygen, which makes it a powerful oxidizing agent. **(2)**

1. Why does ozone act as a powerful oxidizing agent?
2. What happens when ozone reacts with lead sulphide (PbS)?

Q23. Read the passage given below and answer the following questions:

Crystal Field Theory (CFT) treats ligands as point charges. In an octahedral complex, the five degenerate d-orbitals split into two sets of different energies: t_{2g} and e_g. **(2)**



1. What is meant by crystal field splitting energy (Δ_o)?
2. Why do transition metal complexes usually exhibit color?

Q24. Match the items given in Column I with the most appropriate items in Column II: **(2)**

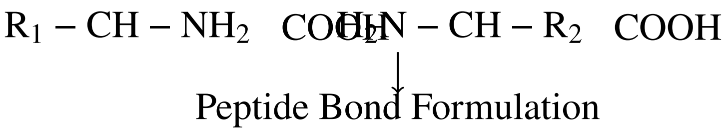
Column I	**Column II**
(a) Lucas reagent	(i) Ammoniacal silver nitrate
(b) Hinsberg reagent	(ii) Alkaline copper sulphate with Rochelle salt
(c) Tollens' reagent	(iii) Conc. HCl + anhydrous $ZnCl_2$
(d) Fehling's solution	(iv) Benzene sulphonyl chloride

Q25. Complete the following reaction equations: **(2)**

1. $CH_3CH_2Cl + KOH\ (aq) \xrightarrow{\Delta}$
2. $CH_3CH_2Cl + KOH\ (alc) \xrightarrow{\Delta}$

Q26. Read the passage given below and answer the following questions:

Proteins are high molecular mass polymers of α-amino acids linked by peptide bonds. They exhibit complex structural organizations referred to as primary, secondary, tertiary, and quaternary structures. **(2)**



$$R_1 - CH - NH_2 \quad COOH \quad H_2N - CH - R_2 \quad COOH$$

$$\downarrow$$

Peptide Bond Formulation

1. What type of linkage joins amino acids in proteins?
2. Briefly describe the primary structure of proteins.

Q27. Write TRUE (T) for the correct statement and FALSE (F) for the incorrect statement: **(2)**

1. Analgesics are medicines used to relieve pain without causing unconsciousness.
2. Antacids are substances that increase the acidity of the stomach.

Q28. Read the passage given below and answer the questions given below:

Corrosion is a process in which metals are slowly eaten away by reaction with air and moisture. The rusting of iron is an electrochemical phenomenon where a galvanic cell is formed on the metal surface. **(2)**

1. Write the chemical formula of rust.
2. Name one effective method to prevent the corrosion of iron.

Section: B

Q29. (i) Define: (a) Molarity, (b) Molality.

OR

(ii) Define: (a) Osmosis, (b) Osmotic pressure. **(2)**

Q30. State the first law of thermodynamics and give its mathematical expression. **(2)**

Q31. (i) State Kohlrausch's law of independent migration of ions.

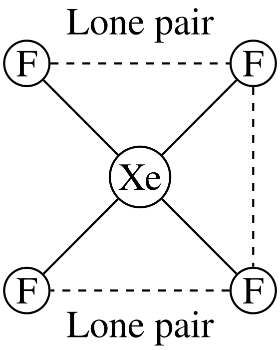
OR

(ii) Define a pseudo first-order reaction and give one example. **(2)**

Q32. (i) Explain why transition elements frequently form complex compounds.

OR

(ii) Draw the structure of the XeF_4 molecule. **(2)**



Q33. What is lanthanoid contraction? State one of its main consequences. **(2)**

Q34. How is the rate of a chemical reaction affected by: (a) Temperature, (b) Surface area of solid reactants? **(2)**

Q35. (i) Write the chemical equation for the reaction of phenol with dilute HNO_3 at low temperature (298 K).

OR

(ii) Write the chemical equation for the Clemmensen reduction of acetone. **(2)**

Q36. What are reducing sugars? Give one example. **(2)**

Q37. Complete the following reaction equations: **(2)**

(a) $CH_3COOH + PCl_5 \rightarrow$

(b) $CH_3CH_2OH \xrightarrow{\text{conc. } H_2SO_4,\ 443\text{ K}}$

Q38. Define the following terms:

A. Half-life of a reaction

B. Activation energy

C. Order of a reaction **(3)**

Q39. (i) Calculate the mass of ascorbic acid ($C_6H_8O_6$) to be dissolved in 75 g of acetic acid to lower its freezing point by 1.5 °C. ($K_f = 3.9\,\mathrm{K\,kg\,mol^{-1}}$).

OR

(ii) A solution of $Ni(NO_3)_2$ is electrolysed between platinum electrodes using a current of 5 amperes for 20 minutes. What mass of nickel is deposited at the cathode? (Atomic mass of Ni = 58.7 u) **(3)**

Q40. Describe the basic principles and steps involved in the preparation of sulphuric acid by the Contact process. **(3)**

Q41. (i) Explain the mechanism of an S_N2 reaction with a suitable example. Discuss its stereochemistry.

OR

(ii) Give a simple chemical test to distinguish between the following pairs of compounds:
(a) Propanal and Propanone
(b) Phenol and Ethanol **(3)**

Q42. (i) Answer the following:

A. Define standard electrode potential.

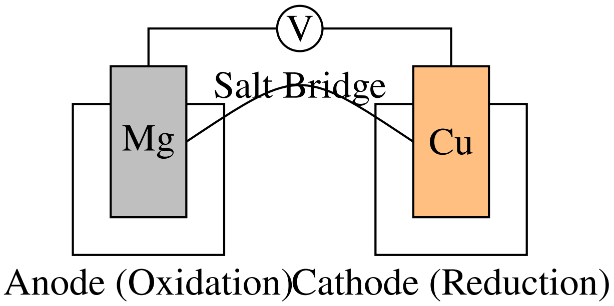
B. Calculate the emf of the cell: $Mg(s)|Mg^{2+}(0.1\,M)||Cu^{2+}(0.01\,M)|Cu(s)$ at 298 K. Given $E^\circ_{Mg^{2+}/Mg} = -2.37\,V$, $E^\circ_{Cu^{2+}/Cu} = +0.34\,V$.

OR

(ii) Answer the following:

A. Derive the integrated rate equation for a first-order reaction.

B. A first-order reaction takes 40 minutes for 30% decomposition. Calculate its half-life. **(5)**



Q43. (i) (1) Write short notes on: (a) Aldol condensation (b) Cannizzaro reaction.

(2) How will you convert: (a) Benzene to aniline (b) Ethanol to ethanoic acid.

OR

(ii) (1) Differentiate between DNA and RNA (any two points).

(2) What happens when proteins are denatured? Give one common example of denaturation. **(5)**

Detailed Solutions

Q1.

Solution

Concept: The mole concept serves as a bridge connecting the macroscopic mass of a substance to the submicroscopic number of constituent chemical particles. One mole of any chemical entity represents an absolute quantity that is governed by Avogadro's constant, which is defined as $N_A = 6.022 \times 10^{23}$ formula units per mole. By calculating the total number of individual molecules within a sample, we can use the molecular formula to determine the precise number of constituent atoms present.

Step 1 — According to fundamental chemical definitions, a single mole of any molecular substance contains exactly 6.022×10^{23} discrete molecules, irrespective of the physical state or chemical composition of the compound under observation.

Step 2 — We are given a sample containing 0.10 mol of pure ammonia gas (NH_3). To determine the total number of individual ammonia molecules contained within this specific molar quantity, multiply the given number of moles by Avogadro's constant:

$$\text{Number of molecules} = 0.10 \text{ mol} \times 6.022 \times 10^{23} \text{ molecules/mol} = 6.022 \times 10^{22} \text{ molecules}$$

Step 3 — Next, analyze the chemical stoichiometry of the compound. The molecular formula for ammonia (NH_3) shows that each independent molecule consists of exactly 1 nitrogen atom covalently bonded to 3 hydrogen atoms. Summing these values gives a total of $1 + 3 = 4$ constituent atoms packed inside every individual molecule.

Step 4 — To evaluate the total atomic count across the entire sample, multiply the total number of ammonia molecules calculated in Step 2 by the atom-to-molecule ratio determined in Step 3:

$$\text{Total number of atoms} = 4 \text{ atoms/molecule} \times 6.022 \times 10^{22} \text{ molecules} = 2.408 \times 10^{23} \text{ atoms}$$

This step completes the conversion from a macroscopic molar quantity to an absolute count of individual subatomic particles.

Final Answer: Option B

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 1

Q2.

Solution

Concept: The electronic configurations of d-block transition metals are dictated by the Aufbau principle, the Pauli exclusion principle, and Hund's rule. However, localized anomalies occur among certain transition elements, particularly within the first transition series ($3d$ row). These electronic deviations arise because completely half-filled (d^5) or fully-filled (d^{10}) subshells possess exceptional thermodynamic stability. This extra stabilization stems from the highly symmetrical spatial distribution of electrons and the maximization of electron exchange energy within degenerate orbitals.

Step 1 — Chromium (Cr) has an atomic number of 24, meaning a neutral chromium atom contains 24 electrons. Following the standard sequential filling order dictated by the Aufbau principle, the expected ground-state electronic configuration would be written as $[\text{Ar}]4s^2 3d^4$, where the lower-energy $4s$ subshell fills completely before electrons enter the $3d$ subshell.

Step 2 — However, this expected configuration places four electrons in the $3d$ subshell, leaving it one electron short of achieving a half-filled state. A $3d^5$ configuration is energetically favored over a $3d^4$ arrangement due to a significant reduction in inter-electronic repulsion and a substantial increase in exchange stabilization energy when all five $3d$ orbitals contain exactly one electron with parallel spins.

Step 3 — To achieve this lower total potential energy state, one electron from the filled $4s$ orbital is promoted into the vacant fifth $3d$ orbital. This shift creates two highly stable, half-filled subshells ($4s^1$ and $3d^5$), yielding the correct ground-state electronic configuration: $[\text{Ar}]4s^1 3d^5$.

Final Answer: Option B

Answer: (B)

Go Back to Question 2

Q3.

Solution

Concept: Valence Shell Electron Pair Repulsion (VSEPR) theory provides a predictive model for mapping the three-dimensional geometric shapes of covalent molecules. The fundamental premise of VSEPR theory states that valence-shell electron pairs (both bonding pairs and non-bonding lone pairs) surrounding a central atom act as regions of localized negative charge. These electron domains arrange themselves spatially to maximize distance and minimize electrostatic repulsions. The final molecular geometry is determined by the total number and arrangement of these bonding and non-bonding domains.

Step 1 — In sulfur hexafluoride (SF_6), sulfur (S) serves as the central atom. Located in Group 16 of the periodic table, a neutral sulfur atom possesses exactly 6 valence electrons in its outermost shell ($3s^2 3p^4$).

Step 2 — The molecular formula indicates that the central sulfur atom is bonded to six individual fluorine (F) atoms. Since each fluorine atom requires a single electron to complete its octet, sulfur shares its six valence electrons to establish six individual, single covalent sulfur-fluorine ($\mathrm{S-F}$) sigma bonds. Consequently, all six valence electrons of sulfur are engaged in bonding, leaving zero non-bonding lone pairs on the central atom.

Step 3 — With a steric number of six (6 bonding pairs $+0$ lone pairs), the central sulfur atom undergoes sp^3d^2 hybridization. To minimize electron domain repulsion, the six bonding pairs point toward the vertices of a regular octahedron. This spatial orientation creates an octahedral molecular geometry with highly symmetric $\mathrm{F-S-F}$ bond angles of exactly 90° and 180°.

Final Answer: Option B

Answer: (B)

Go Back to Question 3

Q4.

Solution

Concept: The physical behavior of gases can be quantified by several empirical gas laws, which relate the macroscopic properties of a gas sample: pressure (P), volume (V), absolute temperature (T), and chemical amount in moles (n). Each classic law isolates the relationship between two specific variables while holding the remaining parameters strictly constant, leading to the formulation of the ideal gas equation.

Step 1 — The core question requires us to identify the specific law that describes an inverse mathematical relationship between the pressure exerted by a gas and the total volume it occupies. This relationship can be expressed by the proportionality $P \propto \frac{1}{V}$, or as the constant product formula $P \times V = k$, provided that the temperature and mass of the gas sample do not change.

Step 2 — To identify the correct law, we evaluate the definitions of the alternative options. Charles's law governs the direct relationship between volume and absolute temperature ($V \propto T$) at constant pressure. Avogadro's law states that volume is directly proportional to the number of moles ($V \propto n$) at constant temperature and pressure. Gay-Lussac's law dictates that pressure is directly proportional to absolute temperature ($P \propto T$) when volume is held constant.

Step 3 — Boyle's law, formulated by Robert Boyle, explicitly states that for a fixed mass of an ideal gas maintained at a constant temperature, the absolute pressure is inversely proportional to the volume it occupies. As volume decreases, gas particles collide more frequently with the container walls, increasing pressure.

Final Answer: Option B

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 4

Q5.

Solution

Concept: In chemical thermodynamics, solutions are categorized based on their mixing behavior across a range of concentrations. An ideal solution is defined as a mixture that obeys Raoult's law across all concentrations and temperatures. From a molecular standpoint, an ideal solution forms when the mixing components have nearly identical molecular structures, sizes, and intermolecular forces. This structural similarity ensures that the solute-solvent interactions in the mixture are energetically equivalent to the solute-solute and solvent-solvent interactions in the pure components.

Step 1 — Consider a binary liquid mixture containing components A and B. In their isolated pure states, the molecules experience cohesive forces designated as $A - A$ and $B - B$ interactions. When mixed to form an ideal solution, the newly established adhesive forces between different molecules, known as $A - B$ interactions, are identical in magnitude and energy to the original $A - A$ and $B - B$ cohesive forces.

Step 2 — Because breaking the old $A - A$ and $B - B$ intermolecular attractions requires the exact same amount of energy that is subsequently released when forming the new $A - B$ attractions, the mixing process is thermally neutral. Therefore, there is no net absorption or release of heat during mixing, meaning the enthalpy change of mixing is zero ($\Delta H_{\text{mix}} = 0$).

Step 3 — Similarly, because the molecules pack together with identical efficiency in both the pure states and the mixture, there is no expansion or contraction of the total volume upon mixing. The final volume equals the sum of the initial volumes, meaning the volume change of mixing is zero ($\Delta V_{\text{mix}} = 0$).

Final Answer: Option C

Answer: (C)

Go Back to Question 5

Q6.

Solution

Concept: Entropy (S) is a fundamental thermodynamic state function that measures the degree of randomness, disorder, or statistical probability within a chemical system. The second law of thermodynamics establishes that spontaneous processes are driven by changes in entropy. For any substance, the absolute entropy depends heavily on its physical state because the freedom of motion and spatial distribution of its molecules vary significantly between solid, liquid, and gaseous phases.

Step 1 — Solid ice represents a highly ordered crystalline state of water. Within this rigid lattice structure, strong intermolecular hydrogen bonds lock individual water molecules into fixed positions. The molecules cannot undergo translational motion and are restricted to minor vibrations around fixed lattice points, representing a low-entropy state with minimal spatial disorder.

Step 2 — When thermal energy is added to the system at its melting point, ice undergoes a phase transition to form liquid water. This added energy ruptures a portion of the rigid hydrogen-bonding network. As a result, the water molecules escape their fixed lattice positions, gaining the freedom to slide, rotate, and undergo continuous translational motion past one another.

Step 3 — This phase change from a highly organized solid to a disordered liquid significantly increases the randomness and number of accessible microstates for the molecules. Because the final state is more disordered than the initial state, the entropy change ($\Delta S = S_{\text{liquid}} - S_{\text{solid}}$) for the melting process is positive ($\Delta S > 0$).

Final Answer: Option C

Answer: (C)

Go Back to Question 6

Q7.

Solution

Concept: In chemical kinetics, the rate constant (k) is a fundamental proportionality factor that links the measured reaction rate to the concentrations of the reacting species, as defined by the empirically determined rate law. While the reaction rate always carries fixed units of concentration over time, the units assigned to the rate constant (k) vary depending on the overall order of the reaction (n), which is the sum of the concentration exponents in the rate law.

Step 1 — Consider a generalized chemical reaction rate law expressed mathematically as:

$$\text{Rate} = k[\text{Reactants}]^n$$

where [Reactants] represents the molar concentration of the starting materials, typically measured in units of moles per liter (mol L^{-1}), and n denotes the overall order of the reaction.

Step 2 — The reaction rate measures the change in solute concentration per unit time, so its units are always fixed as moles per liter per second ($\text{mol L}^{-1}\ \text{s}^{-1}$). For a zero-order chemical reaction, the exponent n equals 0, indicating that the reaction rate is independent of reactant concentrations.

Step 3 — Substituting $n = 0$ into our rate law expression simplifies the equation:

$$\text{Rate} = k[\text{Reactants}]^0 \implies \text{Rate} = k \times 1 \implies k = \text{Rate}$$

Because the rate constant is algebraically equal to the reaction rate under zero-order conditions, the units of k must match the units of the rate exactly, which is $\text{mol L}^{-1}\ \text{s}^{-1}$.

Final Answer: Option B

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 7

Q8.

Solution

Concept: Electrolysis involves driving non-spontaneous chemical reactions using electrical energy. The quantitative relationships governing electrolytic cell behavior were established empirically by Michael Faraday. Faraday's first law of electrolysis relates the mass of chemical products deposited or liberated at an electrode interface to the total quantity of electrical charge that passes through the electrolyte solution.

Step 1 — Faraday's first law states that during electrolysis, the mass (m) of a primary substance that undergoes chemical oxidation or reduction at an electrode is directly proportional to the total quantity of electricity or electrical charge (Q) passed through the electrolytic system.

Step 2 — This relationship can be expressed mathematically as a direct proportionality:

$$m \propto Q$$

Electrical charge (Q), measured in coulombs, is defined as the product of the steady electrical current (I, in amperes) and the total time duration (t, in seconds) of the current flow ($Q = I \times t$). Substituting this definition into the proportionality yields the equation:

$$m = Z \cdot I \cdot t$$

where Z serves as a proportionality constant known as the electrochemical equivalent of the substance, defined as the mass deposited by one coulomb of charge.

Step 3 — Inspecting this mathematical expression confirms that for any given substance, the total mass liberated at an electrode depends on the total electrical charge passed through the solution.

Final Answer: Option B

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 8

Q9.

Solution

Concept: The Brønsted-Lowry acid-base theory defines acids and bases based on proton transfer. According to this framework, an acid is a chemical species capable of donating a hydrogen ion or proton (H^+), whereas a base is a species capable of accepting a proton. When a Brønsted-Lowry acid donates its proton, the remaining fragment is capable of re-accepting a proton, meaning it functions as a base. This remaining fragment is called the conjugate base of the parent acid. An acid and its corresponding conjugate base differ by exactly one proton (H^+).

Step 1 — The problem asks us to identify the conjugate base of the hydrogen sulfate ion, HSO_4^- (also known as the bisulfate ion). Because we are looking for its conjugate base, the HSO_4^- ion must act as a Brønsted-Lowry acid by donating a proton.

Step 2 — To find the conjugate base, write a balanced chemical step showing the removal of exactly one proton (H^+) from the hydrogen sulfate formula unit:

$$HSO_4^- \rightarrow H^+ + SO_4^{2-}$$

Step 3 — Removing the single positive hydrogen ion leaves behind the sulfate ion, SO_4^{2-}. Because this anion can accept a proton to reform the hydrogen sulfate ion, it functions as the conjugate base. This completes the conjugate acid-base pair (HSO_4^-/SO_4^{2-}).

Final Answer: Option B

Answer: (B)

Go Back to Question 9

Q10.

Solution

Concept: In redox chemistry, oxidation numbers are assigned to individual atoms within a chemical species to track electron distribution and chemical changes. These values are determined using a set of established rules based on element electronegativity. For any neutral, uncharged molecule, the fundamental rule states that the algebraic sum of the oxidation states of all constituent atoms must equal zero. If a molecule contains elements with fixed or typical oxidation states, we can set up a linear equation to find the unknown oxidation state of the remaining atom.

Step 1 — We need to find the oxidation state of the central phosphorus (P) atom within a neutral molecule of orthophosphoric acid (H_3PO_4). Let us represent this unknown oxidation state with the variable x.

Step 2 — Next, assign typical oxidation numbers to the remaining elements based on standard rules. Hydrogen (H) is bonded to a non-metal, so it takes its usual oxidation state of $+1$. Oxygen (O) is more electronegative, so it takes its standard oxidation state of -2 since it is not part of a peroxide or fluorine compound.

Step 3 — The molecule contains 3 hydrogen atoms, 1 phosphorus atom, and 4 oxygen atoms. Set up an equation where the sum of these oxidation states equals zero:

$$3(+1) + x + 4(-2) = 0$$

Simplifying the expression:

$$3 + x - 8 = 0 \implies x - 5 = 0 \implies x = +5$$

Thus, phosphorus exists in the +5 oxidation state in H_3PO_4.

Final Answer: Option B

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 10

Q11.

Solution

Concept: Coordination chemistry uses the spin-only magnetic moment formula to determine the number of unpaired d-electrons in a transition metal complex.

Step 1 — Iron (Fe) has an atomic number of 26. Following the standard rules of electron filling, its ground-state electronic configuration is written as $[\mathrm{Ar}]4s^2 3d^6$. The valence shell contains two electrons in the outer $4s$ orbital and six electrons distributed across the five degenerate $3d$ orbitals.

Step 2 — When iron undergoes oxidation to form the ferric ion (Fe^{3+}), it loses a total of three valence electrons. Ionization always removes electrons from the outermost shell first. Therefore, the two electrons in the $4s$ orbital are removed first, followed by one electron from the $3d$ subshell. This sequential ionization yields the stable transition metal electronic configuration: $[\mathrm{Ar}]3d^5$.

Step 3 — According to Hund's rule of maximum multiplicity, the five valence electrons within the $3d$ subshell will occupy the five degenerate $3d$ orbitals individually with parallel spins before any pairing can occur. This spatial arrangement results in exactly five unpaired electrons ($n = 5$).

Step 4 — The spin-only magnetic moment (μ) is calculated using the quantum mechanical formula:

$$\mu = \sqrt{n(n+2)}\ \mathrm{BM}$$

where n represents the total number of unpaired electrons and BM stands for Bohr Magnetons. Substituting $n = 5$ into the equation:

$$\mu = \sqrt{5(5+2)} = \sqrt{5 \times 7} = \sqrt{35} \approx 5.92\ \mathrm{BM}$$

This high value confirms a high-spin state for the ferric ion.

Final Answer: Option B

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 11

Q12.

Solution

Concept: Coordination compounds are stabilized through chelation, where the structural classification of a ligand depends on its denticity.

Step 1 — Denticity is defined as the total number of distinct donor atoms through which a single ligand molecule can simultaneously coordinate or bind to a central transition metal ion. Ligands are categorized as monodentate, bidentate, or polydentate based on this characteristic. The ethylenediaminetetraacetate ion, commonly abbreviated as EDTA^{4-}, is a prominent polydentate chelating agent with the chemical formula $[\mathrm{OOCCH_2}]_2\mathrm{NCH_2CH_2N}[\mathrm{CH_2COO}]_2^{4-}$.

Step 2 — Structural analysis reveals that the EDTA^{4-} anion possesses a total of six potential donor atoms with active lone pairs. It contains two tertiary nitrogen atoms, each carrying a stereochemically active lone pair, and four oxygen atoms originating from its four terminal carboxylate groups ($-\mathrm{COO}^-$), each bearing a negative charge capable of coordination.

Step 3 — Under optimal pH conditions, a single EDTA^{4-} molecule can wrap itself around a central metal cation, using both nitrogen donor atoms and all four carboxylate oxygen donor atoms simultaneously. This concerted binding forms six coordinate covalent bonds, encapsulating the metal within five highly stable, strain-free five-membered chelate rings. Because it utilizes six distinct donor sites, it is classified as a hexadentate ligand.

Final Answer: Option C

Answer: (C)

Go Back to Question 12

Q13.

Solution

Concept: The International Union of Pure and Applied Chemistry (IUPAC) sets standardized nomenclature rules for organic compounds to ensure unique structural identification.

Step 1 — To determine the systematic IUPAC name for an branched aliphatic alcohol, we apply a clear hierarchy of rules. The given condensed structural formula is $CH_3 - CH(CH_3) - CH_2 - OH$.

Step 2 — The first rule dictates selecting the longest continuous carbon backbone that contains the principal functional group, which is the hydroxyl group ($-OH$). In this molecule, the longest continuous carbon chain containing the carbon bonded to the $-OH$ group consists of exactly three carbon atoms. Therefore, the parent alkane chain is identified as propane.

Step 3 — The second rule requires numbering the parent carbon chain sequentially from one end to the other. Priority is given to the principal functional group, meaning the chain must be numbered to grant the hydroxyl-bearing carbon the lowest possible locant number. Numbering from right to left assigns position 1 to the carbon atom attached to the $-OH$ group. Consequently, the secondary methyl branch ($-CH_3$) falls on carbon atom 2.

Step 4 — Combining these structural assignments, we assemble the complete IUPAC name. The methyl substituent is placed as a prefix with its locant, and the suffix "-ol" replaces the terminal "e" of propane, yielding: 2-Methylpropan-1-ol.

Final Answer: Option A

Answer: (A)

Go Back to Question 13

Q14.

Solution

Concept: The regiochemistry of electrophilic addition reactions across unsymmetrical carbon-carbon double bonds is governed by Markovnikov's rule.

Step 1 — Propene ($CH_3 - CH = CH_2$) serves as a classic model for an unsymmetrical alkene. The two alkene carbon atoms share a pi bond but are in different chemical environments: the terminal carbon is bonded to two hydrogen atoms ($= CH_2$), while the internal carbon is bonded to one hydrogen and one methyl group ($-CH =$).

Step 2 — When propene reacts with a polar hydrogen halide such as hydrogen bromide (HBr), the reaction initiates via the electrophilic attack of a proton (H^+). Markovnikov's rule states that the hydrogen atom adds to the alkene carbon that already possesses the greater number of hydrogen atoms. This addition path generates a more stable secondary carbocation intermediate ($CH_3 - CH^+ - CH_3$) due to hyperconjugation and inductive stabilization from adjacent alkyl groups, rather than a less stable primary carbocation.

Step 3 — In the subsequent nucleophilic step, the bromide anion (Br^-) attacks the electron-deficient, planar secondary carbocation center. This selective attack bonds the halogen to the internal carbon atom with fewer hydrogens:

$$CH_3 - CH = CH_2 + HBr \rightarrow CH_3 - CH(Br) - CH_3$$

Step 4 — Consequently, 2-Bromopropane is produced as the major regioisomer, while 1-bromopropane forms only as a minor byproduct.

Final Answer: Option B

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 14

Q15.

Solution

Concept: Organic functional group conversions rely on selecting oxidizing agents with the appropriate reactivity to control oxidation states.

Step 1 — Primary alcohols possess a relatively reactive terminal carbon atom bonded to a hydroxyl group ($-CH_2OH$). When treated with strong, aggressive aqueous oxidizing agents such as acidified potassium permanganate ($KMnO_4$) or potassium dichromate ($K_2Cr_2O_7$), the alcohol is rapidly oxidized. It passes through an unstable aldehyde intermediate and is completely oxidized to a carboxylic acid, preventing isolation of the intermediate.

Step 2 — Evaluating alternative reagents, lithium aluminum hydride ($LiAlH_4$) is a powerful nucleophilic reducing agent, meaning it cannot drive an oxidation pathway.

Step 3 — To stop the oxidation selectively at the aldehyde stage, a mild, anhydrous oxidizing agent must be utilized. Pyridinium chlorochromate (PCC), a complex of chromium(VI) oxide with pyridine and hydrochloric acid, serves this purpose perfectly. Because PCC is used in anhydrous organic solvents like dichloromethane (CH_2Cl_2), it lacks the water required to form an aldehyde hydrate intermediate. This block prevents further oxidation, allowing the reaction to produce aldehydes in high yields:

$$R - CH_2OH \xrightarrow{\text{PCC}} R - CHO$$

Final Answer: Option C

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 15

Q16.

Solution

Concept: Food chemistry evaluates synthetic food additives based on their chemical structures and physiological behavior in the human body.

Step 1 — Carbohydrates like sucrose (table sugar), fructose (fruit sugar), and maltose represent naturally occurring, nutrient-dense disaccharides and monosaccharides. When ingested, these sugars enter metabolic pathways where they undergo enzymatic hydrolysis and oxidation, releasing approximately 4 kcal/g of energy. This high caloric contribution can lead to health challenges for diabetic patients or individuals managing obesity.

Step 2 — To address these dietary concerns, food science utilizes artificial sweetening agents. These are synthetic organic compounds engineered to bind with high affinity to sweet taste receptors on the human tongue, mimicking the taste of sugar. However, because their structures cannot be broken down by human metabolic enzymes, they pass through the body unchanged, providing sweetness without adding calories.

Step 3 — Saccharin, chemically identified as ortho-sulfobenzimide, was the first commercially viable artificial sweetener. It is several hundred times sweeter than sucrose and is excreted completely un-metabolized in urine. This properties make it an important sugar substitute for diabetic diets.

Final Answer: Option B

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 16

Q17.

Solution

Concept: Chemical reaction yields are limited by reaction stoichiometry, which dictates the exact ratios of reactants consumed.

Step 1 — In a multi-component chemical reaction, the reactants are rarely mixed in exact stoichiometric proportions. The limiting reagent is defined as the specific reactant that is completely consumed first during the chemical transformation. Because the reaction stops once this component is exhausted, the limiting reagent sets an absolute ceiling on the maximum theoretical yield of products that can be formed.

Step 2 — Consider the balanced stoichiometric chemical equation for the synthesis of water from diatomic hydrogen and oxygen gases:

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

This stoichiometry shows that exactly 2 moles of hydrogen gas are required to react completely with 1 mole of oxygen gas.

Step 3 — Suppose a reaction vessel is filled with a mixture containing 2 moles of H_2 and 2 moles of O_2. Following the stoichiometric ratio, the 2 moles of H_2 will consume exactly 1 mole of O_2. This leaves 1 mole of oxygen gas unreacted as an excess reagent, while the hydrogen gas is completely consumed. Thus, hydrogen functions as the limiting reagent.

Final Answer: 1. The reactant that gets completely consumed first. 2. Hydrogen (H_2).

Answer: (See above)

Go Back to Question 17

Q18.

Solution

Concept: The Bohr model of the atom introduces quantum mechanical boundaries to describe electronic transitions in hydrogen-like systems.

Step 1 — Niels Bohr's atomic model postulates that electrons revolve around a dense nucleus only in specific, non-radiating circular pathways known as stationary orbits. The total energy (E_n) of an electron confined to one of these quantized orbits is expressed mathematically by the relationship:

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

where Z represents the atomic number of the single-electron species and n signifies the principal quantum number. This equation demonstrates that the absolute value of the electronic energy level is inversely proportional to the square of the principal quantum number (n^2).

Step 2 — The fundamental quantum restriction of the Bohr model is his angular momentum quantization condition. Bohr asserted that an electron can only exist in orbits where its orbital angular momentum ($L = mvr$) is a discrete, integral multiple of a basic quantum unit. The mathematical expression for this constraint is:

$$mvr = \frac{nh}{2\pi}$$

where m is electron mass, v is orbital velocity, r is orbital radius, n is an integer $(1, 2, 3, \ldots)$, and h is Planck's constant. Thus, angular momentum is quantized as a multiple of $h/(2\pi)$.

Final Answer: 1. n^2; 2. $h/(2\pi)$

$\boxed{\textbf{Answer: (See above)}}$

Go Back to Question 18

Q19.

Solution

Concept: Condensed phases of matter are stabilized by intermolecular forces, which depend on molecular dipole moments and electron cloud polarizability.

Step 1 — Hydrogen bonding is a strong, specialized type of dipole-dipole attraction. It occurs exclusively when a hydrogen atom is covalently bonded to a highly electronegative, exceptionally small first-row element, specifically nitrogen, oxygen, or fluorine (N, O, F). This extreme electronegativity difference creates a large partial positive charge on the hydrogen atom. While water (H_2O) exhibits strong hydrogen bonding, hydrogen sulfide (H_2S) does not. The central sulfur atom is larger and less electronegative than oxygen, preventing the formation of a sufficiently strong dipole. Therefore, the first statement is completely false (F).

Step 2 — London dispersion forces represent a universal class of intermolecular attractions that exist between all atoms and molecules, including non-polar species. These transient forces arise from temporary, instantaneous fluctuations in electron density that generate short-lived dipoles, which then induce complementary dipoles in neighboring electron clouds. Because they rely on shifting electron clouds rather than permanent charges, London dispersion forces are generally the weakest of all van der Waals interactions, making the second statement true (T).

Final Answer: 1. False (F); 2. True (T)

Answer: (See above)

Go Back to Question 19

Q20.

Solution

Concept: Modern chemical thermodynamics categorizes macroscopic properties based on how they scale with the total mass of a system.

Step 1 — Extensive properties are thermodynamic variables whose measured values depend directly on the total quantity, mass, or size of the matter enclosed within the system boundaries. Enthalpy (H), which represents the total internal heat content of a system, is a classic extensive property. For instance, burning two moles of a fuel releases exactly twice as much thermal energy as burning a single mole, demonstrating that enthalpy scales linearly with mass.

Step 2 — Intensive properties are thermodynamic parameters whose values remain entirely independent of the total quantity or mass of the substance present. Temperature (T) is an intensive property. If a thermal system in uniform equilibrium is divided into two parts, the temperature of each subsystem remains identical to the original temperature.

Step 3 — In summary, thermodynamic parameters that scale with system mass are termed extensive, whereas mass-independent properties are intensive. Dividing any extensive property by another extensive property yields an intensive value.

Final Answer: 1. extensive; 2. intensive

Answer: (See above)

Go Back to Question 20

Q21.

Solution

Concept: Chemical kinetics utilizes two primary metrics to quantify the rates and molecular pathways of chemical transformations: reaction order and molecularity. While these two concepts are occasionally equal for basic reactions, they are fundamentally distinct in their definition, theoretical basis, and application to multi-step reaction mechanisms.

Step 1 — The order of a reaction is a strictly empirical or experimental quantity. It is defined mathematically as the sum of the concentration exponents within the experimentally determined rate law equation. Reaction order dictates how changing the concentration of specific starting materials alters the observed velocity of the reaction. Because it depends purely on kinetic data, the overall order can take any real value, including zero, negative values, or fractions.

Step 2 — Conversely, molecularity is an entirely theoretical concept derived from proposed reaction mechanisms. It represents the exact number of independent reactant atoms, ions, or molecules that must collide simultaneously in space with correct orientation and sufficient threshold energy to execute an elementary chemical step. Because a negative, fractional, or non-existent chemical species cannot participate in a physical impact, molecularity must always be a positive whole number (typically $1, 2$, or at most 3). It is meaningless for complex, multi-step reactions, where it is only applied to individual elementary steps.

Final Answer: 1. order; 2. molecularity

Answer: (See above)

Go Back to Question 21

Q22.

Solution

Concept: Ozone (O_3) is an allotrope of oxygen that functions as a remarkably powerful oxidizing agent due to its thermodynamic instability relative to diatomic oxygen.

Step 1 — At standard room temperature and pressure, ozone decomposes readily because its breakdown is driven by an increase in entropy and a highly negative enthalpy change (ΔH). This decomposition releases stable molecular oxygen gas (O_2) along with a highly reactive, short-lived monoatomic species known as nascent or atomic oxygen, denoted as $[O]$. This nascent oxygen atom possesses an incomplete valence octet and acts as a strong electrophile, quickly capturing electrons from surrounding substrates. This rapid electron capture drives ozone's strong oxidizing behavior.

Step 2 — The strong oxidizing potential of ozone can be demonstrated through its reaction with heavy metal chalcogenides. When ozone gas is passed into contact with black lead(II) sulfide (PbS), it undergoes a multi-electron redox reaction. The sulfide ion (S^{2-}) in the substrate is oxidized into a sulfate ion (SO_4^{2-}), which converts the black solid into white lead(II) sulfate ($PbSO_4$).

Step 3 — The balanced molecular equation representing this oxidation-reduction process is:

$$\mathrm{PbS(s)} + 4\mathrm{O_3(g)} \rightarrow \mathrm{PbSO_4(s)} + 4\mathrm{O_2(g)}$$

During this reaction, each ozone molecule delivers its extra oxygen atom to the lead sulfide core while releasing stable oxygen gas.

Final Answer: 1. Due to the liberation of nascent oxygen; 2. It oxidizes PbS to $PbSO_4$.

Answer: (See above)

Go Back to Question 22

Q23.

Solution

Concept: Crystal Field Theory (CFT) explains the unique electronic, magnetic, and optical characteristics of transition metal coordination complexes by modeling electrostatic interactions between d-orbitals and incoming ligands.

Step 1 — In an isolated, gas-phase transition metal ion, the five valence d-orbitals are degenerate, meaning they possess identical energy levels. However, when ligands approach the metal ion to form an octahedral coordination complex, an asymmetric electrostatic field is generated. The ligands approach directly along the Cartesian axes, creating greater electrostatic repulsion with the d-orbitals that point along these axes ($d_{x^2-y^2}$ and d_{z^2}). This interaction splits the originally degenerate orbitals into two distinct energy sets: a lower-energy triply degenerate set (t_{2g}: d_{xy}, d_{yz}, d_{zx}) and a higher-energy doubly degenerate set (e_g: $d_{x^2-y^2}, d_{z^2}$). The precise energy difference between these two sets is defined as the crystal field splitting energy, designated as Δ_o.

Step 2 — This splitting explains why transition metal complexes often display vivid colors. When a complex is exposed to visible light, an electron in the lower t_{2g} subshell can absorb a photon matching the energy gap Δ_o. This absorbed energy promotes the electron to the vacant e_g subshell, a process known as a $d - d$ electronic transition. The remaining unabsorbed wavelengths of light pass through the sample, and the human eye perceives the resulting complementary color.

Final Answer: 1. The energy difference between t_{2g} and e_g orbitals; 2. Due to d-d electronic transitions.

Answer: (See above)

Go Back to Question 23

Q24.

Solution

Concept: Qualitative analytical organic chemistry utilizes a variety of specialized synthetic reagents to selectively identify or separate organic functional groups.

Step 1 — Lucas reagent is a specialized solution consisting of concentrated hydrochloric acid (HCl) and anhydrous zinc chloride ($ZnCl_2$). It is used to differentiate primary, secondary, and tertiary aliphatic alcohols based on their rate of substitution. Tertiary alcohols react instantly to form an insoluble alkyl chloride, which creates a cloudy emulsion. This behavior aligns with item (a-iii).

Step 2 — Hinsberg reagent consists of benzene sulfonyl chloride ($C_6H_5SO_2Cl$). It reacts with primary and secondary amines to form sulfonamide derivatives with different solubility properties in alkali solutions, while tertiary amines do not react. This selective reactivity allows for the separation and identification of amines, matching item (b-iv).

Step 3 — Tollens' reagent is an aqueous solution of ammoniacal silver nitrate, formulated as the coordination complex $[Ag(NH_3)_2]^+$. It serves as a mild oxidizing agent that selectively oxidizes aldehydes into carboxylate ions while reducing silver ions into metallic silver, forming a mirror on the container wall. This matches item (c-i).

Step 4 — Fehling's solution is an alkaline mixture containing aqueous copper(II) sulfate stabilized by potassium sodium tartrate (Rochelle salt). It oxidizes aliphatic aldehydes, causing blue Cu^{2+} ions to reduce to a brick-red precipitate of copper(I) oxide (Cu_2O), matching item (d-ii).

Final Answer: a-iii, b-iv, c-i, d-ii

Answer: (See above)

Go Back to Question 24

Q25.

Solution

Concept: The reaction pathway of an haloalkane treated with strong alkali bases is governed by a kinetic competition between nucleophilic substitution and bimolecular elimination reactions. The final distribution of products is highly sensitive to the solvent environment, which modifies the effective nucleophilicity and basicity of the hydroxyl anion (OH^-).

Step 1 — When a primary haloalkane like chloroethane (CH_3CH_2Cl) is heated with a strong base in an aqueous medium ($KOH\ (aq)$), the highly polar water molecules strongly solvate the hydroxide ion via hydrogen bonding. This extensive hydration shell acts as a spatial shield, reducing the basicity of OH^- and preventing it from abstracting a proton. However, the hydroxide ion can still function as an effective nucleophile. It attacks the electrophilic carbon atom via an S_N2 pathway, displacing the chloride leaving group to yield ethanol as the major product:

$$CH_3CH_2Cl + KOH(aq) \xrightarrow{\Delta} CH_3CH_2OH + KCl$$

Step 2 — Conversely, when the reaction is carried out in an alcoholic medium ($KOH\ (alc)$), the hydroxide ion reacts with the solvent to form alkoxide ions ($R-O^-$). Alkoxides are significantly stronger bases than hydroxides. Because the solvent provides minimal stabilization to the negative charge, the unhindered base prefers to abstract a weakly acidic proton from the beta-carbon atom. This abstraction triggers a concerted β-elimination (E2) pathway, creating a carbon-carbon double bond and releasing ethene gas:

$$CH_3CH_2Cl + KOH(alc) \xrightarrow{\Delta} CH_2 = CH_2 + KCl + H_2O$$

Final Answer: 1. $CH_3CH_2OH + KCl$; 2. $CH_2 = CH_2 + KCl + H_2O$

Answer: (See above)

Go Back to Question 25

Q26.

Solution

Concept: Modern structural biochemistry organizes protein architecture into four distinct hierarchical levels: primary, secondary, tertiary, and quaternary structures. This structural framework begins with a linear chain of monomeric amino acid units that are joined together by robust, directional covalent linkages.

Step 1 — The structural backbone of any protein is formed by linking individual α-amino acid monomers. During translation, the carboxylic acid group ($-COOH$) of one amino acid reacts with the amino group ($-NH_2$) of an adjacent amino acid. This condensation reaction eliminates a water molecule to establish a rigid, planar covalent amide linkage, known as a peptide bond ($-CONH-$). The partial double-bond character of the peptide bond restricts rotation, providing structural stability to the polypeptide backbone.

Step 2 — The primary structure of a protein refers to the exact, linear sequence in which these amino acids are linked along the polypeptide chain. This sequence is genetically determined by the corresponding mRNA transcript. The primary structure is vital because the precise arrangement of amino acid side chains dictates how the protein will fold into its final three-dimensional shape. Even a single modification or mutation in this sequence can alter the protein's conformation and compromise its biological function, as seen in disorders like sickle cell anemia.

Final Answer: 1. Peptide bond; 2. The linear sequence of amino acids.

Answer: (See above)

Go Back to Question 26

Q27.

Solution

Concept: Medicinal chemistry and chemical pharmacology classify synthetic and natural drug compounds into distinct functional categories based on their target receptors and therapeutic mechanism of action within the human body.

Step 1 — Analgesics represent a major pharmacological class of medications designed to alleviate or eliminate physical pain. These therapeutic agents are divided into non-addictive, non-narcotic analgesics (such as aspirin, ibuprofen, or paracetamol) and narcotic analgesics (like morphine or codeine). Non-narcotic analgesics function by inhibiting cyclooxygenase (COX) enzymes, preventing the synthesis of inflammatory prostaglandins. These drugs act on peripheral and central pathways to suppress pain transmission without inducing sleep, mental confusion, temporary unconsciousness, or significant nervous system depression. Consequently, the first statement is true (T).

Step 2 — Antacids are common over-the-counter medications formulated to manage hyperacidity in the stomach. Chemically, antacids are weak, non-systemic basic compounds or metal hydroxides, such as magnesium hydroxide [$Mg(OH)_2$] or aluminum hydroxide [$Al(OH)_3$]. When ingested, these basic compounds undergo a simple neutralization reaction with the excess hydrochloric acid present in gastric juices. This chemical neutralization raises the stomach pH, lowering the total acidity to relieve discomfort. Because the second statement incorrectly asserts that antacids function to increase acidity, the claim is false (F).

Final Answer: 1. True (T); 2. False (F)

Answer: (See above)

Go Back to Question 27

Q28.

Solution

Concept: The atmospheric corrosion of transition metals is an electrochemical degradation process known as rusting. Preventing this spontaneous redox reaction requires applying chemical coatings or engineering sacrificial protective interfaces.

Step 1 — Rusting occurs when an iron surface is exposed to oxygen and water. The metal acts as a galvanic cell, where iron is oxidized at an anodic site to Fe^{2+} ions, while oxygen is reduced at a cathodic site to form water. The dissolved ferrous ions undergo further oxidation by atmospheric oxygen to form ferric ions (Fe^{3+}), which precipitate out as a porous, flaky brown solid. The chemical formula of this rust layer is identified as hydrated iron(III) oxide, represented stoichiometrically as $Fe_2O_3 \cdot xH_2O$, where x represents a variable quantity of coordinated water molecules.

Step 2 — Because the rust layer is porous, it cannot protect the underlying iron from further degradation, necessitating external protection methods. Physical methods include painting or applying grease to create an impermeable barrier against air and moisture. A more robust method is galvanization, where the iron is coated with a thin layer of metallic zinc. Because zinc has a more negative standard reduction potential than iron, it serves as a sacrificial anode, oxidizing preferentially to protect the structural iron core even if the outer coating is scratched.

Final Answer: 1. $Fe_2O_3 \cdot xH_2O$; 2. Galvanization (or painting/oiling).

Answer: (See above)

Go Back to Question 28

Q29.

Solution

Concept: Solution chemistry relies on quantitative concentration expressions and thermodynamic colligative properties to analyze multi-component liquid systems.

Step 1 — Alternative (i): This alternative covers mass-volume and mass-mass concentration expressions. (a) Molarity (M) is a temperature-dependent metric defined as the total number of moles of a solute dissolved per single liter of the resulting solution. Because solution volume varies with temperature, molarity values shift with thermal changes. (b) Molality (m) is a temperature-independent metric defined as the number of moles of solute dissolved per single kilogram of pure solvent. Because mass does not change with temperature, molality is preferred for high-precision thermodynamic evaluations.

Step 2 — Alternative (ii): This alternative covers transport phenomena and colligative properties. (a) Osmosis is a spontaneous physical process where pure solvent molecules migrate through a semi-permeable membrane into a more concentrated solution. The semi-permeable membrane allows the small solvent molecules to pass while blocking larger solute particles. (b) Osmotic pressure (Π) is a colligative property defined as the minimum excess hydrostatic pressure that must be applied to the solution side of the membrane to completely halt the osmotic influx of solvent molecules.

Final Answer: Definitions stated in steps.

Answer: (See above)

Go Back to Question 29

Q30.

Solution

Concept: The first law of thermodynamics provides a rigorous mathematical framework for the universal principle of the conservation of energy, tracking heat and work exchanges across system boundaries.

Step 1 — The fundamental postulate of the first law states that energy can neither be created nor destroyed within an isolated system. While energy can be converted between different forms (such as thermal, chemical, electrical, or mechanical energy), the total energy of the universe remains constant. Any energy lost by a thermodynamic system must be gained by its surrounding environment.

Step 2 — To apply this principle to a closed thermodynamic system, we track changes in its internal energy (ΔU), which represents the sum of the kinetic and potential energies of its constituent molecules. The internal energy can be altered by two methods: transferring thermal energy or performing mechanical work.

Step 3 — Following the standard IUPAC chemical sign convention, the first law is expressed mathematically as:

$$\Delta U = q + w$$

where ΔU represents the net change in internal energy, q denotes the heat energy absorbed by the system from its surroundings (positive if endothermic), and w signifies the net work performed on the system by external forces (positive for compression work). This equation shows that internal energy is a state function that depends only on the net energy exchanged during a process.

Final Answer: Energy is conserved; mathematical expression is $\Delta U = q + w$.

Answer: (See above)

Go Back to Question 30

Q31.

Solution

Concept: Physical chemistry utilizes core thermodynamic and kinetic guidelines to interpret electrolytic conductivity and reaction pathways. This problem evaluates how ion migration sets threshold conductivity and how high concentrations of a single component alter overall kinetic behavior.

Step 1 — Alternative (i): Kohlrausch's law of independent migration of ions states that at infinite dilution, where inter-ionic attractions become negligible, the limiting molar conductivity of an electrolyte is equal to the algebraic sum of the individual limiting molar conductivities contributed by its constituent cations and anions. Mathematically, it is expressed as:

$$\Lambda_m^\infty = \nu_+\lambda_+^\infty + \nu_-\lambda_-^\infty$$

where ν_+ and ν_- represent the stoichiometric number of cations and anions released per formula unit, while λ_+^∞ and λ_-^∞ denote their respective limiting molar conductivities.

Step 2 — Alternative (ii): A pseudo first-order reaction is a chemical process that is expected to follow higher-order kinetics based on its molecularity but obeys first-order kinetic laws under specific experimental conditions. This shift occurs when one of the reacting species is present in a large stoichiometric excess relative to the other reactants. Because only a tiny fraction of the excess component is consumed, its total concentration remains practically constant throughout the reaction.

Step 3 — A classic example is the acid-catalyzed chemical hydrolysis of ethyl acetate:

$$\mathrm{CH_3COOC_2H_5 + H_2O \xrightarrow{H^+} CH_3COOH + C_2H_5OH}$$

Because water functions as both the solvent and a reactant, its concentration is vastly larger than that of the ester. The rate law simplifies from Rate $= k'[\mathrm{CH_3COOC_2H_5}][\mathrm{H_2O}]$ to Rate $= k[\mathrm{CH_3COOC_2H_5}]$, where the constant water concentration is absorbed into a new rate constant, $k = k'[\mathrm{H_2O}]$.

Final Answer: Stated above depending on chosen alternative.

Answer: (See above)

Go Back to Question 31

Q32.

Solution

Concept: The physical properties and geometries of inorganic compounds are dictated by transition metal coordination capabilities and Valence Shell Electron Pair Repulsion (VSEPR) theory.

Step 1 — Alternative (i): Transition elements (d-block metals) display a strong tendency to form stable coordination complexes. This property arises from three primary structural factors. First, their relatively small ionic radii create a high charge density. Second, their high positive ionic charges exert a powerful electrostatic attraction on incoming ligands. Third, they possess vacant, low-energy d-orbitals in their valence shells. These empty orbitals act as Lewis acids, accepting electron pairs donated by neutral or anionic ligands to form stable coordinate covalent bonds.

Step 2 — Alternative (ii): In xenon tetrafluoride (XeF_4), xenon (Xe) serves as the central noble gas atom. A neutral xenon atom possesses 8 valence electrons. The molecular formula indicates that xenon forms four single covalent bonds with four fluorine atoms, which consumes four of its valence electrons. The remaining four valence electrons form two non-bonding lone pairs on the central atom.

Step 3 — The central xenon atom has a steric number of six (4 bonding pairs $+2$ lone pairs), meaning it undergoes sp^3d^2 hybridization. According to VSEPR theory, a steric number of six points toward an octahedral electron domain geometry. To minimize intense lone pair-lone pair repulsions, the two lone pairs occupy opposite axial positions at a 180° angle from each other. The four fluorine atoms sit in the equatorial plane, yielding a highly symmetric square planar molecular shape.

Final Answer: Alternative (i): Small size, high charge, vacant d-orbitals. Alternative (ii): Square planar structure shown.

Answer: (See above)

Go Back to Question 32

Q33.

Solution

Concept: The structural parameters of the inner transition metals (f-block elements) are governed by periodic variations in nuclear shielding, which impact the physical properties of downstream transition metals.

Step 1 — Lanthanoid contraction is defined as the steady, progressive decrease in the absolute atomic and ionic radii of the lanthanoid elements with increasing atomic number across the series, spanning from lanthanum ($Z = 57$) to lutetium ($Z = 71$).

Step 2 — This phenomenon is driven by the unique radial distribution and shape of the $4f$ atomic orbitals. As we move across the lanthanoid series, each increase in atomic number adds one proton to the nucleus and one electron to the inner $4f$ subshell. Because the diffuse $4f$ orbitals have a poor spatial distribution, they provide a very weak shielding effect. They fail to shield the outer valence electrons from the growing positive nuclear charge. Consequently, the effective nuclear charge experienced by the outer electrons increases steadily, pulling the valence shells closer to the nucleus and shrinking the atom.

Step 3 — A major chemical consequence of this contraction is observed in the d-block elements. The shrinkage across the $4f$ series cancels out the expected size increase that usually occurs when moving down a group. Therefore, pairs of transition elements in the second ($4d$) and third ($5d$) series that sit in the same vertical group—such as zirconium (Zr) and hafnium (Hf), or niobium (Nb) and tantalum (Ta)—possess nearly identical atomic and ionic radii. Because they share almost identical sizes and valence structures, these pairs exhibit nearly indistinguishable chemical properties, making them exceptionally difficult to separate using traditional chemical methods.

Final Answer: Gradual decrease in atomic/ionic size; results in similar radii for 4d and 5d series elements.

Answer: (See above)

Go Back to Question 33

Q34.

Solution

Concept: According to collision theory, the macroscopic rate of a chemical reaction is determined by two main factors: the total frequency of collisions between reactant molecules and the fraction of those collisions that possess sufficient kinetic energy and proper spatial orientation to overcome the activation energy barrier.

Step 1 — (a) Temperature: Raising the temperature of a reaction mixture significantly increases its kinetic velocity. According to the Maxwell-Boltzmann distribution, higher temperatures shift the molecular energy curve toward higher values, increasing the average kinetic energy of the particles. This change slightly increases the overall collision frequency, but its main effect is expanding the total fraction of reactant molecules that possess a kinetic energy equal to or greater than the required activation energy (E_a). As a result, the frequency of mathematically effective collisions increases, causing the reaction rate to rise exponentially.

Step 2 — (b) Surface area: For heterogeneous chemical reactions involving a solid reactant and a liquid or gaseous phase, the reaction is physically confined to the phase boundary. Grinding a large, solid reactant mass into a fine powder significantly increases its total effective surface area while keeping the total mass constant.

Step 3 — Increasing the total surface area expands the number of active solid reactant atoms or molecules exposed directly to the surrounding fluid phase. This structural expansion allows a higher number of collisions to occur simultaneously per unit time. Because the absolute collision frequency increases, the overall reaction rate rises proportionally.

Final Answer: Rate increases with rising temperature and with greater surface area.

Answer: (See above)

Go Back to Question 34

Q35.

Solution

Concept: Aromatic organic chemistry involves managing regioselective substitution pathways on activated aromatic rings, while synthetic carbonyl chemistry relies on selective reduction methods to convert functional groups.

Step 1 — Alternative (i): Phenol (C_6H_5OH) undergoes electrophilic aromatic substitution very easily because the lone pairs on its hydroxyl oxygen atom resonate into the benzene ring. This electron donation increases electron density, making the $-OH$ group strongly activating and ortho/para-directing. When treated with dilute nitric acid (dil. HNO_3) at a controlled temperature of 298 K, phenol undergoes mononitration. This reaction yields a mixture of two structural regioisomers: ortho-nitrophenol and para-nitrophenol:

$$C_6H_5OH + \text{dil. } HNO_3 \rightarrow C_6H_4(OH)(NO_2)\ [\text{o- and p-isomers}] + H_2O$$

These isomers can be separated via steam distillation due to differences in intramolecular versus intermolecular hydrogen bonding.

Step 2 — Alternative (ii): The Clemmensen reduction is a classic organic reaction used to convert the carbonyl group ($C = O$) of aldehydes and ketones directly into a methylene group ($-CH_2-$). This transformation is achieved using zinc amalgam ($Zn - Hg$) in concentrated hydrochloric acid (HCl), which serves as a powerful reducing medium.

Step 3 — When propanone (acetone, CH_3COCH_3) is subjected to Clemmensen reduction conditions, the central carbonyl carbon undergoes a four-electron reduction, losing its oxygen atom to form water while gaining two hydrogen atoms. This transformation converts the ketone directly into the aliphatic alkane propane:

$$CH_3COCH_3 + 4[H] \xrightarrow{Zn-Hg\ /\ \text{conc. } HCl} CH_3CH_2CH_3 + H_2O$$

Final Answer: Stated chemical equations appropriately.

$\boxed{\textbf{Answer: (See above)}}$

Go Back to Question 35

Q36.

Solution

Concept: Carbohydrate biochemistry classifies saccharides based on their structural architecture and their ability to participate in single-electron redox reactions with mild metallic coordination complexes.

Step 1 — Reducing sugars are defined as carbohydrates that can act as reducing agents because they contain a free, unmasked aldehyde or alpha-hydroxy ketone group within their molecular structure. In an aqueous solution, these sugars establish a dynamic equilibrium between their cyclic ring structures (hemiacetals or hemiketals) and their open-chain forms, exposing the reactive carbonyl center.

Step 2 — Due to this open-chain equilibrium, reducing sugars can readily donate electrons to reduce mild oxidizing agents in alkaline solutions. For example, they reduce Tollens' reagent (ammoniacal silver nitrate), precipitating silver ions into metallic silver (Ag^+ to Ag^0). They also reduce Fehling's solution (alkaline copper sulfate tartrate), converting soluble blue copper(II) ions into an insoluble brick-red precipitate of copper(I) oxide (Cu^{2+} to Cu^+). Non-reducing sugars, like sucrose, cannot undergo this oxidation because their anomeric carbons are locked within a glycosidic bond, preventing them from opening into the reactive carbonyl form.

Step 3 — All monosaccharides are reducing sugars, including aldoses like glucose and ketoses like fructose, which tautomerizes to an aldose under basic conditions. Many disaccharides, such as maltose and lactose, are also reducing sugars because they retain one unsubstituted anomeric hemiacetal carbon atom that can freely open its ring.

Final Answer: Sugars containing free aldehyde/ketone groups capable of reducing Tollens/Fehling's. Example: Glucose.

Answer: (See above)

Go Back to Question 36

Q37.

Solution

Concept: Aliphatic organic synthesis uses nucleophilic acyl substitution to prepare acid derivatives and controls thermodynamic conditions to drive elimination pathways in alcohols.

Step 1 — (a) Reaction of Ethanoic Acid with PCl_5: When ethanoic acid (acetic acid, CH_3COOH) reacts with phosphorus pentachloride (PCl_5), it undergoes a nucleophilic acyl substitution reaction. The highly nucleophilic hydroxyl group ($-OH$) on the carboxylic acid attacks the phosphorus center, leading to a series of steps where the hydroxyl group is displaced and replaced by a chloride nucleophile ($-Cl$).

Step 2 — This substitution breaks down the phosphorus pentachloride reagent, yielding acetyl chloride (ethanoyl chloride) as the primary organic product, alongside phosphorus oxychloride and hydrogen chloride gas:

$$\mathrm{CH_3COOH + PCl_5 \rightarrow CH_3COCl + POCl_3 + HCl(g)}$$

Step 3 — (b) Dehydration of Ethanol at 443 K: Heating primary ethanol (CH_3CH_2OH) with an excess of concentrated sulfuric acid (conc. H_2SO_4) at a high temperature of 443 K drives an acidic intramolecular dehydration pathway. The sulfuric acid protonates the hydroxyl group, converting it into an excellent leaving group ($-OH_2^+$). At 443 K, a bimolecular substitution path is suppressed in favor of an elimination pathway (E1 or E2). The conjugate base abstracts a proton from the adjacent beta-carbon atom, causing water to depart and forming a carbon-carbon pi bond. This reaction yields ethene gas as the major product:

$$\mathrm{CH_3CH_2OH \xrightarrow[443\ K]{conc.\ H_2SO_4} CH_2 = CH_2(g) + H_2O}$$

Final Answer: (a) $CH_3COCl + POCl_3 + HCl$; (b) $CH_2 = CH_2 + H_2O$

$\boxed{\textbf{Answer: (See above)}}$

Go Back to Question 37

Q38.

Solution

Concept: Chemical kinetics utilizes a set of standardized thermodynamic and mathematical definitions to model reaction rates, describe electronic barriers, and calculate concentration changes over time.

Step 1 — A. **Half-life** ($t_{1/2}$): The half-life of a chemical reaction is defined as the absolute time interval required for the initial concentration of a reactant to decrease to exactly one-half of its original value. For a first-order reaction, the half-life is a constant value independent of initial concentrations, expressed as $t_{1/2} = \frac{0.693}{k}$. For a zero-order reaction, it depends directly on the starting concentration, expressed as $t_{1/2} = \frac{[\mathrm{A}]_0}{2k}$.

Step 2 — B. **Activation energy** (E_a): According to collision theory, activation energy is the minimum threshold of extra energy that colliding reactant molecules must absorb beyond their base ground-state kinetic energy to reach the transition state. This energy allows them to form an activated complex and successfully cross the potential energy barrier to yield products. Lower activation energies result in faster reaction rates.

Step 3 — C. **Order of a reaction**: The overall order of a reaction is an empirical quantity defined as the mathematical sum of all the exponents to which the reactant concentration terms are raised within the experimentally determined rate law expression. If a rate law is written as $\text{Rate} = k[\mathrm{A}]^x[\mathrm{B}]^y$, the overall order equals $x + y$, indicating how sensitive the reaction rate is to concentration changes.

Final Answer: The definitions as provided in the steps.

Answer: (See above)

Go Back to Question 38

Q39.

Solution

Concept: Physical chemistry applies colligative properties to determine molecular mass and uses Faraday's laws of electrolysis to calculate mass changes at electrode boundaries.

Step 1 — Alternative (i): Freezing point depression (ΔT_f) is a colligative property governed by the formula:

$$\Delta T_f = K_f \times m = K_f \times \left(\frac{w_B \times 1000}{M_B \times W_A} \right)$$

where w_B is solute mass, M_B is solute molar mass, W_A is solvent mass in grams, and K_f is the cryoscopic constant. We are given $\Delta T_f = 1.5$ K, $K_f = 3.9$ K kg mol^{-1}, and $W_A = 75$ g of acetic acid solvent. The solute is ascorbic acid ($C_6H_8O_6$), which has a molar mass of:

$$M_B = (6 \times 12) + (8 \times 1) + (6 \times 16) = 72 + 8 + 96 = 176 \text{ g mol}^{-1}$$

Step 2 — Rearranging the colligative equation to isolate the unknown solute mass w_B yields:

$$w_B = \frac{\Delta T_f \times M_B \times W_A}{K_f \times 1000} = \frac{1.5 \times 176 \times 75}{3.9 \times 1000} = \frac{19800}{3900} \approx 5.077 \text{ g}$$

Thus, 5.077 g of ascorbic acid must be dissolved.

Step 3 — Alternative (ii): To calculate the electrolytic mass deposition, first find the total electrical charge (Q) passed through the cell using current (I) and time (t):

$$Q = I \times t = 5.0 \text{ A} \times (20 \times 60) \text{ s} = 6000 \text{ C}$$

The reduction reaction for nickel ions at the cathode interface is:

$$\text{Ni}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Ni(s)}$$

This stoichiometry shows that reducing 1 mole of metallic nickel ($M = 58.7$ g mol^{-1}) requires 2 moles of electrons ($n = 2$). The charge required per mole is 2×96500 C $= 193000$ C.

Step 4 — Applying Faraday's first law equation to determine the total mass (m) deposited yields:

$$m = \frac{M \times Q}{n \times F} = \frac{58.7 \times 6000}{2 \times 96500} = \frac{352200}{193000} \approx 1.825 \text{ g}$$

Thus, approximately 1.825 g of nickel is deposited on the cathode.

Final Answer: Alternative (i): 5.07 g; Alternative (ii): 1.825 g

Answer: (See above)

Go Back to Question 39

Q40.

Solution

Concept: The Contact process is the primary industrial method for manufacturing high-purity sulfuric acid (H_2SO_4). It relies on chemical equilibria, catalytic oxidation, and controlled absorption steps to manage the reaction safely.

Step 1 — The first stage of the process involves generating sulfur dioxide (SO_2) gas. This is accomplished either by burning elemental sulfur in dry air or by roasting sulfide ores, such as iron pyrites (FeS_2), in a furnace with an excess of oxygen:

$$\mathrm{S(s) + O_2(g) \longrightarrow SO_2(g)}$$

The resulting gas stream is passed through purification units to remove dust and arsenic impurities, which can poison the catalyst.

Step 2 — The second stage is the catalytic oxidation of sulfur dioxide to sulfur trioxide (SO_3). The purified SO_2 gas is mixed with oxygen and passed through a catalytic converter containing vanadium pentoxide (V_2O_5) at an optimized temperature of 720 K and a pressure of 2 bar:

$$\mathrm{2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)} \quad \Delta H = -196.6\ \mathrm{kJ\ mol^{-1}}$$

According to Le Chatelier's principle, because this oxidation is highly exothermic, intermediate temperatures and low pressures maximize the yield of SO_3.

Step 3 — The third stage involves converting SO_3 to sulfuric acid. Directly dissolving SO_3 gas in water is avoided because the reaction is violently exothermic and creates a dense, unmanageable mist of sulfuric acid droplets. Instead, the SO_3 gas is absorbed into concentrated 98% sulfuric acid to form a heavy, oily liquid known as oleum or pyrosulfuric acid ($H_2S_2O_7$):

$$\mathrm{SO_3(g) + H_2SO_4(l) \longrightarrow H_2S_2O_7(l)}$$

In the final step, the oleum is diluted with a calculated volume of water to safely yield sulfuric acid of the desired commercial concentration:

$$\mathrm{H_2S_2O_7(l) + H_2O(l) \longrightarrow 2H_2SO_4(l)}$$

Final Answer: The steps are burning sulfur, catalytic oxidation to SO3, absorption into oleum, and dilution.

$\boxed{\textbf{Answer: (See above)}}$

Go Back to Question 40

Q41.

Solution

Concept: Stereochemistry in nucleophilic substitution and chemical differentiation tests.

Step 1 — Alternative (i): The S_N2 reaction is a concerted, single-step process. A nucleophile attacks the electrophilic carbon from the side directly opposite to the leaving group.

Step 2 — As the nucleophile forms a bond, the leaving group departs simultaneously. The molecule passes through a planar transition state. This back-side attack forces the remaining three bonds to flip over, like an umbrella in the wind, leading to an inversion of configuration. Example: Reaction of OH^- with methyl chloride yields methanol with inversion.

Step 3 — Alternative (ii): (a) Tollens' Test: Propanal (an aldehyde) gives a silver mirror with Tollens' reagent. Propanone (a ketone) does not react. (b) Iodoform Test / Ferric Chloride Test: Ethanol gives a positive iodoform test (yellow precipitate of CHI_3) while phenol does not. Alternatively, phenol gives a violet color with neutral $FeCl_3$, while ethanol does not.

Final Answer: Mentioned stereochemical inversion for (i), Tollens and Ferric Chloride/Iodoform tests for (ii).

Answer: (See above)

Go Back to Question 41

Q42.

Solution

Concept: Electrochemistry (Nernst Equation) and Chemical Kinetics.

Step 1 — Alternative (i) A: Standard electrode potential is the potential of a half-cell when the concentration of all species involved is unity (1 M) under standard conditions (298 K, 1 atm).

Step 2 — Alternative (i) B: Standard cell potential $E^\circ_{cell} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}} = 0.34 - (-2.37) = 2.71\,\text{V}$. Number of electrons transferred $n = 2$. The Nernst equation: $E_{cell} = E^\circ_{cell} - \frac{0.0591}{2} \log \frac{[\text{Mg}^{2+}]}{[\text{Cu}^{2+}]}$. $E_{cell} = 2.71 - 0.02955 \log\left(\frac{0.1}{0.01}\right) = 2.71 - 0.02955 \log(10) = 2.71 - 0.02955 = 2.68\,\text{V}$.

Step 3 — Alternative (ii) A: For a first-order reaction, Rate $= -\frac{d[R]}{dt} = k[R]$. Separating variables: $\frac{d[R]}{[R]} = -k\,dt$. Integrating from $t = 0$ ($[R]_0$) to t ($[R]$): $\ln \frac{[R]}{[R]_0} = -kt \implies k = \frac{2.303}{t} \log \frac{[R]_0}{[R]}$.

Step 4 — Alternative (ii) B: For 30% decomposition, $[R] = 0.70[R]_0$. $k = \frac{2.303}{40} \log \frac{100}{70} = \frac{2.303}{40} \times 0.1549 = 0.0089\,\text{min}^{-1}$. Half-life $t_{1/2} = \frac{0.693}{k} = \frac{0.693}{0.0089} \approx 77.7$ minutes.

Final Answer: Alternative (i): 2.68 V; Alternative (ii): Derivation provided; Half-life is approx 77.7 min.

Answer: (See above)

Go Back to Question 42

Q43.

Solution

Concept: Organic named reactions and biomolecular differences.

Step 1 — Alternative (i) 1(a): Aldol Condensation: Aldehydes or ketones containing at least one α-hydrogen atom react in the presence of dilute alkali to form β-hydroxy aldehydes (aldols) or β-hydroxy ketones (ketols), which lose water on heating to form α, β-unsaturated compounds. **1(b):** Cannizzaro reaction: Aldehydes lacking an α-hydrogen atom undergo self-oxidation and reduction (disproportionation) upon heating with concentrated alkali, yielding an alcohol and a carboxylic acid salt.

Step 2 — Alternative (i) 2: (a) Benzene is first nitrated with conc. HNO_3/conc. H_2SO_4 to form nitrobenzene. Then it is reduced with Sn/HCl to yield aniline. (b) Ethanol is treated with acidified $KMnO_4$ or $K_2Cr_2O_7$ to undergo complete oxidation to ethanoic acid.

Step 3 — Alternative (ii) 1: DNA contains the sugar 2-deoxyribose, while RNA contains ribose. DNA contains the base thymine (T), while RNA contains uracil (U) instead. DNA is mostly double-stranded, RNA is single-stranded.

Step 4 — Alternative (ii) 2: When a protein is subjected to physical change (like heating) or chemical change (like pH change), its hydrogen bonds are disturbed. Globules unfold, helices uncoil, and the protein loses its biological activity. This is denaturation. Primary structure remains intact. Common example: Coagulation of egg white on boiling.

Final Answer: Written explanations and conversions.

$\boxed{\textbf{Answer: (See above)}}$

Go Back to Question 43

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	B	3	B	4	B	5	C
6	C	7	B	8	B	9	B	10	B
11	B	12	C	13	A	14	B	15	C
16	B								