Nagaland Board Class 12 Chemistry Question Paper with Solutions(Memory Based)

Time Allowed :3 Hour	Maximum Marks :60	Total Questions :24

General Instructions

Read the following instructions very carefully and strictly follow them:

- Answers to this Paper must be written on the paper provided separately.
- You will not be allowed to write during the first 15 minutes
- This time is to be spent in reading the question paper.
- The time given at the head of this Paper is the time allowed for writing the answers,
- The paper has four Sections.
- Section A is compulsory - All questions in Section A must be answered.
- You must attempt one question from each of the Sections B, C and D and one other question from any Section of your choice.

1. State Raoult's Law for volatile solutes and explain its deviations.

Correct Answer: Raoult's Law states that the partial vapor pressure of each volatile component in a solution is proportional to its mole fraction, and deviations occur due to differences in intermolecular forces causing positive or negative deviations.

Solution:
Concept: Raoult's Law describes the vapor pressure behavior of ideal solutions containing volatile components. It relates the partial vapor pressure of each component to its mole fraction in the liquid phase.
Step 1: Statement of Raoult's Law. For a solution of volatile liquids, the partial vapor pressure of each component is proportional to its mole fraction in the solution.

$$p_A = x_A p_A^\circ \quad \text{and} \quad p_B = x_B p_B^\circ$$

where p_A° and p_B° are vapor pressures of pure components and x_A, x_B are their mole fractions. Total vapor pressure:

$$P = p_A + p_B$$

Step 2: Ideal solution behavior. Raoult's Law is strictly followed by ideal solutions where:

- Intermolecular forces between unlike molecules are similar to those between like molecules
- No heat change on mixing
- Volume of solution is additive

Step 3: Positive deviation from Raoult's Law. Occurs when intermolecular attractions between unlike molecules are weaker than those in pure components.

- Vapor pressure becomes higher than predicted
- Boiling point decreases
- Example: Ethanol–acetone mixture

Step 4: Negative deviation from Raoult's Law. Occurs when intermolecular attractions between unlike molecules are stronger than those in pure components.

- Vapor pressure becomes lower than expected
- Boiling point increases
- Example: Chloroform–acetone mixture

Conclusion: Raoult's Law explains vapor pressure behavior in ideal solutions, while deviations arise due to differences in intermolecular interactions, leading to positive or negative deviations.

Quick Tip

Positive deviation = weaker intermolecular forces and higher vapor pressure; Negative deviation = stronger forces and lower vapor pressure.

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2. Define Molar Conductivity and explain its variation with concentration for strong and weak electrolytes.

Correct Answer: Molar conductivity is the conductance of a solution containing one mole of electrolyte, and it increases with dilution — slightly for strong electrolytes and sharply for weak electrolytes due to increased ionization.

Solution:
Concept: Molar conductivity measures the ability of an electrolyte solution to conduct electricity per mole of electrolyte. It depends on the number of ions and their mobility in solution.
Step 1: Definition of Molar Conductivity. Molar conductivity (Λ_m) is defined as the conductance of the volume of solution containing one mole of electrolyte placed between two electrodes.

$$\Lambda_m = \frac{\kappa}{c}$$

where κ = conductivity and c = molar concentration. Unit: S cm^2 mol^{-1}.
Step 2: Variation with concentration. Molar conductivity increases on dilution because:

- Interionic attractions decrease
- Ionic mobility increases
- Degree of ionization may increase

Step 3: Strong electrolytes. Strong electrolytes (e.g., HCl, NaCl) are almost completely ionized even at higher concentrations.

- Λ_m increases slightly with dilution
- Increase is mainly due to reduced interionic interactions
- Variation follows Kohlrausch's law:

$$\Lambda_m = \Lambda_m^\circ - A\sqrt{c}$$

Step 4: Weak electrolytes. Weak electrolytes (e.g., CH_3COOH, NH_4OH) are partially ionized.

- Λ_m increases sharply with dilution
- Ionization increases significantly at low concentration
- At infinite dilution, they approach Λ_m°

Conclusion: Molar conductivity increases with dilution for all electrolytes, but the rise is small for strong electrolytes and large for weak electrolytes due to increased ionization.

Quick Tip

Strong electrolytes show a slight increase in molar conductivity on dilution, while weak electrolytes show a sharp increase due to increased ionization.

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3. Calculate the EMF of a cell using the Nernst Equation.

Correct Answer: The EMF of a cell at non-standard conditions is calculated using the Nernst equation: $E = E^\circ - \frac{0.0591}{n} \log Q$ at 298 K.

Solution:
Concept: The Nernst Equation is used to calculate the EMF (electromotive force) of an electrochemical cell under non-standard conditions by considering ion concentrations or partial pressures.
Step 1: General form of Nernst Equation. At temperature T (in Kelvin):

$$E = E^\circ - \frac{RT}{nF} \ln Q$$

where E = cell EMF, E° = standard EMF, R = gas constant, T = temperature, n = number of electrons transferred, F = Faraday constant, Q = reaction quotient.
Step 2: At 298 K (room temperature). The equation simplifies to:

$$E = E^\circ - \frac{0.0591}{n} \log Q$$

Step 3: Steps to calculate EMF.

- Write the balanced cell reaction
- Determine E° using standard electrode potentials
- Calculate reaction quotient Q using concentrations or pressures

- Substitute values into the Nernst equation

Step 4: Illustrative example. For the cell:

$$\text{Zn}|\text{Zn}^{2+}(0.01\,M)||\text{Cu}^{2+}(1\,M)|\text{Cu}$$

Given $E^\circ = 1.10\,V$ and $n = 2$:

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

$$E = 1.10 - \frac{0.0591}{2}\log(0.01)$$

$$E = 1.10 - \frac{0.0591}{2}(-2) = 1.10 + 0.0591 = 1.1591\,V$$

Conclusion: The Nernst Equation helps calculate cell EMF under non-standard conditions by incorporating concentration or pressure effects.

Quick Tip

At 298 K, use $E = E^\circ - \frac{0.0591}{n}\log Q$ to quickly calculate EMF under non-standard conditions.

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4. Explain the difference between Physisorption and Chemisorption.

Correct Answer: Physisorption involves weak van der Waals forces and is reversible, while chemisorption involves strong chemical bonds and is usually irreversible.

Solution:
Concept: Adsorption is the accumulation of molecules on the surface of a solid or liquid. Based on the nature of forces involved, adsorption is classified into physisorption and chemisorption.
Step 1: Physisorption. Physisorption (physical adsorption) occurs due to weak intermolecular forces such as van der Waals forces.

- Low enthalpy of adsorption
- Reversible in nature
- Occurs at low temperatures
- Multilayer adsorption possible
- No specific surface requirement

Step 2: Chemisorption. Chemisorption (chemical adsorption) involves formation of strong chemical bonds between adsorbate and adsorbent.

- High enthalpy of adsorption
- Usually irreversible
- Occurs at higher temperatures

- Only monolayer adsorption
- Highly specific in nature

Step 3: Key Differences.

- **Nature of forces:** Physisorption — weak van der Waals forces; Chemisorption — strong chemical bonds.
- **Reversibility:** Physisorption is reversible; chemisorption is usually irreversible.
- **Temperature dependence:** Physisorption favored at low temperature; chemisorption at higher temperature.
- **Layer formation:** Physisorption forms multilayers; chemisorption forms a monolayer.

Conclusion: Physisorption and chemisorption differ mainly in the strength of interaction and reversibility, with physisorption being weak and reversible and chemisorption being strong and specific.

Quick Tip

Physisorption = weak, reversible, multilayer; Chemisorption = strong, specific, monolayer adsorption.

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5. Define Colligative Properties and provide two examples.

Correct Answer: Colligative properties are properties of solutions that depend on the number of solute particles, not their nature; examples include lowering of vapor pressure and elevation of boiling point.

Solution:
Concept: Colligative properties are physical properties of solutions that depend only on the number of solute particles present, rather than their chemical identity. These properties are especially significant for dilute solutions.
Step 1: Definition. Colligative properties are those properties of a solution that depend on the ratio of the number of solute particles to solvent molecules, regardless of the nature of the solute.
Step 2: Key characteristic. They depend on concentration (number of particles) and not on:

- Chemical nature of solute
- Molecular structure
- Type of bonding

Step 3: Examples of colligative properties. Any two examples:

- Lowering of vapor pressure
- Elevation of boiling point
- Depression of freezing point

- Osmotic pressure

Conclusion: Colligative properties are important in understanding solution behavior and depend solely on the number of solute particles present.

Quick Tip

Colligative properties depend only on the number of solute particles — not their identity.

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6. What is Lanthanoid Contraction and what are its consequences?

Correct Answer: Lanthanoid contraction is the gradual decrease in atomic and ionic radii of lanthanoids with increasing atomic number, leading to similarities in properties of elements and affecting transition metals and periodic trends.

Solution:
Concept: The lanthanoids (elements from La to Lu) show a steady decrease in size across the series. This phenomenon is known as lanthanoid contraction and plays an important role in determining periodic properties.
Step 1: Definition of Lanthanoid Contraction. Lanthanoid contraction refers to the gradual decrease in atomic and ionic radii of lanthanoid elements with increase in atomic number from La (57) to Lu (71).
Step 2: Cause of Lanthanoid Contraction. It occurs due to:

- Poor shielding effect of 4f electrons
- Increase in nuclear charge across the series
- Greater attraction between nucleus and outer electrons

Step 3: Consequences of Lanthanoid Contraction.

- **Similarity between 4d and 5d transition elements:** Elements like Zr and Hf have nearly identical sizes and properties.
- **Difficulty in separation of lanthanoids:** Very small differences in ionic radii make their separation challenging.
- **Effect on basic strength of hydroxides:** Basicity of lanthanoid hydroxides decreases across the series.
- **Higher density and hardness:** Due to decreasing size and increasing effective nuclear charge.

Conclusion: Lanthanoid contraction significantly influences periodic trends, transition metal similarities, and chemical behavior of elements in the periodic table.

Quick Tip

Lanthanoid contraction occurs due to poor shielding by 4f electrons and leads to similar properties of 4d and 5d elements like Zr and Hf.

7. Discuss Werner's Theory of coordination compounds.

Correct Answer: Werner's Theory explains coordination compounds based on primary and secondary valencies, distinguishing ionizable and non-ionizable ligands and explaining geometry and bonding in complexes.

Solution:
Concept: Werner's Theory, proposed by Alfred Werner in 1893, laid the foundation of modern coordination chemistry. It explained the structure, bonding, and properties of coordination compounds that earlier theories failed to describe.
Step 1: Main postulates of Werner's Theory. Werner proposed that metals in coordination compounds exhibit two types of valencies:

- **Primary valency** (ionizable valency)
- **Secondary valency** (non-ionizable valency)

Step 2: Primary valency.

- Corresponds to the oxidation state of the metal
- Satisfied by negative ions
- Ionizable and can be detected in solution
- Example: Cl^- ions outside the coordination sphere

Step 3: Secondary valency.

- Corresponds to the coordination number of the metal
- Satisfied by ligands (neutral molecules or anions)
- Non-ionizable and remain within the coordination sphere
- Responsible for geometry of the complex

Step 4: Spatial arrangement of ligands. Werner suggested that ligands attached through secondary valencies occupy fixed positions in space, giving definite geometries such as:

- Octahedral (coordination number 6)
- Square planar (coordination number 4)
- Tetrahedral (coordination number 4)

Step 5: Example. In $CoCl_3 \cdot 6NH_3$:

- Three Cl^- satisfy primary valency
- Six NH_3 molecules satisfy secondary valency

Significance: Werner's Theory successfully explained:

- Ionization behavior of complexes
- Existence of coordination numbers

- Isomerism in coordination compounds
- Geometry of complexes

Conclusion: Werner's Theory revolutionized coordination chemistry by introducing the concepts of primary and secondary valencies and explaining the structure and bonding of coordination compounds.

Quick Tip

Werner's Theory distinguishes primary (ionizable) and secondary (non-ionizable) valencies and explains coordination number and geometry of complexes.

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8. Explain the SN1 and SN2 mechanisms with suitable examples and reactivity orders.

Correct Answer: SN1 reactions proceed via a two-step carbocation mechanism with first-order kinetics, while SN2 reactions occur in a single step with backside attack and second-order kinetics, showing different reactivity orders.

Solution:
Concept: Nucleophilic substitution reactions involve the replacement of a leaving group by a nucleophile. Based on the reaction mechanism and kinetics, they are classified as SN1 and SN2 reactions.
Step 1: SN1 Mechanism (Unimolecular Nucleophilic Substitution).

- Occurs in two steps:
  1. Formation of a carbocation intermediate (slow, rate-determining step)
  2. Attack by nucleophile (fast step)
- Rate depends only on substrate concentration:

$$\text{Rate} = k[\text{R–X}]$$

- Favored by tertiary substrates and polar protic solvents

Example: Hydrolysis of tert-butyl bromide:

$$(CH_3)_3C\text{–Br} \rightarrow (CH_3)_3C^+ \rightarrow (CH_3)_3C\text{–OH}$$

Reactivity order (SN1):

$$3^\circ > 2^\circ > 1^\circ > \text{methyl}$$

Step 2: SN2 Mechanism (Bimolecular Nucleophilic Substitution).

- Occurs in a single concerted step
- Nucleophile attacks from the backside while leaving group departs
- Leads to inversion of configuration (Walden inversion)

- Rate depends on both substrate and nucleophile:

$$\text{Rate} = k[\text{R–X}][\text{Nu}^-]$$

- Favored by primary substrates and polar aprotic solvents

Example: Reaction of methyl bromide with hydroxide ion:

$$CH_3Br + OH^- \rightarrow CH_3OH + Br^-$$

Reactivity order (SN2):

$$\text{methyl} > 1^\circ > 2^\circ > 3^\circ$$

Step 3: Key Differences.

- **Mechanism:** SN1 is two-step; SN2 is one-step.
- **Intermediate:** SN1 forms carbocation; SN2 has no intermediate.
- **Kinetics:** SN1 first-order; SN2 second-order.
- **Stereochemistry:** SN1 gives racemization; SN2 gives inversion.
- **Substrate preference:** SN1 favors tertiary; SN2 favors primary.

Conclusion: SN1 and SN2 reactions differ fundamentally in mechanism, kinetics, stereochemistry, and substrate preference, making them essential concepts in organic reaction mechanisms.

Quick Tip

SN1: two-step, carbocation, 3° favored; SN2: one-step, backside attack, methyl and 1° favored.

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9. Why is Phenol more acidic than alcohols?

Correct Answer: Phenol is more acidic than alcohols because its conjugate base (phenoxide ion) is stabilized by resonance, whereas alkoxide ions from alcohols lack such stabilization.

Solution:
Concept: Acidity depends on the stability of the conjugate base formed after the loss of a proton. Greater stability of the conjugate base leads to higher acidity.
Step 1: Formation of conjugate bases.

- Phenol loses H^+ to form phenoxide ion ($C_6H_5O^-$)
- Alcohols lose H^+ to form alkoxide ions (RO^-)

Step 2: Resonance stabilization in phenol. The negative charge on the oxygen atom in the phenoxide ion is delocalized over the aromatic ring through resonance. This distribution of charge stabilizes the conjugate base.
Step 3: Lack of resonance in alcohols. Alkoxide ions do not have resonance stabilization. The negative charge remains localized on the oxygen atom, making them less stable.

Step 4: Effect of hybridization. In phenol, the oxygen is attached to an sp^2-hybridized carbon of the benzene ring, which has a higher electronegativity than the sp^3 carbon in alcohols, further stabilizing the phenoxide ion.
Conclusion: Due to resonance stabilization and the influence of the aromatic ring, phenoxide ions are more stable than alkoxide ions, making phenol more acidic than alcohols.

Quick Tip

Phenol is more acidic because its conjugate base is resonance-stabilized, while alcohols form unstable alkoxide ions.

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10. Differentiate between DNA and RNA.

Correct Answer: DNA is a double-stranded molecule containing deoxyribose sugar and thymine, responsible for genetic storage, while RNA is usually single-stranded, contains ribose sugar and uracil, and is involved in protein synthesis.

Solution:
Concept: DNA (Deoxyribonucleic Acid) and RNA (Ribonucleic Acid) are nucleic acids that play crucial roles in genetic information storage and expression. They differ in structure, composition, and function.
Step 1: Structural differences.

- DNA is double-stranded and forms a double helix.
- RNA is usually single-stranded.

Step 2: Sugar component.

- DNA contains deoxyribose sugar.
- RNA contains ribose sugar.

Step 3: Nitrogenous bases.

- DNA bases: Adenine (A), Guanine (G), Cytosine (C), Thymine (T).
- RNA bases: Adenine (A), Guanine (G), Cytosine (C), Uracil (U).

Step 4: Function.

- DNA stores and transmits genetic information.
- RNA helps in protein synthesis (mRNA, tRNA, rRNA).

Step 5: Location.

- DNA is mainly found in the nucleus (also mitochondria).
- RNA is found in nucleus and cytoplasm.

Conclusion: DNA serves as the genetic blueprint of life, whereas RNA plays a functional role in expressing this genetic information through protein synthesis.

Quick Tip

DNA = double-stranded, deoxyribose, thymine, genetic storage; RNA = single-stranded, ribose, uracil, protein synthesis.

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11. How can you distinguish between Aldehydes and Ketones using the Tollen's or Fehling's test?

Correct Answer: Aldehydes give positive results with Tollen's and Fehling's tests (silver mirror or red precipitate), while ketones generally do not react with these reagents.

Solution:
Concept: Aldehydes and ketones both contain the carbonyl group, but aldehydes are easily oxidized while ketones are resistant to mild oxidation. This difference is used in qualitative tests like Tollen's and Fehling's tests.
Step 1: Tollen's Test (Silver Mirror Test).

- Reagent: Ammoniacal silver nitrate (Tollen's reagent).
- Aldehydes reduce Ag^{+} to metallic silver, forming a shiny silver mirror on the test tube.
- Ketones generally do not give this reaction.

Observation:

- Aldehyde $\rightarrow$ Silver mirror formed
- Ketone $\rightarrow$ No reaction

Step 2: Fehling's Test.

- Reagent: Fehling's solution (alkaline Cu^{2+} complex).
- Aldehydes reduce Cu^{2+} to Cu_2O, forming a brick-red precipitate.
- Ketones usually do not react (except some α-hydroxy ketones).

Observation:

- Aldehyde $\rightarrow$ Brick-red precipitate
- Ketone $\rightarrow$ No precipitate

Step 3: Reason for difference. Aldehydes contain a hydrogen atom attached to the carbonyl carbon, making them easily oxidizable. Ketones lack this hydrogen and are resistant to mild oxidizing agents.
Conclusion: Tollen's and Fehling's tests help distinguish aldehydes from ketones based on the ease of oxidation of aldehydes.

Quick Tip

Aldehydes give silver mirror (Tollen's) and red precipitate (Fehling's), while ketones generally give negative results.
