PUNJAB-BOARD-CLASS-12-CHEMISTRY-053-A-2025 with Solutions

Time Allowed :3 Hours	**Maximum Marks :**80	**Total Questions :**21

General Instructions

1. All questions are compulsory.
2. Question paper consists of 18 questions divided into 4 sections A, B, C and D.
3. Section A comprises of 1 question of 20 multiple choice type questions of 1 mark each.
4. Section B comprises of 7 questions of 2 marks each.
5. Section C comprises of 7 questions of 4 marks each.
6. Section D comprises of 3 questions of 6 marks each.
7. An internal choice is provided in 3 questions of Section C and D each. You have to attempt only one of the alternatives in all such cases.
8. Use of calculator is not allowed.

It has been observed that nucleus of a living cell is responsible for this transmission of inherent characters, also called heredity. The particles in the nucleus of cell, responsible for heredity, are called chromosomes which are made up of proteins and another type of biomolecules called nucleic acids. These are mainly of two types, the deoxyribonucleic acids (DNA) and ribonucleic acid (RNA). Since nucleic acids are long chain polymers of nucleotides, so they are also called polynucleotides. RNA molecules are of three types and they perform different functions. They are named as messenger RNA (m-RNA), ribosomal RNA (r-RNA) and transfer RNA (t -RNA).

1(i). Give full form of DNA and RNA.
Correct Answer: DNA: Deoxyribonucleic acid, RNA: Ribonucleic acid

Solution:
The paragraph explicitly mentions the two types of nucleic acids found in the nucleus of a living cell.

DNA stands for Deoxyribonucleic acid.

RNA stands for Ribonucleic acid.

Quick Tip

Remember that the difference in names comes from the sugar moiety: Deoxyribose in DNA and Ribose in RNA.

1(ii). How many types of RNA are there?
Correct Answer: Three types

Solution:
According to the provided text, RNA molecules are of three types.

These types are listed as messenger RNA (m-RNA), ribosomal RNA (r-RNA), and transfer RNA (t-RNA).

Quick Tip

The three types of RNA play distinct roles in protein synthesis: m-RNA carries the code, t-RNA brings amino acids, and r-RNA forms the ribosome structure.

1(iii). Who is responsible for heredity?
Correct Answer: The nucleus of a living cell

Solution:
The first sentence of the passage states that ”It has been observed that nucleus of a living cell is responsible for this transmission of inherent characters, also called heredity.”

Therefore, the nucleus is the organelle responsible for heredity.

Quick Tip

While the nucleus is the organelle, the specific molecular carriers of heredity within the nucleus are the chromosomes and DNA.

1(iv). Define heredity.
Correct Answer: Transmission of inherent characters

Solution:
Based on the text, heredity is defined as ”this transmission of inherent characters”.

It refers to the passing of genetic traits from parents to offspring.

Quick Tip

Heredity is the biological process responsible for the resemblance between parents and offspring.

1(v). How many types of nucleic acids are there?
Correct Answer: Two types

Solution:
The passage states that nucleic acids ”are mainly of two types”.

These two types are identified as deoxyribonucleic acids (DNA) and ribonucleic acid (RNA).

Quick Tip

DNA is primarily the genetic material, while RNA is involved in the expression of that genetic information.

1(vi). CO is stronger ligand than Cl^{-1}.
Correct Answer: True

Solution:
The strength of a ligand is determined by its position in the spectrochemical series.

Carbon monoxide (CO) is a strong field ligand and acts as a π-acceptor, placed at the high end of the series.

Chloride ion (Cl^{-1}) is a weak field ligand, placed at the lower end of the series.

Therefore, CO causes greater crystal field splitting than Cl^{-1}, making it a stronger ligand.

Quick Tip

Recall the spectrochemical series order: Halogens $<$ OH $<$ H_2O $<$ NH_3 $<$ CN $<$ CO. Ligands with Carbon donors (CO, CN) are generally very strong.

1(vii). The colour produced in Victor Meyer test for primary alcohol is deep blue.
Correct Answer: False

Solution:
In the Victor Meyer test, different classes of alcohols produce distinct colours.

Primary alcohols react to produce a blood-red colouration (due to the formation of nitrolic acid).

Secondary alcohols produce a deep blue colouration (due to the formation of pseudonitrol).

Therefore, the statement that primary alcohols produce a deep blue colour is incorrect.

Quick Tip

Mnemonic for Victor Meyer Test colours: RBC (Red, Blue, Colourless) corresponds to Primary (1°), Secondary (2°), and Tertiary (3°) alcohols respectively.

1(viii). Formic acid is obtained from red ants.
Correct Answer: True

Solution:
The name ”formic acid” (methanoic acid) is derived from the Latin word ”formica”, which means ant.

It was historically first isolated by the distillation of the bodies of red ants.

Thus, the statement is factually correct.

Quick Tip

Methanoic acid is the IUPAC name for formic acid. It is also responsible for the stinging sensation in ant bites.

1(ix). IUPAC name of Acetone is Butanone.
Correct Answer: False

Solution:
Acetone is the common name for the ketone with the formula CH_3COCH_3.

Its IUPAC name is Propanone, as it contains a three-carbon chain.

Butanone is the IUPAC name for Methyl Ethyl Ketone ($CH_3COCH_2CH_3$), which has a four-carbon chain.

Therefore, Acetone is not Butanone.

Quick Tip

"Prop-" indicates 3 carbons, while "But-" indicates 4 carbons. Acetone is the simplest ketone with 3 carbons.

1(x). $Ni(CO)_4$ is diamagnetic.
Correct Answer: True

Solution:
In Nickel Tetracarbonyl $[Ni(CO)_4]$, the oxidation state of Nickel is 0 (since CO is a neutral ligand).

The electronic configuration of Ni(0) is [Ar] $3d^8$ $4s^2$.

CO is a strong field ligand, which causes the two electrons from the 4s orbital to pair up with the electrons in the 3d orbital.

This results in a $3d^{10}$ configuration with no unpaired electrons.

Since there are no unpaired electrons, the complex is diamagnetic.

Quick Tip

Species with no unpaired electrons are diamagnetic and are weakly repelled by magnetic fields.

1(xi). The units of ebullioscopic constant is :
(A) K kg mol^{-1}
(B) mol kg K^{-1}
(C) kg mol^{-1} K^{-1}
(D) K mol kg^{-1}
Correct Answer: (A) K kg mol^{-1}

Solution:
The ebullioscopic constant (K_b) relates the elevation in boiling point (ΔT_b) to the molality (m) of the solution: $\Delta T_b = K_b \cdot m$.

Rearranging for K_b, we get $K_b = \frac{\Delta T_b}{m}$.

The unit of temperature change (ΔT_b) is Kelvin (K).

The unit of molality (m) is mol kg^{-1}.

Therefore, the unit of K_b is $\frac{\text{K}}{\text{mol kg}^{-1}} = \text{K kg mol}^{-1}$.

Quick Tip

Both ebullioscopic (K_b) and cryoscopic (K_f) constants have the same units: K kg mol^{-1}.

1(xii). Galvanisation is applying a coating of :
(A) Cr
(B) Cu
(C) Zn
(D) Pb
Correct Answer: (C) Zn

Solution:
Galvanisation is a specific metallurgical process used to protect steel or iron from rusting.

This involves applying a protective layer of Zinc (Zn) to the metal.

Zinc acts as a sacrificial anode, corroding in preference to the underlying iron.

Therefore, the correct coating material is Zinc.

Quick Tip

Think of "Galvanisation" and "Zinc" together. It is the most common method for rust prevention on iron sheets.

1(xiii). The units of first order reaction :
(A) s^{-1}
(B) s
(C) mol L^{-1}
(D) L^{-1} s
Correct Answer: (A) s^{-1}

Solution:
For a reaction of n-th order, the rate law is Rate $= k[A]^n$.

The units of the rate constant k are given by the general formula $(\text{mol L}^{-1})^{1-n}\text{s}^{-1}$.

For a first order reaction, $n = 1$.

Substituting $n = 1$ into the formula: $(\text{mol L}^{-1})^{1-1}\text{s}^{-1} = (\text{mol L}^{-1})^{0}\text{s}^{-1} = \text{s}^{-1}$.

Alternatively, since Rate $(\text{mol L}^{-1}\ \text{s}^{-1}) = k\times$ Concentration (mol L^{-1}), k must have units of s^{-1}.

Quick Tip

The unit of the rate constant for a first-order reaction is strictly time^{-1} and is independent of concentration units.

1(xiv). What is the mole fraction of benzene in solution containing 30% by mass in carbon tetrachloride ?
(A) 0.540
(B) 0.459
(C) 0.500
(D) 0.300
Correct Answer: (B) 0.459

Solution:
Let the total mass of the solution be 100 g.

Mass of Benzene (C_6H_6) = 30 g. Mass of Carbon tetrachloride (CCl_4) = 100 - 30 = 70 g.

Molar mass of Benzene (C_6H_6) $= 12(6) + 1(6) = 78$ g/mol.

Molar mass of $CCl_4 = 12 + 35.5(4) = 12 + 142 = 154$ g/mol.

Moles of Benzene (n_B) $= \frac{30}{78} \approx 0.385$ mol.

Moles of CCl_4 (n_A) $= \frac{70}{154} \approx 0.455$ mol.

Total moles $= 0.385 + 0.455 = 0.840$ mol.

Mole fraction of Benzene (X_B) $= \frac{n_B}{n_{total}} = \frac{0.385}{0.840} \approx 0.4583$.

This value is closest to 0.459.

Quick Tip

Mole fraction is a dimensionless quantity. Always ensure you calculate moles using the correct molar masses ($C = 12, H = 1, Cl = 35.5$).

1(xv). The porous membrane used in reverse osmosis plant is made up of :
(A) Cellulose acetone
(B) Potassium nitrate
(C) Mercuric iodide
(D) Starch
Correct Answer: (A) Cellulose acetone

Solution:
Reverse osmosis requires a semi-permeable membrane that allows solvent to pass but blocks solute.

The most common material used for this membrane is Cellulose Acetate.

Option (A) says "Cellulose acetone", which appears to be a typo for Cellulose Acetate found in the original exam paper (confirmed by Hindi version "Cellulose Acetate").

Options B, C, and D are chemical salts or carbohydrates not typically used as membrane films for RO.

Therefore, (A) is the intended correct answer.

Quick Tip

In exam questions, if you see a slight typo like "Cellulose Acetone" instead of "Cellulose Acetate", choose it if it's clearly the intended answer among unrelated distractors.

1(xvi). What is DDT among the following :
(A) Fertilizer
(B) Biodegradable pollutant
(C) Non-Biodegradable pollutant
(D) Green House gas
Correct Answer: (C) Non-Biodegradable pollutant

Solution:
DDT (Dichlorodiphenyltrichloroethane) is a synthetic organochlorine insecticide.

It is chemically stable and does not break down easily in the environment by natural biological processes.

Because it persists in the environment and accumulates in the food chain (biomagnification), it is classified as a non-biodegradable pollutant.

Quick Tip

DDT is the classic example of a non-biodegradable pollutant that led to the decline of bird populations due to eggshell thinning.

1(xvii). In the following, strongest Acid is :
(A) CH_3CH_2COOH
(B) CH_3COOH
(C) C_6H_5COOH
(D) $C_6H_5CH_2COOH$
Correct Answer: (C) C_6H_5COOH

Solution:
We compare the acid strengths based on the stability of their conjugate bases and pK_a values.

Acetic acid (CH_3COOH) has a pK_a of 4.76. Propanoic acid (CH_3CH_2COOH) has a pK_a of 4.88.

Benzoic acid (C_6H_5COOH) has a pK_a of 4.20. The phenyl group exerts an electron-withdrawing effect (due to sp^2 carbons) which stabilizes the carboxylate ion relative to alkyl groups.

Phenylacetic acid ($C_6H_5CH_2COOH$) has a pK_a of 4.31. The -I effect of the phenyl ring is diminished by the intervening CH_2 group compared to direct attachment in Benzoic acid.

Since a lower pK_a indicates a stronger acid, Benzoic acid (pK_a 4.20) is the strongest among the given options.

Quick Tip

General order of acidity: Formic Acid > Benzoic Acid > Acetic Acid. Aromatic carboxylic acids are generally stronger than aliphatic ones (except Formic).

1(xviii). Benzioc Acid reacts with $LiAlH_4$ to give :
(A) Ethylene
(B) Methyl Benzene
(C) Phenol
(D) Benzyl Alcohol
Correct Answer: (D) Benzyl Alcohol

Solution:
Lithium Aluminium Hydride ($LiAlH_4$) is a strong reducing agent.

It reduces carboxylic acids (-COOH) directly to primary alcohols ($-CH_2OH$).

The reaction is: $C_6H_5COOH \xrightarrow{LiAlH_4} C_6H_5CH_2OH$.

The product $C_6H_5CH_2OH$ is named Benzyl Alcohol.

Quick Tip

$LiAlH_4$ is strong enough to reduce acids, esters, and ketones to alcohols. It does not reduce the benzene ring itself under normal conditions.

1(xix). Vinegar is dilute aqeous solution of :
(A) Ethanoic acid
(B) Benzoic acid
(C) Citric acid
(D) Oxalic acid

Correct Answer: (A) Ethanoic acid

Solution:
Vinegar is a common household item used for cooking and preservation.

Chemically, it consists of a dilute solution of acetic acid in water (typically 5-8%).

The IUPAC name for acetic acid is Ethanoic acid.

Quick Tip

The word vinegar comes from French "vin aigre" meaning sour wine, which is formed when ethanol in wine oxidizes to ethanoic acid.

1(xx). The oxidation state of Fe in $[Fe(CN)_6]^{-3}$:
(A) +3
(B) +2
(C) +4
(D) -3
Correct Answer: (A) +3

Solution:
Let the oxidation state of Iron (Fe) be x.

The cyanide ligand (CN) has a charge of -1. There are 6 cyanide ions.

The overall charge on the complex ion is -3.

The equation for the sum of oxidation states is: $x + 6(-1) = -3$.

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

Therefore, the oxidation state of Fe is +3.

Quick Tip

Always equate the sum of oxidation states of the central metal and ligands to the total charge on the coordination sphere. CN is always -1.

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2. Write two differences between double salt and co-ordination compounds.
Correct Answer: Double salts dissociate completely into simple ions in solution, whereas

coordination compounds retain their identity and do not dissociate into simple constituent ions completely.

Solution:
1. Dissociation: Double salts (e.g., Mohr's salt) completely dissociate into their constituent simple ions when dissolved in water. Coordination compounds (e.g., Potassium ferrocyanide) do not completely dissociate; the complex ion remains intact.

2. Properties: The properties of a double salt are essentially the same as those of its constituent compounds. The properties of a coordination compound are different from its constituents.

3. Valency: In double salts, the metal exhibits normal valency. In coordination compounds, the metal satisfies two types of valencies: primary (oxidation state) and secondary (coordination number).

Quick Tip

Remember: Double salts exist only in solid state, while coordination compounds exist in both solid and solution states.

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3. Define monodentate ligands and give example.
Correct Answer: Ligands that coordinate to a central metal atom through a single donor

atom. Examples: H_2O, NH_3, Cl^-.

Solution:
Definition: A monodentate (or unidentate) ligand is a ligand that has only one donor atom capable of forming a coordinate bond with the central metal ion.

Examples:
1. Ammonia ($:NH_3$) - The Nitrogen atom is the donor.
2. Water ($H_2O:$) - The Oxygen atom is the donor.
3. Chloride ion (Cl^-) - Acts as a donor.

Quick Tip

"Mono" means one and "dentate" refers to teeth/binding sites. So, "one-toothed" ligands bind at one site only.

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4 . Why do alcohols have higher boiling point than haloalkanes of the same molecular mass ?
Correct Answer: Due to the presence of intermolecular hydrogen bonding in alcohols.

Solution:
1. Alcohols (R-OH) contain a highly electronegative oxygen atom attached to a hydrogen atom, which allows them to form intermolecular hydrogen bonds.

2. These hydrogen bonds are strong attractive forces that require significant energy to break during boiling.

3. Haloalkanes (R-X) are polar but cannot form hydrogen bonds with each other; they only have weaker dipole-dipole interactions and Van der Waals forces.

4. Consequently, the boiling point of alcohols is much higher than that of haloalkanes of comparable molecular mass.

Quick Tip

Hydrogen bonding is the key factor for the unusually high boiling points of alcohols, water, and carboxylic acids compared to other organic compounds.

OR

4 . How will you convert propan-1-ol to propan-2-ol ?
Correct Answer: By dehydration to propene followed by hydration according to Markovnikov's

rule.

Solution:
Step 1: Dehydration: Heat Propan-1-ol with concentrated H_2SO_4 at 443 K to form Propene.
$CH_3CH_2CH_2OH \xrightarrow[443\text{ K}]{\text{conc. } H_2SO_4} CH_3CH{=}CH_2 + H_2O$

Step 2: Hydration: Treat Propene with water in the presence of acid (Acid-catalyzed hydration). The addition follows Markovnikov's rule, where the OH group attaches to the more substituted carbon (the middle one).
$CH_3CH{=}CH_2 + H_2O \xrightarrow{H^+} CH_3CH(OH)CH_3$ (Propan-2-ol)

Quick Tip

Conversion of 1° alcohol to 2° alcohol always involves an alkene intermediate. Dehydration → Alkene → Markovnikov Hydration.

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5 . Describe Rosenmund reduction.
Correct Answer: Partial reduction of acid chlorides to aldehydes using H_2 and Pd/$BaSO_4$.

Solution:
1. Definition: Rosenmund reduction is a chemical reaction used to convert acid chlorides (acyl chlorides) into aldehydes.

2. Reagents: Hydrogen gas (H_2) is passed through the solution in the presence of a catalyst, which is Palladium (Pd) deposited on Barium Sulphate ($BaSO_4$). The catalyst is often poisoned with sulfur or quinoline to prevent further reduction to alcohols.

3. Reaction:
$\text{R-COCl} + H_2 \xrightarrow{\text{Pd/BaSO}_4} \text{R-CHO} + \text{HCl}$

4. Example: Benzoyl chloride is reduced to Benzaldehyde.
$C_6H_5COCl + H_2 \xrightarrow{\text{Pd/BaSO}_4} C_6H_5CHO + HCl$

Quick Tip

$BaSO_4$ acts as a catalyst poison here. Without it, the highly active Pd catalyst would reduce the aldehyde further into a primary alcohol.

OR

5 . Lower carboxylic acids are highly soluble in water. Explain.
Correct Answer: Due to the formation of hydrogen bonds with water molecules.

Solution:
1. Lower carboxylic acids (like Methanoic acid, Ethanoic acid) have a polar carboxyl group (-COOH).

2. The oxygen atoms in the carboxyl group and the hydrogen atom of the -OH group can form hydrogen bonds with water molecules.

($R\text{-}COOH \cdots OH_2$)

3. This extensive hydrogen bonding allows the acid molecules to mix freely with water.

4. As the size of the hydrophobic alkyl chain (R) increases, the solubility decreases because the hydrophobic interaction overcomes the hydrogen bonding.

Quick Tip

"Like dissolves like." Since water is polar and H-bonded, it dissolves other polar, H-bonding substances like lower carboxylic acids.

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6. How will you obtain chlorobenzene from aniline ?
Correct Answer: Using the Sandmeyer reaction (Diazotization followed by treatment with CuCl/HCl).

Solution:
Step 1: Diazotization: Aniline is treated with Sodium Nitrite ($NaNO_2$) and Hydrochloric acid (HCl) at a low temperature (0-5°C) to form Benzene Diazonium Chloride.
$C_6H_5NH_2 + NaNO_2 + 2HCl \xrightarrow{0-5^\circ C} C_6H_5N_2^+Cl^- + NaCl + 2H_2O$

Step 2: Sandmeyer Reaction: The Benzene Diazonium Chloride is treated with Cuprous Chloride (Cu_2Cl_2 or CuCl) in HCl.
$C_6H_5N_2^+Cl^- \xrightarrow{CuCl/HCl} C_6H_5Cl + N_2$

The product C_6H_5Cl is Chlorobenzene.

Quick Tip

The diazonium salt is a versatile intermediate. Changing the copper salt allows you to make Bromobenzene (CuBr) or Benzonitrile (CuCN) as well.

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7. Explain why methylamine is a stronger base than Ammonia ?
Correct Answer: Due to the electron-donating inductive effect (+I) of the methyl group.

Solution:
1. Basicity depends on the availability of the lone pair on the nitrogen atom to accept a proton.

2. In Methylamine (CH_3NH_2), the methyl group (-CH_3) is an electron-releasing group (has a +I effect).

3. This effect increases the electron density on the nitrogen atom, making the lone pair more available for donation compared to Ammonia (NH_3).

4. Additionally, the methylammonium ion formed after accepting a proton is stabilized by the +I effect of the methyl group, shifting the equilibrium forward.

Thus, Methylamine is more basic than Ammonia.

Quick Tip

In gas phase, basicity order is $3^\circ > 2^\circ > 1^\circ > NH_3$. In aqueous phase, solvation effects change this order, but all alkyl amines remain stronger than ammonia.

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8. Give two differences between DNA and RNA.
Correct Answer: Difference in sugar (Deoxyribose vs Ribose) and base (Thymine vs Uracil),

and structure (Double vs Single stranded).

Solution:
1. Sugar: DNA contains the sugar 2-deoxyribose, whereas RNA contains the sugar ribose.

2. Nitrogenous Bases: DNA contains the pyrimidine base Thymine (T). RNA contains Uracil (U) instead of Thymine. (Both contain Adenine, Guanine, and Cytosine).

3. Structure: DNA usually exists as a double-stranded helix. RNA usually exists as a single-stranded molecule.

Quick Tip

An easy way to remember: DNA = Double stranded, Deoxyribose. RNA = Ribose, and "U" comes after "T" alphabetically? No, just remember U replaces T.

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9. Give two differences between ideal and non-ideal solution.
Correct Answer: Ideal solutions obey Raoult's law at all concentrations; Non-ideal solutions

do not. Enthalpy and volume of mixing are zero for Ideal, non-zero for Non-ideal.

Solution:
1. Raoult's Law: Ideal solutions obey Raoult's law ($P_A = P_A^0 X_A$) over the entire range of concentration. Non-ideal solutions deviate (positively or negatively) from Raoult's law.

2. Thermodynamics of Mixing: For an ideal solution, the enthalpy of mixing (ΔH_{mix}) is zero, and the volume of mixing (ΔV_{mix}) is zero. For a non-ideal solution, $\Delta H_{mix} \neq 0$ and $\Delta V_{mix} \neq 0$.

Quick Tip

Ideal solutions are rare (e.g., Benzene + Toluene). Most real solutions are non-ideal due to differences in intermolecular forces between solute and solvent.

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10 . Calculate the molal elevation constant of water, it being given that 0.1 molal aqueous solution of a substance boils at 100.052°C.
Correct Answer: 0.52 K kg mol^{-1}

Solution:
Given:
Molality of solution, $m = 0.1$ molal.
Boiling point of solution, $T_b = 100.052$°C.
Boiling point of pure water, $T_b^0 = 100$°C.

Calculate elevation in boiling point (ΔT_b):
$\Delta T_b = T_b - T_b^0 = 100.052 - 100 = 0.052$°C (or 0.052 K).

Formula for elevation in boiling point:
$\Delta T_b = K_b \times m$

Rearrange to solve for K_b:
$K_b = \frac{\Delta T_b}{m}$
$K_b = \frac{0.052}{0.1}$
$K_b = 0.52$ K kg mol^{-1}.

Quick Tip

The value 0.52 K kg/mol is a standard constant for water. If you get a calculation result far from this, check your math!

OR

10 . 18 gm of glucose ($C_6H_{12}O_6$) is dissolved in 1 kg of water in a saucepan. At what temperature will the water boil at 1.013 bar pressure ? K_b for water is 0.52 K kg mol^{-1}.
Correct Answer: 373.202 K (or 100.052°C)

Solution:
Given:
Mass of solute (Glucose), $w_2 = 18$ g.
Molar mass of Glucose ($C_6H_{12}O_6$), $M_2 = 180$ g/mol.
Mass of solvent (Water), $w_1 = 1$ kg.
$K_b = 0.52$ K kg mol^{-1}.

Step 1: Calculate moles of glucose (n_2):
$n_2 = \frac{18}{180} = 0.1$ mol.

Step 2: Calculate Molality (m):
$m = \frac{\text{moles of solute}}{\text{mass of solvent in kg}} = \frac{0.1}{1} = 0.1$ m.

Step 3: Calculate Elevation in boiling point (ΔT_b):
$\Delta T_b = K_b \times m = 0.52 \times 0.1 = 0.052$ K.

Step 4: Calculate Boiling Point of solution (T_b):
Pure water boils at 373.15 K (100°C) at 1.013 bar.
$T_b = T_b^0 + \Delta T_b = 373.15 + 0.052 = 373.202$ K.
(In Celsius: $100 + 0.052 = 100.052$°C).

Quick Tip

Always check the pressure units. 1.013 bar is standard atmospheric pressure, so pure water boils at 100°C.

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11. Give two differences between Galvanic Cell and Electrolytic cell.
Correct Answer: Galvanic converts chemical to electrical energy; Electrolytic converts electrical to chemical. Anode polarity differs (-ve in Galvanic, +ve in Electrolytic).

Solution:
1. Energy Conversion: A Galvanic cell converts chemical energy into electrical energy (spontaneous reaction). An Electrolytic cell converts electrical energy into chemical energy (non-spontaneous reaction).

2. Polarity of Electrodes: In a Galvanic cell, the anode is negative and the cathode is positive. In an Electrolytic cell, the anode is positive and the cathode is negative.

Quick Tip

In both cells, oxidation always occurs at the anode and reduction at the cathode. Only the sign changes.

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12. How many Coulombs of electricity are required for complete oxidation of 90 gm of H_2O ?
Correct Answer: 964,870 C

Solution:
The oxidation reaction of water is:
$H_2O \rightarrow 2H^+ + \frac{1}{2}O_2 + 2e^-$

1. Moles of Water:
Molar mass of H_2O = 18 g/mol.
Moles of $H_2O = \frac{90}{18} = 5$ moles.

2. Electrons required:
From the equation, oxidation of 1 mole of H_2O releases 2 moles of electrons.
So, 5 moles of H_2O will release $5 \times 2 = 10$ moles of electrons.

3. Charge Calculation:
Charge of 1 mole of electrons (1 Faraday) ≈ 96487 C.
Total Charge $= 10 \times 96487 = 964870$ C.

Quick Tip

Always start by writing the balanced half-reaction to determine 'n' (number of electrons transferred per mole).

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13. Give two differences between order of reaction and molecularity of reaction.
Correct Answer: Order is experimental and can be fractional/zero. Molecularity is theoretical and must be a whole number.

Solution:
1. Definition/Determination: Order is the sum of powers of concentration terms in the experimental rate law; it is an experimental quantity. Molecularity is the number of reacting species colliding simultaneously in an elementary step; it is a theoretical concept.

2. Values: Order can be zero, fractional, or an integer. Molecularity can only be a positive integer (1, 2, 3) and cannot be zero or fractional.

Quick Tip

Molecularity has no meaning for complex (multi-step) reactions, whereas order applies to both elementary and complex reactions.

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14 . The rate constant for a first order reaction is 60 sec^{-1}. How much time will it take to reduce the concentration of the reaction to 1/10th of its initial value ?
Correct Answer: 0.038 seconds

Solution:
For a first-order reaction, the integrated rate equation is:
$t = \frac{2.303}{k} \log \frac{[A]_0}{[A]}$

Given:
$k = 60\ \text{s}^{-1}$.
We want the final concentration $[A]$ to be $\frac{1}{10}$ of initial $[A]_0$.
So, $\frac{[A]_0}{[A]} = 10$.

Substitute values:
$t = \frac{2.303}{60} \log(10)$
Since $\log(10) = 1$:
$t = \frac{2.303}{60}$
$t \approx 0.03838$ s.

Rounding to significant figures, $t \approx 3.84 \times 10^{-2}$ s.

Quick Tip

Memorize $\ln(10) \approx 2.303$. This conversion factor is ubiquitous in kinetics problems involving base-10 logs.

OR

14 . Calculate the half-life time of a first order reaction having K=8min^{-1}.
Correct Answer: 0.087 min

Solution:
For a first-order reaction, the half-life ($t_{1/2}$) is given by the formula:
$t_{1/2} = \frac{0.693}{k}$

Given:
$k = 8 \text{ min}^{-1}$.

Substitute the value:
$t_{1/2} = \frac{0.693}{8}$
$t_{1/2} = 0.086625$ min.

Rounding to reasonable precision: $t_{1/2} \approx 0.087$ min (or approx 5.2 seconds).

Quick Tip

The half-life of a first-order reaction is constant and independent of the initial concentration.

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15. Why do Zr and Hf exhibit similar properties ?
Correct Answer: Due to Lanthanoid Contraction.

Solution:
1. Zirconium (Zr) belongs to the 4d series and Hafnium (Hf) belongs to the 5d series of transition elements.

2. Usually, atomic size increases down a group. However, the filling of 4f orbitals before Hf results in "Lanthanoid Contraction" (poor shielding by f-electrons).

3. This contraction causes the atomic radius of Hf (159 pm) to be virtually identical to that of Zr (160 pm).

4. Because they have similar atomic radii and the same valence shell configuration, they possess very similar physical and chemical properties.

Quick Tip

Zr and Hf are often called "chemical twins" because separating them is extremely difficult due to this similarity.

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16. Calculate the two third life of a first reaction having K=5.48 × $10^{-14}$$s^{-1}$.
Correct Answer: 2.01×10^{13} seconds

Solution:
"Two-third life" ($t_{2/3}$) is the time required for the reaction to be 2/3 complete.
This means the amount consumed is 2/3, so the amount remaining $[A]$ is $1 - 2/3 = 1/3$ of $[A]_0$.
So, $\frac{[A]_0}{[A]} = 3$.

Formula: $t = \frac{2.303}{k} \log \frac{[A]_0}{[A]}$

Substitute values ($k = 5.48 \times 10^{-14}$ s^{-1}):
$t_{2/3} = \frac{2.303}{5.48 \times 10^{-14}} \log(3)$

We know $\log(3) \approx 0.4771$.
$t_{2/3} = \frac{2.303 \times 0.4771}{5.48 \times 10^{-14}}$
$t_{2/3} = \frac{1.0987}{5.48} \times 10^{14}$
$t_{2/3} \approx 0.2005 \times 10^{14}$
$t_{2/3} \approx 2.0 \times 10^{13}$ s.

Quick Tip

Make sure you understand if "2/3 life" means remaining is 2/3 or consumed is 2/3. In kinetics contexts, it usually refers to completion, so remaining = 1 - completion.

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17 . Compare the acidic character of Primary, Secondary and Tertiary alcohol.
Correct Answer: Primary > Secondary > Tertiary.

Solution:
1. The acidity of alcohols depends on the stability of the alkoxide ion (R-O$^-$) formed after releasing a proton.

2. Alkyl groups are electron-releasing (+I effect). They increase electron density on the oxygen atom, destabilizing the negative charge on the alkoxide ion.

3. Primary alcohols (1°): Have one alkyl group. Least +I effect. Alkoxide is most stable. Strongest acid.

4. Secondary alcohols (2°): Have two alkyl groups. Moderate +I effect.

5. Tertiary alcohols (3°): Have three alkyl groups. Maximum +I effect. Alkoxide is least stable. Weakest acid.

Order of Acidity: $1° > 2° > 3°$.

Quick Tip

Acidity is inversely proportional to the +I effect of the attached groups. More alkyl groups = Less acidic.

OR

17 . Explain Reimer Tiemann reaction of Phenols.
Correct Answer: Treatment of phenol with chloroform and aq. NaOH introduces a -CHO group at ortho position (Salicylaldehyde).

Solution:
1. Reaction: When phenol is treated with chloroform ($CHCl_3$) in the presence of aqueous sodium hydroxide (NaOH) at 340K, followed by acid hydrolysis.

2. Mechanism: The reaction involves an electrophilic substitution where the electrophile is dichlorocarbene ($:CCl_2$).

3. Product: An aldehyde group (-CHO) is introduced, predominantly at the ortho position to the phenolic -OH group.

4. Equation:
Phenol + $CHCl_3$ + 3NaOH → Salicylaldehyde (2-Hydroxybenzaldehyde) + 3NaCl + $2H_2O$.

Quick Tip

This is a specific method to synthesize Salicylaldehyde. If CCl_4 is used instead of $CHCl_3$, the product is Salicylic Acid (Kolbe-like product).

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18. Why is aniline less basic than ethylamine ?

Correct Answer: Due to resonance in aniline, the lone pair on nitrogen is delocalized into the benzene ring and less available for protonation.

Solution:

1. Resonance Effect: In aniline ($C_6H_5NH_2$), the lone pair of electrons on the nitrogen atom is in conjugation with the benzene ring. It participates in resonance, delocalizing the negative charge over the ortho and para positions of the ring. This makes the lone pair less available for donation to an acid.

2. Inductive Effect: The phenyl group exerts a -I (electron withdrawing) effect, further reducing electron density on nitrogen. In contrast, the ethyl group in ethylamine has a +I (electron releasing) effect, increasing electron density on nitrogen.

3. Stability of Conjugate Acid: The anilinium ion formed by protonation is less stable because resonance is disrupted (to an extent), whereas the ethylammonium ion is stabilized by the +I effect of the ethyl group.

Quick Tip

Key phrase: "Delocalization of lone pair." Whenever an amine's N is attached to a benzene ring, basicity drops drastically.

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19 . Calculate the molar conductance Λ_m° for $CaCl_2$, given that $\lambda^\circ(Ca^{+2}) = 119.5$ S cm^2 mol^{-1} and $\lambda^\circ(Cl^-) = 76.3$ S cm^2 mol^{-1}.

Correct Answer: 272.1 S cm^2 mol^{-1}

Solution:

According to Kohlrausch's Law of independent migration of ions, the limiting molar conductivity of an electrolyte is the sum of the limiting ionic conductivities of the cation and anion, multiplied by the number of ions per formula unit.

Formula for $CaCl_2$:
$\Lambda_m^\circ(\mathrm{CaCl_2}) = \lambda^\circ(\mathrm{Ca^{2+}}) + 2 \times \lambda^\circ(\mathrm{Cl^-})$

Substitute values:
$\Lambda_m^\circ = 119.5 + 2 \times (76.3)$
$\Lambda_m^\circ = 119.5 + 152.6$
$\Lambda_m^\circ = 272.1 \text{ S cm}^2 \text{ mol}^{-1}$.

Quick Tip

Don't forget the stoichiometry! $CaCl_2$ produces two chloride ions, so you must multiply the chloride conductivity by 2.

OR

19 . Write the Nearest equation and calculate the e.m.f of the following cell at 298K.
$Fe(s)$ — Fe^{2+}(0.001M) —— H^+(1M) H_2(1atm) — Pt.
Given $E^\circ_{Fe^{+2}/Fe} = -0.44$ V.
Correct Answer: +0.5285 V (approx +0.53 V)

Solution:
Cell Reaction: $Fe(s) + 2H^+ \rightarrow Fe^{2+} + H_2(g)$
Here, $n = 2$ electrons transferred.

$E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$
Cathode is SHE (H^+/H_2), so $E^\circ = 0.00$ V.
Anode is Fe/Fe^{2+}, so $E^\circ = -0.44$ V.
$E^\circ_{\text{cell}} = 0 - (-0.44) = +0.44$ V.

Nernst Equation:
$E_{\text{cell}} = E^\circ_{\text{cell}} - \frac{0.059}{n} \log \frac{[\text{Products}]}{[\text{Reactants}]}$
$E_{\text{cell}} = 0.44 - \frac{0.059}{2} \log \frac{[Fe^{2+}]}{[H^+]^2}$

Substitute values ($[Fe^{2+}] = 10^{-3}$, $[H^+] = 1$):
$E_{\text{cell}} = 0.44 - 0.0295 \log \frac{10^{-3}}{1^2}$
$E_{\text{cell}} = 0.44 - 0.0295 \times (-3)$
$E_{\text{cell}} = 0.44 + 0.0885$
$E_{\text{cell}} = 0.5285$ V.

Quick Tip

Pay attention to the signs. $\log(10^{-3})$ is -3, so the term adds to the standard potential. Lower product concentration increases voltage.

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20 . Write the reaction: (i) Wurtz-fitting reaction (ii) Ullmann reaction (iii) Gattermann reaction (iv) Hunsdiecker reaction (v) Balz-Schiemann reaction

Solution:
(i) Wurtz-Fittig Reaction: Reaction of an aryl halide with an alkyl halide and sodium metal to form substituted benzene.
$C_6H_5X + 2Na + R\text{-}X \xrightarrow{\text{Dry Ether}} C_6H_5\text{-}R + 2NaX$

(ii) Ullmann Reaction: Heating an aryl iodide with copper powder to form biaryl.
$2\ C_6H_5I + 2Cu \xrightarrow{\Delta} C_6H_5\text{-}C_6H_5$ (Biphenyl) $+ 2CuI$

(iii) Gattermann Reaction: Modification of Sandmeyer reaction using Copper powder instead of CuCl.
$C_6H_5N_2^+Cl^- \xrightarrow{\text{Cu/HCl}} C_6H_5Cl + N_2$

(iv) Hunsdiecker Reaction: Reaction of silver salt of carboxylic acid with Bromine to form alkyl bromide (Decarboxylation).
$R\text{-}COOAg + Br_2 \xrightarrow{CCl_4,\Delta} R\text{-}Br + CO_2 + AgBr$

(v) Balz-Schiemann Reaction: Preparation of fluorobenzene from diazonium salt using HBF_4.
$C_6H_5N_2^+Cl^- + HBF_4 \rightarrow C_6H_5N_2^+BF_4^- \xrightarrow{\Delta} C_6H_5F + N_2 + BF_3$

Quick Tip

Name reactions are high-yield questions. Create a chart: Reactant → Reagent → Product for each.

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20 a. Write four differences between SN^2 and SN^1 reaction.
Correct Answer: Mechanism steps, Order, Stereochemistry, Reactivity order.

Solution:
1. Steps: SN^1 is a two-step reaction (formation of carbocation, then nucleophile attack). SN^2 is a single-step concerted reaction (bond breaking and making happen simultaneously).

2. Kinetics: SN^1 is first order (Unimolecular), Rate $\propto$ [Alkyl Halide]. SN^2 is second order (Bimolecular), Rate $\propto$ [Alkyl Halide][Nucleophile].

3. Stereochemistry: SN^1 leads to racemization (retention + inversion). SN^2 leads to complete inversion of configuration (Walden inversion).

4. Reactivity Order: For SN^1: $3^\circ > 2^\circ > 1^\circ$ (due to carbocation stability). For SN^2: $1^\circ > 2^\circ > 3^\circ$ (due to steric hindrance).

Quick Tip

SN1 = "1" stands for Unimolecular, but it has 2 steps. SN2 = "2" stands for Bimolecular, but it has 1 step.

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20 b. Define Optical activity.

Correct Answer: The ability of a substance to rotate the plane of polarized light.

Solution:

Optical activity is the property of certain organic substances to rotate the plane of plane-polarized light when it is passed through their solution.

If the compound rotates light to the right (clockwise), it is dextrorotatory (d or +).

If it rotates light to the left (counter-clockwise), it is levorotatory (l or -).

This property arises due to molecular chirality (lack of a plane of symmetry).

Quick Tip

A carbon atom attached to four different groups is a chiral center, which is the primary source of optical activity in organic molecules.

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21 a. Give three differences between Lanthanoids and Actinoids.

Correct Answer: Binding energy, Oxidation states, Magnetic properties/Radioactivity.

Solution:

1. Oxidation States: Lanthanoids show +3 as the dominant oxidation state, with occasional +2 or +4. Actinoids show a wider range of oxidation states (+3, +4, +5, +6, +7) due to comparable energies of 5f, 6d, and 7s shells.

2. Binding Energy: 4f electrons (Lanthanoids) have higher binding energy and are more deeply buried. 5f electrons (Actinoids) have lower binding energy and are more available for bonding (covalent character).

3. Radioactivity: Only Promethium is radioactive among Lanthanoids. All Actinoids are radioactive.

Quick Tip

Actinoid contraction is greater than Lanthanoid contraction due to poorer shielding by 5f electrons compared to 4f electrons.

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21 b. Explain why Cu^{+2} salts are coloured while Zn^{+2} salts are colourless ?
Correct Answer: Cu^{+2} has unpaired d-electron (d-d transition), Zn^{+2} has full d-shell (no d-d transition).

Solution:
1. Cu^{+2} Configuration: Copper (atomic number 29) has configuration [Ar] $3d^{10}$ $4s^1$. Cu^{+2} is [Ar] $3d^9$.
It has one unpaired electron in the d-orbital. This allows for d-d transitions (movement of electron between split d-orbitals) by absorbing visible light, resulting in colour.

2. Zn^{+2} Configuration: Zinc (atomic number 30) has configuration [Ar] $3d^{10}$ $4s^2$. Zn^{+2} is [Ar] $3d^{10}$.
The d-subshell is completely filled. There are no empty d-orbitals for electron transition. Hence, no visible light is absorbed, and the salts appear colourless (white).

Quick Tip

Colour in transition metals usually requires an incomplete d-subshell (d^1 to d^9). d^0 and d^{10} are generally colourless.

OR

21 a. Transition metals form alloys with other metals. Explain.
Correct Answer: Similar atomic radii allow substitution in crystal lattice.

Solution:
1. Transition metals have very similar atomic sizes (radii) within a series (e.g., Cr, Mn, Fe, Co, Ni).

2. Because the atoms are of similar size, atoms of one metal can easily replace the atoms of another metal in its crystal lattice without disrupting the structure significantly.

3. This ready substitution allows the formation of solid solutions or alloys (like Brass, Bronze, Steel) which are hard and have high melting points.

Quick Tip

Interstitial compounds are different: they form when small atoms (H, C, N) get trapped in the lattice gaps. Alloys involve metal-metal substitution.

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21 b. How many unpaired electrons are present in Fe^{+3}, Zn^{+2} and Mn^{+2} ?
Correct Answer: Fe^{+3}: 5, Zn^{+2}: 0, Mn^{+2}: 5.

Solution:
1. Fe^{+3} (Iron, Z=26):
Neutral Fe: [Ar] 3d^6 4s^2.
Fe^{+3} (remove 2 from s, 1 from d): [Ar] 3d^5.
Hund's rule: 5 electrons in 5 d-orbitals $\implies$ 5 unpaired electrons.

2. Zn^{+2} (Zinc, Z=30):
Neutral Zn: [Ar] 3d^{10} 4s^2.
Zn^{+2} (remove 2 from s): [Ar] 3d^{10}.
All electrons paired $\implies$ 0 unpaired electrons.

3. Mn^{+2} (Manganese, Z=25):
Neutral Mn: [Ar] 3d^5 4s^2.
Mn^{+2} (remove 2 from s): [Ar] 3d^5.
Hund's rule: 5 electrons in 5 d-orbitals $\implies$ 5 unpaired electrons.

Quick Tip

Half-filled (d^5) and fully-filled (d^{10}) shells are extra stable. Both Fe^{+3} and Mn^{+2} are d^5.
