CBSE Class 12 Chemistry 2026 — Set 2 — Answer Key

English Medium

Time Allowed: 3 Hours

General Instructions:

1. This is an answer key — each question is shown with its correct answer and a step-by-step explanation.
2. Questions appear in the original paper order.

Q.1

Consider the following reaction :

$Zn(s) + Ag_2O(s) + H_2O(l) \rightarrow Zn^{2+}(aq) + 2Ag(s) + 2OH^-(aq)$

Given : $E^\circ_{Ag^+/Ag} = 0.80$ V

$E^\circ_{Zn^{2+}/Zn} = -0.76$ V

1 F = 96500 C mol^{-1}

The $\Delta_r G^\circ$ for the above reaction is :

(a) –301.080 kJ mol^{-1} <<

(b) +310.080 kJ mol^{-1}

(c) –326.070 kJ mol^{-1}

(d) –375.060 kJ mol^{-1}

Explanation:

$E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{anode} = E^\circ_{Ag^+/Ag} - E^\circ_{Zn^{2+}/Zn} = 0.80 - (-0.76) = 1.56$ V.

The reaction involves 2 moles of electrons (n = 2).

$\Delta_r G^\circ = -nFE^\circ_{cell} = -2 \times 96500 \times 1.56 = -301{,}080$ J $mol^{-1} = -301.080$ kJ mol^{-1}.

Q.2

Identify the correct statement :

(a) Molecularity of a reaction is an experimental quantity.

(b) For complex reactions molecularity has no meaning. <<

(c) Molecularity of a reaction can be zero or even a fraction.

(d) Molecularity more than three is very common in chemical reactions.

Explanation:

Molecularity is defined only for elementary reactions.

For complex (multi-step) reactions, the concept of overall molecularity has no meaning — each elementary step has its own molecularity.

Molecularity is a theoretical quantity (not experimental), cannot be zero or fractional, and molecularity > 3 is extremely rare.

Q.3

The order for the given reaction is :

A + 2B → Products

Rate = k[A]^(1/2)[B]^1

(a) 1.5 <<

(b) 1

(c) 0.5

(d) 2

Explanation:

Overall order = sum of exponents in the rate law = ½ + 1 = 1.5.

Q.4

Electronic configuration of chromium is :

(a) 3d4 4s1

(b) 3d4 4s2

(c) 3d5 4s1 <<

(d) 3d5 4s2

Explanation:

Chromium (Z = 24) has the configuration [Ar] 3d5 4s1.

This is due to extra stability of a half-filled 3d subshell (3d5).

The expected [Ar] 3d4 4s2 is overridden by this stability.

Q.5

The correct IUPAC name of the complex [Pt(NH3)2Cl2] is :

(a) diamminedichloridoplatinum (IV)

(b) diamminedichloridoplatinum (II) <<

(c) dichloridodiammineplatinum (IV)

(d) dichloridodiammineplatinum (II)

Explanation:

IUPAC rules: ligands are listed alphabetically — ammine (NH3) comes before chlorido (Cl–).

Pt carries charge: 2(0) + 2(–1) + x = 0, so x = +2.

Name: diamminedichloridoplatinum(II).

Q.6

Which of the following is a heteroleptic complex ?

(a) 3+

(b) 3+

(c) 2+

(d) + <<

Explanation:

A heteroleptic complex contains two or more different types of ligands.

[Co(NH3)4Cl2]+ has both NH3 and Cl– ligands, making it heteroleptic.

The others have only one type of ligand (homoleptic).

Q.7

Which of the following molecules is chiral in nature ?

(a) Propan–2–ol

(b) Butan–2–ol <<

(c) 1–Bromobutane

(d) 2–Bromopropane

Explanation:

Butan-2-ol (CH3CH(OH)CH2CH3) has a chiral centre at C-2, which is bonded to four different groups: –OH, –H, –CH3, and –CH2CH3.

Propan-2-ol has two identical CH3 groups at C-2 (not chiral).

1-Bromobutane and 2-Bromopropane do not have four different groups at any carbon.

Q.8

Identify the correct increasing order of boiling points of the given compounds :

(a) Propan–1–ol < butan–1–ol < butan–2–ol < pentan–1–ol

(b) Pentan–1–ol < butan–1–ol < butan–2–ol < Propan–1–ol

(c) Propan–1–ol < butan–2–ol < butan–1–ol < pentan–1–ol <<

(d) Butan–1–ol < Butan–2–ol < Propan–1–ol < Pentan–1–ol

Explanation:

Boiling points of alcohols increase with molecular mass (more carbons) and decrease with branching.

Propan-1-ol (C3, bp 97°C) < Butan-2-ol (C4 branched, bp 99.5°C) < Butan-1-ol (C4 straight, bp 117°C) < Pentan-1-ol (C5, bp 138°C).

Straight-chain alcohols have higher bp than branched isomers of the same formula.

Q.9

Identify the compound produced by the reduction of Ethanenitrile with Lithium aluminium hydride :

(a) Ethylamine <<

(b) Ethanal

(c) Propylamine

(d) Methylamine

Explanation:

LiAlH4 reduces the nitrile group –C≡N to –CH2NH2 without changing the carbon count: CH3CN + 4[H] →

CH3CH2NH2.

Ethanenitrile has 2 carbons, so the product is ethylamine.

Q.10

The base which is present in DNA but not in RNA is :

(a) Guanine

(b) Cytosine

(c) Thymine <<

(d) Adenine

Explanation:

DNA contains Adenine, Guanine, Cytosine, and Thymine.

RNA contains Adenine, Guanine, Cytosine, and Uracil (instead of Thymine).

Thus Thymine is present in DNA but not RNA.

Q.11

Proteins are polymers of α-amino acids which are joined to each other by :

(a) Covalent Bond

(b) Peptide Bond <<

(c) Glycosidic Bond

(d) Coordinate Bond

Explanation:

In proteins, α-amino acids are linked by peptide bonds (also called amide bonds), formed between the –COOH group of one amino acid and the –NH2 group of the next, with loss of water.

Q.12

Which of the following reactions is not explained by the open chain structure of glucose ?

(a) Glucose on prolonged heating with HI forms n-hexane.

(b) Glucose reacts with hydroxylamine to form an oxime.

(c) Glucose gets oxidized to gluconic acid on reaction with bromine water.

(d) Glucose exists in two different crystalline forms, alpha (α) and beta (β). <<

Explanation:

The existence of glucose in two crystalline forms (α and β anomers) is explained by the cyclic (pyranose) ring structure of glucose, not the open chain structure.

The open chain structure explains reactions involving the aldehyde group (oxime formation with NH2OH, oxidation to gluconic acid with Br2 water) and the hydroxyl groups (n-hexane formation with HI).

Q.13

Assertion (A) : The molecularity of the given reaction is 2

2HI —> H2 + I2

Reason (R) : Two molecules of the reactants are involved in simultaneous collision between them.

(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A). <<

(b) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(c) Assertion (A) is true, but Reason (R) is false.

(d) Assertion (A) is false, but Reason (R) is true.

Explanation:

Assertion is true: decomposition of HI is bimolecular (molecularity = 2) since 2HI molecules collide simultaneously.

Reason is true and correctly explains the assertion — molecularity is defined as the number of molecules simultaneously colliding in an elementary step.

Option (A) is correct.

Q.14

Assertion (A) : Zinc, cadmium and mercury are not considered as transition elements.

Reason (R) : These elements have completely filled d orbitals in their ground state as well as in their common oxidation states.

(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A). <<

(b) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(c) Assertion (A) is true, but Reason (R) is false.

(d) Assertion (A) is false, but Reason (R) is true.

Explanation:

Assertion is true: Zn, Cd, Hg are not transition elements.

Reason is true and explains correctly: transition elements must have partially filled d orbitals in ground state or in any common oxidation state.

Zn (d10), Cd (d10), Hg (d10) have completely filled d orbitals in both ground state (d10) and their common +2 state (d10), so they are excluded.

Q.15

Assertion (A) : Aromatic primary amines can be prepared by Gabriel Phthalimide synthesis.

Reason (R) : Aryl halides do not undergo nucleophilic substitution with the anion formed by phthalimide.

(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(b) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(c) Assertion (A) is true, but Reason (R) is false.

(d) Assertion (A) is false, but Reason (R) is true. <<

Explanation:

Assertion is false: Gabriel phthalimide synthesis cannot be used to prepare aromatic primary amines because aryl halides do not undergo nucleophilic substitution with phthalimide anion (reason is true).

The reaction requires an alkyl halide.

So Reason is true but Assertion is false — option (D).

Q.16

Assertion (A) : Glucose gets oxidized to six carbon gluconic acid on reaction with bromine water.

Reason (R) : The carbonyl group is absent in the open chain structure of glucose.

(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(b) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(c) Assertion (A) is true, but Reason (R) is false. <<

(d) Assertion (A) is false, but Reason (R) is true.

Explanation:

Assertion is true: Glucose (an aldehyde) is oxidised by bromine water to gluconic acid (a 6-carbon carboxylic acid).

Reason is false: the open chain structure of glucose DOES contain a carbonyl (aldehyde –CHO) group.

That is precisely why bromine water oxidises it.

So Assertion is true, Reason is false — option (C).

Q.17

The concentration of the reactant is reduced from 0.6 mol L–1 to 0.2 mol L–1 in 5 minutes in a first order reaction. Calculate rate constant of the reaction. (log 3 = 0.48)

Answer: $k = 0.221\ min^{-1}$ ($= 3.68 \times 10^{-3}\ s^{-1}$)

Explanation:

First order: $k = (2.303/t) \log([A]_0/[A])$.

$[A]_0 = 0.6$, $[A] = 0.2$ mol L^{-1}, $t = 5$ min.

$k = (2.303/5) \times \log 3 = (2.303/5) \times 0.48 = 1.10544/5 = 0.221\ min^{-1}$.

In seconds ($t = 300$ s): $k = 1.10544/300 = 3.68 \times 10^{-3}\ s^{-1}$.

OR

Q.17

Rate constant k for the first order reaction is 2.54 × 10–3 s–1. Calculate the time required for three-fourth of the reactant to decompose. (log 4 = 0.60)

Answer: $t \approx 544$ s

Explanation:

Three-fourths decomposed → $[A] = [A]_0/4$.

$t = (2.303/k) \log 4 = (2.303 \times 0.60)/(2.54 \times 10^{-3}) = 1.3818/(2.54 \times 10^{-3}) = 544$ s.

Q.18

(a) Define activation energy.

(b) Write the unit of rate constant for

(i) zero order reaction

(ii) second order reaction.

Answer: (a) Activation energy is the minimum extra amount of energy absorbed by the reactant molecules so that their energy becomes equal to the threshold value, making their collision effective to give products. (b)(i) mol L–1 s–1 (or mol L–1 time–1) (ii) L mol–1 s–1 (or mol–1 L s–1)

Explanation:

(a) Activation energy (Ea): the difference between the threshold energy and the average energy of the reactant molecules.

(b)(i) For zero order: rate = k[A]0 = k, so units of k = units of rate = mol L–1 s–1.

(ii) For second order: rate = k[A]2, so k = rate/[A]2 = (mol L–1 s–1)/(mol L–1)2 = L mol–1 s–1.

Q.19

(a) First ionization enthalpy of Cr is lower than that of Zn. Why ?

(b) Mention any one property of the transition elements which makes them good catalysts.

Answer: (a) Zn has a completely filled 3d10 4s2 configuration giving extra stability, so more energy is needed to remove an electron from Zn than from Cr (3d5 4s1). (b) Transition elements have variable oxidation states (ability to change oxidation state easily), which allows them to form intermediate compounds with reactants, facilitating catalysis.

Explanation:

(a) Cr has configuration [Ar] 3d5 4s1 and Zn has [Ar] 3d10 4s2.

The completely filled 3d10 in Zn provides extra stability.

Therefore, the first ionization enthalpy of Zn is higher than that of Cr.

(b) Transition metals are good catalysts due to: variable oxidation states / ability to adsorb reactants on their surface (large surface area) / ability to form intermediate compounds.

Q.20

(a) Define coordination number.

(b) Indicate the type of isomerism exhibited by the following complex :

[Co(en)3]Cl3

Answer: (a) Coordination number is the total number of ligand donor atoms directly bonded to the central metal atom/ion in a coordination complex. (b) Optical isomerism (the complex exhibits optical isomerism as it has a non-superimposable mirror image due to the tris-chelate structure).

Explanation:

(a) In [Co(en)3]Cl3, coordination number = 6 (each en is a bidentate ligand, 3 × 2 = 6 donor atoms).

(b) [Co(en)3]3+ is a tris-chelate complex with D3 symmetry and no plane of symmetry or centre of inversion;

it exists as non-superimposable mirror images (Δ and Λ enantiomers) — optical isomerism.

Q.21

(a) Draw the structure of the given compound :

4–Bromo–3–methylpent–2–ene

(b) What happens when chloroethane is treated with aqueous potassium hydroxide ?

Answer: (a) Structure: CH3–CH=C(CH3)–CH(Br)–CH3 — a 5-carbon chain with a double bond between C2 and C3, methyl on C3, and Br on C4. (b) Chloroethane (CH3CH2Cl) reacts with aqueous KOH by nucleophilic substitution (SN2): CH3CH2Cl + KOH(aq) → CH3CH2OH + KCl. The product is ethanol.

Explanation:

(a) 4-Bromo-3-methylpent-2-ene: parent chain = pentene (5C), double bond at C2–C3, methyl at C3, Br at C4.

Structure: CH3–CH=C(CH3)–CHBr–CH3.

(b) Aqueous KOH favours substitution over elimination.

CH3CH2Cl undergoes SN2 with OH– to give CH3CH2OH (ethanol) + Cl–.

Q.22

When 1.5 g of a non-volatile solute was dissolved in 90 g of benzene, the boiling point of benzene got raised from 353.23 K to 353.93 K. Calculate the molar mass of the solute. (Given Kb for benzene = 2.52 K kg mol–1)

Answer: 60 g mol–1

Explanation:

ΔTb = 353.93 – 353.23 = 0.70 K.

Using ΔTb = Kb × m (where m = molality): m = ΔTb/Kb = 0.70/2.52 = 0.2778 mol kg–1.

Molality = moles of solute / mass of solvent (kg) = n / 0.090 kg.

Therefore n = 0.2778 × 0.090 = 0.025 mol.

Molar mass = mass/moles = 1.5/0.025 = 60 g mol–1.

Q.23

Calculate emf of the following cell at 298 K :

Sn | Sn2+ (0.001 M) || H+ (0.01 M) | H2(g) (1 bar) | Pt(s)

Given : E°Sn2+/Sn = –0.14 V,

E°H+/H2 = 0.00 V [log 10 = 1]

Answer: 0.11 V (≈ 0.1104 V)

Explanation:

Anode: $Sn \rightarrow Sn^{2+} + 2e^-$; cathode: $2H^+ + 2e^- \rightarrow H_2$.

E°cell = 0.00 – (–0.14) = 0.14 V; n = 2.

$Q = [Sn^{2+}]/[H^+]^2 = 0.001/(0.01)^2 = 10$.

E = 0.14 – (0.0592/2) log 10 = 0.14 – 0.0296 = 0.1104 V ≈ 0.11 V.

Q.24

(a) Complete and balance the following equations :

(i) 2KMnO4 –(513 K)–>

(ii) Na2Cr2O7 + 2KCl —>

(b) Why is it difficult to separate lanthanoid elements in pure state ?

Answer: (a)(i) $2KMnO_4 \rightarrow K_2MnO_4 + MnO_2 + O_2$ (heated at 513 K)

(a)(ii) $Na_2Cr_2O_7 + 2KCl \rightarrow K_2Cr_2O_7 + 2NaCl$ (sodium dichromate is converted to potassium dichromate; $K_2Cr_2O_7$ crystallises out as it is less soluble)

(b) Lanthanoids have very similar atomic/ionic radii (lanthanoid contraction) and nearly identical chemical properties, so they are very difficult to separate in the pure state.

Explanation:

(a)(i) On heating at 513 K, $KMnO_4$ decomposes to potassium manganate, manganese dioxide and oxygen;

the equation is balanced (2 Mn, 8 O each side: 2×4 = 4 + 2 + 2).

(ii) Double decomposition: $Na_2Cr_2O_7 + 2KCl \rightarrow K_2Cr_2O_7 + 2NaCl$.

(b) The steady decrease in size across the 4f series (lanthanoid contraction) leaves successive Ln^{3+} ions with almost the same size and chemistry, so ordinary chemical methods cannot separate them.

Q.25

(a) [Co(NH3)6]3+ is diamagnetic whereas [CoF6]3– is paramagnetic. Justify the statement. [Atomic number of Co = 27]

(b) Write the electronic configuration for d4 ion if Δ0 > P on the basis of crystal field theory.

Answer: (a) Co3+ has configuration [Ar] 3d6. In [Co(NH3)6]3+, NH3 is a strong field ligand causing large Δ0 > P (pairing energy), so all 6 electrons pair up in t2g (t2g6 eg0) — diamagnetic (no unpaired electrons). In [CoF6]3–, F– is a weak field ligand with small Δ0 < P, so electrons remain unpaired following Hund's rule: t2g4 eg2 — 4 unpaired electrons, paramagnetic.

(b) For a d4 ion with Δ0 > P (strong field): t2g4 eg0 (all 4 electrons in t2g, one pair formed, 2 unpaired electrons).

Explanation:

Co^{3+} is d^6.

(a) NH_3 is a strong-field ligand ($\Delta_o > P$): electrons pair up to give $t_2g^6\ eg^0$ →

no unpaired electrons →
diamagnetic.
F^- is a weak-field ligand ($\Delta_o < P$): electrons stay unpaired to give $t_{2g}^4 eg^2$ →
4 unpaired electrons →
paramagnetic.
(b) d^4 with $\Delta_o > P$ (low spin): $t_{2g}^4 eg^0$, with 2 unpaired electrons.

Q.26

(a) Write the major product in the following reaction :
Cyclohexene + Br_2 (heat) → ?
(b) Define Racemic mixture.
(c) p-dichlorobenzene has a higher melting point as compared to its ortho and meta isomers. Why ?

Answer: (a) 3-Bromocyclohexene (allylic substitution of cyclohexene with Br_2 on heating).
(b) A racemic mixture is an equimolar mixture of the d- (+) and l- (–) enantiomers; it is optically inactive because the rotations cancel (external compensation).
(c) p-Dichlorobenzene is symmetrical and packs better in the crystal lattice, giving stronger intermolecular forces and hence a higher melting point than the o- and m- isomers.

Explanation:
(a) With Br_2 at high temperature, substitution occurs at the allylic position, giving 3-bromocyclohexene.
Note: this answer is unconfirmed, because Br_2 can also add across the C=C to give 1,2-dibromocyclohexane.
(b) Racemic mixture = 50:50 of two enantiomers, optically inactive.
(c) Higher symmetry of the para isomer →
better packing in the crystal lattice →
higher melting point.

Q.27

Write the reaction involved in :

(a) Rosenmund's reduction

(b) Cannizzaro's reaction

(c) Hell–Volhard–Zelinsky reaction

Answer: (a) Rosenmund's reduction: An acid chloride (RCOCl) is reduced to an aldehyde (RCHO) using H2 gas over a palladium-barium sulphate catalyst (Pd/BaSO4). Example: CH3COCl + H2 –(Pd/BaSO4)–> CH3CHO + HCl

(b) Cannizzaro's reaction: An aldehyde without alpha hydrogen undergoes self-oxidation-reduction (disproportionation) on treatment with concentrated NaOH. One molecule is oxidised to a carboxylate salt and another is reduced to an alcohol. Example: 2HCHO + NaOH(conc.) → HCOONa + CH3OH (or: 2C6H5CHO + NaOH → C6H5COONa + C6H5CH2OH)

(c) Hell–Volhard–Zelinsky reaction: A carboxylic acid with alpha hydrogen reacts with Cl2 or Br2 in presence of red phosphorus to give alpha-halogenated carboxylic acid. Example: CH3COOH + Cl2 –(P)–> ClCH2COOH + HCl

Explanation:

(a) RCOCl + H_2 →

RCHO + HCl over $Pd/BaSO_4$; the poisoned catalyst stops reduction at the aldehyde.

(b) Cannizzaro: 2RCHO (no α-H) + conc.

NaOH → $RCOO^-Na^+$ + RCH_2OH.

(c) HVZ: $RCH_2COOH + X_2 \rightarrow RCHXCOOH + HX$ in the presence of red phosphorus (α-halogenation).

Q.28

(a) Define the following term :

Reducing sugar

(b) Differentiate between the following :

(i) Fibrous proteins and globular proteins

(ii) Nucleotide and nucleoside

Answer: (a) A reducing sugar is a carbohydrate that can reduce Fehling's solution or Tollens' reagent. It contains a free aldehyde (–CHO) or free ketone (–CO–) group capable of acting as a reducing agent. All monosaccharides and some

disaccharides (e.g., maltose, lactose) are reducing sugars.

(b)(i) Fibrous proteins: thread-like molecules arranged in long chains or fibers; insoluble in water; provide structural support (e.g., collagen, keratin, myosin). Globular proteins: spherical/compact molecules; generally soluble in water; perform dynamic functions such as catalysis, transport, and regulation (e.g., insulin, haemoglobin, enzymes).

(ii) Nucleoside: a compound formed by the union of a nitrogenous base with a pentose sugar (ribose or deoxyribose) by N-glycosidic bond. No phosphate group. Nucleotide: a nucleoside with one or more phosphate groups attached to the sugar. Nucleotide = Nucleoside + Phosphate group.

Explanation:

(a) A reducing sugar has a free aldehyde/ketone (hemiacetal/hemiketal) group, so it reduces Tollens' or Fehling's reagent;
sucrose is non-reducing.

(b)(i) Fibrous proteins: long thread-like chains, insoluble in water (keratin, myosin);
globular proteins: folded spherical chains, soluble in water (insulin, haemoglobin).

(ii) Nucleoside = base + sugar; nucleotide = base + sugar + phosphate.

OR

Q.28

Write the reaction of glucose with the following :

(a) H2N–OH

(b) (CH3CO)2O

(c) conc.HNO3

Answer: (a) Glucose + NH_2OH → glucose oxime: $CHO–(CHOH)_4–CH_2OH + NH_2OH \rightarrow CH=NOH–(CHOH)_4–CH_2OH + H_2O$

(b) Glucose + $(CH_3CO)_2O$ → glucose pentaacetate: all five –OH groups are acetylated; $C_6H_{12}O_6 + 5(CH_3CO)_2O \rightarrow C_6H_7O_6(COCH_3)_5 + 5CH_3COOH$

(c) Glucose + conc. HNO_3 → saccharic (glucaric) acid: $CHO–(CHOH)_4–CH_2OH + 4[O] \rightarrow HOOC–(CHOH)_4–COOH + H_2O$ (both –CHO and $–CH_2OH$ oxidised to –COOH)

Explanation:

(a) Oxime formation shows a carbonyl (–CHO) group in the open chain.

(b) Acetylation of five –OH groups gives the pentaacetate, showing five hydroxyl groups.

(c) Conc. HNO_3 is a strong oxidant that oxidises both ends of the chain to –COOH, giving saccharic acid.

Q.29(a)

[Case Study — Osmosis] Osmosis is a process by which the molecules of a solvent pass from a solution of low solute concentration to a solution of high solute concentration through a semi-permeable membrane. Osmotic pressure is a colligative property. When the applied pressure on a solution exceeds its osmotic pressure, reverse osmosis occurs.

(a) Calculate the amount of CaCl2 (i = 2.59) dissolved in 2.46 litre of water such that its osmotic pressure is 0.70 atm at 27°C.

[Given : R = 0.082 L atm K–1 mol–1, molar mass of CaCl2 = 111 g mol–1]

Answer: 3.0 g

Explanation:

$\pi = iCRT = i(w/M)(RT/V)$.

$w = \pi VM/(iRT) = (0.70 \times 2.46 \times 111)/(2.59 \times 0.082 \times 300) = 191.1/63.71 = 3.0$ g.

($n = 0.0270$ mol; $T = 27 + 273 = 300$ K.)

Q.29(b)

[Case Study — Osmosis]

(b) When raisins are kept in water, they get swollen. Name the phenomenon involved in this process.

Answer: Osmosis

Explanation:

Raisins contain a concentrated sugar solution.

When placed in water, solvent (water) molecules pass through the semi-permeable membrane of the raisin's skin from the dilute solution (pure water) to the concentrated solution inside the raisin — this is osmosis.

The raisin swells as water enters.

OR

Q.29(b)

[Case Study — Osmosis]

(b) Why is osmotic pressure more advantageous than other colligative properties ?

Answer: Osmotic pressure is more advantageous because: (1) It can be measured at room temperature — no need to heat or cool the solution. (2) It is a large measurable quantity even for dilute solutions (e.g., a 0.001 M solution at 25°C gives $\pi \approx 0.025$ atm, easily measurable). (3) It is especially useful for determining molar masses of large molecules like proteins and polymers where ΔT_b and ΔT_f changes are too small to measure accurately.

Explanation:

For dilute solutions, ΔT_b and ΔT_f are extremely small and difficult to measure precisely.

Osmotic pressure, even for very dilute or high molar mass solute solutions, gives a measurable value and can be determined at room temperature without phase change complications.

Q.29(c)

[Case Study — Osmosis]

(c) Which phenomenon is responsible for desalination of sea water ?

Answer: Reverse osmosis

Explanation:

In reverse osmosis, a pressure greater than the osmotic pressure of sea water is applied.

This forces water molecules from the sea water (high solute concentration side) through a semi-permeable membrane to the fresh water side, effectively removing dissolved salts.

This is the principle behind desalination plants.

Q.30(a)

Like NH3, nitrogen atom of amine is trivalent and carries an unshared pair of electrons. Nitrogen orbitals in amines are sp3 hybridised and the geometry of amines is pyramidal.

(a) Complete the following equations :

(i) CH3CONH2 –(i) LiAlH4 / (ii) H2O→

(ii) 4-Nitrotoluene (p-CH3–C6H4–NO2) –(Fe + HCl)→

Answer: (i) $CH_3CONH_2 + 4[H]$ ($LiAlH_4$, then H_2O) → $CH_3CH_2NH_2$ (ethanamine)

(ii) p-CH_3–C_6H_4–NO_2 + 6[H] (Fe/HCl) → p-CH_3–C_6H_4–NH_2 (4-methylaniline, p-toluidine) + $2H_2O$

Explanation:

(i) $LiAlH_4$ reduces the amide –$CONH_2$ to –CH_2NH_2.

(ii) Fe/HCl reduces the aromatic –NO_2 group to –NH_2;

the methyl group (para) is unchanged, giving p-toluidine.

Q.30(b)

[Case Study — Amines]

(b) Why do primary amines have higher boiling points than tertiary amines ?

Answer: Primary amines have two N–H bonds and can form extensive intermolecular hydrogen bonds. Tertiary amines have no N–H bond (all three hydrogens on nitrogen are replaced by alkyl groups), so they cannot form hydrogen bonds with each other. Since primary amines have stronger

intermolecular forces (due to hydrogen bonding), they require more energy to vaporise and thus have higher boiling points than tertiary amines of comparable molecular mass.

Explanation:

Hydrogen bonding requires both a hydrogen donor (N–H) and acceptor (lone pair on N).

1° amines: –NH2 has 2 H available → strong H-bonding → high bp.

3° amines: no N–H → no H-bonding between molecules → lower bp.

2° amines fall in between (one N–H).

Q.30(c)

(c) Classify the following amines as primary, secondary or tertiary :

(i) 2-(N,N-dimethylamino)naphthalene, i.e. a naphthalene ring bearing $–N(CH_3)_2$

(ii) 2-aminonaphthalene, i.e. a naphthalene ring bearing $–NH_2$

Answer: (i) Tertiary amine (3°) — N,N-dimethyl-2-naphthylamine: nitrogen is bonded to two –CH3 groups and one naphthyl ring carbon, no N–H bond.

(ii) Primary amine (1°) — 2-naphthylamine (naphthalen-2-amine): nitrogen is bonded to only one carbon (the naphthyl ring) and carries two H atoms (–NH2 group).

Explanation:

Structure (i) is a naphthalene ring bearing an –N(CH3)2 group — N is attached to two methyl carbons and one ring carbon, zero N–H bonds: TERTIARY amine.

Structure (ii) is a naphthalene ring bearing an –NH2 group — N is attached to one ring carbon and two hydrogens: PRIMARY amine.

Classification rule: count carbons on N — 1C = primary, 2C = secondary, 3C = tertiary.

OR

Q.30(c)

[Case Study — Amines]

(c) Out of Butan–1–amine and Butan–1–ol, which is more soluble in water ?

Answer: Butan–1–ol is more soluble in water than Butan–1–amine.

Explanation:

Both form hydrogen bonds with water, but oxygen is more electronegative than nitrogen, so the O–H···O hydrogen bonds of butan-1-ol with water are stronger than the N–H···O bonds of butan-1-amine.

As the passage states, amines are less soluble in water than alcohols because of the lower electronegativity of nitrogen.

Hence butan-1-ol is more soluble.

Q.31

(a) How will you convert the following :

(i) Propanone to Propene

(ii) Benzoic acid to Benzaldehyde

(iii) Benzene to m-Nitroacetophenone

(b) (i) Arrange the following compounds in increasing order of their reactivity towards HCN :

$(CH_3)_2C=O$, $(CH_3)_3C–CO–C(CH_3)_3$, CH_3CHO

(ii) Identify the compounds, which would undergo Aldol condensation :

HCHO, C_6H_5CHO, CH_3CHO, cyclohexanone (six-membered ring ketone)

Answer: (a)(i) CH_3COCH_3 –(NaBH$_4$ or LiAlH$_4$)→ $CH_3CH(OH)CH_3$ –(conc. H_2SO_4, heat)→ $CH_3CH=CH_2$

(a)(ii) C_6H_5COOH –($SOCl_2$)→ C_6H_5COCl –(H_2, Pd–$BaSO_4$)→ C_6H_5CHO (Rosenmund)

(a)(iii) C_6H_6 –(CH_3COCl, anhyd. $AlCl_3$)→ $C_6H_5COCH_3$ –(conc. HNO_3/conc. H_2SO_4)→ m-$O_2N–C_6H_4–COCH_3$ (–$COCH_3$ is meta-directing)

(b)(i) $(CH_3)_3C–CO–C(CH_3)_3 < CH_3COCH_3 < CH_3CHO$

(b)(ii) CH_3CHO and cyclohexanone (both have α-hydrogens); HCHO and C_6H_5CHO have no α-H.

Explanation:

(a)(i) Reduce the ketone to propan-2-ol, then dehydrate.

(ii) Rosenmund reduction of benzoyl chloride.

(iii) Acylation first, then nitration, since –$COCH_3$ directs meta.

(b)(i) More steric hindrance and more +I groups lower reactivity towards nucleophilic addition of HCN: di-tert-butyl ketone < acetone < ethanal.

(ii) Aldol condensation needs at least one α-H: ethanal and cyclohexanone qualify; methanal and benzaldehyde have none.

OR

Q.31

(a) Give chemical tests to distinguish between the following pairs of compounds :

(i) Acetophenone and Benzophenone

(ii) Propanal and Propanone

(iii) Pentan–2–one and Pentan–3–one

(b) (i) Which of the following acids is stronger and why ?

CH2FCOOH, CH3COOH

(ii) Arrange the following compounds in the increasing order of their boiling points :

CH3OCH3, CH3CH2CH3, CH3CH2OH, CH3CHO

Answer: (a)(i) Acetophenone ($C_6H_5COCH_3$) vs Benzophenone ($C_6H_5COC_6H_5$): Iodoform test — Acetophenone has a $CH_3CO–$ group and gives yellow precipitate of CHI_3 (iodoform) with I_2/NaOH. Benzophenone does not give iodoform test (no $CH_3CO–$ group).

(a)(ii) Propanal (CH_3CH_2CHO) vs Propanone (CH_3COCH_3): Tollens' test (or Fehling's test) — Propanal (aldehyde) gives silver mirror with Tollens' reagent / red precipitate with Fehling's solution. Propanone (ketone) does not react. Alternatively, iodoform test: propanone (has $CH_3CO–$) gives a yellow CHI_3 precipitate; propanal (no $CH_3CO–$ group) does not.

(a)(iii) Pentan–2–one ($CH_3COCH_2CH_2CH_3$) vs Pentan–3–one ($CH_3CH_2COCH_2CH_3$): Iodoform test — Pentan-2-one has a methyl group ($CH_3CO–$) and gives positive iodoform test (yellow CHI_3 precipitate) with

I2/NaOH. Pentan-3-one does not give iodoform test.

(b)(i) CH2FCOOH is stronger than CH3COOH. Fluorine is highly electronegative and exerts a strong –I (inductive) electron-withdrawing effect, which stabilises the carboxylate anion (CH2FCOO–) by dispersing the negative charge, making it easier to release a proton. The higher acidity of CH2FCOOH is due to the electron-withdrawing –I effect of F.

(b)(ii) Increasing order of boiling points: CH3CH2CH3 < CH3OCH3 < CH3CHO < CH3CH2OH. Propane (bp –42°C) < Dimethyl ether (bp –24°C) < Acetaldehyde (bp 20°C) < Ethanol (bp 78°C). Alcohol has the highest bp due to strong intermolecular H-bonding. Acetaldehyde has higher bp than ether/alkane due to dipole-dipole interactions. Ether bp > alkane despite similar MW due to polarity.

Explanation:

(a)(i) Acetophenone ($CH_3CO–$) gives yellow CHI_3 with I_2/NaOH; benzophenone does not.

(ii) Propanal reduces Tollens'/Fehling's reagent; propanone does not.

(iii) Pentan-2-one ($CH_3CO–$) gives the iodoform test; pentan-3-one does not.

(b)(i) CH_2FCOOH is stronger: the –I effect of F stabilises the carboxylate ion.

(ii) Boiling points rise with intermolecular attraction: $CH_3CH_2CH_3$ (–42 °C) < CH_3OCH_3 (–24 °C) < CH_3CHO (20 °C) < CH_3CH_2OH (78 °C, hydrogen bonding).

Q.32

(a) The conductivity of 0.1 mol L–1 solution of NaCl is 1.06 × 10–2 S cm–1. Calculate its molar conductivity and degree of dissociation.

λ°Na+ = 50.1 S cm2 mol–1

λ°Cl– = 76.5 S cm2 mol–1

(b) (i) Following cell reaction occurs in a galvanic cell :

2Ag+(aq) + Zn(s) → 2Ag(s) + Zn2+(aq) E°(cell) = +1.56 V

Predict the direction of flow of current.

(ii) Differentiate between a primary battery and a secondary battery.

Answer: (a) Molar conductivity Λm = κ × 1000/c = (1.06 × 10–2 × 1000)/0.1 = 106 S cm2 mol–1. λ°m(NaCl) = λ°Na+ + λ°Cl– = 50.1 + 76.5 = 126.6 S cm2 mol–1.

Degree of dissociation α = Λm/λ°m = 106/126.6 = 0.837 (83.7%).

(b)(i) In the galvanic cell, Zn is oxidised at the anode (–) and Ag+ is reduced at the cathode (+). Conventional current flows from cathode (Ag electrode, positive terminal) to anode (Zn electrode, negative terminal) through the external circuit. Or: current flows from Ag to Zn in the external circuit.

(b)(ii) Primary battery: cannot be recharged; once discharged, it must be discarded (e.g., dry cell, mercury cell). Secondary battery (storage cell): can be recharged by passing an electric current through it in the reverse direction; can be reused multiple times (e.g., lead storage battery, Ni-Cd battery).

Explanation:

(a) $\Lambda m = \kappa \times 1000/c = (1.06 \times 10^{-2} \times 1000)/0.1 = 106$ S cm² mol⁻¹.

$\Lambda°m(NaCl) = 50.1 + 76.5 = 126.6$ S cm² mol⁻¹.

$\alpha = 106/126.6 = 0.837$.

(b)(i) $E°cell > 0$, so Zn is the anode and Ag the cathode; electrons flow Zn → Ag, so conventional current flows from Ag to Zn in the external circuit.

(ii) A primary battery cannot be recharged;
a secondary battery can be recharged and reused.

OR

Q.32

(a) Resistance of a conductivity cell filled with 0.1 M KCl solution is 100 Ω. If the resistance of the same cell when filled with 0.01 mol L–1 KCl solution is 300 Ω, calculate the conductivity and molar conductivity of 0.01 mol L–1 KCl solution. The conductivity of 0.1 M KCl solution is 1.29 × 10–2 S cm–1.

(b) (i) Write any two advantages of H2–O2 fuel cell.

(ii) Why does the cell potential of mercury cell remain constant throughout the life ?

Answer: (a) Cell constant (G*) = κ × R = 1.29 × 10–2 S cm–1 × 100 Ω = 1.29 cm–1. Conductivity of 0.01 M KCl: κ = G*/R = 1.29/300 = 4.3 × 10–3 S cm–1. Molar conductivity Λm = (κ × 1000)/c = (4.3 × 10–3 × 1000)/0.01 = 430 S cm2 mol–1.

(b)(i) Two advantages of H2–O2 fuel cell: (1) High efficiency — directly converts chemical energy to electrical energy (no combustion losses). (2) Pollution-free — the only product is water (no harmful byproducts). (3) Can operate continuously as long as fuel (H2) and oxidant (O2) are supplied.

(b)(ii) In the mercury cell, the overall cell reaction is: Zn(s) + HgO(s) → ZnO(s) + Hg(l). The electrolyte (KOH/ZnO paste) and the electrodes are solids/paste — there is no change in ionic concentrations in the electrolyte during discharge. Since the reaction does not involve any solution-phase ions whose concentration would change, the EMF (which depends on activity/concentration of species) remains constant throughout the life of the cell.

Explanation:

(a) Cell constant = κ(known) × R(known) = 1.29 × 10–2 × 100 = 1.29 cm–1.

Then κ(unknown) = cell constant / R(unknown) = 1.29/300 = 4.3 × 10–3 S cm–1.

Λm = 1000κ/c = 1000 × 4.3 × 10–3 / 0.01 = 430 S cm2 mol–1.

(b)(ii) Mercury cell: all reactants and products are solid/liquid; no change in electrolyte composition →

constant EMF.

Q.33

An organic compound 'A', with molecular formula C2H6O reacts with active metals such as sodium to give compound 'B' and hydrogen gas. 'A' on treatment with iodine and sodium hydroxide gives 'C' and in presence of H2SO4 at 413 K gives 'D' (C4H10O). 'D' on reaction with excess of HI gives 'E'. Identify 'A', 'B', 'C', 'D' and 'E' and write all the reactions involved.

Answer: A = ethanol (C_2H_5OH); B = sodium ethoxide (C_2H_5ONa); C = iodoform (CHI_3); D = diethyl ether ($C_2H_5OC_2H_5$); E = ethyl iodide (C_2H_5I).

Reactions:

(1) $2C_2H_5OH + 2Na \rightarrow 2C_2H_5ONa + H_2\uparrow$

(2) $C_2H_5OH + 4I_2 + 6NaOH \rightarrow CHI_3\downarrow + HCOONa + 5NaI + 5H_2O$

(3) $2C_2H_5OH \xrightarrow{\text{(conc. } H_2SO_4,\ 413\ K)} C_2H_5OC_2H_5 + H_2O$

(4) $C_2H_5OC_2H_5 + 2HI\ (\text{excess}) \rightarrow 2C_2H_5I + H_2O$

Explanation:

C_2H_6O reacting with Na gives H_2, so A is an alcohol: ethanol (not dimethyl ether).

Ethanol contains $CH_3CH(OH)–$ and gives iodoform with I_2/NaOH.

Intermolecular dehydration with H_2SO_4 at 413 K gives diethyl ether ($C_4H_{10}O$);

excess HI cleaves it to ethyl iodide.

OR

Q.33

(a) Write the reagents which are used in the given conversions :

(i) Phenol to 2,4,6–tribromophenol

(ii) Propene to propan–1–ol

(iii) Butan–2–one to butan–2–ol

(b) Explain the mechanism of acid catalyzed hydration of alkene to form corresponding alcohol.

Answer: (a)(i) Phenol to 2,4,6-tribromophenol: Reagent = Bromine water (Br2/H2O). Phenol reacts with bromine water to give 2,4,6-tribromophenol (white precipitate) + 3HBr.

(a)(ii) Propene to propan-1-ol: Reagent = (i) B2H6/THF (diborane) then (ii) H2O2/NaOH (Hydroboration-oxidation, anti-Markovnikov addition). This gives the primary alcohol (propan-1-ol).

(a)(iii) Butan-2-one to butan-2-ol: Reagent = NaBH4 (sodium borohydride) or LiAlH4 (followed by H2O/H+). Reduction of ketone to secondary alcohol.

(b) Mechanism of acid-catalyzed hydration of alkene:

Step 1 (Protonation): The alkene reacts with H+ (from H2SO4 or H3PO4) — the proton adds to the less substituted carbon (following Markovnikov's rule), generating the more stable carbocation (secondary > primary).

CH3–CH=CH2 + H+ → CH3–CH+(–CH3) (sec-carbocation)

Step 2 (Nucleophilic attack): A water molecule acts as a nucleophile and attacks the carbocation, forming an oxonium ion.

CH3–CH+–CH3 + H2O → CH3–CH(OH2+)–CH3

Step 3 (Deprotonation): The oxonium ion loses a proton to give the alcohol.

$CH_3–CH(OH_2^+)–CH_3 \rightarrow CH_3–CH(OH)–CH_3 + H^+$

The overall product follows Markovnikov's rule (OH goes to the more substituted carbon).

Explanation:

(a)(i) Br_2/H_2O (aqueous bromine) — phenol's –OH group activates the ring strongly; electrophilic aromatic substitution occurs at all three ortho/para positions simultaneously.

(ii) Hydroboration-oxidation gives anti-Markovnikov product (primary alcohol).

(iii) $NaBH_4$ or $LiAlH_4$ reduces ketone to secondary alcohol.

(b) The mechanism is: electrophilic addition of H^+ (from acid) to form carbocation → nucleophilic attack by water →

loss of proton.

The rate-determining step is carbocation formation.