# SRMJEEE Chemistry Sample Paper – 9

**Duration: 41 Minutes** **Maximum Marks: 35**

## Instructions

- This paper contains **35** Multiple Choice Questions (Single Correct Answer), modelled on the Chemistry section of **SRMJEEE** (SRM Joint Engineering Entrance Examination).
- Each correct answer carries **+1 mark**. There is **no negative marking**; an unattempted or wrong answer scores 0.
- Only **one** option is correct. Choose carefully.
- The actual SRMJEEE is a **computer-based test** conducted in remote-proctored online mode, with all sections sharing a common time window and no per-section limit.
- Personal calculators, mobile phones, log tables and other electronic gadgets are strictly prohibited.

**Q1.** The number of moles of NaOH present in $500$ mL of a $0.2$ M aqueous NaOH solution is:

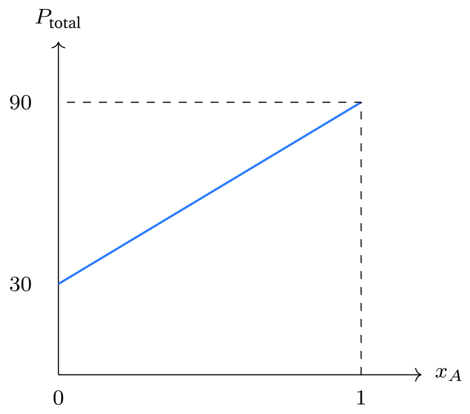
(A) $0.1$ mol

(B) $0.2$ mol

(C) $0.4$ mol

(D) $1.0$ mol

**Q2.** For an ideal binary solution of liquids A and B, the total vapour pressure varies linearly with $x_A$, as shown. The graph meets the axis $x_A = 1$ at $90$ mmHg and the axis $x_A = 0$ at $30$ mmHg. The vapour pressure of *pure* A, $P_A^\circ$, is:



(A) 30 mmHg

(B) 90 mmHg

(C) 60 mmHg

(D) 120 mmHg

**Q3.** The elevation in boiling point of a solution of $0.5$ mol of a non-volatile, non-electrolyte solute in $1$ kg of water is $(K_b = 0.52$ K kg mol$^{-1}$, $i = 1)$:

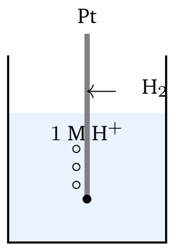
(A) $0.52$ K

(B) $1.04$ K

(C) $0.26$ K

(D) $0.13$ K

**Q4.** The standard hydrogen electrode (SHE), shown below, is used as a reference for measuring electrode potentials. By international convention, its standard electrode potential is taken to be:



1 bar, 298 K

(A) $+0.76$ V

(B) $-0.34$ V

(C) $+1.10$ V

(D) $0.00$ V

**Q5.** For a *weak* electrolyte such as acetic acid, the molar conductivity $\Lambda_m$ shows a sharp rise on dilution. This is mainly because dilution:

(A) increases the degree of dissociation, releasing many more ions

(B) increases the number of solvent molecules only

(C) decreases the total number of ions in solution

(D) converts the weak electrolyte into a strong one

**Q6.** One mole of electrons (the Avogadro number of electrons) carries a total charge of approximately:

(A) $1.6 \times 10^{-19}$ C

(B) $96500$ C

(C) $6.02 \times 10^{23}$ C

(D) $9650$ C

**Q7.** The acid-catalysed hydrolysis of ethyl acetate, carried out in a large excess of water, follows first-order kinetics although it involves two reactants. Such a reaction is called:

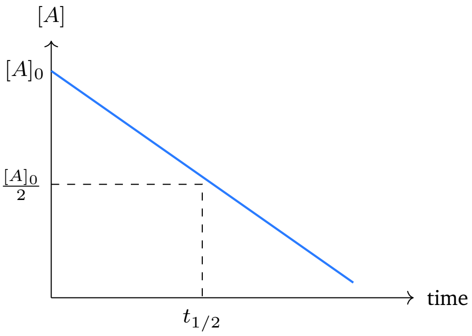
(A) a zero-order reaction

(B) a true second-order reaction

(C) a pseudo-first-order reaction

(D) a third-order reaction

**Q8.** For a zero-order reaction, $[A]$ falls linearly with time as shown. The half-life $t_{1/2}$ of a zero-order reaction is:



(A) independent of $[A]_0$

(B) inversely proportional to $[A]_0$

(C) proportional to $1/[A]_0^2$

(D) directly proportional to $[A]_0$

**Q9.** According to the Maxwell–Boltzmann distribution and the Arrhenius idea, the fraction of molecules possessing energy equal to or greater than the activation energy $E_a$ is given by:

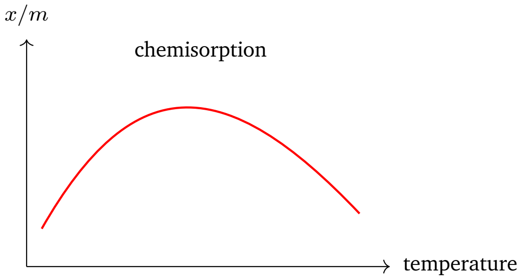
(A) $e^{-E_a/RT}$

(B) $e^{+E_a/RT}$

(C) $E_a/RT$

(D) $RT/E_a$

**Q10.** The graph shows how the extent of chemisorption $(x/m)$ of a gas on a solid varies with temperature at constant pressure. The initial *rise* of the curve is because chemisorption:



(A) is purely physical and needs no energy

(B) requires activation energy, supplied by raising the temperature

(C) decreases steadily with temperature throughout

(D) is independent of temperature

**Q11.** The process by which a fresh precipitate is converted into a colloidal sol on adding a small amount of a suitable electrolyte is called:

(A) dialysis

(B) coagulation

(C) peptization

(D) emulsification

**Q12.** Which of the following is an example of a *water-in-oil* (w/o) emulsion?

(A) milk

(B) vanishing cream

(C) a foam

(D) butter (cold cream)

**Q13.** As one moves down group 17 from fluorine to iodine, the physical state and colour of the elemental halogens change as:

(A) pale-yellow gas → greenish-yellow gas → red-brown liquid → violet-black solid

(B) colourless gas at every step

(C) solid → liquid → gas → solid

(D) violet solid → red liquid → yellow gas ($F_2$ last)

**Q14.** The oxidation state of iodine in iodine heptafluoride, $IF_7$, is:

(A) $+5$

(B) $+7$

(C) $+1$

(D) $-1$

**Q15.** The electron-gain enthalpy of chlorine is more negative than that of fluorine. The best explanation is that:

(A) chlorine has a higher nuclear charge than fluorine

(B) fluorine is less electronegative than chlorine

(C) the small, compact F atom causes strong electron–electron repulsion in the added electron

(D) chlorine has a smaller atomic size than fluorine

**Q16.** Which of the following ions has the *largest* number of unpaired $d$-electrons and is therefore the most strongly paramagnetic?

(A) $Sc^{3+}$ ($d^0$)

(B) $Cu^{2+}$ ($d^9$)

(C) $Ti^{3+}$ ($d^1$)

(D) $Mn^{2+}$ ($d^5$)

**Q17.** The oxidation state of chromium in the chromate ion, $CrO_4^{2-}$, is:

(A) $+6$

(B) $+3$

(C) $+4$

(D) $+2$

**Q18.** A direct consequence of the lanthanide contraction is that:

(A) the radius of Hf is much larger than that of Zr

(B) Zr and Hf have almost identical atomic radii and very similar properties

(C) the lanthanides show no resemblance to one another

(D) the $5d$ elements are far lighter than the $4d$ elements

**Q19.** In the complex $[Pt(NH_3)_2Cl_2]$, the oxidation number of platinum is:

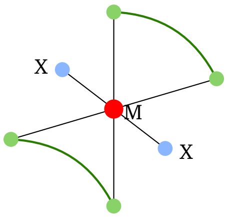
(A) 0

(B) +4

(C) +2

(D) +1

**Q20.** An octahedral complex of the type $[M(AA)_2X_2]$, where AA is a symmetrical bidentate ligand (such as ethylenediamine) and X is a monodentate ligand, exists as cis and trans forms; the cis form is also optically active. The total number of stereoisomers is:



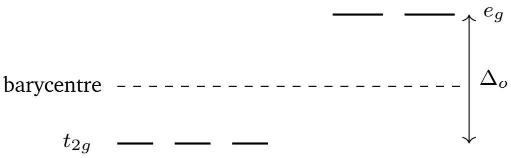
(A) 1

(B) 2

(C) 4

(D) 3 (trans + a pair of cis enantiomers)

**Q21.** In an octahedral complex the $d$-orbitals split by $\Delta_o$, and the observed colour is complementary to the wavelength absorbed during a $t_{2g} \rightarrow e_g$ transition. A complex with a *larger* $\Delta_o$ will absorb light of:



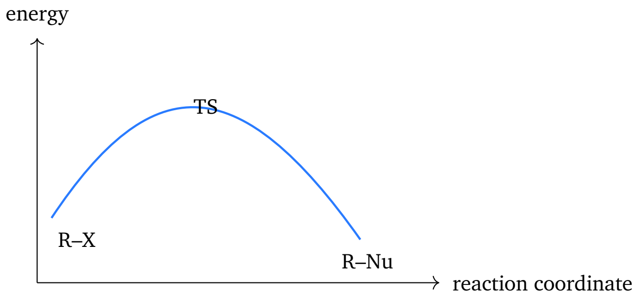
(A) shorter wavelength (higher energy)

(B) longer wavelength (lower energy)

(C) the same wavelength regardless of $\Delta_o$

(D) zero frequency

**Q22.** The energy profile of a nucleophilic substitution is shown. Among R–F, R–Cl, R–Br and R–I, the fastest substitution occurs with the substrate whose leaving group is the:



(A) smallest and most basic ($F^-$)

(B) weakest base / best leaving group ($I^-$)

(C) the one forming the strongest C–X bond

(D) identical for all four halides

**Q23.** A Grignard reagent (RMgX) is prepared by the reaction of an alkyl halide with magnesium metal in:

(A) aqueous KOH

(B) dilute sulphuric acid

(C) dry ether

(D) liquid ammonia

**Q24.** Towards nucleophilic substitution, benzyl chloride ($C_6H_5CH_2Cl$) is much more reactive than chlorobenzene ($C_6H_5Cl$) because in benzyl chloride:

(A) the C–Cl bond has partial double-bond character

(B) chlorine is directly attached to the aromatic ring

(C) resonance shortens the C–Cl bond

(D) the C–Cl bond is on an $sp^3$ carbon and gives a resonance-stabilised benzyl carbocation

**Q25.** When ethanol is warmed with acetic acid in the presence of a little concentrated $H_2SO_4$, the main organic product is ethyl acetate. The reverse reaction (ethyl acetate + water) is called:

(A) ester hydrolysis

(B) esterification

(C) saponification only in acid

(D) dehydration

**Q26.** In the industrial cumene process, phenol is manufactured along with an important by-product. This by-product is:

(A) benzene

(B) acetone

(C) toluene

(D) benzoic acid

**Q27.** Lower ethers such as diethyl ether are appreciably soluble in water (to about the same extent as the corresponding alcohols) because the ether oxygen:

(A) donates a proton to water

(B) is positively charged

(C) has lone pairs and can accept hydrogen bonds from water

(D) makes the molecule strongly ionic

**Q28.** Both the Clemmensen reduction (Zn–Hg/conc. HCl) and the Wolff–Kishner reduction ($NH_2NH_2$, then KOH/heat) convert the carbonyl group $>C=O$ of an aldehyde or ketone into:

(A) a $>CHOH$ group

(B) a –COOH group

(C) a $C=C$ double bond

(D) a –$CH_2$– (methylene) group

**Q29.** When benzaldehyde is treated with concentrated NaOH, it undergoes the Cannizzaro reaction. The two products are:

(A) benzyl alcohol and sodium benzoate

(B) benzoic acid and benzene

(C) two molecules of benzoic acid

(D) toluene and sodium benzoate

**Q30.** Which of the following is the *stronger* acid, and why?

(A) $CH_3COOH$, because of the electron-donating methyl group

(B) $FCH_2COOH$ is stronger than $CH_3COOH$, because F withdraws electrons and stabilises the carboxylate

(C) both have exactly the same strength

(D) $CH_3COOH$, because it has more hydrogen atoms

**Q31.** When a primary aliphatic amine (R–$NH_2$) reacts with nitrous acid ($HNO_2$, i.e. $NaNO_2$/HCl), the gas evolved with brisk effervescence is:

(A) $NH_3$

(B) $NO_2$

(C) $N_2$

(D) $H_2$

**Q32.** Aromatic (aryl) diazonium salts can be isolated at low temperature, whereas aliphatic diazonium salts cannot. The reason is that the aryl diazonium ion is:

(A) less reactive because of its larger size

(B) stabilised by hydrogen bonding with water

(C) ionic and therefore involatile

(D) stabilised by resonance (delocalisation) with the benzene ring

**Q33.** Hofmann elimination of a quaternary ammonium hydroxide gives predominantly the alkene that is:

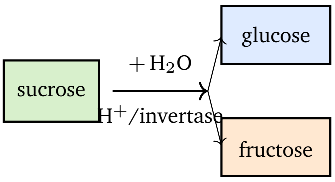
(A) the least substituted (Hofmann product)

(B) the most substituted (Saytzeff product)

(C) a cyclic alkene only

(D) an equal mixture of all possible alkenes

**Q34.** Sucrose, a disaccharide, is hydrolysed (by dilute acid or invertase) into an equimolar mixture of two monosaccharides, as represented below. These two products are:



(A) two molecules of glucose

(B) glucose and fructose (invert sugar)

(C) glucose and galactose

(D) two molecules of fructose

**Q35.** Enzymes are highly efficient biological catalysts. Chemically, an enzyme is best described as:

(A) a lipid that speeds up only fat metabolism

(B) a simple inorganic salt

(C) a protein that is highly specific for its substrate

(D) a nucleic acid that copies DNA

# Detailed Solutions

## Q1.

### Solution

**Concept — Moles from molarity:** molarity $M = \dfrac{\text{moles of solute}}{\text{volume of solution in litres}}$, so moles $= M \times V_{(\text{L})}$.

**Step 1 — Convert the volume:** $500$ mL $= 0.5$ L.

**Step 2 — Multiply:** moles $= 0.2 \times 0.5 = 0.1$ mol of NaOH.

**Why other options are wrong:**

- (B) $0.2$ uses the full $1$ L instead of $0.5$ L.
- (C),(D) use $2$ L or wrong arithmetic.

**Final Answer:** $0.1$ mol $\Rightarrow \boxed{\text{A}}$

**Answer: (A)** Go Back to Q1

## Q2.

### Solution

**Concept — Raoult's law for an ideal solution:** $P_{\text{total}} = x_A P_A^\circ + x_B P_B^\circ$. At $x_A = 1$ the solution is pure A, so the line meets that axis at $P_A^\circ$; at $x_A = 0$ it meets the axis at $P_B^\circ$.

**Step 1 — Read the end-points:** at $x_A = 0$, $P_{\text{total}} = 30$ mmHg $= P_B^\circ$; at $x_A = 1$, $P_{\text{total}} = 90$ mmHg $= P_A^\circ$.

**Step 2 — Identify pure A:** the dashed construction at $x_A = 1$ meets the line at $90$ mmHg, which is exactly $P_A^\circ$.

**Why other options are wrong:**

- (A) $30$ is $P_B^\circ$ (pure B), read at $x_A = 0$.
- (C) $60$ is the mid-point value at $x_A = 0.5$; (D) $120$ is not on the line.

**Final Answer:** $P_A^\circ = 90$ mmHg $\Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q2

## Q3.

**Solution**

**Concept — Elevation of boiling point:** $\Delta T_b = i\,K_b\,m$, where $m$ is the molality and $i$ the van't Hoff factor.

**Step 1 — Molality:** $0.5$ mol in $1$ kg water $\Rightarrow m = 0.5$ mol kg$^{-1}$.

**Step 2 — Substitute ($i = 1$):**

$$\Delta T_b = 1 \times 0.52 \times 0.5 = 0.26\text{ K}.$$

**Why other options are wrong:**

- (A) $0.52$ uses $m = 1$; (B) $1.04$ uses $m = 2$ or $i = 2$.
- (D) $0.13$ halves the result once too often.

**Final Answer:** $\Delta T_b = 0.26\text{ K} \Rightarrow \boxed{\text{C}}$

**Answer: (C)** Go Back to Q3

## Q4.

**Solution**

**Concept — Standard hydrogen electrode (SHE):** the SHE (Pt in contact with $H_2$ at $1$ bar and $1$ M $H^+$ at $298$ K) is the primary reference. Its standard electrode potential is *defined* as exactly zero so that all other electrode potentials can be measured relative to it.

**Step 1 — Apply the convention:** $E^\circ_{H^+/H_2} = 0.00$ V by international agreement.

**Step 2 — Use it as a scale:** a metal that is a better reducing agent than $H_2$ gets a negative $E^\circ$, a poorer one a positive $E^\circ$.

**Why other options are wrong:**

- (A) $+0.76$ and (B) $-0.34$ are signed potentials of other electrodes, not the SHE.
- (C) $+1.10$ is a Daniell-cell EMF, not an electrode potential.

**Final Answer:** $E^\circ_{\text{SHE}} = 0.00\text{ V} \Rightarrow \boxed{\text{D}}$

**Answer: (D)** Go Back to Q4

## Q5.

### Solution

**Concept — Weak electrolyte on dilution:** a weak electrolyte is only partly ionised. Its molar conductivity depends mainly on the degree of dissociation $\alpha$.

**Step 1 — Effect of dilution:** as the solution is diluted, $\alpha$ rises sharply (Ostwald's dilution law), so the number of free ions per mole increases steeply, and $\Lambda_m$ shows a sharp, continuous rise toward $\Lambda_m^\circ$.

**Step 2 — Contrast with strong electrolytes:** a strong electrolyte is already fully ionised, so its $\Lambda_m$ rises only slightly on dilution.

**Why other options are wrong:**

- (B) adding solvent is just the means; the cause is increased dissociation.
- (C) the number of ions per mole increases; (D) dilution does not change the chemical nature of the electrolyte.

**Final Answer:** dilution increases dissociation, releasing more ions $\Rightarrow \boxed{\text{A}}$

**Answer: (A)** Go Back to Q5

## Q6.

### Solution

**Concept — Charge of one mole of electrons:** the total charge is the Faraday constant, $F = N_A \times e$, where $N_A = 6.02 \times 10^{23}$ and $e = 1.6 \times 10^{-19}$ C.

**Step 1 — Multiply:**

$$F = (6.02 \times 10^{23})(1.6 \times 10^{-19}) \approx 96500 \text{ C}.$$

**Step 2 — Interpret:** one mole of electrons ($= 1$ faraday) carries about $96500$ C of charge.

**Why other options are wrong:**

- (A) $1.6 \times 10^{-19}$ is the charge of a *single* electron.
- (C) $6.02 \times 10^{23}$ is only the count, not the charge; (D) $9650$ is off by a factor of ten.

**Final Answer:** $\approx 96500$ C (one faraday) $\Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q6

## Q7.

### Solution

**Concept — Pseudo-first-order reaction:** a reaction that is really higher order can appear first order if all reactants except one are present in large excess, so their concentrations stay effectively constant.

**Step 1 — Apply to ester hydrolysis:** $CH_3COOC_2H_5 + H_2O \rightarrow CH_3COOH + C_2H_5OH$. Water is in huge excess, so $[H_2O]$ is essentially constant and the rate depends only on [ester].

**Step 2 — Result:** rate $= k'$[ester] with $k' = k[H_2O]$, i.e. pseudo-first-order kinetics.

**Why other options are wrong:**

- (A),(D) the rate does depend on the ester concentration, and it is not third order.
- (B) although molecularity is two, the observed *order* is one because of the excess water.

**Final Answer:** a pseudo-first-order reaction $\Rightarrow \boxed{\text{C}}$

**Answer: (C)** **Go Back to Q7**

## Q8.

### Solution

**Concept — Zero-order kinetics:** for a zero-order reaction the rate is constant, and $[A] = [A]_0 - kt$, a straight line of slope $-k$ (as shown).

**Step 1 — Set $[A] = [A]_0/2$:**

$$\frac{[A]_0}{2} = [A]_0 - k\,t_{1/2} \;\Rightarrow\; t_{1/2} = \frac{[A]_0}{2k}.$$

**Step 2 — Conclusion:** $t_{1/2} \propto [A]_0$ — the half-life is *directly proportional* to the initial concentration (unlike first order, where it is independent of $[A]_0$).

**Why other options are wrong:**

- (A) independence of $[A]_0$ describes a first-order half-life.
- (B) inverse proportionality applies to a second-order reaction; (C) has no basis.

**Final Answer:** $t_{1/2} \propto [A]_0 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q8

## Q9.

### Solution

**Concept — Activation energy and the Boltzmann factor:** only molecules with energy $\geq E_a$ can react. The fraction of such molecules at temperature $T$ is given by the Boltzmann factor.

**Step 1 — Write the fraction:**

$$\text{fraction with } E \geq E_a = e^{-E_a/RT}.$$

This same factor appears in the Arrhenius equation $k = A\,e^{-E_a/RT}$.

**Step 2 — Behaviour:** the fraction (and hence $k$) increases as $T$ rises or as $E_a$ falls.

**Why other options are wrong:**

- (B) a positive exponent would grow without bound and is unphysical.
- (C),(D) the dependence is exponential, not a simple ratio of $E_a$ and $RT$.

**Final Answer:** fraction $= e^{-E_a/RT} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q9

## Q10.

### Solution

**Concept — Activated (chemical) adsorption:** chemisorption involves the formation of chemical bonds and therefore needs activation energy, like an ordinary reaction.

**Step 1 — Initial rise:** at low temperature few molecules have the required activation energy, so chemisorption is small. Raising the temperature supplies this energy, so $x/m$ first *increases* with temperature.

**Step 2 — Later fall:** adsorption is exothermic, so at still higher temperatures desorption dominates and $x/m$ falls again — giving the maximum seen in the curve.

**Why other options are wrong:**

- (A) that describes physisorption, which needs no activation energy.
- (C) the curve first rises before falling; (D) it clearly depends on temperature.

**Final Answer:** chemisorption needs activation energy, supplied by heating $\Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q10

## Q11.

### Solution

**Concept — Peptization:** the dispersion of a freshly prepared precipitate into colloidal particles on adding a small quantity of a suitable electrolyte (the peptizing agent) is called peptization.

**Step 1 — Mechanism:** the precipitate adsorbs the common ion from the electrolyte, acquires charge, and the like-charged particles repel one another and break apart into a stable sol (e.g. freshly precipitated $Fe(OH)_3$ peptized by $FeCl_3$).

**Why other options are wrong:**

- (A) dialysis removes electrolytes through a membrane (the opposite use).
- (B) coagulation is the aggregation of a sol into a precipitate; (D) emulsification disperses one liquid in another.

**Final Answer:** peptization $\Rightarrow \boxed{\text{C}}$

**Answer: (C)** Go Back to Q11

## Q12.

### Solution

**Concept — Types of emulsion:** in a water-in-oil (w/o) emulsion, water is the dispersed phase and oil is the continuous medium; in oil-in-water (o/w) it is the reverse.

**Step 1 — Classify butter:** butter (and cold cream) consists of water droplets dispersed in fat (oil), so it is a *water-in-oil* emulsion.

**Why other options are wrong:**

- (A) milk is an oil-in-water emulsion (fat dispersed in water).
- (B) vanishing cream is oil-in-water; (C) a foam is a gas dispersed in a liquid, not an emulsion.

**Final Answer:** butter / cold cream (water-in-oil) $\Rightarrow \boxed{\text{D}}$

**Answer: (D)** Go Back to Q12

## Q13.

### Solution

**Concept — Trends in the halogens:** down group 17 the colour deepens (the absorption shifts to longer wavelength) and the physical state changes from gas to liquid to solid as molecular size and van der Waals forces increase.

**Step 1 — State the sequence:** $F_2$ is a pale-yellow gas, $Cl_2$ a greenish-yellow gas, $Br_2$ a red-brown liquid, and $I_2$ a violet-black solid.

**Why other options are wrong:**

- (B) the halogens are coloured, not colourless.
- (C),(D) reverse or scramble the correct state/colour order down the group.

**Final Answer:** pale-yellow gas → greenish-yellow gas → red-brown liquid → violet-black solid $\Rightarrow \boxed{\text{A}}$

**Answer: (A)** Go Back to Q13

## Q14.

### Solution

**Concept — Oxidation-state balance:** fluorine, the most electronegative element, is always $-1$ in its compounds. The sum of oxidation states equals the overall charge (zero here).

**Step 1 — Set up for $IF_7$:** $x + 7(-1) = 0 \Rightarrow x - 7 = 0$.

**Step 2 — Solve:** $x = +7$, the highest oxidation state shown by iodine (its molecule is pentagonal bipyramidal).

**Why other options are wrong:**

- (A) $+5$ is iodine in $IF_5$; (C) $+1$ occurs in ICl.
- (D) $-1$ is iodine in iodides such as KI.

**Final Answer:** oxidation state of $\text{I} = +7 \Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q14

## Q15.

**Solution**

**Concept — Electron-gain enthalpy anomaly:** although electron-gain enthalpy generally becomes less negative down a group, fluorine is the exception: chlorine ($-349$ kJ mol$^{-1}$) releases more energy than fluorine ($-328$ kJ mol$^{-1}$).

**Step 1 — Reason:** the F atom is very small, so the incoming electron enters a compact $2p$ subshell already crowded with electrons, producing strong electron–electron repulsion that partly offsets the energy released.

**Step 2 — Compare Cl:** the larger Cl atom has a more diffuse $3p$ subshell, less repulsion, and so a more negative electron-gain enthalpy.

**Why other options are wrong:**

- (A) F actually has the higher nuclear charge per unit size, yet still releases less energy.
- (B),(D) F is the *more* electronegative and the *smaller* atom; these are not the cause of the anomaly.

**Final Answer:** the small F atom causes strong electron–electron repulsion $\Rightarrow \boxed{\text{C}}$

**Answer: (C)** **Go Back to Q15**

## Q16.

**Solution**

**Concept — Paramagnetism and unpaired electrons:** the magnetic moment $\mu = \sqrt{n(n+2)}$ BM increases with the number $n$ of unpaired electrons. The ion with the most unpaired $d$-electrons is the most strongly paramagnetic.

**Step 1 — Count unpaired electrons:** $Sc^{3+}$ ($d^0$, $n = 0$), $Ti^{3+}$ ($d^1$, $n = 1$), $Cu^{2+}$ ($d^9$, $n = 1$), $Mn^{2+}$ ($d^5$, $n = 5$ — all five $d$-orbitals singly occupied).

**Step 2 — Pick the maximum:** $Mn^{2+}$ has $n = 5$, the largest, giving $\mu = \sqrt{5 \times 7} \approx 5.9$ BM.

**Why other options are wrong:**

- (A) $Sc^{3+}$ is diamagnetic ($d^0$).
- (B),(C) $Cu^{2+}$ and $Ti^{3+}$ have only one unpaired electron each.

**Final Answer:** $Mn^{2+}$ ($d^5$, five unpaired electrons) $\Rightarrow \boxed{\text{D}}$

**Answer: (D)** **Go Back to Q16**

## Q17.

### Solution

**Concept — Oxidation state in an oxoanion:** for $CrO_4^{2-}$, oxygen is $-2$ and the sum of oxidation states equals the ion charge, $-2$.

**Step 1 — Set up:** $x + 4(-2) = -2 \Rightarrow x - 8 = -2$.

**Step 2 — Solve:** $x = +6$, the highest oxidation state of chromium (same as in dichromate, $Cr_2O_7^{2-}$).

**Why other options are wrong:**

- (B) $+3$ occurs in $Cr^{3+}/Cr_2O_3$; (D) $+2$ in $CrCl_2$.
- (C) $+4$ is not the chromate value.

**Final Answer:** oxidation state of Cr $= +6 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q17

## Q18.

### Solution

**Concept — Lanthanide contraction:** the steady decrease in size across the $4f$ series almost exactly cancels the normal size increase expected on going from the second ($4d$) to the third ($5d$) transition series.

**Step 1 — Consequence for Zr and Hf:** as a result, Hf (just after the lanthanides) has almost the same atomic radius as Zr above it, so the two elements have remarkably similar chemical and physical properties and are very hard to separate.

**Why other options are wrong:**

- (A) Hf is *not* much larger than Zr — that is the whole point of the contraction.
- (C) lanthanides closely resemble one another; (D) $5d$ elements are in fact much *denser*/heavier, not lighter.

**Final Answer:** Zr and Hf have nearly identical radii and similar properties $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q18

## Q19.

### Solution

**Concept — Oxidation number in a neutral complex:** the sum of the metal oxidation number and the ligand charges equals the overall charge of the complex.

**Step 1 — Ligand charges in [Pt($NH_3$)$_2$$Cl_2$]:** $NH_3$ is neutral ($0$ each) and $Cl^-$ is $-1$ each (two of them, total $-2$).

**Step 2 — Solve:** $x + 2(0) + 2(-1) = 0 \Rightarrow x - 2 = 0 \Rightarrow x = +2$. (This is the well-known square-planar complex cisplatin/transplatin.)

**Why other options are wrong:**

- (A) $0$ ignores the two chloride charges.
- (B) $+4$ would need four $Cl^-$; (D) $+1$ does not balance the charge.

**Final Answer:** oxidation number of Pt $= +2 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q19

## Q20.

### Solution

**Concept — Stereoisomerism of [M(AA)$_2$$X_2$]:** with two symmetrical bidentate ligands and two identical monodentate ligands, an octahedral complex shows both geometrical and optical isomerism.

**Step 1 — Geometrical isomers:** the two X groups can be *cis* (adjacent) or *trans* (opposite) — two geometrical forms.

**Step 2 — Optical isomerism:** the *trans* form has a plane of symmetry (optically inactive), but the *cis* form is chiral and exists as a pair of non-superimposable enantiomers ($d$ and $l$).

**Step 3 — Total count:** $1$ (trans) $+ 2$ (cis $d$ and $l$) $= 3$ stereoisomers.

**Why other options are wrong:**

- (A),(B) ignore the optical activity of the cis form.
- (C) $4$ over-counts; the trans form is not chiral.

**Final Answer:** $3$ stereoisomers (trans $+$ cis enantiomer pair) $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q20

## Q21.

### Solution

**Concept — Colour and the crystal-field splitting $\Delta_o$:** a complex absorbs a photon whose energy matches $\Delta_o$ to promote a $t_{2g} \to e_g$ electron. Since $E = h\nu = hc/\lambda$, a larger $\Delta_o$ means a larger absorbed energy and hence a *shorter* wavelength.

**Step 1 — Relate $\Delta_o$ and $\lambda$:** $\Delta_o = \dfrac{hc}{\lambda_{\text{absorbed}}}$, so $\lambda_{\text{absorbed}} \propto \dfrac{1}{\Delta_o}$.

**Step 2 — Conclusion:** stronger-field ligands give a larger $\Delta_o$, absorb shorter-wavelength (higher-energy) light, and the complex appears the complementary colour.

**Why other options are wrong:**

- (B) longer wavelength corresponds to a *smaller* $\Delta_o$.
- (C) the absorbed wavelength clearly depends on $\Delta_o$; (D) a real $d$–$d$ transition has a non-zero frequency.

**Final Answer:** larger $\Delta_o \Rightarrow$ shorter-wavelength absorption $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q21

## Q22.

### Solution

**Concept — Leaving-group ability:** a good leaving group is a weak base (the conjugate base of a strong acid), because it can carry away the bonding electrons easily. Better leaving groups lower the energy of the transition state and speed up substitution.

**Step 1 — Compare the halides:** basicity falls $F^- > Cl^- > Br^- > I^-$, so leaving-group ability rises F $<$ Cl $<$ Br $<$ I. The C–I bond is also the weakest and longest.

**Step 2 — Fastest substrate:** R–I reacts fastest because $I^-$ is the weakest base / best leaving group.

**Why other options are wrong:**

- (A) $F^-$ is the strongest base and worst leaving group, so R–F is slowest.
- (C) a strong C–X bond hinders departure; (D) the rates differ markedly across the halides.

**Final Answer:** the best leaving group, $I^-$ (R–I fastest) $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q22

## Q23.

### Solution

**Concept — Grignard reagent formation:** an alkyl (or aryl) halide reacts with magnesium turnings in dry (anhydrous) ether to give the organomagnesium halide, RMgX.

**Step 1 — Reaction:** R–X + Mg $\xrightarrow{\text{dry ether}}$ R–Mg–X.

**Step 2 — Why dry ether:** the reaction must be strictly anhydrous because Grignard reagents react violently with water (and any compound with an acidic H), destroying the reagent.

**Why other options are wrong:**

- (A),(B) aqueous KOH and dilute acid contain water/acidic protons that would decompose RMgX.
- (D) liquid ammonia is not the standard medium for Grignard formation.

**Final Answer:** dry ether $\Rightarrow \boxed{\text{C}}$

**Answer: (C)** Go Back to Q23

## Q24.

### Solution

**Concept — Reactivity towards nucleophilic substitution:** the ease of substitution depends on the carbon bearing the halogen and on the stability of any intermediate carbocation.

**Step 1 — Chlorobenzene:** Cl is on an $sp^2$ ring carbon; resonance gives the C–Cl bond partial double-bond character, so it is short, strong and very unreactive.

**Step 2 — Benzyl chloride:** Cl is on an $sp^3$ (benzylic) carbon. On ionisation it gives a benzyl carbocation that is strongly resonance-stabilised by the ring, so benzyl chloride undergoes substitution very readily.

**Why other options are wrong:**

- (A),(C) describe chlorobenzene (the *unreactive* compound), not benzyl chloride.
- (B) direct attachment to the ring is exactly what makes chlorobenzene *less* reactive.

**Final Answer:** benzylic $sp^3$ C–Cl giving a resonance-stabilised benzyl carbocation $\Rightarrow \boxed{\text{D}}$

**Answer: (D)** Go Back to Q24

## Q25.

### Solution

**Concept — Esterification and its reverse:** an alcohol and a carboxylic acid combine, with loss of water, to form an ester (esterification). Adding water to the ester reverses this, splitting it back into the acid and alcohol.

**Step 1 — Forward reaction:** $C_2H_5OH + CH_3COOH \xrightarrow{H^+} CH_3COOC_2H_5 + H_2O$ (esterification).

**Step 2 — Reverse reaction:** $CH_3COOC_2H_5 + H_2O \xrightarrow{H^+} CH_3COOH + C_2H_5OH$. Breaking an ester with water is, by definition, (acid) hydrolysis.

**Why other options are wrong:**

- (B) esterification is the *forward* reaction, not the reverse.
- (C) saponification is hydrolysis by *alkali*, giving a salt; (D) dehydration removes water rather than adding it.

**Final Answer:** the reverse reaction is ester hydrolysis $\Rightarrow \boxed{A}$

**Answer: (A)** Go Back to Q25

## Q26.

### Solution

**Concept — Cumene process:** phenol is made industrially by air-oxidation of cumene (isopropylbenzene) to cumene hydroperoxide, which is then cleaved by dilute acid.

**Step 1 — The acid cleavage:** cumene hydroperoxide rearranges and breaks to give *phenol* and *acetone* in one step.

**Step 2 — Significance:** acetone is the valuable co-product that makes the process economical.

**Why other options are wrong:**

- (A) benzene is the starting material for making cumene, not the by-product.
- (C),(D) toluene and benzoic acid are not formed in the cumene process.

**Final Answer:** acetone $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q26

## Q27.

### Solution

**Concept — Solubility of ethers:** although ethers have no O–H bond and cannot *donate* hydrogen bonds, the oxygen carries two lone pairs and can *accept* hydrogen bonds from water molecules.

**Step 1 — Hydrogen-bond acceptance:** water donates H to the ether oxygen, so lower ethers (small carbon chains) dissolve in water to about the same extent as the corresponding alcohols.

**Step 2 — Limit:** solubility falls as the hydrocarbon part grows, since the molecule becomes more hydrophobic.

**Why other options are wrong:**

- (A) the ether oxygen accepts, it does not donate, a proton.
- (B),(D) the ether oxygen is not positively charged and the molecule is not ionic.

**Final Answer:** the lone-pair oxygen accepts H-bonds from water $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q27

## Q28.

### Solution

**Concept — Reduction of a carbonyl to methylene:** both the Clemmensen and the Wolff–Kishner reductions completely remove the carbonyl oxygen, converting $>C{=}O$ all the way to $>CH_2$.

**Step 1 — Clemmensen:** Zn–Hg amalgam with concentrated HCl reduces $>C{=}O$ to $-CH_2-$ (used for acid-stable compounds).

**Step 2 — Wolff–Kishner:** the carbonyl is first converted to a hydrazone (with $NH_2NH_2$), which on heating with KOH/ethylene glycol gives the $-CH_2-$ group (used for base-stable compounds).

**Why other options are wrong:**

- (A) $>CHOH$ would result from a milder reduction (e.g. $NaBH_4$), not from these methods.

- (B),(C) no $-$COOH or C$=$C is formed; both methods give the fully reduced methylene.

**Final Answer:** a $-CH_2-$ (methylene) group $\Rightarrow \boxed{\text{D}}$

$\boxed{\textbf{Answer: (D)}}$ **Go Back to Q28**

## Q29.

**Solution**

**Concept — Cannizzaro reaction:** an aldehyde with no $\alpha$-hydrogen, on treatment with concentrated alkali, disproportionates — one molecule is oxidised and another reduced.

**Step 1 — Apply to benzaldehyde:** $2\,C_6H_5CHO + NaOH \rightarrow C_6H_5CH_2OH + C_6H_5COONa$. One molecule is reduced to benzyl alcohol; the other is oxidised to the benzoate salt.

**Step 2 — Identify products:** benzyl alcohol (the alcohol) and sodium benzoate (the carboxylate salt).

**Why other options are wrong:**

- (B),(C) free benzoic acid forms only on acidification, and both molecules are not oxidised.
- (D) toluene is not a Cannizzaro product.

**Final Answer:** benzyl alcohol and sodium benzoate $\Rightarrow \boxed{\text{A}}$

$\boxed{\textbf{Answer: (A)}}$ **Go Back to Q29**

## Q30.

**Solution**

**Concept — Inductive effect on acidity:** an electron-withdrawing substituent near the $-$COOH group stabilises the carboxylate anion (disperses its negative charge), making the acid stronger; an electron-donating group does the opposite.

**Step 1 — Compare the two acids:** in $FCH_2COOH$ the electronegative fluorine withdraws electron density ($-$I effect), stabilising the $FCH_2COO^-$ ion; in $CH_3COOH$ the methyl group *donates* electrons (+I), destabilising the anion.

**Step 2 — Conclusion:** $FCH_2COOH$ ($pK_a \approx 2.6$) is markedly stronger than $CH_3COOH$ ($pK_a \approx 4.8$).

**Why other options are wrong:**

- (A),(D) the electron-donating $CH_3$ *weakens* acetic acid; the number of H atoms is irrelevant.
- (C) the two acids are clearly not of equal strength.

**Final Answer:** $FCH_2COOH$ is the stronger acid $\Rightarrow \boxed{B}$

$\boxed{\textbf{Answer: (B)}}$ **Go Back to Q30**

## Q31.

### Solution

**Concept — Primary amine with nitrous acid:** a primary aliphatic amine reacts with $HNO_2$ ($NaNO_2$ + HCl) to form a very unstable diazonium salt that immediately decomposes, liberating nitrogen gas.

**Step 1 — Reaction:** $R\text{–}NH_2 + HNO_2 \rightarrow [R\text{–}N_2^+] \rightarrow R\text{–}OH + N_2\uparrow + H_2O$. The brisk effervescence of $N_2$ is a test for a primary aliphatic amine.

**Step 2 — Identify the gas:** the gas evolved is nitrogen, $N_2$.

**Why other options are wrong:**

- (A) $NH_3$ is not evolved here; (B) $NO_2$ is not the product gas.
- (D) $H_2$ is not liberated in this reaction.

**Final Answer:** nitrogen gas, $N_2 \Rightarrow \boxed{C}$

$\boxed{\textbf{Answer: (C)}}$ **Go Back to Q31**

## Q32.

### Solution

**Concept — Stability of diazonium salts:** an aryl diazonium ion, $Ar\text{–}N_2^+$, is stabilised because the positive charge and the $\pi$ system of the $-N{=}N-$ group are delocalised into the aromatic ring by resonance.

**Step 1 — Aromatic vs aliphatic:** this resonance is possible only with an attached benzene ring, so aryl diazonium salts are stable enough to be isolated near $0\text{–}5\ ^\circ C$.

**Step 2 — Aliphatic case:** an alkyl diazonium ion has no such ring to delocalise the charge, so it decomposes instantly, releasing $N_2$.

**Why other options are wrong:**

- (A) stability is due to resonance, not merely to size.
- (B),(C) hydrogen bonding and involatility are not the reason for the extra stability.

**Final Answer:** resonance delocalisation into the benzene ring $\Rightarrow \boxed{\text{D}}$

$\boxed{\textbf{Answer: (D)}}$ **Go Back to Q32**

## Q33.

### Solution

**Concept — Hofmann elimination:** heating a quaternary ammonium hydroxide brings about $\beta$-elimination. Unlike acid-catalysed dehydration, it follows the Hofmann rule and gives mainly the *least*-substituted alkene.

**Step 1 — Reason:** the bulky $-\text{NR}_3^+$ leaving group and the bulky base make the base abstract the more accessible proton from the *less* hindered $\beta$-carbon (the one with more H atoms), giving the terminal/less-substituted alkene.

**Step 2 — Result:** the major product is the Hofmann (least-substituted) alkene.

**Why other options are wrong:**

- (B) the most-substituted (Saytzeff) alkene is favoured in ordinary acid dehydration, not in Hofmann elimination.
- (C),(D) a single cyclic product or an equal mixture is not what the Hofmann rule predicts.

**Final Answer:** the least-substituted (Hofmann) alkene $\Rightarrow \boxed{\text{A}}$

$\boxed{\textbf{Answer: (A)}}$ **Go Back to Q33**

## Q34.

### Solution

**Concept — Hydrolysis of sucrose:** sucrose is a disaccharide made of one glucose and one fructose unit joined by a glycosidic linkage. Hydrolysis (dilute acid or the enzyme invertase) breaks this linkage.

**Step 1 — Products:** $C_{12}H_{22}O_{11} + H_2O \rightarrow C_6H_{12}O_6$ (glucose) $+ C_6H_{12}O_6$ (fructose), giving an equimolar mixture.

**Step 2 — Invert sugar:** sucrose is dextrorotatory, but the product mixture is levorotatory (the strong negative rotation of fructose dominates), so the optical rotation *inverts* — hence the name invert sugar.

**Why other options are wrong:**

- (A),(D) sucrose yields one glucose *and* one fructose, not two of either.
- (C) galactose comes from lactose, not sucrose.

**Final Answer:** glucose and fructose (invert sugar) $\Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q34

## Q35.

### Solution

**Concept — Enzymes:** enzymes are biological catalysts that enormously speed up biochemical reactions by lowering the activation energy. Chemically, almost all enzymes are globular *proteins*.

**Step 1 — Specificity:** each enzyme has a precisely shaped active site that fits only its particular substrate (the lock-and-key / induced-fit idea), so enzyme action is highly specific.

**Step 2 — Conclusion:** an enzyme is a protein that is highly specific for its substrate.

**Why other options are wrong:**

- (A) enzymes are proteins, not lipids, and act on many kinds of substrates.
- (B) they are large biomolecules, not simple inorganic salts; (D) copying DNA is the role of nucleic acids/specific enzymes, not the defining chemical nature of an enzyme.

**Final Answer:** a substrate-specific protein catalyst $\Rightarrow \boxed{\text{C}}$

**Answer: (C)** Go Back to Q35

## Answer Key

| Q | Ans | Q | Ans | Q | Ans | Q | Ans | Q | Ans |
|---|---|---|---|---|---|---|---|---|---|
| 1 | A | 2 | B | 3 | C | 4 | D | 5 | A |
| 6 | B | 7 | C | 8 | D | 9 | A | 10 | B |
| 11 | C | 12 | D | 13 | A | 14 | B | 15 | C |
| 16 | D | 17 | A | 18 | B | 19 | C | 20 | D |
| 21 | A | 22 | B | 23 | C | 24 | D | 25 | A |
| 26 | B | 27 | C | 28 | D | 29 | A | 30 | B |
| 31 | C | 32 | D | 33 | A | 34 | B | 35 | C |