Chemistry (Theory) – Code 043

CBSE Class 12 Board Examination 2027 – Practice Paper No. 2

Practice Question Paper

Time: 3 hours **Max. Marks: 70**

(1) There are 33 questions in this question paper with internal choice.
(2) SECTION A consists of 16 multiple-choice questions carrying 1 mark each.
(3) SECTION B consists of 5 very short answer questions carrying 2 marks each.
(4) SECTION C consists of 7 short answer questions carrying 3 marks each.
(5) SECTION D consists of 2 case-based questions carrying 4 marks each.
(6) SECTION E consists of 3 long answer questions carrying 5 marks each.
(7) All questions are compulsory.
(8) Use of log tables and calculators is not allowed.

SECTION A Questions 1 to 16 are multiple choice questions. Only one of the choices is correct. Select and write the correct choice as well as the answer to these questions. **[16]**

1 Which of the following units of concentration of a solution does **not** change when the temperature of the solution changes?

(A) Molarity
(B) Molality
(C) Mass by volume percentage (w/V)
(D) Volume percentage (V/V)

2 A student fills a conductivity cell of cell constant 1.2 cm^{-1} with a solution and measures its resistance as 300 Ω. The conductivity of the solution is:

(A) 4.0×10^{-3} S cm^{-1}
(B) 2.5×10^{2} S cm^{-1}
(C) 3.6×10^{2} S cm^{-1}
(D) 2.8×10^{-3} S cm^{-1}

3 The rate constant of a reaction is 3.0×10^{-4} mol^{-1} L s^{-1}. The overall order of the reaction is:

(A) zero
(B) one
(C) two
(D) three

4 Transition metals form interstitial compounds with small atoms such as H, C and N. Which of the following statements about these compounds is **incorrect**?

(A) Their melting points are higher than those of the pure metals.
(B) They are very hard.
(C) They retain metallic conductivity.
(D) They are chemically very reactive.

5 Which of the following lanthanoid ions has the electronic configuration [Xe] $4f^7$? (Atomic numbers: Sm = 62, Eu = 63, Gd = 64, Tb = 65)

(A) Sm^{3+}
(B) Eu^{3+}
(C) Gd^{3+}
(D) Tb^{3+}

6 Which of the following is a **homoleptic** complex?

(A) $[Co(NH_3)_4Cl_2]^+$
(B) $K_3[Cr(C_2O_4)_3]$
(C) $[Pt(NH_3)_2Cl_2]$
(D) $[Co(en)_2(NO_2)Cl]^+$

7 Phenol is treated with chloroform in the presence of aqueous sodium hydroxide, and the product is then acidified. The main product is:

(A) benzoic acid
(B) salicylaldehyde (2-hydroxybenzaldehyde)
(C) salicylic acid (2-hydroxybenzoic acid)
(D) benzaldehyde

8 Ethanenitrile (CH_3CN) is reduced with stannous chloride and hydrochloric acid, and the product is then hydrolysed with water. The organic compound finally obtained is:

(A) ethanal
(B) ethanamine
(C) ethanoic acid
(D) ethanol

9 In the industrial reduction of nitrobenzene to aniline, iron scrap and hydrochloric acid are preferred because:

(A) iron is a stronger reducing agent than any other metal
(B) the $FeCl_2$ formed is hydrolysed and releases HCl, so only a small amount of acid is needed
(C) iron reduces nitrobenzene to azobenzene, which then changes to aniline
(D) aniline formed by this method is free from water

10 A patient's blood takes an unusually long time to clot after a small cut. Deficiency of which vitamin is the most likely cause?

(A) Vitamin A
(B) Vitamin B_{12}
(C) Vitamin C
(D) Vitamin K

11 The molar mass of ethanoic acid (CH_3COOH, 60 g mol^{-1}) found from the depression in freezing point is nearly 120 g mol^{-1} in benzene, but slightly less than 60 g mol^{-1} in water. This is because ethanoic acid:

(A) dissociates in benzene and associates in water
(B) associates (forms dimers) in benzene and dissociates slightly in water
(C) associates in both solvents
(D) reacts with benzene to form a heavier compound

12 For many reactions the rate constant nearly doubles for a 10 K rise in temperature. The main reason is that:

(A) the activation energy of the reaction decreases on heating
(B) the fraction of molecules having energy equal to or greater than the activation energy increases sharply
(C) the total number of collisions per second doubles
(D) the enthalpy change of the reaction becomes more negative

13 **Assertion (A):** On dilution, the molar conductivity of a weak electrolyte such as ethanoic acid increases steeply.
Reason (R): On dilution, the number of ions per unit volume of the solution increases.
Select the most appropriate answer from the options given below:

(A) Both A and R are true, and R is the correct explanation of A.
(B) Both A and R are true, but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

14 **Assertion (A):** The C–Cl bond length in chlorobenzene is shorter than that in chloromethane.
Reason (R): In chlorobenzene the carbon atom attached to chlorine is sp^2 hybridised.
Select the most appropriate answer from the options given below:

(A) Both A and R are true, and R is the correct explanation of A.
(B) Both A and R are true, but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

15 **Assertion (A):** Carboxylic acids do not give the characteristic reactions of the carbonyl group, such as the formation of oximes with hydroxylamine.
Reason (R): Carboxylic acids exist as hydrogen-bonded dimers in the vapour phase and in aprotic solvents.
Select the most appropriate answer from the options given below:

(A) Both A and R are true, and R is the correct explanation of A.
(B) Both A and R are true, but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

16 **Assertion (A):** All naturally occurring α-amino acids are optically active.
Reason (R): Most naturally occurring α-amino acids have the L-configuration.
Select the most appropriate answer from the options given below:

(A) Both A and R are true, and R is the correct explanation of A.
(B) Both A and R are true, but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

SECTION B Questions 17 to 21 are very short answer questions carrying 2 marks each. **[10]**

17 (A) (I) Write the IUPAC name of $[Pt(NH_3)_4(NO_2)Cl]SO_4$.
(II) Write the formula of tetraamminecopper(II) tetrachloridoplatinate(II). Name the type of isomerism it shows with $[Pt(NH_3)_4][CuCl_4]$.

OR

(B) (I) Low spin tetrahedral complexes are rarely observed. Give reason.
(II) Write the formula and the IUPAC name of the ionisation isomer of $[Pt(NH_3)_4Cl_2]Br_2$.

18 (I) Enzymes are needed only in very small amounts in the body. How does an enzyme increase the rate of a reaction? Name the enzyme that catalyses the hydrolysis of maltose and name the product.
(II) Thyroxine is a hormone produced in the thyroid gland. Of which amino acid is it a derivative? Why does a diet poor in iodine lead to enlargement of the thyroid gland, and how is this condition commonly prevented?

19 (I) Write the equation for the preparation of 2-fluoropropane from 2-bromopropane using silver fluoride. Name the reaction.
(II) Alkyl chlorides are made by replacing the –OH group of alcohols with HCl, but chlorobenzene cannot be prepared from phenol in this way. Why?

20 Write the chemical equations for the following and name the organic product formed:
(I) Phenol is treated with concentrated nitric acid.
(II) Salicylic acid (2-hydroxybenzoic acid) is treated with acetic anhydride in the presence of a few drops of conc. H_2SO_4.

21 (I) Write the equations for the preparation of propan-1-amine by the Gabriel phthalimide synthesis.
(II) Write the equation for the reaction of ethanamine with ethanoyl chloride. Why is this reaction carried out in the presence of pyridine?

SECTION C Questions 22 to 28 are short answer questions carrying 3 marks each. **[21]**

22 A cell is set up at 298 K as follows:

$Zn(s) \mid Zn^{2+}(0.10\ M) \mid\mid H^{+}(aq) \mid H_2(g, 1\ bar) \mid Pt(s)$

Its emf is found to be 0.6715 V.

Given: $E°(Zn^{2+}/Zn) = -0.76$ V, $2.303RT/F = 0.059$ V.

(I) Write the cell reaction.

(II) Calculate the pH of the solution in the hydrogen electrode compartment.

(III) The solution in the hydrogen electrode compartment is replaced by a solution of pH 3, everything else remaining the same. Calculate the new emf of the cell.

23 (I) Write the equation for the reaction of chlorobenzene with methyl chloride in the presence of anhydrous $AlCl_3$ and name the major product.

(II) Write the equation for the reaction that takes place when bromobenzene is treated with sodium metal in dry ether. Name the reaction and the product.

(III) Which of the two compounds, $C_6H_5CH(Cl)CH_3$ and $C_6H_5CH_2CH_2Cl$, undergoes S_N1 hydrolysis faster? Give reason.

24 An organic compound A (C_3H_8O) liberates hydrogen gas with sodium metal. It gives turbidity with Lucas reagent at room temperature, but not immediately. On oxidation with acidified potassium dichromate, A gives B (C_3H_6O), which gives a yellow precipitate with iodine and sodium hydroxide but does not reduce Tollens' reagent. When A is heated with concentrated phosphoric acid, it gives a gas C that decolourises bromine water.

Identify A, B and C. Write the equations for (i) the conversion of A into B, (ii) the conversion of A into C and (iii) the reaction of B with methylmagnesium bromide followed by hydrolysis.

25 A student crystallised glucose in two ways. From a concentrated solution at 303 K she obtained crystals melting at 419 K. From a hot saturated solution at 371 K she obtained crystals melting at 423 K.

(I) Name these two forms of glucose. What is the term used for such isomers, and at which carbon atom do they differ?

(II) Draw the Haworth structure of the form that melts at 423 K.

(III) Glucose is written as D-(+)-glucose. What do the symbols 'D' and '(+)' indicate?

26 Three isomeric amines P, Q and R have the molecular formula C_7H_9N, and each molecule contains a benzene ring.

• P reacts with nitrous acid at 273–278 K with brisk evolution of nitrogen gas and gives an alcohol of formula C_7H_8O.

• Q reacts with benzenesulphonyl chloride to give a product that is insoluble in aqueous KOH.

• R, whose $-CH_3$ group is para to the $-NH_2$ group, reacts with $NaNO_2$ and HCl at 273–278 K to give a diazonium salt that is stable at this temperature.

Identify P, Q and R and write one equation for the reaction of each described above.

27 (A) Write the main organic product and name the reaction in each of the following:

(I) $C_6H_6 + CO + HCl$ –(anhydrous $AlCl_3/CuCl$)→ ?

(II) $C_6H_5COONa + NaOH$ –(CaO, heat)→ ?

(III) $C_6H_5CHO + CH_3COCH_3$ (equimolar) –(dil. NaOH)→ ?

OR

(B) (I) Give a simple chemical test to distinguish between pentanal and pentan-3-one.

(II) Chloroethanoic acid is a stronger acid than ethanoic acid. Explain.

(III) Write the equation for the preparation of ethyl ethanoate from ethanoic acid. What is the role of concentrated H_2SO_4 in this reaction?

28 How will you bring about the following conversions? Write the chemical equations with reagents and conditions.

(I) 2-Bromopropane to 2-methylpropanoic acid

(II) Toluene to benzaldehyde (through side chain chlorination)

(III) Ethanoyl chloride to propanone

SECTION D Questions 29 and 30 are case-based questions carrying 4 marks each. **[8]**

29 **Electrolysis of brine in a chlor-alkali plant**

Chlor-alkali plants near Thane and in other industrial areas of India pass electricity through concentrated aqueous sodium chloride (brine). Three useful products are obtained: chlorine gas at the anode, hydrogen gas at the cathode, and sodium hydroxide, which collects in the solution. Chlorine is used to disinfect drinking water and to make PVC; sodium hydroxide is used in making soap, paper and textiles. In an electrolytic cell, the products depend on the species present and on their electrode potentials. Some processes, though feasible, are so slow that an extra potential, called overpotential, is needed.

(Given: $E°(Na^+/Na) = -2.71$ V, $E°(H^+/½H_2) = 0.00$ V, $E°(½Cl_2/Cl^-) = 1.36$ V, $E°(O_2, H^+/H_2O) = 1.23$ V; 1 F = 96500 C mol^{-1}; Na = 23, O = 16, H = 1, Cl = 35.5 g mol^{-1})

Answer the following questions:

(I) Hydrogen, and not sodium, is obtained at the cathode because:

(A) Na^+ ions move towards the anode

(B) reduction of H^+ (from water) has a much higher E° value than reduction of Na^+

(C) E° of Na^+/Na is more positive than that of $H^+/½H_2$

(D) hydrogen has a lower molar mass than sodium

(II) Going by the E° values (1.23 V is lower than 1.36 V), water should be oxidised at the anode more easily than Cl^- ions, yet chlorine and not oxygen is the main product. This is because of:

(A) the overpotential of oxygen

(B) the higher molar mass of chlorine

(C) the reaction of oxygen with sodium hydroxide

(D) the greater solubility of chlorine in brine

(IIIA) A current of 2.5 A is passed through brine for 64 minutes 20 seconds. Calculate the mass of chlorine liberated at the anode and the mass of sodium hydroxide formed.

OR

(IIIB) (a) What are the products at the cathode and at the anode when molten NaCl is electrolysed?

(b) What happens at the cathode and at the anode when aqueous $CuSO_4$ is electrolysed using copper electrodes?

30 **Why complexes of the same metal have different colours**

According to crystal field theory, in an octahedral complex the five d orbitals of the metal ion split into a lower set of three (t_{2g}) and a higher set of two (e_g) orbitals. The energy gap is the crystal field splitting energy, Δ_o. Ligands that cause a larger splitting are called strong field ligands. When white light falls on the complex, an electron jumps from a t_{2g} to an e_g orbital (d–d transition) by absorbing light whose energy equals Δ_o, and the complex shows the complementary colour. A larger Δ_o means light of higher energy, i.e. shorter wavelength, is absorbed. Students in a college laboratory recorded the following for two complexes of Cr^{3+} (Z of Cr = 24):

Complex	Light absorbed	Wavelength absorbed (approx.)	Colour seen
$[Cr(H_2O)_6]^{3+}$	yellow	575 nm	violet
$[Cr(NH_3)_6]^{3+}$	blue	465 nm	yellow

Answer the following questions using only the information and data given above:

(I) Which conclusion follows from the data?

(A) Δ_o for $[Cr(NH_3)_6]^{3+}$ is larger than for $[Cr(H_2O)_6]^{3+}$, so NH_3 is a stronger field ligand than H_2O.

(B) Δ_o for $[Cr(H_2O)_6]^{3+}$ is larger, so H_2O is a stronger field ligand.

(C) Both complexes have the same Δ_o, as both contain Cr^{3+}.

(D) The colour seen is the colour of the light absorbed.

(II) Which statement is true for **both** complexes in the table?

(A) Both are diamagnetic.

(B) Both have the configuration $t_{2g}^3 e_g^0$ with three unpaired electrons.

(C) $[Cr(NH_3)_6]^{3+}$ is low spin with one unpaired electron.

(D) $[Cr(H_2O)_6]^{3+}$ has two electrons in the e_g set.

(IIIA) Cr^{2+} forms $[Cr(H_2O)_6]^{2+}$ (H_2O weak field, $\Delta_o < P$) and $[Cr(CN)_6]^{4-}$ (CN^- strong field, $\Delta_o > P$). Write the t_{2g}/e_g configuration of the metal ion in each, and calculate the spin-only magnetic moment of each.

OR

(IIIB) (a) $[Co(NH_3)_6]^{3+}$ absorbs light of about 475 nm, while $[Co(NH_3)_5Cl]^{2+}$, in which one NH_3 is replaced by Cl^-, absorbs light of about 535 nm. What does this show about the field strength of Cl^- compared with NH_3? Explain.

(b) State one limitation of crystal field theory.

SECTION E Questions 31 to 33 are long answer questions carrying 5 marks each. **[15]**

31 (A) (I) 1.80 g of a non-volatile non-electrolyte X is dissolved in 50.0 g of water. The boiling point of water rises by 0.208 K. Calculate the molar mass of X. Also calculate the freezing point of this solution. (K_b of water = 0.52 K kg mol^{-1}, K_f of water = 1.86 K kg mol^{-1}, freezing point of water = 273.15 K)

(II) Two liquids A and B form a solution in which the A–B attractions are stronger than the A–A and B–B attractions. State (a) the type of deviation from Raoult's law, (b) the sign of $\Delta_{mix}H$, (c) the sign of $\Delta_{mix}V$, and (d) the type of azeotrope such a pair may form.

OR

(B) (I) Methanol and ethanol form a nearly ideal solution. At a certain temperature the vapour pressures of pure methanol and pure ethanol are 16.0 kPa and 8.0 kPa respectively, and a solution of the two has a vapour pressure of 12.8 kPa at the same temperature. Calculate (a) the mole fraction of methanol in the solution, (b) the mole fraction of methanol in the vapour in equilibrium with the solution and (c) the mass of methanol that must be mixed with 46.0 g of ethanol to make this solution. (C = 12, H = 1, O = 16 g mol^{-1})

(II) (a) A beaker of pure water and a beaker of sugar solution are kept side by side in a sealed glass chamber. After some days the level of water in the first beaker falls and the level of the sugar solution rises. Explain.

(b) Why are the tanks used by scuba divers filled with air diluted with helium?

32 (A) Answer the following:

(I) In the preparation of potassium permanganate, the green manganate ion (MnO_4^{2-}) disproportionates in a neutral or acidic solution. Write the balanced ionic equation for this change in acidic solution.

(II) Iron(III) ions catalyse the reaction between iodide and persulphate (peroxodisulphate) ions. Write the two steps that show how Fe^{3+} works as a catalyst.

(III) Transition metals readily form alloys with one another. Give reason.

(IV) Calculate the spin-only magnetic moment of Cu^{2+} (Z = 29).

(V) Chromium (Z = 24) has the configuration [Ar] $3d^5 4s^1$ and copper (Z = 29) has [Ar] $3d^{10} 4s^1$, instead of $3d^4 4s^2$ and $3d^9 4s^2$. Explain.

OR

(B) Answer the following:

(I) Write the equation for the decomposition of potassium permanganate on heating at 513 K.

(II) Why is it difficult to separate the lanthanoids from one another?

(III) Draw the structure of the dichromate ion, $Cr_2O_7^{2-}$.

(IV) Calculate the spin-only magnetic moment of Ti^{2+} (Z = 22).

(V) Complete and balance the following equation for the oxidation of a manganese(II) salt by peroxodisulphate in the laboratory:

$Mn^{2+} + S_2O_8^{2-} + H_2O \rightarrow$

33 (A) (I) In a textile-mill effluent treatment tank, a dissolved dye is bleached by first order kinetics. Its concentration is 0.80 mg L^{-1} two hours after the treatment starts and 0.20 mg L^{-1} six hours after the treatment starts. Calculate (a) the half-life, (b) the rate constant and (c) the concentration of the dye when the treatment started (t = 0). (Given: log 2 = 0.301, log 4 = 0.602)

(II) (a) The decomposition of ammonia on a hot platinum surface is a zero order reaction at high pressure. Explain.

(b) A reaction takes place in several steps. Which step decides the overall rate of the reaction, and what is it called?

OR

(B) (I) In a zero order reaction the concentration of the reactant falls from 0.90 mol L^{-1} to 0.60 mol L^{-1} in 25 minutes. Calculate (a) the rate constant, (b) the time taken for the concentration to fall from 0.90 mol L^{-1} to 0.30 mol L^{-1} and (c) the half-life of the reaction when the initial concentration is 0.90 mol L^{-1}.

(II) (a) According to collision theory, not every collision between molecules having energy equal to or more than the threshold energy forms products. Why?

(b) The rate constant of a first order reaction is 2.31×10^{-2} min^{-1}. Calculate its half-life.

All the best for your exam!