

SAMPLE PAPER (2023 -24)

CHEMISTRY THEORY (043)

Max. Marks:70

Time: 3 hours

General Instructions:

Read the following instructions carefully.

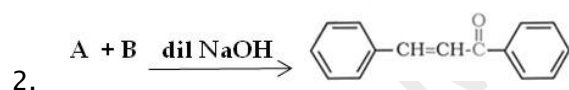
- There are 33 questions in this question paper with internal choice.
- SECTION A consists of 16 multiple-choice questions carrying 1 mark each.
- SECTION B consists of 5 short answer questions carrying 2 marks each.
- SECTION C consists of 7 short answer questions carrying 3 marks each.
- SECTION D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

SECTION A

The following questions are multiple-choice questions with one correct answer. Each question carries 1 mark. There is no internal choice in this section.

1. Which of the following solutions will have the highest conductivity at 298 K?

- | | |
|--|---|
| (a) 0.01 M HCl solution | (b) 0.1 M HCl solution |
| (c) 0.01 M CH ₃ COOH solution | (d) 0.1 M CH ₃ COOH solution |



Identify A and B:

- | | |
|---|--|
| (a) A = 1-phenylethanal, B = acetophenone | (b) A = Benzophenone, B = formaldehyde |
| (c) A = Benzaldehyde, B = Acetophenone | (d) A = Benzophenone, B = Acetophenone |
3. The vitamins which can be stored in our body are:
- | | |
|---------------------------|---------------------------|
| (a) Vitamin A, B, D and E | (d) Vitamin A, C, D and K |
| (c) Vitamin A, B, C and D | (d) Vitamin A, D, E and K |
4. What is IUPAC name of the ketone A, which undergoes iodoform reaction to give CH₃CH=C(CH₃)COONa and yellow precipitate of CHI₃?
- | | |
|-----------------------------|----------------------------|
| (a) 3-Methylpent-3-en-2-one | (b) 3-Methylbut-2-en-1-one |
| (c) 2, 3-Dimethylethanone | (d) 3-Methylpent-4-one |
5. Which of the following is not correct?

- (a) In haloarenes, the electron pairs on halogen atom are in conjugation with π -electrons of the ring.
- (b) The carbon-magnesium bond is covalent and non-polar in nature.
- (c) During S_N1 reaction, the carbocation formed in the slow step being sp^2 hybridised is planar.
- (d) Out of $CH_2=CH-Cl$ and $C_6H_5CH_2Cl$, $C_6H_5CH_2Cl$ is more reactive towards S_N1 reaction
6. Match the properties with the elements of 3d series:
- (i) lowest enthalpy of atomisation (p) Sc
- (ii) shows maximum number of oxidation states (q) Mn
- (iii) transition metal that does not form coloured compounds (r) Zn
- (s) Ti
- (a) (i) (r), (ii) (q), (iii) (p) (b) (i) (r), (ii) (s), (iii) (p)
- (c) (i) (p), (ii) (q), (iii) (r) (d) (i) (s), (ii) (r), (iii) (p)
7. Which of the following statement is true?
- (a) molecularity of reaction can be zero or a fraction.
- (b) molecularity has no meaning for complex reactions.
- (c) molecularity of a reaction is an experimental quantity
- (d) reactions with the molecularity three are very rare but are fast.
8. In which of the following solvents, the $C_4H_8NH_3^+X^-$ is soluble;
- (a) ether (b) acetone (c) water (d) bromine water
9. Which of the following observation is shown by 2-phenyl ethanol with Lucas Reagent?
- (a) Turbidity will be observed within five minutes
- (b) No turbidity will be observed
- (c) Turbidity will be observed immediately
- (d) Turbidity will be observed at room temperature but will disappear after five minutes.
10. If the initial concentration of substance A is 1.5 M and after 120 seconds the concentration of substance A is 0.75 M, the rate constant for the reaction if it follows zero-order kinetics is:
- (a) $0.00625 \text{ molL}^{-1}\text{s}^{-1}$ (b) 0.00625 s^{-1} (c) $0.00578 \text{ molL}^{-1}\text{s}^{-1}$ (d) 0.00578 s^{-1}
11. Anisole undergoes bromination with bromine in ethanoic acid even in the absence of iron (III) bromide catalyst
- (a) Due to the activation of benzene ring by the methoxy group.
- (b) Due to the de-activation of benzene ring by the methoxy group. (c) Due to the increase in electron density at ortho and para positions (d) Due to the formation of stable carbocation.
12. The trend of which property is represented by the following graph?

- (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. Given below are two statements labelled as Assertion (A) and Reason (R)

Assertion (A): During electrolysis of aqueous copper sulphate solution using copper electrodes hydrogen gas is released at the cathode.

Reason (R): The electrode potential of Cu^{2+}/Cu is greater than that of H^+/H_2

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

This section contains 5 questions with internal choice in one question. The following questions are very short answer type and carry 2 marks each.

17. a. Radioactive decay follows first – order kinetics. The initial amount of two radioactive elements X and Y is 1 gm each. What will be the ratio of X and Y after two days if their half-lives are 12 hours and 16 hours respectively?
- b. The hypothetical reaction $P + Q \rightarrow R$ is half order w.r.t 'P' and zero order w.r.t 'Q'. What is the unit of rate constant for this reaction?
18. A 5% solution of $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ (MW = 322) is isotonic with 2% solution of non-electrolytic, non-volatile substance X. Find out the molecular weight of X.
19. (a) Arrange the isomeric dichlorobenzene in the increasing order of their boiling point and melting points.
- b. Explain why the electrophilic substitution reactions in haloarenes occur slowly and require more drastic conditions as compared to those in benzene.
20. (a) Out of p-tolualdehyde and p-nitrobenzaldehyde, which one is more reactive towards nucleophilic addition reactions, why?
- b. Write the structure of the product formed when acetone reacts with 2,4 DNP reagent.

OR

Convert the following:

- (a) Benzene to m-nitrobenzaldehyde
- (b) Bromobenzene to benzoic acid
21. (a) DNA fingerprinting is used to determine paternity of an individual. Which property of DNA helps in the procedure?
- (b) What structural change will occur when a native protein is subjected to change in pH?

SECTION C

This section contains 7 questions with internal choice in one question. The following questions are short answer type and carry 3 marks each.

22. (a) Write the formula for the following coordination compound
Bis(ethane-1,2-diamine) dihydroxidochromium(III) chloride
- (b) Does ionization isomer for the following compound exist? Justify your answer. $\text{Hg}[\text{Co}(\text{SCN})_4]$
- (c) Is the central metal atom in coordination complexes a Lewis acid or a Lewis base? Explain.
23. (a) Can we construct an electrochemical cell with two half-cells composed of ZnSO_4 solution and zinc electrodes? Explain your answer.
- (b) Calculate the λ_m^0 for Cl^- ion from the data given below:

$$\Lambda^0_m \text{MgCl}_2 = 258.6 \text{ Scm}^2\text{mol}^{-1} \text{ and } \lambda^0_m \text{Mg}^{2+} = 106 \text{ Scm}^2\text{mol}^{-1}$$

- (c) The cell constant of a conductivity cell is 0.146 cm^{-1} . What is the conductivity of 0.01 M solution of an electrolyte at 298 K , if the resistance of the cell is 1000 ohm ?
24. Write the name of the reaction, structure and IUPAC name of the product formed when (any 2):
- phenol reacts with CHCl_3 in the presence of NaOH followed by hydrolysis.
 - $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}(\text{CH}_3)\text{ONa}$ reacts with $\text{C}_2\text{H}_5\text{Br}$
 - $\text{CH}_3\text{CH}_2\text{CN}$ reacts with stannous chloride in the presence of hydrochloric acid followed by hydrolysis
25. You are given four organic compounds "A", "B", "C" and "D". The compounds "A", "B" and "C" form an orange-red precipitate with 2,4 DNP reagent. Compounds "A" and "B" reduce Tollen's reagent while compounds "C" and "D" do not. Both "B" and "C" give a yellow precipitate when heated with iodine in the presence of NaOH . Compound "D" gives brisk effervescence with sodium bicarbonate solution. Identify "A", "B", "C" and "D" given the number of carbon atoms in three of these carbon compounds is three while one has two carbon atoms. Give an explanation for your answer.
26. When sucrose is hydrolysed the optical rotation values are measured using a polarimeter and are given in the following table:

S.No.	Time (hours)	Specific Rotation
1	0	$+ 66.5^\circ$
2	∞	-39.9°

- Account for the two specific rotation values.
 - What is the specific name given to sucrose based on the above observation?
 - One of the products formed during the hydrolysis of sucrose is a glucose, that reacts with hydroxylamine to give compound A. Identify compound A.
27. An organic compound A with the molecular formula $(+)\text{C}_4\text{H}_9\text{Br}$ undergoes hydrolysis to form $(+)\text{C}_4\text{H}_9\text{OH}$. Give the structure of A and write the mechanism of the reaction.
28. The rate constants of a reaction at 200K and 500K are 0.02s^{-1} and 0.20s^{-1} respectively. Calculate the value of E_a (Given $2.303R = 19.15 \text{ JK}^{-1}\text{mol}^{-1}$)

SECTION D

The following questions are case-based questions. Each question has an internal choice and carries 4 (1+1+2) marks each. Read the passage carefully and answer the questions that follow.

29. **Crystal field splitting by various ligands**

Metal complexes show different colours due to d-d transitions. The complex absorbs light of specific wavelength to promote the electron from t_{2g} to e_g level. The colour of the complex is due to the transmitted light, which is complementary of the colour absorbed.

The wave number of light absorbed by different complexes of Cr ion are given below:

Complex	Wavenumber of light absorbed (cm ⁻¹)	Energy of light absorbed (kJ/mol)
[CrA ₆] ³⁻	13640	163
[CrB ₆] ³⁺	17830	213
[CrC ₆] ³⁺	21680	259
[CrD ₆] ³⁻	26280	314

Answer the following questions:

(a) Out of the ligands “A”, “B”, “C” and “D”, which ligand causes maximum crystal field splitting? Why?

OR

Which of the two, “A” or “D” will be a weak field ligand? Why?

(b) Which of the complexes will be violet in colour? [CrA₆]³⁻ or [CrB₆]³⁺ and why? (Given: If 560 – 570 nm of light is absorbed, the colour of the complex observed is violet.)

(c) If the ligands attached to Cr³⁺ ion in the complexes given in the table above are water, cyanide ion, chloride ion, and ammonia (not in this order)

Identify the ligand, write the formula and IUPAC name of the following:

(i) [CrA₆]³⁻ (ii) [CrC₆]³⁺

30. The lead-acid battery represents the oldest rechargeable battery technology. Lead acid batteries can be found in a wide variety of applications including small-scale power storage such as UPS systems, ignition power sources for automobiles, along with large, grid-scale power systems. The spongy lead act as the anode and lead dioxide as the cathode. Aqueous sulphuric acid is used as an electrolyte. The half-reactions during discharging of lead storage cells are: Anode: $\text{Pb(s)} \rightarrow \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{PbSO}_4(\text{s}) + 2\text{e}^-$

Cathode: $\text{PbO}_2(\text{s}) + 4\text{H}^+(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) + 2\text{e}^- \rightarrow \text{PbSO}_4(\text{s}) + 2\text{H}_2\text{O}$

There is no safe way of disposal and these batteries end – up in landfills. Lead and sulphuric acid are extremely hazardous and pollute soil, water as well as air. Irrespective of the environmental challenges it poses, lead-acid batteries have remained an important source of energy.

Designing green and sustainable battery systems as alternatives to conventional means remains relevant. Fuel cells are seen as the future source of energy. Hydrogen is considered a green fuel. Problem with fuel cells at present is the storage of hydrogen. Currently, ammonia and methanol are being used as a source of hydrogen for fuel cell. These are obtained industrially, so add to the environmental issues.

If the problem of storage of hydrogen is overcome, is it still a “green fuel?” Despite being the most abundant element in the Universe, hydrogen does not exist on its own so needs to be extracted from the water using electrolysis or separated from carbon fossil fuels. Both of these processes require a significant amount of energy which is currently more than that gained from the hydrogen itself. In addition, this extraction typically requires the use of fossil fuels. More research is being conducted in this field to solve these problems. Despite the problem of no good means to extract Hydrogen, it is a uniquely abundant and renewable source of energy, perfect for our future zero-carbon needs.

Answer the following questions:

- How many coulombs have been transferred from anode to cathode in order to consume one mole of sulphuric acid during the discharging of lead storage cell?
- How much work can be extracted by using lead storage cell if each cell delivers about 2.0 V of voltage? ($1 F = 96500 C$)
- Do you agree with the statement – “Hydrogen is a green fuel.” Give your comments for and against this statement and justify your views.

OR

Imagine you are a member of an agency funding scientific research. Which of the following projects will you fund and why?

- safe recycling of lead batteries
- extraction of hydrogen

SECTION E

The following questions are long answer type and carry 5 marks each. All questions have an internal choice.

31. Attempt **any five** of the following:

- Which of the following ions will have a magnetic moment value of 1.73 BM.
 Sc^{3+} , Ti^{3+} , Ti^{2+} , Cu^{2+} , Zn^{2+}
- In order to protect iron from corrosion, which one will you prefer as a sacrificial electrode, Ni or Zn? Why? (Given standard electrode potentials of Ni, Fe and Zn are $-0.25 V$, $-0.44 V$ and $-0.76 V$ respectively.)
- The second ionization enthalpies of chromium and manganese are 1592 and 1509 kJ/mol respectively. Explain the lower value of Mn.
- Give two similarities in the properties of Sc and Zn.
- What is actinoid contraction? What causes actinoid contraction?
- What is the oxidation state of chromium in chromate ion and dichromate ion?
- Write the ionic equation for reaction of KI with acidified $KMnO_4$.

32. (a) What is the effect of temperature on the solubility of glucose in water?

- (b) Ibrahim collected a 10mL each of fresh water and ocean water. He observed that one sample labeled "P" froze at 0 °C while the other "Q" at -1.3°C. Ibrahim forgot which of the two, "P" or "Q" was ocean water. Help him identify which container contains ocean water, giving rationalization for your answer.
- (c) Calculate Van't Hoff factor for an aqueous solution of $K_3 [Fe(CN)_6]$ if the degree of dissociation (α) is 0.852. What will be boiling point of this solution if its concentration is 1 molal? ($K_b=0.52 \text{ K kg/mol}$)

OR

- (a) What type of deviation from Rault's Law is expected when phenol and aniline are mixed with each other? What change in the net volume of the mixture is expected? Graphically represent the deviation.
- (b) The vapour pressure of pure water at a certain temperature is 23.80 mm Hg. If 1 mole of a non-volatile non-electrolytic solute is dissolved in 100g water, Calculate the resultant vapour pressure of the solution.
33. An organic compound with molecular formula $C_7H_7NO_2$ exists in three isomeric forms, the isomer 'A' has the highest melting point of the three. 'A' on reduction gives compound 'B' with molecular formula C_7H_9N . 'B' on treatment with $NaNO_2/HCl$ at 0-5 °C to form compound 'C'. On treating C with H_3PO_2 , it gets converted to D with formula C_7H_8 , which on further reaction with CrO_2Cl_2 followed by hydrolysis forms 'E' C_7H_6O . Write the structure of compounds A to E. Write the chemical equations involved.

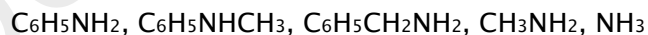
OR

(a) Account for the following:

- (i) N-ethylbenzenesulphonyl amide is soluble in alkali .
- (ii) Reduction of nitrobenzene using Fe and HCl is preferred over Sn and HCl.

(b) Arrange the following in:

(i) decreasing order of pK_b values



(ii) increasing order of solubility in water



(iii) decreasing boiling point

