CHEMISTRY (Theory)

Time allowed : 3 hours *Maximum Marks : 70*

GENERAL INSTRUCTIONS :

(i) All questions are compulsory.

(ii) Marks for each question are indicated against it.

(iii) Question numbers 1 to 5 are very short-answer, carrying 1 mark each. Answer these in one word or about one-sentence each.

(iv) Question numbers 6 to 12 are short-answer, carrying 2 marks each. Answer these in about 30 words each.

(v) Question numbers 13 to 24 are short-answer questions of 3 marks each. Answer these in about 40 words each.

(vi) Question numbers 25 and 27 are long-answer questions of 5 marks each. Answer these in about 70 words each.

(vii) Use Log Tables, if necessary. Use of calculators is not permitted.

QUESTION PAPER CODE 56/1/1

1. What is the maximum possible corrdination number of an atom in an hcp crystal structure of an element ? 1

2. State the formula relating pressure of a gas with its mole fraction in a liquid solution in contact with it. 1

3. Express the relation between the half-life period of a reactant and its initial concentration if the reaction involved is of second order. 1

4. How are formalin and trioxane related to methanal ? 1

5. Why are primary amines higher boiling than tertiary amines ? 1

6. Show that the Heisenberg Uncertainty Principle is of negligible significance for an object of $10^{-6}\,kg$ mass. $(\frac{h}{4\pi} = 0.528\times10^{-34}\,kg\ m^2s^{-1})$ 2

OR

On the basis of Heisenberg Uncertainty Principle show that electron $(mass = 9\times10^{-31}\,kg)$ cannot exist within an atomic nucleus of radius 10^{-15} m. $(\frac{h}{4\pi} = 0.528\times10^{-34}\,kg\ m^2s^{-1})$

7. On the basis of the following $\Delta_r G°$ values at 1073 K :

$$S_2(s) + 2\,O_2\,(g) \rightarrow 2\,SO_2(g);\ \Delta_r G° = -544\ kJ\ mol^{-1}$$

$$2\,Zn\,(s) + O_2\,(g) \rightarrow 2\,ZnO\,(s);\ \Delta_r G° = -480\ kJ\ mol^{-1}$$

$$2\,Zn\,(s) + S_2\,(s) \rightarrow 2\,ZnS\,(s);\ \Delta_r G° = -293\ kJ\ mol^{-1}$$

Show that the roasing of zinc sulphide to form zinc oxide is a spontaneous process. 2

8. Write one chemical reaction each to show that
   (i) Tin (II) chloride is a reducing agent.
   (ii) Chlorine gas can be obtained from bleaching powder. 2

9. Describe the steps involved in the preparation of either potassium dichromate from sodium chromate **or** potassium permanganate from manganese dioxide. 2

10. What are enantiomers and diastereomers ? Differentiate between chiral and achiral molecules. 2

11. Give an illustration of Reimer-Tiemann reaction. 2

12. How is bakelite made and what is its major use ? Why is bakelite a thermosetting polymer ? 2

13. (a) What is meant by linear combination of atomic orbitals ?

    (b) Illustrate bonding and antibonding molecular orbitals based on homonuclear dihydrogen molecule. 3

OR

What kinds of molecular forces are expected to exist between the species in any three of the following pairs constituting mixtures ?

(i) He and N_2
(ii) Cl_2 and NO_3^-
(iii) NH_3 and CO_2
(iv) H_2S and HBr

14. Aluminium metal forms a cubic close-packed crystal structure. Its atomic radius is 125×10^{-12} m.
   (a) Calculate the length of the side of the unit cell.
   (b) How many such unit cells are there in 1.00 m^3 of aluminium ? 3

15. A solution is made by dissolving 30 g of a non-volatile solute in 90 g of water. It has a vapour pressure of 2.8 kPa at 298 K. At 298 K, vapour pressure of pure water is 3.64 kPa. Calculate the molar mass of the solute. 3

16. Comment on the validity of the following statements, giving reasons : 3

(i) Thermodynamically an exothermic reaction is sometimes not spontaneous.

(ii) The entropy of steam is more than that of water at its boiling point.

(ii) The equilibrium constant for a reaction is one or more if $\Delta_r G°$ for it is less than zero.

17. A first order reaction takes 69.3 minutes for 50% completion. Set up an equation for determining the time needed for 80% completion of this reaction.
(Calculation of result is not required) 3

18. Illustrate with examples : 3

(i) Lyophilic and Lyophobic sols

(ii) Multimolecular and Macromolecular colloids

(iii) Homogeneous and Heterogeneous catalysis

19. The E° values in respect of electrodes of chromium (Z = 24), manganese (Z = 25) and iron (Z = 26) are :

$$Cr^{3+}/Cr^{2+} = -0.4V; \quad Mn^{3+}/Mn^{2+} = +1.5V; \quad Fe^{3+}/Fe^{2+} = +0.8V$$

On the basis of the above information compare the feasibilities of further oxidation of their +2 oxidation states. 3

20. Draw a sketch to show the splitting of d-orbitals in an octahedral crystal field. State for a d^6 ion how the actual configuration of the split d-orbitals in an octahedral crystal field is decided by the relative values of Δ_0 and P. 3

21. (a) Write the structural formula of 3-phenylprop-2-enal.

(b) Write one chemical equation each to illustrate the following reactions :

(i) Aldol condensation

(ii) Cannizzaro's reaction 3

22. (a) Assign a reason for each of the following statements :

(i) Alkylamines are stronger bases than arylamines.

(ii) Acetonitrile is preferred as solvent for carrying out several organic reactions.

(b) How would you convert methylamine into ethylamine ? 3

23. When the nuclides $^{27}_{13}Al$, $^{24}_{12}Mg$ and $^{27}_{14}Si$ are separately subjected to (α, n) nuclear reactions, three separate new nuclides are produced, each of which further undergoes one positron emission finally giving stable nuclei. Write the nuclear equations for the reactions involved in these cases. 3

24. (a) State the function along with one example each of :

(i) Antihistamines

(ii) Antioxidants

(b) What are hybrid propellants ? 3

25. (a) Define electrical conductivity and molar conductivity of a solution and write the units of molar conductivity.

(b) The E° values correspoinding to the following two reduction electrode processes are :

(i)

(ii) $Cu^{2+}/Cu^{+} = +0.16\ V$

Formulate the galvanic cell for their combination. What will be the standard cell potential for it ? Calculate $\Delta_r G°$ for the cell reaction .

(F = 96500 C mol^{-1}) 2, 3

OR

(a) In the button cell, widely used in watches and other devices, the following reaction takes place :

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

Determine E° and $\Delta_r G°$ for the reaction. $Cu^{+}/Cu = +0.52\ V$

Given $E°_{Ag^{+}/Ag} = 0.80\ V$, $E°_{Zn^{2+}/Zn} = -0.76\ V$

(b) Explain with examples the terms weak and strong electrolytes. How can these be distinguished ?

26. (a) Assign an appropriate reason for each of the following statements :

(i) SiF_6^{2-} is known but $SiCl_6^{2-}$ is not known.

(ii) More metal fluorides are ionic in nature than metal chlorides.

(iii) Solid phosphorus pentachloride exhibits some ionic character.

(b) Write the structural formulae for the following :

(i) BrF_3

(ii) $XeOF_4$ 3, 2

OR

(a) Assign a reason for each of the following :

(i) In group 14 the tendency for catenation decreases with increasing atomic numbers.

(ii) In group 15 the bond angle H—M—H decreases in the following order

NH_3 (107.8°), PH_3 (93.6°), AsH_3 (91.8°)

(iii) Sulphur hexafluoride is used as a gaseous electrical insulator.

(b) Complete the following reaction equations :

(i) $R_2SiCl_2 + H_2O \rightarrow$

(ii) $XeF_4 + H_2O \rightarrow$ 3, 2

27. (a) Write chemical equations for the reactions of glucose with

(i) acetic anhydride and

(ii) ammoniacal silver nitrate solution.

(b) Draw simple Fischer projections of D-glucose and L-glucose.

(c) What do you understand by replication by DNA ? How does DNA differ from RNA structurally ? 2, 1, 2

OR

(a) Write the following about protein synthesis :

(i) Name the location where protein synthesis occurs.

(ii) How do 64 codons code for only 20 amino acids ?

(iii) Which of the two bases of the codon are most important for coding ?

(b) What deficiency diseases are caused due to lack of vitamins A, B, B_6 and K in human diet ? 3, 2

QUESTION PAPER CODE 56/1

1. How many atoms can be assigned to its unit cell if an element forms (i) a body centred cubic cell, and (ii) a face centred cubic cell ? 1

2. What would be the value of Van't Hoff factor for a dilute solution of K_2SO_4 in water ? 1

3. Express the relation between the half-life period of a reactant and its initial concentration for a reaction of n^{th} order. 1

4. Mention a chemical property in which methanoic acid differs from acetic acid. 1

5. How is the basic strength of aromatic amines affected by the presence of an electron releasing group on the benzene ring ? 1

6. State the de Broglie relationship. How do de Broglie waves of a moving particle differ from electromagnetic waves ? 2

OR

Show that the uncertainty principle is of little significance for an object of mass 10^{-3} g. $(\frac{h}{4\pi} = 0.527 \times 10^{-34}\ kg\ m^2\ s^{-1})$

7. Predict the products of electrolysis obtained at the electrodes in each case when the electrodes used are of platinum : 2

(i) An aqueous solution of $AgNO_3$.

(ii) An aqueous solution of H_2SO_4.

8. State the basic reason for each of the following statements : 2

(i) InCl undergoes disproportionation reaction but TICI does not.

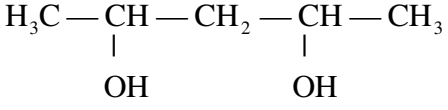
(ii) $AlCl_3$ acts as a Lewis acid.

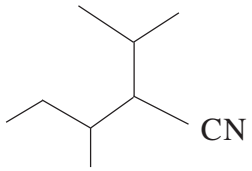
9. Write chemical equations for the following reactions : 2

(i) $Ca_3(PO_4)_2 + SiO_2 + C \rightarrow$

(ii) $XeF_6 + H_2O \rightarrow$

10. Identify and mark the presence of centres of chirality, if any, in the following molecules. Mention the number of stereoisomers possible in each case. 2

(i) 

(ii) 

11. Explain how an OH group attached to a carbon in the benzene ring activates benzene towards electrophilic substitution. 2

12. How are polymers classified on the basis of forces operating between their molecules? To which of these classes does nylon-66 belong ? 2

13. (a) Use the LCAO method for the formation of molecular orbitals in case of homonuclear diatomic hydrogen molecule.

(b) Which of the following has higher bond dissociation energy and why ?

(i) N_2^+ or (ii) O_2^+ 3

OR

What kinds of molecular forces exist between the species in the following pairs of particles and why ?

(i) He and N_2

(ii) Cl_2 and NO_3^-

(iii) NH_3 and CO

14. Aluminium crystallises in a face centred cubic close-packed structure. Its atomic radius is 125×10^{-12} m.

(a) What is the length of the edge of the unit cell ?

(b) How many such unit cells are there in a 1.00 m^3 piece of aluminium ? 3

15. State Henry's law for solubility of gas in a liquid. Explain the significance of Henry's law constant (K_H). At the same temperature, hydrogen is more soluble in water than helium. Which of them will have a higher value of K_H and why ? 3

16. The activation energy of a reaction is $75.2\ kJ\ mol^{-1}$ in the absence of a catalyst and $50.14\ kJ\ mol^{-1}$ with a catalyst. How many times will the rate of reaction grow in the presence of the catalyst if the reaction proceeds at 25°C ?
$(R = 8.314\ J\ K^{-1}\ mol^{-1})$ 3

17. How do size of particles of adsorbent, pressure of gas and prevailing temperature influence the extent of adsorption of a gas on a solid ? 3

18. (a) Write the structural formula of hex-2-en-4-ynoic acid.

(b) To illustrate the following reactions write one chemical equation for each :

(i) Cross aldol condensation

(ii) Hofmann bromamide reaction 3

19. Write the chemical reaction equation stating the reaction conditions required for each of the following conversions : 3

(i) Methyl bromide to ethyl amine

(ii) Aniline to phenol

(iii) p-toluidine to 2-bromo-4-methylaniline

20. (a) Write the corresponding chemical reaction equation to show that

(i) PbO_2 can act as an oxidising agent.

(ii) All the bonds in a molecule of PCl_5 are not equivalent.

(b) Write the structural formula for either XeF_2 ***or*** IF_3. 3

21. Draw a sketch to show the splitting of d-orbitals in an octahedral crystal field. State clearly how the actual configuration in split d-orbitals in an octahedral crystal field is decided by the magnitudes of Δ_0 and P values. 3

22. The E° values at 298 K corresponding to the following two reduction electrode processes are :

(i) $Cu^{+} / Cu = +0.52$ V

(ii) $Cu^{2+} / Cu^{+} = +0.16$ V

Formulate the galvanic cell for their combination. What will be the cell potential ? Calculate the $\Delta_r G°$ for the cell reaction. $(F = 96500 \text{ C mol}^{-1})$ 3

23. The radioactive isotope $^{60}_{27}Co$, can be made by an (n, p) or an (n, γ) nuclear reaction. State the appropriate target nucleus for each reaction. If the half-life of is 7 years, how long will it take for complete annihilation and why ? 3

24. Describe the following with an example each : 3

(i) Antimicrobials

(ii) Acid dyes

(iii) Antioxidants

25. (a) The standard Gibbs energy change values $(\Delta_r G°)$ at 1773 K are given for the following reactions : $^{60}_{27}Co$

$$4\,Fe + 3\,O_2 \rightarrow 2\,Fe_2\,O_3; \quad \Delta_r G° = -1487 \text{ kJ mol}^{-1}$$

$$4\,Al + 3\,O_2 \rightarrow 2\,Al_2\,O_3; \quad \Delta_r G° = -22500 \text{ kJ mol}^{-1}$$

$$2\,CO + O_2 \rightarrow 2\,CO_2; \quad \Delta_r G° = -515 \text{ kJ mol}^{-1}$$

Find out the possibility of reducing Fe_2O_3 and Al_2O_3 with CO at this temperature.

(b) Comment on the following statements giving reasons :

(i) An exothermic reaction is sometimes not spontaneous.

(ii) Reactions with $\Delta_r G°$ value less than zero always have equilibrium constants greater than 1. 5

OR

(a) The half-reactions are

(i) $Fe^{3+} + e^{-} \rightarrow Fe^{2+}, \; E° = 0.76$ V

(ii) $Ag^{+} + e^{-} \rightarrow Ag, \quad E° = 0.80$ V

Calculate Kc for the following reaction at 25° C:

$$Ag^{+} + Fe^{2+} \rightarrow Fe^{3+} + Ag$$

$(F = 96500 \text{ C mol}^{-1})$

(b) Define the following terms :

(i) Isothermal and Adiabatic processes

(ii) State variables/State functions

26. (a) Given below are the electrode potential values, E° for some of the first row of transition elements :

Element →	V(23)	Cr(24)	Mn(24)	Fe(26)	Co(27)	Ni(28)	Cu(29)
	−1.18	0.91	1.18	0.44	0.28	0.25	+0.34

Explain the irregularities in these values on the basis of electronic structures of atoms.

(b) Complete the following reaction equations :

(i)

(ii) $MnO_4^- + Fe^{2+} + H^+ \rightarrow$ 5

OR

(a) How would you account for the following :

(i) Cobalt (II) is stable in aqueous solution but in the presence of complexing reagents it is easily oxidised.

(ii) The transition elements exhibit high enthalpy of atomization.

(iii) Of the d^4 species, Cr^{2+} is strongly reducing while Mn (III) is strongly oxidising.

(b) Name the chief ore of copper and write the reactions involved in its extraction from that ore.

27. (a) Write the chemical reactions of glucose with (i) NH_2OH and (ii) $(CH_3CO)_2O$. Also draw simple Fischer projections of D-glucose and L-glucose.

(b) Name the food sources and the deficiency diseases caused due to lack of any two of vitamins A, C, E and K. 5

OR

(a) State the composition and functional differences between DNA and RNA. Describe the mechanism of replication of DNA.

(b) Define 'mutation'.

Marking Scheme— Chemistry

General Instructions :

1. The Marking Scheme provides general guidelines to reduce subjectivity in the marking. The answers given in the marking Scheme are suggested answers. The content is thus indicative. If a student has given any other answer which is different from the one given in the Marking Scheme, but conveys the same meaning, such answers should be given full weightage.
2. Evaluation is to be done as per instructions provided in the marking scheme. It should not be done according to one's own interpretation or any other consideration — Marking Scheme should be strictly adhered to and religiously followed.
3. If a question has parts, please award marks in the right hand side for each part. Marks awarded for different parts of the question should then be totalled up and written in the left hand margin and circled.
4. If a question does not have any parts, marks be awarded in the left-hand margin.
5. If a candidate has attempted an extra question, marks obtained in the question attempted first should be retained and the other answer should be scored out.
6. No marks to be deducted for the cumulative effect of an error. It should be penalized only once.
7. A full scale of marks 0-100 has to be used. Please do not hesitate to award full marks if the answer deserves it.

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EXPECTED ANSWERS/VALUE POINTS

1. 12 — 1

2. $p = K_H.x$
   p = partial pressure; x = mole fraction. (not essentional) — 1

3. $t_{½} \alpha 1/[R]_0$ — 1

4. 40% solution of methanal is called formalin.
   Trimer of methanal is called trioxane.
   [A dilute solution only not to be accepted] — ½ + ½

5. Because of H-bonding. — 1

6. If uncertainty Principle is applied to an object of mass 1 milligram or 10^{-6} kg, then

$$\Delta v.\Delta x = \frac{h}{4\pi m}$$ ½

$$= \frac{0.528\times10^{-34}\text{ kg m}^2\text{s}^{-1}}{10^{-6}\text{ kg}}$$ ½

$$= 0.528\times10^{-28}\text{ m}^2\text{s}^{-1}$$ ½

The value $\Delta v.\Delta x$ obtained is extremely small and therefore of no real significance. ½

OR

The radius of atomic nucleus is therefore the uncertainty in its position $(\Delta x) = 10^{-15}$ m

According to uncertainty principle

$$\Delta x.m\Delta v = \frac{h}{4\pi}, \text{ mass of electron} = 9.1\times10^{-31}\text{ kg}$$ ½

$$\Delta v = \frac{0.528\times10^{-34}\text{ Js}}{(9.1\times10^{-31}\text{ kg})\times10^{-15}\text{ m}}$$ ½

$= 5.9\times10^{10}\text{ ms}^{-1}$ 10^{-15} m, ½

Thus if electron is to exist in the atomic nucleus its velocity would be about 200 times the velocity of light. Since no particle can have a velocity greater than light, electron cannot exist in the nucleus. ½

7. Roasting of ZnS occurs as follows :

$$2\,ZnS + 3\,O_2 \rightarrow 2\,ZnO + 2\,SO_2$$ ½

For this reaction $\Delta_r G°$ is calculated as below

$$\Delta_r G° = \sum \Delta_f G°(\text{products}) - \sum \Delta_f G°(\text{reactants})$$

$$= \{-480 + (-544) - (-293)\}\text{ kJ mol}^{-1}$$

$$= -1024 + 293 = -731\text{ kJ mol}^{-1}$$ 1

Since $\Delta_r G°$ for roasting reaction is negative, it is a spontaneous process. ½

8. (i) $SnCl_2$ can reduce $HgCl_2$ e.g.,

$SnCl_2 + 2\,HgCl_2 \rightarrow SnCl_4 + Hg_2Cl_2$ (or any other equation) 1

(ii) $CaOCl_2 + 2\,HCl \rightarrow CaCl_2 + 2Cl_2 + H_2O$

(Full credit for correct reactants and products) 1

9. (i) Na_2CrO_4 on being acidified gives $Na_2Cr_2O_7$

$$2\,Na_2CrO_4 + 2H^+ \rightarrow Na_2Cr_2O_7 + 2Na^+ + H_2O$$ 1

From the solution, sodium dichromate can be crystallized, its solution is then treated with KCl.

$$Na_2Cr_2O_7 + 2KCl \rightarrow K_2Cr_2O_7 + 2NaCl$$ 1

$K_2Cr_2O_7$ being less soluble can be crystallized out from the solution.

(ii) $KMnO_4$ from MnO_2

$$2MnO_2 + 4KOH + O_2 \rightarrow 2K_2MnO_4 + 2H_2O$$ 1

$$2MnO_4^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O$$ 1

OR

$$MnO_2 \xrightarrow{\text{Fuse with KOH, oxidize with air or } KNO_3} MnO_4^{2-}$$ 1

Manganate

$$MnO_4^{2-} \xrightarrow{\text{electroytic oxidation in alkaline solution}} MnO_4^-$$ 1

permanganate

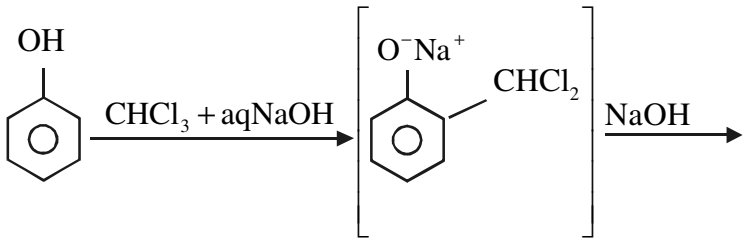
10. (a) **Enantiomers** : The stereoisomers related to each other as non-superimposable mirror images are called enantiomers. ½

(b) **Diastereomers** : The stereoisomers which are not mirror images of each other are called diastereomers. ½

(c) Those molecules which are non- superimposable on their mirror images are said to be Chiral, while the molecules which are superimposable on their mirror images are achiral. **OR a difference based on symmetry may also be accepted.** ½ + ½

11. On treating phenol with chloroform in the presence of sodium hydroxide, a – CHO group is introduced at ortho position of benzene ring.

This reaction is known as Reimer-Tiemann reaction.



Intermediate