

CHEMISTRY - I
(CHM 1001)

Time Allotted : 2½ hrs

Full Marks : 60

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group - A

1. Answer any twelve:

12 × 1 = 12

Choose the correct alternative for the following

- (i) Which of the following is always true for a spontaneous change at any temperature?
(a) $\Delta H < 0$ and $\Delta S > 0$ (b) $\Delta H < 0$ and $\Delta S < 0$
(c) $\Delta H > 0$ and $\Delta S < 0$ (d) $\Delta H > 0$ and $\Delta S > 0$.
- (ii) Joule-Thomson effect is related to
(a) Adiabatic compression (b) Adiabatic expansion
(c) Isothermal expansion (d) Isothermal compression.
- (iii) Which is the correct order of electronegativity along a group?
(a) $\text{Li} < \text{Na} < \text{K} < \text{Rb} < \text{Cs}$ (b) $\text{Li} < \text{K} < \text{Na} < \text{Rb} < \text{Cs}$
(c) $\text{Li} > \text{Na} > \text{K} > \text{Rb} > \text{Cs}$ (d) $\text{Li} > \text{Na} > \text{K} = \text{Rb} > \text{Cs}$.
- (iv) An electrochemical cell can behave like an electrolytic cell when
(a) $E_{\text{cell}} = 0$ (b) $E_{\text{cell}} > E_{\text{ext}}$
(c) $E_{\text{ext}} > E_{\text{cell}}$ (d) $E_{\text{cell}} = E_{\text{ext}}$
- (v) Which of the following electromagnetic radiations has the highest wavelength?
(a) Radio wave (b) Infrared (c) Ultraviolet (d) Gamma rays.
- (vi) (2R, 4S)-2,4-dichloropentane and (2R, 4R)-2,4-dichloropentane are
(a) Enantiomers (b) Diastereomers
(c) Identical (d) None of these.
- (vii) Which of the following elements has the highest electron affinity?
(a) $[\text{Ne}] 3s^2 3p^3$ (b) $[\text{Ne}] 3s^2 3p^4$ (c) $[\text{Ne}] 3s^2 3p^5$ (d) $[\text{Ne}] 3s^1 3p^3$.
- (viii) The probability of finding an electron inside nucleus of an atom must be
(a) zero (b) unity (c) infinity (d) double.
- (ix) The element of symmetry which is NOT present in CH_4 is?
(a) Rotational axis of symmetry (b) Plane of symmetry
(c) Centre of symmetry (d) Alternating axis of symmetry.

- (x) An electrophile must possess
 (a) Lone pair of electrons (b) Negative charge
 (c) Vacant orbital (d) None of these.

Fill in the blanks with the correct word

- (xi) The negative E° values indicate that the concerned reactions are _____.
- (xii) The numerical value of magnetic quantum number corresponding to p_x orbital is _____.
- (xiii) The state of hybridization of oxygen in H_2O is _____.
- (xiv) Optically active compounds in their 50% d/l mixture will be optically _____.
- (xv) When 2-bromobutane is treated with ethanolic KOH, the major product will be _____.

Group - B

2. (a) What is the relation between enthalpy and internal energy? A sample of a gas initially at $25^\circ C$ is compressed from 50 litre to 5 litre adiabatically and reversibly. Calculate the final temperature ($C_v = 10 \text{ cal mol}^{-1}$). [CO3/LOCQ]
- (b) Prove that the Joule-Thomson effect is isoenthalpic in nature. [CO4/IOCQ]
- (c) Calculate the standard cell potentials of a galvanic cell in which the following reaction takes place
 $2Cr(s) + 3Cd^{2+}(aq) \longrightarrow 2Cr^{3+}(aq) + 3Cd$. Calculate the ΔG° of the reaction. (Given: $E^\circ_{Cr^{3+}/Cr} = -0.74 \text{ V}$ & $E^\circ_{Cd^{2+}/Cd} = -0.40 \text{ V}$). [CO1/IOCQ]
- (d) What is the difference between Galvanic and Electrolytic Cells? What is the purpose of using Nafion membrane in H_2-O_2 fuel cell operating in acid environment? [CO2/LOCQ]
- (1 + 2) + 3 + 3 + (1 + 2) = 12**

3. (a) Show four steps of a Carnot engine in P – V graph, write the equation in each operation / step and obtain the total work done by the system in a cycle. [CO4/LOCQ]
- (b) Determine ΔH_{vap} for a substance that has a measured vapor pressure of 24.3 torr at 273 K and 135 torr. at 325 K. [CO1/IOCQ]
- (c) Consider the cell reaction $Zn + 2Ag^{+2} \rightarrow Zn^{+2} + 2Ag$. Represent the cell configuration & find out the E°_{cell} (given that, $E^\circ_{Zn^{2+}/Zn} = 0.76 \text{ V}$ & $E^\circ_{Ag^+/Ag} = 0.80 \text{ V}$). [CO2/IOCQ]
- (d) What is electrochemical corrosion? Write the electrode and electrolytic components of lead acid storage cell. [CO2/LOCQ]
- 3 + 3 + 3 + (1 + 2) = 12**

Group - C

4. (a) Draw the structure of XeF_2 molecule and mention the state of hybridization of the central atom. [CO3/LOCQ]

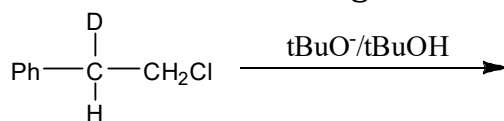
- (b) Write down the differences between the bonding and antibonding molecular orbitals. [C03/LOCQ]
- (c) What do you understand by forbidden energy gap? Explain how the conductivity of a semiconductor varies with increasing temperature. [C02/IOCQ]
- (d) Find the screening constant and effective nuclear charge of a d-electron of Mn [Z=25] atom. [C04/LOCQ]
- (e) Arrange the hydrogen atoms of the following compounds in the order of decreasing acidity.
C₂H₆, C₂H₄, C₂H₂ — Give reasons. [C03/LOCQ]
- 2 + 2 + 3 + 2 + 3 = 12**
5. (a) Draw the MO energy level diagram of O₂ molecule. Write its electronic configuration and calculate bond order. [C03/LOCQ]
- (b) What do you understand by doping? Why Germanium doped with phosphorus is called as n-type semiconductor? [C02/LOCQ]
- (c) Arrange Cu, Ag, Au in order of increasing ionization potential. Give reasons. [C04/IOCQ]
- (d) State the principle of HSAB concept of acids and bases. Complete the following reaction with reason, LiI + CsF →. [C01/LOCQ]
- 3 + (1 + 2) + 3 + 3 = 12**

Group - D

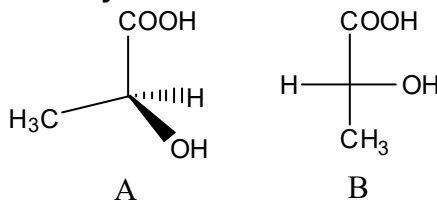
6. (a) Calculate the uncertainty in velocity of a cricket ball (mass=0.1kg), if the uncertainty in its position is of the order of 100 pm. [[C03](IOCQ)]
- (b) Write down all the possible values of m along with their symbols (to designate orbital) for an electron with l=2. [[C04](LOCQ)]
- (c) What are the criteria for a molecule to be IR active? IR spectra of benzaldehyde and phenyl methyl ketone show pronounced absorption peak at 1700 cm⁻¹. What does this indicate? [C05/IOCQ]
- (d) On passing monochromatic light through a 0.01(M) solution in a cell of thickness 1 cm, the intensity of the transmitted light was reduced to 20%. Calculate the molar extinction coefficient of the substance. [C05/LOCQ]
- 3 + 3 + 3 + 3 = 12**
7. (a) What are the significances of the four quantum numbers n, l, m and s?. [C03/IOCQ]
- (b) What are the significances of ψ and ψ^2 ? [C03/LOCQ]
- (c) With help of the Jablonski diagram, compare and contrast between Fluorescence and Phosphorescence. Why phosphorescence is less probable than fluorescence? [C05/IOCQ]
- (d) What is meant by quantum yield (QY)? A chemical substance absorbs 3×10^{18} quanta of light per sec. On irradiation for 20 minutes, 0.003 mole of the substance was found to have reacted. Calculate the quantum yield of the process. [C05/IOCQ]
- 4 + 2 + 3 + 3 = 12**

Group - E

8. (a) Show that meso tartaric acid contains an S_2 axis. [CO6/IOCQ]
 (b) Identify the major product of the following reaction. Justify your answer.



- (c) Discuss chain isomers with example. How it differs from position isomerism? [CO6/LOCQ]
 (d) Draw the geometrical isomers of 1, 2 dimethyl cyclohexane. [CO6/LOCQ]
 (e) Find out the absolute configuration of each of the stereocentres of the following molecules A and B. Identify the relation between them



[CO6/IOCQ]
 $2 + 2 + (2 + 1) + 2 + (1 + 1 + 1) = 12$

9. (a) Depict the synthetic route and uses of Aspirine. [[CO6](LOCQ)]
 (b) Explain why the rate of nucleophilic substitution reaction of CH_3I with N_3^- ion in DMF is found to be 4.5×10^{14} times faster as compared to reaction rate in methanol. [[CO6] (IOCQ)]
 (c) Differentiate between enantiomer and diastereomers. Explain with appropriate example(s). [[CO6](LOCQ)]
 (d) Draw the energy profile diagram of the different conformations of n-butane. Consider rotation about the C(2) - C(3) single bond. [[CO6](LOCQ)]
 (e) Write short note on the Clemmensen reduction. [[CO6](LOCQ)]

$(2 + 1) + 2 + 2 + 3 + 2 = 12$

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	57.29	42.71	0

Course Outcome (CO):

After the completion of the course students will be able to learn about the topic and apply in their respective fields: The subject code CHM1001 corresponds to chemistry theory classes for the first year B. Tech students, which is offered as Engineering Chemistry and is common for all branches of engineering subjects. The course provides basic knowledge of theory based subjects like quantum mechanics, thermodynamics, reaction dynamics, electrochemistry, structure and reactivity of molecules with the following outcome:

- Knowledge acquisition of bulk properties of materials and understanding of reaction processes using thermodynamic considerations.
- Conception of energy conversion and its importance in clean energy scenario, the operating principles for batteries, fuel cells and the materials and reactions involved there in, their applications as sustainable energy devices, particularly in automobiles sectors to reduce environmental pollution.
- Analytic view of microscopic chemistry in terms of atomic structure, molecular orbital and intermolecular forces to reinforce strong background on materials science and engineering.
- Rationalize periodic trends of elements to explain various physic-chemical properties.
- Understanding of the spectrum of electromagnetic radiation used for exciting different molecular energy levels in various spectroscopic techniques.
- Knowledge of stereochemistry and conception of the mechanism of major chemical reactions involved in synthesis of drug molecules.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.