

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) Adiabatic expansion following Joule-Thompson effect is
(a) iso-thermal (b) iso-enthalpic
(c) iso-entropic (d) iso-baric
- (ii) Which of the following behaves as rechargeable battery?
(a) Daniel Cell (b) Pb acid storage cell
(c) Leclanche Cell (d) PEM Fuel cell.
- (iii) The transition in the vibrational energy levels of molecule occurs due to absorption in
(a) UV region (b) Visible region
(c) IR region (d) Microwave region.
- (iv) The elements known as alkaline earth metals are
(a) Li, Na, K, Rb (b) B, Al, Ga, In
(c) Be, Mg, Ca, Sr (d) He, Ne, Ar, Kr
- (v) The correct order of dehydrohalogenation reaction in 1°, 2° and 3° alkyl halide is
(a) 2° > 3° > 1° (b) 3° > 2° > 1°
(c) 3° > 1° > 2° (d) 1° > 2° > 3°
- (vi) Which among the followings is not an acceptable solution of Schrodinger's wave equation?
(a) ψ must be continuous (b) ψ must be infinite
(c) ψ must be single valued (d) $+\infty$ to $-\infty$, ψ^2 must be equal to 1.
- (vii) S_N1 reaction on optically active substrates mainly gives
(a) Retention in configuration (b) Inversion in configuration
(c) Racemic product (d) No product is obtained.
- (viii) The type of isomerism shown by Penta-2, 3-diene is
(a) Geometrical (b) Optical
(c) Conformational (d) None of these
- (ix) The bond order of superoxide ion is
(a) 1 (b) 1.5 (c) 2 (d) 2.5
- (x) The element of symmetry present in the anti staggered form of meso tartaric acid is
(a) Proper axis of symmetry (b) Plane of symmetry
(c) Centre of symmetry (d) None of these.

Fill in the blanks with the correct word

- (xi) Considering the Carnot Engine, if temperature of the source is greater than that of the sink, the efficiency of the engine is _____ than one.
- (xii) The Debye force is the interaction between an ion and a _____.
- (xiii) The first ionisation potential of Be is _____ than that of B.
- (xiv) The frequency range of fingerprint region in infrared spectroscopy is _____ cm⁻¹.
- (xv) Isomerism among compounds due to migration of proton is known as _____.

Group - B

2. (a) Define the term: Efficiency of Carnot cycle (η). Heat supplied to a Carnot engine is 1800 kJ. How much work can be derived by the engine operating between 100°C and 0°C?

[[C01][10CQ]]

- (b) What do you mean by chemical potential (μ)? Write down the Clapeyron-Clausius equation mentioning its application. [[CO1/LOCQ]]
- (c) Represent schematically the cell configuration for the half cell reactions
 $\text{Mg} = \text{Mg}^{+2} (0.01 \text{ M}) + 2\text{e}; E^0(\text{red}) = - 2.34 \text{ V}$
 $\text{Sn}^{+2} (0.1 \text{ M}) + 2\text{e} = \text{Sn}; E^0(\text{red}) = - 0.136 \text{ V}$
 Calculate EMF of the above cell at 25°C and evaluate ΔG^0 of the reaction. [[CO2/IOCQ]]
- (d) Express the overall charging-discharging reactions in a Pd acid storage cell. [[CO2/LOCQ]]

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

3. (a) Define heat capacity of a system and show that heat capacity at constant pressure is greater than that at constant volume. [[CO1/LOCQ]]
- (b) 10 mole of an ideal gas at initial pressure of 1 atm at 0° C expanded reversibly under isothermal condition to a final pressure of 0.1 atm. Calculate the work done by the gas, internal energy change, entropy change and heat absorbed by the system ($R = 8.314 \text{ JK}^{-1} \text{ deg}^{-1} \text{ mol}^{-1}$). [[CO1/IOCQ]]
- (c) Give a schematic representation of Hydrogen-Oxygen (Polymer Electrolyte Membrane) Fuel Cell. Express the anode and cathode reactions. [[CO2/IOCQ]]
- (d) Configure the commonly used reference Calomel electrode and express the half cell reaction. [[CO2/LOCQ]]

3 + 4 + 3 + 2 = 12

Group - C

4. (a) Draw the molecular orbital energy level diagram of B_2 molecule. Calculate the bond order of this molecule and also account for its magnetic behaviour. [[CO3/LOCQ]]
- (b) What are the n-type and p-type semiconductor? Give examples for each type. What is the current carrier in these two types of semiconductors? [[CO3/LOCQ]]
- (c) Explain the SHAB principle using suitable examples. $[\text{AlF}_6]^{3-}$ is the more stable complex compared to $[\text{AlI}_6]^{3-}$ explain. [[CO4/LOCQ]]

(2 + 1 + 1) + (2 + 1 + 1) + (2 + 2) = 12

5. (a) Draw the structure and mention the hybridization of ClF_3 molecule. [[CO3/LOCQ]]
- (b) Write the conditions of formation of molecular orbitals resulting from the combination of atomic orbitals. [[CO3/IOCQ]]
- (c) Why Ge is preferred over Si as a semiconductor material at room temperature? [[CO3/LOCQ]]
- (d) What do you mean by effective nuclear charge? Calculate effective nuclear charge of the valence electron of Cl ($Z=17$) atom. [[CO4/IOCQ]]
- (e) How electronegativity of elements changes while moving down a group in the periodic table? Why Ga has more electronegativity than Al. [[CO4/LOCQ]]

2 + 2 + 2 + 3 + 3 = 12

Group - D

6. (a) Calculate the wavelength of spectral lines when an electron drops from 3rd to the 2nd Bohr orbit in a hydrogen atom. ($R_H=1.09678 \times 10^5 \text{ cm}^{-1}$). In which region of electromagnetic spectrum does this radiation fall? [[CO3/IOCQ]]
- (b) From Heisenberg's uncertainty principle show that, electron can't exist in nucleus (radius of nucleus = 10^{-14}). [[CO3/LOCQ]]
- (c) Write down the Schrodinger's wave equation mentioning the terms involved in the equation. [[CO3/LOCQ]]
- (d) Write any two limitations of Bohr's atomic model. [[CO3/LOCQ]]
- (e) The UV spectrum of acetone shows two peaks at $\lambda_{\text{max}}=280 \text{ nm}$ ($\epsilon_{\text{max}}=15$) and $\lambda_{\text{max}}=190 \text{ nm}$ ($\epsilon_{\text{max}}=100$). Identify the type of electronic transition in each case. Which one of the transitions is more intense? [[CO5/IOCQ]]

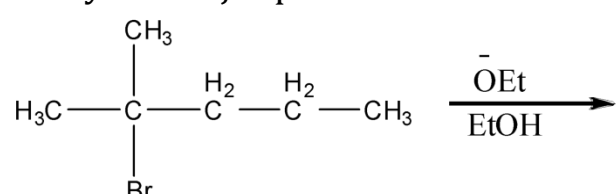
(2 + 1) + 2 + 2 + 2 + 3 = 12

7. (a) What is the importance of de Broglie's relation? Consider a beam of electron with a speed of $5.31 \times 10^6 \text{ m/s}$, calculate the de Broglie wavelength (Mass of electron = $9.11 \times 10^{-31} \text{ kg}$; $h=6.626 \times 10^{-34} \text{ Js}$). [[CO3/IOCQ]]
- (b) State and explain Pauli's exclusion principle. [[CO3/LOCQ]]
- (c) What do you understand by force constant of a bond? How force constant is related to its vibrational frequency? Among C=C and C-C which one will absorb at higher frequency for stretching vibration and why? [[CO5/HOCQ]]
- (d) Differentiate between Fluorescence and Phosphorescence with illustrations and giving examples of each. [[CO5/LOCQ]]

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

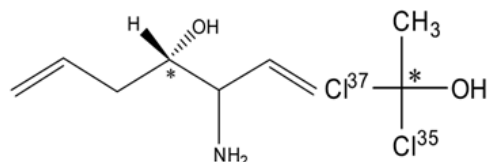
Group - E

8. (a) Define plane of symmetry. Identify rotational axis of proper fold and the total number of σ planes present in Formaldehyde molecules. [[CO6/LOCQ]]
- (b) Identify the major product of the following reaction. Justify your answer.



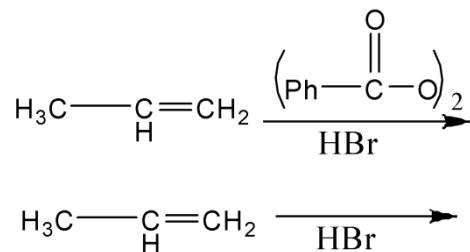
[[CO6/IOCQ]]

(c) Identify the absolute configuration of each stereocenter of the following structures.



[[CO6/IOCQ]]

(d) Predict the major product(s) of the following reactions and explain their formation.



[[CO6/LOCQ]]

(2 + 2) + (1 + 1) + (1 + 1) + (2 + 2) = 12

9. (a) Depict the synthetic route and uses of Ibuprofen.

[[CO6](LOCQ)]

(b) Explain the higher percentage of enol form of ethyl acetoacetate in comparison to acetone, providing suitable structure.

[[CO6](IOCQ)]

(c) Differentiate between asymmetric and dissymmetric molecule with example.

[[CO6](LOCQ)]

(d) Draw the fully eclipsed and anti-staggered conformations of n-butane in Newman projection formula.

[[CO6](LOCQ)]

(e) Write short note on MPV reduction.

[[CO6](LOCQ)]

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

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	61.46	34.38	4.16

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 CHM 1001 corresponds to Chemistry Theory classes (Chemistry-1) for the first year B. Tech students, offered as Chemistry for Engineering and is common to all Branches of Engineering Disciplines. The course provides basic knowledge of theory and applications in the subjects like Thermodynamics, Quantum mechanics, Electrochemistry, & Energy conversion, Structure and reactivity of molecules. Spectroscopic techniques and their applications, Synthesis & use of Drug molecules. The Course Outcome for the subject code CHM 1001, is furnished below:

1. Knowledge acquisition of bulk properties of materials and understanding of reaction processes using thermodynamic considerations.
2. 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.
3. Analytic view of microscopic chemistry in terms of atomic structure, molecular orbital and intermolecular forces to reinforce strong background on materials science and engineering.
4. Rationalize periodic trends of elements to explain various physico - chemical properties.
5. Understanding of the spectrum of electromagnetic radiation used for exciting different molecular energy levels in various spectroscopic techniques.
6. 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.

