

20/20/20 - CHEM - 119

L-1/T-1/IPE

Date: 09/09/2025

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-1 B. Sc. Engineering Examinations 2024-2025

Sub: **CHEM 119** (Chemistry-I)

Full Marks: 210

Time: 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

**SECTION - A**

There are **FOUR** questions in this section. Answer to **Question No. 1** is **COMPULSORY**.

Answer any **TWO** questions from **Question 2-4**.

1. (a) How do intermolecular interactions in non-ideal mixtures lead to deviations from Raoult's law? Illustrate your answer with appropriate diagrams. (CO1) (10)
- (b) Differentiate between membrane solution theory and vapor pressure theory for osmosis through a semipermeable membrane. (CO2) (10)
- (c) At room temperature and atmospheric pressure, H<sub>2</sub>O exists as a liquid while CO<sub>2</sub> exists as a gas. Justify this observation using appropriate phase diagrams. (CO3) (10)
- (d) Sketch the diagram of a bomb calorimeter and write down the principle of measurement of calorific value of a fuel. (CO4) (5)
2. (a) An aqueous solution of sugar or glucose boils at a temperature higher than that of pure water at atmospheric pressure. Using thermodynamic principles, derive a relation between the concentration of the solution and the elevation in boiling point, stating any necessary assumptions. (15)
- (b) Why are the deep-sea divers at risk of experiencing high-pressure gas intoxication, and how does increased ambient pressure affect the solubility of gases like nitrogen in the bloodstream? (12)
- (c) What is the lowest molality of ethylene glycol solution that will protect your car's coolant from freezing at 0°F? (Assume the solution is ideal.) The freezing point depression constant is 1.86 K. kg/mol, and the boiling point elevation constant is 0.512°C kg/mol. (8)
3. (a) Draw the phase diagram of sulfur, and answer the following: (15)
  - (i) Identify two-phase and three-phase equilibria that exist in the diagram.
  - (ii) How does a metastable equilibrium form in the S system?
  - (iii) A four-phase equilibrium is not possible in the sulfur system-justify.
- (b) Identify the differences between a simple eutectic system and a congruently melting system with appropriate phase diagram. (12)
- (c) Using a phase diagram, explain the principle behind freeze-drying. (8)

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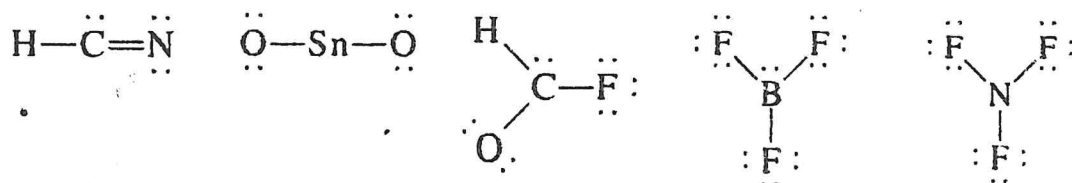
4. (a) What is the half-life of a reaction? Prove that the half-life of a zero-order reaction depends on the initial concentration, whereas that of a first-order reaction does not. (15)
- (b) Identify and explain the salient features of the collision theory of reaction rates. (12)
- (c) 1/2 of the initial concentration was consumed in 23 minutes for a first-order reaction. Calculate the time required to complete 9/10 of the reaction. (8)

SECTION - B

There are **FOUR** questions in this section. Answer to **Question No. 5** is **COMPULSORY**.

Answer any **TWO** questions from **Question 6-8**.

5. (a) What will be magnetic properties of  $C_2$  and  $O_2$ ? Explain according to their MOT diagram? (CO1) (10)
- (b) A molecule having formula  $AX_4$  have three different geometries-tetrahedral, square planer and seesaw. Explain the overall dipole moment based on the shapes of these molecules. (CO2) (10)
- (c) The following Lewis structures for (a) HCN, (b)  $SnO_2$ , (c) HCOF, (d)  $BF_3$ , and (e)  $NF_3$  are incorrect. Explain what is wrong with each one and give a correct structure for the molecule. (Relative positions of atoms are shown correctly.) (CO3) (10)



- (d) How does s-p mixing contribute to change the energy ordering of the molecular orbitals in the MOT diagram? (CO4) (5)
6. (a) What were the developments that led to the formulation of Bohr's atomic model? Write down the defects of the Bohr model. (10)
- (b) How does the de Broglie equation show the wave-particle duality of electron? Show that de Broglie's and Bohr's concepts are in agreement with each other. (15)
- (c) Draw and describe the change of probability density, spherical surface area, and radial probability with the increase of distance from the nucleus. (10)

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7. (a) Describe the chemical reactions used for the isolation of rare gases from dry air. (10)
- (b) "All Arrhenius acids are also Brønsted acids, but all Arrhenius bases are not Brønsted bases. – Justify. (8)
- (c) Why can salts be acidic, basic, or neutral? Explain with appropriate examples. (10)
- (d) Dimethylamine,  $(\text{CH}_3)_2\text{NH}$ , a key intermediate in detergent manufacture, has a  $K_b$  of  $5.9 \times 10^{-4}$ . What is the pH of 1.5 M  $(\text{CH}_3)_2\text{NH}$ ? (7)
8. (a) Show the orbital occupancy for high-spin and low-spin octahedral complexes of  $d^6$  through  $d^7$  metal ions. (10)
- (b) Find the APF of simple cubic structure and face-centered cubic structure and show that face-centered cubic structure has an APF about 1.5 times than simple cubic structure. (15)
- (c) How can an X-ray diffraction pattern be used to find information about crystalline structure? (10)