

UNIVERSITY EXAMINATIONS

FIRST SEMESTER 2025/2026 ACADEMIC YEAR

**FIRST YEAR EXAMINATION FOR THE DEGREES OF
BACHELOR OF EDUCATION (SCIENCE) BACHELOR OF
SCIENCE, BIOMED AND BIOCHEMISTRY**

CHEM 112: INTRODUCTION TO PHYSICAL CHEMISTRY

STREAMS: *BEd(Sc), BSc (Gen), Biomed/Biochem*

TIME: *2 HRS*

DAY: *WEDNESDAY [8.30 – 10.30 A.M]*

DATE: *04/02/2026*

THIS QUESTION PAPER CONSISTS OF FIVE (5) PAGES

PLEASE DO NOT OPEN UNTIL THE INVIGILATOR SAYS SO.

USEFUL DATA

$$R = 0.0821 \text{ Latm}^{-1} \text{ K}^{-1} = 8.314 \text{ JK}^{-1} \text{ mol}^{-1}$$

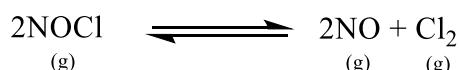
$$P = 1 \text{ atm} = 101325 \text{ Nm}^2 = 101325 \text{ pa} = 760 \text{ torr} = 760 \text{ mmHg}$$

$$H = 1, C = 12, N = 14, O = 16, Br = 80$$

Attempt ALL the Questions**QUESTION ONE (30 MARKS)**

- a.) State the following
- Avogadro's law
 - Kinetic theory of gases **(2 Marks)**
- b.) State two properties of gases which differentiate them from solids and liquids **(2 Marks)**
- c.) A given mass of a gas occupies a volume of 240 cm^3 at a pressure of 1.25 atm. By how much would the volume change if the pressure is changed to 570 torr? **(3 Marks)**
- d.) A student at the back of a class releases the weeping gas, $\text{C}_6\text{H}_{11}\text{OBr}$, and moves towards the front of the class. At the same time, the teacher in front of the class releases the laughing gas, N_2O . If there are 13 equidistant rows in the class, determine the row at which the student will be laughing and weeping simultaneously. **(3 Marks)**
- e.) A mixture of helium and oxygen gases are used in 'air' tanks for deep sea diving. For a particular dive, 12 L of O_2 and 46 L of He at 25°C and 1.0 atm were pumped into a 5.0 L tank. Calculate the:
- Partial pressure of each gas **(5 Marks)**
 - Total pressure in the tank at 25°C
- f.) Deviation from ideal gas behaviour depends on two factors. State **(2 Marks)**
- g.) 1.0 moles of CO_2 was found to occupy 0.05L at 0°C . Compute the pressure exerted by the gas assuming that;
- The gas behaves like an ideal gas **(1.5 Marks)**
 - The gas behaves like a real gas ($a = 3.955 \text{ LatmK}^{-1} \text{ mol}^{-1}$, $b = 0.04267 \text{ Lmol}^{-1}$) **(1.5 Marks)**
- (2.5 Marks)**

- h.) State whether each of the following statements is true or false about chemical equilibrium
- The reaction stops at the equilibrium (2 Marks)
 - Equilibrium can be attained in both closed and open systems
 - Value of equilibrium constant does not depend upon the initial concentration of reactants.
 - Equilibrium can be initiated from either side of the reaction i.e. from reactants side or products side.
- i.) In an experiment, 2.0 moles of NOCl were placed in a one-liter flask. The equilibrium



was established at 25 °C and the concentration of NO was found to be 0.66 molL⁻¹.

- Use a graph to illustrate how the equilibrium was achieved (3 Marks)
- Calculate the value of K_c for the reaction at the given temperature (4 Marks)

QUESTION TWO (20 MARKS)

a.) Define the following;

- Electrode potential (2 Marks)
- Enthalpy

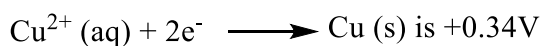
b.) Combustion of ethane from CO₂ and H₂O. Given the information in the table;

Formula and state of compound	C ₂ H ₆ (g)	CO ₂ (g)	H ₂ O (l)
Standard enthalpy of formation (at 298K)/kJmol ⁻¹	-85	-394	-286

- Calculate the enthalpy of combustion of ethane (3 Marks)
- Calculate the energy released when 100 g of ethane is completely burned. (2 Marks)

c.) The standard electrode potential for the half-reaction $\text{Fe}^{3+}(\text{aq}) + \text{e}^{-} \longrightarrow \text{Fe}^{2+}(\text{aq})$ is +0.77V

While that for the half-reaction



- i. The standard electrode potential for $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^{-} \longrightarrow \text{Cu}(\text{s})$, was measured directly using a standard hydrogen electrode. Draw a well labelled diagram to demonstrate how this was done.

(6 Marks)

The half-reactions $\text{Fe}^{3+}(\text{aq}) + \text{e}^{-} \longrightarrow \text{Fe}^{2+}(\text{aq})$ and $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^{-} \longrightarrow \text{Cu}(\text{s})$ can also be used together to make a galvanic cell.

- ii. Write the conventional representation for this cell. **(1 Mark)**

- iii. Deduce the emf of the cell if both electrodes are set up under standard conditions. **(2 Marks)**

- iv. Suggest how the value of the emf of the cell would change if the concentration of Fe^{2+} ion was decreased. Explain your answer **(2 Marks)**

- v. If the K_b for 0.1M $\text{NH}_3(\text{aq})$ is 1.8×10^{-5} M. Calculate the pH of this solution. **(2 Marks)**

QUESTION THREE (20 MARKS)

- a) Define the following terms as used in chemical kinetics **(4 Marks)**

- i. Molecularity of a reaction
- ii. Rate law
- iii. Activation energy
- iv. Order of a reaction

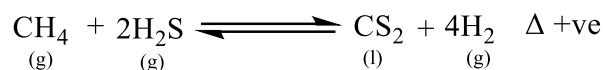
- b) Derive the 1st order half-life expression from the following hypothetical rate equation.

**(3 Marks)**

- c) For the reaction $2\text{NO}(\text{g}) + \text{H}_2(\text{g}) \longrightarrow \text{N}_2\text{O}(\text{g}) + \text{H}_2\text{O}(\text{g})$, the following rate data were collected:

Initial [NO], MolL ⁻¹	Initial [H ₂], MolL ⁻¹	Initial rate, MolL ⁻¹ s ⁻¹
0.60	0.37	3.0×10^4
1.20	0.37	1.2×10^{-3}
1.20	0.74	1.2×10^{-3}

- i. Deduce the orders of the reaction with respect to NO and H₂ and hence deduce the rate equation for the reaction. **(3 Marks)**
- ii. Calculate a value for the rate constant for the reaction and state its units. **(3 Marks)**
- d.) Consider the gas phase reaction below;

**(1 Mark)**

- i. Write the equilibrium constant K_c expression for the above reaction

Predict the effect on the value of K_c for the above reaction when;

(3 Marks)

- ii. The temperature is increased
- iii. The pressure is increased

Predict the shift in equilibrium for the above reaction when;

(3 Marks)

- iv. CS₂ is increased
- v. Temperature is decreased