



# MAASAI MARA UNIVERSITY

REGULAR UNIVERSITY EXAMINATIONS  
2023/2024 ACADEMIC YEAR  
FIRST YEAR FIRST SEMESTER

SCHOOL OF PURE, APPLIED AND HEALTH SCIENCES  
BACHELOR OF SCIENCE IN CHEMISTRY AND  
BACHELOR OF EDUCATION SCIENCE

**COURSE CODE: CHE 1104-1**

**COURSE TITLE: BASIC PHYSICAL CHEMISTRY**

**DATE: 2/2/2024**

**TIME: 1430-1630 HRS**

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## **INSTRUCTIONS TO CANDIDATES**

1. Answer Question **ONE** and any other **THREE** questions
2. Avogadro's constant =  $6.022 \times 10^{23} \text{ mol}^{-1}$
3. Boltzmann constant,  $k = 1.3805 \times 10^{-23} \text{ JK}^{-1}$
4. Gas constant  $R = 8.314 \text{ JK}^{-1} \text{ mol}^{-1} = 0.0821 \text{ Latm K}^{-1} \text{ mol}^{-1}$
5.  $1 \text{ atm} = 1.01325 \times 10^5 \text{ Nm}^{-2}$

*This paper consists of **five** printed pages. Please turn over.*

## QUESTION ONE (30 marks) Compulsory

a. State whether each of the following statements is true or false, thereafter provide a rebuttal or support.

i) The rate of diffusion of a gas is directly proportional to its molar mass. (2 marks)

ii) The number of collisions between gas molecules decreases with increase of temperature. (2 marks)

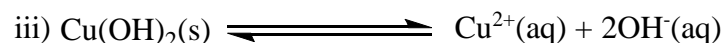
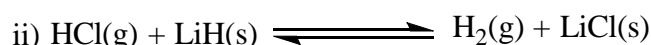
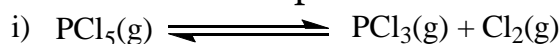
iii) A real gas does not behave ideally even at the Boyle temperature (2 marks)

iv) The attractive forces between the molecules of a gas are higher at higher temperatures (2 marks)

b. A teacher enters in a classroom from the front door while a student from the back door. There are 13 equidistant rows of benches in the classroom. The teacher releases the laughing gas ( $\text{N}_2\text{O}$ ) from the first bench while the student releases the weeping gas ( $\text{C}_6\text{H}_{11}\text{OBr}$ ) from the last bench. At which row will the student start laughing and weeping simultaneously. (C=12, H=1, O=16, Br=80 and N=14)

(3 marks)

c. To describe the equilibrium position of a chemical reaction, it is often necessary to give the equilibrium constant for the said reaction. Write the equilibrium constant expressions for the following chemical equations.



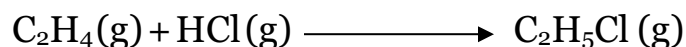
(3 marks)

d. Thermochemistry is a branch of physical chemistry that deals with heat changes accompanying chemical transformation. There are two fundamental laws of thermochemistry based on the principle of conservation of energy.

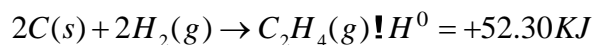
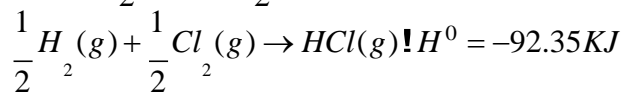
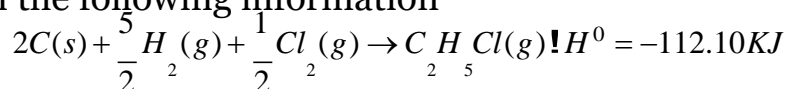
i. Discuss the two laws giving relevant general examples.

(4 marks)

ii. Hence or otherwise, calculate the enthalpy of the reaction below:



Given the following information



(5 marks)

e. The proportionality constant labeled R is called the universal gas constant. This constant is a number that connects P, V, T and n and can be used to interrelate the properties of a gas.

i) Prove that the numerical value of the gas constant is 0.0821 litre atom  $K^{-1} Mol^{-1}$  or 8.314  $JK^{-1} Mol^{-1}$ . (4 marks)

ii) Explain the instances where the different R values are used. (3 marks)

### QUESTION TWO (10 marks)

a. Gases have shown significant deviations from the ideal behavior at high pressures and low temperatures. This has led to the modifications of the kinetic theory of gases to account for the real gases.

i) Sketch a plot of PV vs P at constant temperature indicating where ideal gases should be and equally indicating the behavior of  $H_2$ , He,  $N_2$  and  $CO_2$  (2 marks)

ii) The deviation from ideality for  $CO_2$  at 273K and 100 atm pressure is given by a factor 0.2007. Calculate the volume occupied by 0.1 mole of the gas considering the deviations and compare this value when assuming ideality. (3 marks)

b. The deviations of gases from ideal behavior are due to two faulty assumptions made in the kinetic theory of gases.

- i. State the two faulty assumptions made in the kinetic theory of gases. (2 marks)
- ii. Give a stepwise outline on how the two errors were corrected to arrive at a modified equation. (3 marks)

### **QUESTION THREE (10 marks)**

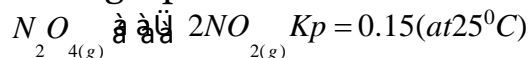
- a. Enthalpy of a reaction is defined as the amount of heat absorbed or evolved in the transformation of the reactants at a given temperature and pressure into the products at the same conditions. It is given different names depending upon the types of reaction. Discuss the following types of Enthalpies.
  - i) Enthalpy of hydrogenation (1.5 marks)
  - ii) Enthalpy of neutralization (1.5 marks)
  - iii) Differential enthalpy of solution (1.5 marks)
  - iv) Enthalpy of phase transition (1.5 marks)
- b. The enthalpy of neutralization of ammonium hydroxide by hydrochloric acid is  $-51.46 \text{ kJ/mol}$  while that of the formation of undissociated water from hydrogen and hydroxyl ions is  $-57.32 \text{ kJ/mol}$ . Calculate the enthalpy of ionization of ammonium hydroxide. (4 marks)

### **QUESTION FOUR (10 marks)**

- a. The ideal gas law is useful for calculating any one of the four properties of a gas when the other three are known.
  - i) Describe the gas laws mathematically and thus derive the ideal gas law. (6 marks)
  - ii) Hence or otherwise deduce the combined gas law. (4 marks)

### QUESTION FIVE (10 marks)

- a. When you find a bottle of concentrated nitric acid in the laboratory, it often has a brown gas,  $\text{NO}_2$ , hovering over the surface of the liquid. This simple molecule can bind to another  $\text{NO}_2$  unit.  $\text{NO}_2$  and its dimer,  $\text{N}_2\text{O}_4$ , are in equilibrium in the gas phase.



If the total pressure of an equilibrium mixture of  $\text{N}_2\text{O}_4$  and  $\text{NO}_2$  is 1.5atm;

- Calculate the partial pressure of each gas (8 Marks)
- Using the calculated values, verify that  $K_p=0.15$  at  $25^\circ\text{C}$  (2 marks)

/END/