



# MERU UNIVERSITY OF SCIENCE AND TECHNOLOGY

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## University Examinations 2022/2023

THIRD YEAR, SPECIAL/SUPPLEMENTARY EXAMINATION FOR THE DEGREE OF  
BACHELOR OF SCIENCE IN MEDICAL LABORATORIES

### HMM 3126: PHYSICAL CHEMISTRY

DATE: AUGUST 2023

TIME: 2 HOURS

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**INSTRUCTIONS:** *answer question one and any other two questions*

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#### QUESTION ONE (30 MARKS)

- a) Distinguish;
- (i) Open from closed system
  - (ii) Extensive from intensive properties
  - (iii) Homogenous and heterogeneous system
  - (iv) Isothermal from adiabatic process
- b) A gas expands from 4.0 litres to 12.0 litres constant temperature. Calculate the work done (in joules) by the gas if it expands against a vacuum and against pressure of 2.4 bar (4 marks)
- c) State the first law of thermodynamics (2 marks)
- d) Calculate the change in entropy when 3 moles of a perfect gas is allowed to expand at 300K from a volume of 2dm<sup>3</sup> to 13dm<sup>3</sup>, given that  $R = 8.314 \text{ JK}^{-1} \text{ mol}^{-1}$  (3 marks)
- e) The standard enthalpy of formation of gaseous NH<sub>3</sub> at 25°C is  $-46.1 \text{ kJ mol}^{-1}$ . Estimate its value at 127°C given the following values of molar heat capacity at constant pressure (4 marks)
- $\text{NH}_3(\text{g}) = 29.75 \text{ JK}^{-1} \text{ mol}^{-1}$
- $\text{H}_2(\text{g}) = 27.28 \text{ JK}^{-1} \text{ mol}^{-1}$
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$$N_2(g) = 28.58 \text{ JK}^{-1}\text{mol}^{-1}$$

- f) Distinguish the diathermic from adiabatic walls (4 marks)
- g) (i) State Avagadro's law (2 marks)
- (ii) During the course of a reaction 0.25 mol of gas phase reactant becomes 0.60 moles of gas phase product. The initial volume of the gaseous reactant is  $125\text{cm}^3$ .  
What is the volume of gaseous product? (3 marks)

### QUESTION TWO (20 MARKS)

- a) Calculate the work done during the expansion of 3.2g of oxygen gas from 10.0L to 20.0L in an isothermal process at  $127^\circ\text{C}$ . assume ideal gas behavior (given that  $O=16$  and  $R = 8.314\text{Jmol}^{-1}\text{K}^{-1}$ ) (6 marks)
- b) Explain two causes of deviation of real gases from ideality (4 marks)
- c) Distinguish between
- (i) Isolated from open system (2 marks)
  - (ii) Adiabatic from isothermal system (2 marks)
  - (iii) Intensive and extensive properties (2 marks)
- d) Considering a gas in a glass cylinder fitted with a weightless, frictionless, movable piston at a certain temperature, pressure (P) and volume (v), show that work (W) done during the expansion of the gas can be expressed as  $W = P\Delta V$  (4 marks)

### QUESTION THREE (20 MARKS)

- a) From the first law of thermodynamics, show that the heat capacities at constant pressure and constant volume relates with the equation (10 marks)
- $$C_p = C_v + R$$
- b) The equation for the molar heat capacity of butane is  $C_p = (19.41 + 0.233 T) \text{ J mol}^{-1}\text{K}^{-1}$ . Calculate the heat necessary to raise the temperature of 3.00 moles of butane from 298 K to 573 K at constant pressure (7 marks)
- c) Forces have different physical origin and work can be done in a variety of ways. List three types of work in thermodynamics (3 marks)

**QUESTION FOUR (20 MARKS)**

- a) From the first law of thermodynamics, show that; (6 marks)

$$C_v = \frac{\partial u}{\partial T}$$

- b) Calculate the work, heat and change in internal energy involved in the expansion of 3.5 moles CO<sub>2</sub> gas from 20.0L in an isothermal process at 400K. assume ideal gas behavior (R = 8.314Jmol<sup>-1</sup>K<sup>-1</sup>) (6 marks)

- c) Discuss three postulates/assumptions for the kinetic molecular theory for ideal gases. (6 marks)

- d) Define spontaneous process (2 marks)