



# THE CATHOLIC UNIVERSITY OF EASTERN AFRICA

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**MAIN EXAMINATION**

**SEPTEMBER –DECEMBER 2021**

**FACULTY OF SCIENCE**

**DEPARTMENT OF CHEMISTRY**

**REGULAR PROGRAMME**

**CHEM 201: PHYSICAL CHEMISTRY II**

**Date: DECEMBER 2021**

**Duration: 2 Hours**

**INSTRUCTIONS: Answer Question ONE and any TWO Questions**

Useful Information

$$R = 8.3145 \text{ Jk}^{-1} \text{ mol}^{-1}$$

$$1 \text{ atm} = 101325 \text{ N/m}^2$$

Q1. a) Using the 1<sup>st</sup> and 2<sup>nd</sup> laws of thermodynamics, show that:

$$\Delta s = C_v \ln T + R \ln V \quad (7$$

marks)

b) One mol of an ideal gas at 25<sup>o</sup>c was allowed to expand isothermally and reversibly from 1080.25 KPa to 10.8025kPa against a pressure that was gradually reduced. Calculate

(i) the work done. (3 marks)

(ii)  $\Delta E$ ,  $\Delta H$  and Q (6 marks)

(iii)  $\Delta s$  and  $\Delta G$  (6

marks)

c) Briefly define the following terms as used in thermodynamics.

(i) state variables

(ii) extensive properties

(iii) entropy

(iv) reversible process

(8 marks)

Q2. a) Using the pathways or otherwise derive the Kirchoff's equation

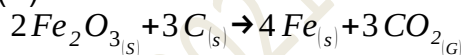
$$\Delta H_{r,T}^{\circ} = \Delta H_{r,298}^{\circ} + \left( \int_{298}^T (C_{p,P} - C_{p,R}) dT \right)$$

(10 marks)

b) Using a carnot cycle show that entropy is a state function. (10 marks)

Q3. a) Briefly discuss how the change in temperature affects the spontaneity of a given reaction. (8 marks)

b) Calculate the temperature at which it is thermodynamically possible for carbon to reduce iron (iii) oxide to iron under standard conditions by the endothermic reaction.



Component	$\Delta H_f / KJmol^{-1}$	$S^{\circ} / Jmol^{-1}K$
$Fe_2O_{3(s)}$	-824.2	89.4
$C_{(s)}$	0	5.7
$Fe_{(s)}$	0	27.3
$CO_{2(g)}$	-393.5	213.7

(8 marks)

c) Calculate the work done when 1.5 mol of a gas expands from 10dm<sup>3</sup> to 15dm<sup>3</sup> against a constant pressure of 1 atmosphere.

Q4. a) (i) Plot on the same graph the variation of absolute entropy versus temperature for H<sub>2</sub> and CH<sub>3</sub>Cl in the range 0k to 300k. (6 marks)  
(ii) Explain the variation for the graph in (i). (4 marks)

b) Liquid water at 373k is in equilibrium with water vapour at 1 atm pressure if  $\Delta H_{vap}$  at 373k in 40.60kj mol<sup>-1</sup>. Calculate

(i)  $\Delta G$  and  $\Delta S$

(ii) Suppose the water vapour pressure is 0.900 atm. What are the values of  $\Delta G$  and  $\Delta S$  for the vapourization process? (6

marks)

- Q5. a) Consider the system  $M_{(g)} \rightleftharpoons N_{(g)}$  at  $25^{\circ}\text{C}$ . Given that  $G^{\circ}_M = 8996 \text{ J mol}^{-1}$  and  $G^{\circ}_N = 11718 \text{ J mol}^{-1}$ , Calculate the value of the equilibrium constant for this reaction. **(6 marks)**
- b) Calculate the equilibrium pressure that results if 1.00 mol  $M_{(g)}$  at 1.00 atm and 1.00 mol  $N_{(g)}$  at 1.00 atm are mixed together at  $25^{\circ}\text{C}$ . **(8 marks)**
- c) Given that  $G = H - TS$ ,  $E = Q + W$  and  $H = E + PV$ . Show that for 1 mol of an ideal gas  $dG = Vdp - SdT$ . **(6 marks)**

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