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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

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

$1\ atm = 101325\ N/m^2$

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

$$\Delta s = CvInT + RInV$$ **(7 marks)**

b) One mol of an ideal gas at 25^0c 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) ΔE, ΔH and Q **(6 marks)**

(iii) Δs and ΔG **(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

$$\Delta H^{o}_{r,T} = \Delta H^{o}_{r,298} + \left(\int_{298}^{T} \left(C_{p,P} - C_{pR} \right) dT \right)$$

(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. $2Fe_2O_{3(S)} + 3C_{(s)} \rightarrow 4Fe_{(s)} + 3CO_{2(G)}$

Component	$\Delta H_f / Kjmol^{-1}$	**S°/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^3 to 15dm^3 against a constant pressure of 1 atmosphere.

Q4. a) (i) Plot on the some graph the variation of absolute entropy versus temperature for H_2 and CH_3Cl 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 ΔH_{vap} at 373k in 40.60kj mol^{-1}. Calculate
(i) ΔG and ΔS

(ii) Suppose the water vapour pressure is 0.900 atm. What are the values of ΔG and ΔS for the vapourization process? **(6 marks)**

Q5. a) Consider the system $M_{(g)} \rightleftharpoons N_{(g)}$ at 25^0c. Given that $G^{0}{}_{M} = 8996\ Jmol^{-1}$ and $G^{0}{}_{N} = 11718\ Jmol^{-1}$, Calculate the value of the equilibrium constant for this reaction. **(6 marks)**

b) Calculate the equilibrium pressure that results if 1.00mol $M_{(g)}$ at 1.00 atm and 1.00 mol $N_{(g)}$ at 1.00 atm are mixed together at 25^0c. **(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)**

END