THE CATHOLIC UNIVERSITY OF EASTERN AFRICA

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MAIN EXAMINATION

SEPTEMBER – DECEMBER 2019 TRIMESTER

FACULTY OF SCIENCE

DEPARTMENT OF CHEMISTRY

REGULAR PROGRAMME

CHEM 201: PHYSICAL CHEMISTRY II

Date: DECEMBER 2019	**Duration: 2 Hours**
INSTRUCTIONS: Answer Question ONE and any other Two Questions	

Q1. a) Substances A and B are known to form a simple binary mixture. The tie line X-Y intercepts the liquidus when the X_B = 0.85 and the solidus when X_B = 0.21.

i. Sketch the diagram for the A-B alloy mixture explaining its different sections. **(4 marks)**

ii. Calculate the solid: liquid ratios on a point on the tie line when X_B = 0.55. **(4 marks)**

b) The van der Waals constants for Benzene are: $a = 18.24 l^2 \div mol^{-2}; b = 0.1154 l.mol^{-1}$. Using the van der Waals equation of state, calculate the pressure of 0.56 moles of Benzene with a volume of 5.67 litres at a temperature of 235K (R = 0.082057 litres. atm/ K.mol.)

(4 marks)

c) 0.44 moles of a gas experiences a ΔT of 78K. If it's corresponding ΔU is 28.5J:

i. Calculate it's heat capacity at constant pressure (C_P) assuming that R = 8.314 J/mol.K) **(5 marks)**

ii. Calculate the ΔH for the reaction **(3 marks)**

d) The gas undergoes an isothermal expansion at 250K from 10.19 litres to 19.12 litres. It then undergoes an adiabatic expansion to 21.78 litres as the temperature falls to 201K. Calculate the work done in these two steps.
(5 marks)

e) If:

$CH_2O_{(g)} + H_2O_{(g)} \rightarrow CH_{4(g)} + O_{2(g)} \quad \Delta H = +275.6\,kJ$ … 1

$CH_2O_{(g)} + O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(g)} \quad \Delta H = -526.7\,kJ$ … 2

$H_2O_{(l)} \rightarrow H_2O_{(g)} \quad \Delta H = 44.0\,kJ$ … 3

Calculate the ΔH for:

$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(l)}$ **(5 marks)**

Q2. a) Platinum and silver form a peritectic alloy. The melting point of Ag is 920°C while that of Pt is 1750°C. The peritectic temperature is 1200°C. Sketch the peritectic phase diagram of these two metals indicating its components.
(5 marks)

b) Two similar metals of the same size and cross-sectional area are contacted with each other. Temperature of the hotter metal is 1070 K and that of the colder metal is 120 K. Calculate the entropy change due to heat transfer after contact. (C_V = 0.871 J/g. K) **(5 marks)**

c) Using the Kirchhoff's law, calculate the molar enthalpy change for liquid water when it experiences a temperature increase from 27K to 539K. (a = 75.29 J/mol. K; b = 0 J/mol.K^2; c = 0 J.K/ mol.)
(4 marks)

d) Substances A and B react in the following way:

A + B ⟶ C + D

The table below depicts the concentrations of the reactants and products at different temperatures:

Temp. (K)	207	273	387	498	567
Conc. of A (mg/l)	7.02	5.87	4.23	3.66	1.56
Conc. of B (mg/l)	7.45	6.75	5.93	5.03	3.32
Conc. of C (mg/l)	5.26	7.12	8.02	8.30	9.11
Conc. of D (mg/l)	5.33	7.63	8.65	9.04	9.82

Using the Van't Hoff equation graphically determine if the reaction is exothermic or endothermic in nature (R = 8.314 J/ K. mol.) (Use graph paper provided) **(6 marks)**

Q3. a) Using a relevant expression: Define the term '*internal pressure'.* Give reasons why it differs between ideal and non-ideal gases? **(4 marks)**

b) Substance X and Y form a peritectic alloy. The melting point of X is 1038°C while that of Y is 3070°C. The peritectic temperature is 2545°C. Sketch the peritectic phase diagram labelling all the relevant parts. **(6 marks)**

c) The standard enthalpy of combustion of propane is exothermic. Using a relevant expression, explain **(4 marks)**

d) Using a well- labelled diagram, describe the different steps in the Carnot cycle **(6 marks)**

Q4. a)

i. Using a well- labelled diagram, describe the one component system **(5 marks)**

ii. Using the phase rule, calculate the degrees of freedom for a point in:

- The liquid phase
- The liquid- solid interface
- The triple point **(3 marks)**

b) Explain the differences in the degrees of freedom between the three points **(3 marks)**

c) Gas A T_A = 146 K) and gas B (U_B = 35 J and T_B = 726 K) contained in two compartments separated from their surroundings. Calculate the entropy change (ΔS) if the partition between the two compartments is removed and the two gases are allowed to mix **(5 marks)**

d) Using a relevant expression, explain how efficiency of the carnot cycle could be calculated **(4 marks)**

Q5. a) Gas A and Gas B are formed out of the same molecules. Using the Maxwell distribution of gases, explain why Gas A molecules at temperature T_A have a higher kinetic energy than Gas B (Temp. T_B) (Assume that $T_A > T_B$)
(6 marks)

b) Explain the applications of thermodynamics in:
i. Protein Folding
ii. Mineral Exploration **(4 marks)**

c) Calculate the mass of a 28.98 L sample of ammonia gas measured at standard conditions.
Hint: Use K units for temperature and atm. units for Pressure.
(R = 0.0821 L. atm./ mol. K, mass number for N = 14; H = 1). **(6 marks)**

e) Using a relevant diagram, describe the differences between the following thermodynamic processes:
i. Adiabatic Process
ii. Isochoric Process
iii. Isothermal Process
iv. Isobaric Process **(4 marks)**

END