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MAIN EXAMINATION

AUGUST – DECEMBER 2018 TRIMESTER

FACULTY OF SCIENCE

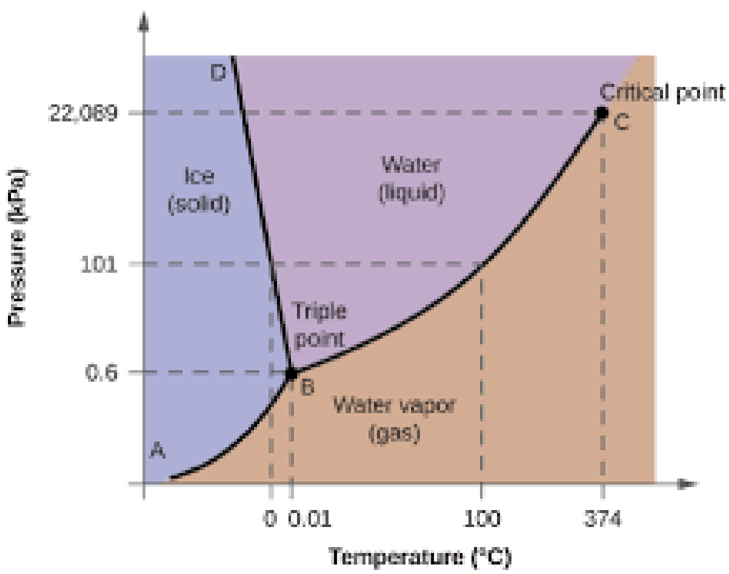
DEPARTMENT OF NATURAL SCIENCE (CHEMISTRY)

REGULAR PROGRAMME

CHEM 201: PHYSICAL CHEMISTRY II

Date: DECEMBER 2018	**Duration: 2 Hours**
INSTRUCTIONS: Answer Question ONE and ANY OTHER TWO Questions	

Q1. Use the phase diagram below to answer questions 1(a), 1(b) and 1(c) below:

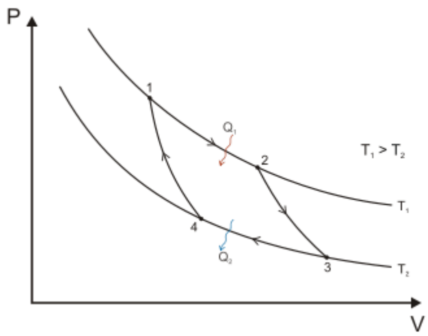


a) The line D-B shows a separation between the solid and liquid phases of water. Discuss why more liquid water is formed when the pressure is increased **(4 marks)**

b) Point C is called the super critical point. Describe the state of water at this particular point **(3 marks)**

c) The boiling point of water in Mombasa is slightly higher than the boing point of water at the top of Mt. Kenya. Explain with reference to B-C on the diagram **(3 marks)**

Use the Carnot Cycle diagram below to answer questions 1(d) and 1(e) below:



d) Elaborate the processes taking place from points:

i) 1 to 2 **(4 marks)**

ii) 2 to 3 **(4 marks)**

e) Calculate the work done(w) and internal energy (Δu) when a sample of an ideal gas is expanded from 1L to 5L at 3 atm and simultaneously cooled from 300K to 200K. Assume that its heat capacity at constant volume (C_v) is 0.15 kJ/ mol. K **(8 marks)**

f) Calculate the enthalpy change for the following reaction:

$$2PCl_{3(s)} + 2Cl_{2(g)} \rightarrow 2PCl_{5(s)}$$

Where:

(1) $2P_{(s)} + 3Cl_{2(g)} \rightarrow 2PCl_{3(l)}$ ... $\Delta_r H(1) = -640kJ$

(2) $2P_{(s)} + 5Cl_{2(g)} \rightarrow 2PCl_{5(s)}$ ... $\Delta_r H(2) = -887kJ$ **(4 marks)**

Q2. a) Define the term 'Enthalpy of Combustion'. **(3 marks)**

b) A student measured 70ml of water into a beaker and lit the burner. When the temperature of water had gone up by 11.5°C, he found out that 0.150 grams of propan-2-ol had been burnt.

i) Calculate the energy in kJ produced by burning 0.150 g of propan-2-ol. (Specific capacity of water is 4.18 J g^{-1} K^{-1}) **(4 marks)**

ii) Calculate the enthalpy change of combustion of Propan-2-ol in kJ mol^{-1} **(4 marks)**

c) Describe the Ideal Gas Law **(4 marks)**

d) Calculate the work done by 0.4 moles of a gas in Joules if it expands from $10cm^3$ to $40cm^3$ at room temperature **(5 marks)**

Q3. a) Define the term 'Entropy' **(3 marks)**

b) The specific heat capacity of copper metal at constant volume (C_v) is 0.386 J g^{-1} K^{-1}. If two pieces of copper metal of the same cross-sectional area but of different temperature are joined to each other, calculate the change in entropy (ΔS) due to heat transfer (Piece A has a temperature of 25K while Piece B has a temperature of 375K) **(4 marks)**

c) Use the following reaction to answer questions c(i) and c(ii):

$$A + B \leftrightarrow C + D$$

If the concentrations of the reactants and the products at different temperatures are as follows:

SPECIES	**CONCENTRATIONS AT 298K (MOLES)**	**CONCENTRATIONS AT 398K (MOLES)**
A	3.5	1.1
B	2.3	0.2
C	0.3	2.4
D	0.5	2.8

Calculate:

i) ΔG of the reaction at 298K **(3 marks)**

ii) ΔG of the reaction at 398K **(3 marks)**

d) Using relevant expressions, describe the Van't Hoff equation **(4 marks)**

e) Using the Van't Hoff equation, determine whether the reaction in (c) above is exothermic or endothermic in nature (use the graph paper provided) **(3 marks)**

Q4. a) Describe the Lever Rule as used in phase equilibria **(4 marks)**

b) At temperature T, the molar ratio of A is 0.8 on the liquidus line and 0.2 on the solidus line. Calculate the percentage of liquid and solid at point O where the molar ratio of A is 0.55 **(6 marks)**

c) Define the term 'Compressibility' as used in the non- ideal gas equation of state **(4 marks)**

d) Calculate the pressure of 0.5 moles of ammonia gas contained in a 0.25 litre container at 400K using the van der waals non-ideal gas equation of state $(a_{NH_3} = 4.304; b_{NH_3} = 0.037)$ **(6 marks)**

Q5. a) A partition divides two chambers of equal volume of an ideal gas. The temperature of one chamber is elevated to 450K while the other one remains at 298K. If the internal energy change (Δu) is 15.5 J mol^{-1}, calculate the entropy change when the partition is removed and the gases are allowed to mix **(6 marks)**

b) i) Define heat capacity at constant volume (C_v) **(4 marks)**

ii) Calculate the heat capacity at constant volume (C_v) of an ideal gas having a change in internal energy (ΔU) of 0.55 J mol^{-1} when there is a temperature change (ΔT) of 5K **(5 marks)**

iii) Calculate the heat capacity at constant pressure of the ideal gas above if 0.65 moles of the gas were used **(5 marks)**
(ΔH = 0.78kJmol^{-1})

END