MACHAKOS UNIVERSITY

ISO 9001:2015 Certified

UNIVERSITY EXAMINATIONS 2018/2019

SCHOOL OF PURE AND APPLIED SCIENCES
DEPARTMENT OF PHYSICAL SCIENCES

FOURTH YEAR SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION (SCIENCE)

SCH 403: PHASE EQUILIBRIA

DATE: 26/7/2019 **TIME: 2:00 – 4:00 PM**

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks).

Required data

- Gas Constant, R = 8.314 $JK^{-1}mol^{-1}$ = 0.08206 L atm K^{-1} mol^{-1}
- 0 ℃ = 273 K

Section A - Compulsory

1. a) Water exhibits three phases i.e. ice, liquid water and vapour.

   i) Sketch a well labeled phase diagram of water (8 marks)

   ii) Show that the triple point of water is invariant (2 marks)

   b) Using a Heat vs. Temperature diagram, explain how one mole of ice changes when heat is added to it. (8 marks)

   c) Briefly explain why Pb-Sn alloys are used as solders (2 marks)

   d) Distinguish between;

   i) Osmosis and osmotic pressure (2 marks)

   ii) Triple point and Eutectic point (2 marks)

   iii) Congruent melting point and incongruent melting point (2 marks)

   iv) Boiling point elevation and freezing point depression of a solution (2 marks)

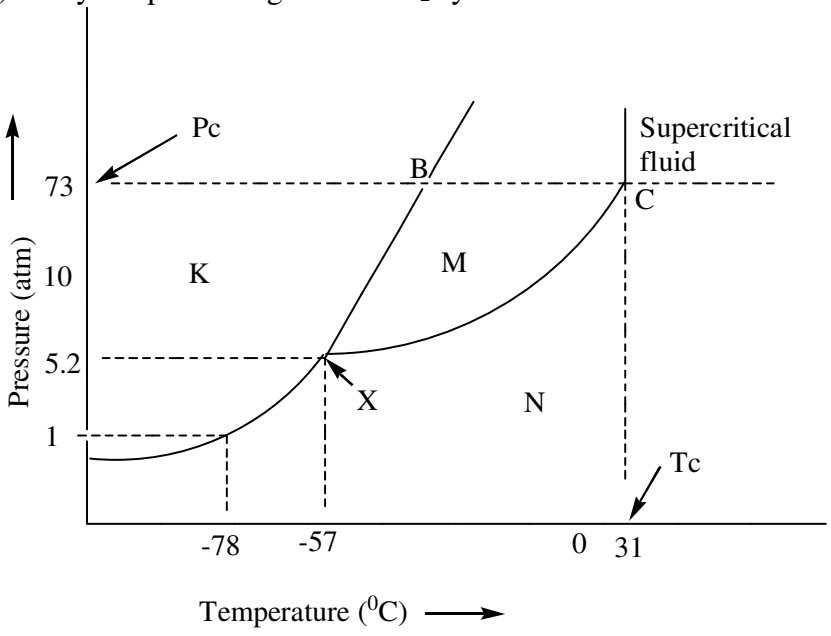
   v) A phase and a component (2 marks)

Section B

Answer any two questions

2. a) State the phase rule and clearly explain the meaning of the terms employed in the rule (4 marks)

   b) Study the phase diagram of CO_2 system and answer the following questions:



Describe what happens to a CO_2 sample when the following changes are made:

i) The temperature increased from -100 ºC to 0 ºC at constant pressure of 2 atm (2 marks)

ii) The pressure is reduced from 72 atm to 5 atm at a constant temperature of 30 ºC (2 marks)

iii) The pressure is first increased from 3.5 atm to 76 atm at -10 ºC and the temperature is then increased from -10 ºC to 45 ºC (3 marks)

iv) Apply the phase rule at point labeled X and comment on the result obtained. (2 marks)

v) Identify phases M and N (1 mark)

vi) State the significance of temperature Tc and Pressure Pc (1 mark)

c) i) Define colligative properties (1 mark)

ii) The vapour pressures of pure CCl_4 (molecular weight 154 g) and $SnCl_4$ (molecular weight 170 g) at 25 ºC are 229.6 mmHg and 476.6 mmHg respectively. Calculate the total vapour pressure of the mixture containing 10 g of CCl_4 and 15 g of $SnCl_4$ respectively (4 marks)

3. a) Use the following data to draw a phase diagram for a substance A and B system:

i) Melting point of B is 655 ºC

ii) Melting point of A is 500 ºC

iii) One Eutectic point at 180 ºC with 25% A and another at 350 ºC with 85 % of A.

iv) A solid compound BA_2 is formed which melts at 580 ºC. (8 marks)

b) Sketch clearly a well labeled phase diagram for sulphur system (6 marks)

From the diagram;

i) identify all the triple points and the melting point of each allotrope (2 marks)

ii) Discuss the application of the phase rule in the sulphur system (4 marks)

4. a) i) State the Raoult's Law (1 mark)

ii) Calculate the vapour pressure of a solution containing 11.7 g benzene (MW = 78) and 4.6 g methylbenzene (MW = 92) at 50 °C, if the vapour pressure of the pure components at this temperature are 3.6×10^4 Nm^{-2} and 1.12×10^4 Nm^{-2}, respectively. (4 marks)

b) Explain how the molecular weight of a substance in solution can be determined from its osmotic pressure (5 marks)

b) The variation of vapour pressure of a substance with temperature is given by

$\frac{dP}{dT} = \frac{\Delta H_v}{T(V_B - V_A)}$. Show that $\text{Ln}\, P = \frac{-\Delta H_v}{RT} + \text{constant}$. Explain what each of the terms represents and the approximations made. (5 marks)

ii) Determine the enthalpy of vaporization of water from the following data, expressing the results in J/mol.

Boiling Temperature of water = 373 K

The rate of change of pressure with temperature = 2.717 cmHg/K

Density of water = 0.962 g/ml

Density of water vapour = 5.973 x 10^{-4} g/ml

Density of mercury = 13.59 g /ml

Acceleration due to gravity = 981 cm/s^2 (5 marks)

5: a) i) State the Henry's law (1 mark)

ii) List three conditions for applicability of Henry's law (3 marks)

iii) Briefly describe the properties of an ideal solution. (2 marks)

b) Define the following terms as used in phase equilibria:

i) Degree of freedom (1 mark)

ii) Isomorphous system (1 mark)

iii) Critical temperature (1 mark)

iv) Azeotropic mixture (1 mark)

c) i) Sketch a Cu-Ni binary phase diagram clearly showing all the phases (5 marks)

ii) Explain how the Lever Rule can be used to determine the amount of each phase of the Cu-Ni alloy mixture (5 marks)