



MACHAKOS UNIVERSITY

University Examinations 2017/2018

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

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

SCH 403: PHASE EQUILIBRIA

DATE: 18/12/2017

TIME: 8.30-10.30 AM

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, $R = 8.314 \text{ JK}^{-1}\text{mol}^{-1} = 0.08206 \text{ L atm K}^{-1} \text{ mol}^{-1}$
- $0^\circ\text{C} = 273 \text{ K}$

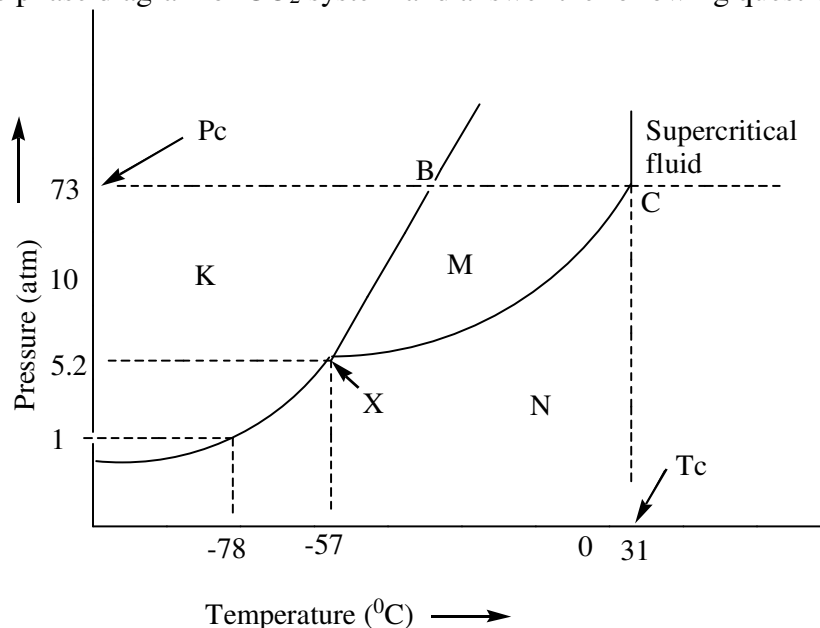
Section A - Compulsory

1. a) 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)

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

c) Study the phase diagram of CO₂ system and answer the following questions:



Describe what happens to a CO₂ sample when the following changes are made:

- i) The temperature increased from -100 °C to 0 °C 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 °C (2 marks)
- iii) The pressure is first increased from 3.5 atm to 76 atm at -10 °C and the temperature is then increased from -10 °C to 45 °C (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 T_c and Pressure P_c (1 mark)
- d) 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°C 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)

SECTION B: ANSWER ANY TWO QUESTIONS

2. Water exhibits three phases i.e. ice, liquid water and vapour.
- a) 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)
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°C
- ii) Melting point of A is 500°C
- iii) One Eutectic point at 180°C with 25% A and another at 350°C with 85 % of A.
- iv) A solid compound BA_2 is formed which melts at 580°C . (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 $3.6 \times 10^4 \text{ Nm}^{-2}$ and $1.12 \times 10^4 \text{ Nm}^{-2}$, respectively. (4 marks)

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

c) 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 $\ln P = \frac{-\Delta H_v}{RT} + \text{constant}$. 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 = 5.973×10^{-4} g/ml

Density of mercury = 13.59 g /ml

Acceleration due to gravity = 981 cm/s² (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) Freezing point (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)