



MACHAKOS UNIVERSITY

University Examination for 2019/2020 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCE

**FOURTH YEAR FIRST SEMESTER EXAMINATION FOR THE DEGREE OF
BACHELOR OF EDUCATION SCIENCE AND BACHELOR OF EDUCATION
(SPECIAL NEEDS)**

SCH 403: PHASE EQUILIBRIA

DATE:

TIME: 2 HOURS

INSTRUCTIONS:

1. Question **ONE** is **COMPULSORY** (Section A) (30mks)
2. Answer **ANY** other **TWO** questions from **Section B** (each 20marks)

SECTION A (COMPULSORY)

QUESTION ONE (30 MARKS)

- a) State the phase rule and clearly explain the meaning of the terms employed in the rule (3mks)
- b) Define colligative properties and give two examples (3mks)
- c) Briefly describe the properties of an ideal solution. (3 mks)
- d) i) State the Henry's law (2 mks)
- ii) List three conditions under which Henry's law is applicable (3mks)
- e) Define colligative properties and give two examples (3mks)
- f) Explain the effects adding solute on freezing point (3mks)
- g) Calculate the osmotic pressure of 0.015M solution of glucose $C_6H_{12}O_6$ in water at $25^\circ C$ ($R=0.0821L.atm/Mol.k$). (3mks)
- h) Differentiate between boiling point and boiling point elevation (3mks)
- i) Calculate the total pressure of benzene and toluene over a solution of 0.661Mol benzene and 0.227Mol toluene at $25^\circ C$. Their vapour pressure when pure are 96.0 atm and 27 torr respectively. (4mks)

SECTION B

QUESTION TWO

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

$$\frac{dP}{dT} = \frac{\Delta H_v}{T(V_B - V_A)}. \text{ Show that } \ln P = \frac{-\Delta H_v}{RT} + \text{constant. Explain what each of the terms}$$

represents and the approximations made. (6 mks)

- b) The vapour pressure of ethyl ether is 401mmHg at 18°C. Calculate its vapour pressure at 32°C given its ΔH_{vap} is 26Kj/Mol (6mks)

- c) Water exhibits three phases i.e. ice, liquid water and vapour.

i) Sketch a well labeled phase diagram of water (6 mks)

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

QUESTION THREE (20MKS)

- a) If the normal boiling of a substance is 335k and its enthalpy of vaporization is 92.1kJ/mol.

i) Calculate its boiling point when pressure is increased to 5.0 atm (6mks)

ii) What is the vapor pressure of the substance at 300k (6mks)

- b) Distinguish between;

i) Triple point and Eutectic point (2mks)

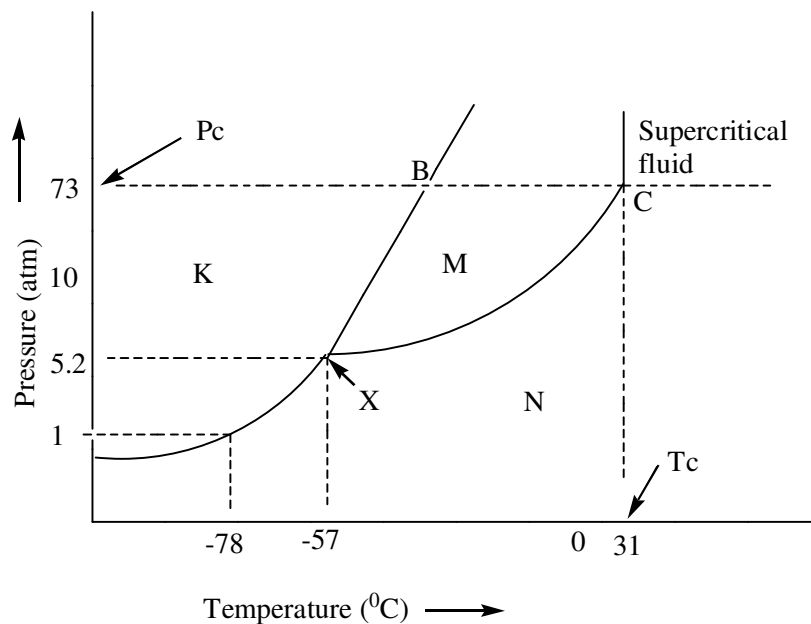
ii) Congruent melting point and incongruent melting point (2mks)

iii) Boiling point elevation and freezing point depression of a solution (2mks)

iv) A phase and a component (2mks)

QUESTION FOUR (20MKS)

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



a) 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 mks)

ii) The pressure is reduced from 72 atm to 5 atm at a constant temperature of 30 °C

(2 mks)

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

mks)

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

(2 mks)

v) Identify phases M and N

(2 mks)

vi) State the significance of temperature T_c and Pressure P_c (1 mk)

- b) Given the normal boiling point of a substance is 335K and its enthalpy of vaporization is 92.1 KJ/Mol, calculate its boiling point when its pressure is increased to 5 atm. (Hint: at Normal boiling point pressure is 1 atm. (8mks)

QUESTION FIVE

- a) Define the following terms as used in phase equilibria:

- i) Degree of freedom (1 mk)
- ii) Isomorphous system (1 mk)
- iii) Critical temperature (1 mk)
- iv) Azeotropic mixture (1 mk)

- b) i) State the Raoult's Law (2mks)
- 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 (6mks)

- c) i) The vapour pressure of ethyl alcohol at a certain temperature is 79.3 torr. Calculate the vapour pressure of ethyl alcohol in solution at that temperature if 0.175 moles of glucose are dissolved in 0.909 Mol of the alcohol (5mks)
- ii) Calculate the vapor pressure lowering of alcohol (3mks)