



MACHAKOS UNIVERSITY

University Examinations 2020/2021

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR FIRST SEMESTER EXAMINATION FOR

MASTER OF SCIENCE (CHEMISTRY)

SCH 803: ADVANCED CHEMICAL THERMODYNAMICS

DATE: 15/05/2021

TIME: 8:30 - 11:30 AM

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 15 marks).

SECTION A - COMPULSORY.

QUESTION ONE (30 MARKS)

- a) Using examples, differentiate the following terms as used in thermodynamics
- i) Chemical potential and Electrical potential (2 marks)
 - ii) Species and substances (2 marks)
 - iii) Homogeneous mixture and a solution (2 marks)
- b)
- i) By the aid of equations, explain the fugacity of a pure gas (3 marks)
 - ii) Explain the dependence of fugacity of a gas on pressure and temperature (4 marks)
- c)
- i) Derive the Gibbs- Duhem equation (4 marks)
 - ii) Explain the applications of the Gibbs- Duhem theory (4 marks)
- d) Explain three methods of evaluating the activity coefficients of nonelectrolyte substances (9 marks)

SECTION B: ANSWER ANY TWO QUESTIONS

QUESTION TWO (15 MARKS)

- a) i) Derive the Debye –Huckel equation (5 marks)
ii) Explain the applications of Debye –Huckel theory (5 marks)
- b) Show that the chemical potential of a cation is given by $\mu_+ = \mu_+^0 + RT \ln a_+ + z_+ F \phi$
(Explain all the terms used in the equation) (5 marks)

QUESTION THREE (15 MARKS)

- a) Define the following terms as used in thermodynamics;
i) Molality (1 mark)
ii) Activity coefficient of a species (1 mark)
iii) Electrolyte (1 mark)
- b) i) State Henry's law. (1 mark)
ii) Calculate the solubility of carbon dioxide in water at 0 °C and a pressure of 3.00 atm. The solubility of carbon dioxide is 0.348 g/100 mL in water at 0 °C and 1.00 atm. (3 marks)
- c) Show that the change in Gibbs's free energy (ΔG) for a process at a constant temperature and pressure is given by $\Delta G = \Delta A + P\Delta V$ (where A is the Helmholtz Free energy function, P is pressure and V is the volume) (4 marks)
- d) Derive the equation of state of a real gas and compare it with that of a real gas mixture (4 marks)

QUESTION FOUR (20 MARKS)

- a) i) State Raoult's Law (1 mark)
ii) Calculate the vapour pressure of a solution containing 16.7 g benzene (MW = 78) and 9.6 g methylbenzene (MW = 92) at 70 °C, if the vapour pressures of the pure components at this temperature are $4.6 \times 10^4 \text{ Nm}^{-2}$ and $2.12 \times 10^4 \text{ Nm}^{-2}$, respectively. (4 marks)
iii) Using equations, show that a certain solvent obeys the Raoult's law for fugacity (5 marks)
- b) The concept of entropy is used to derive an expression for the maximum efficiency of an engine. Such an engine must function in cycles. Briefly explain the Carnot Cycle and derive the formula used to calculate the efficiency of an engine (5 marks)

QUESTION FIVE (20 MARKS)

- a) Differentiate the following terms as used in thermodynamics
- i) Ideal dilute solution and an ideal liquid mixture (2 marks)
 - ii) Ideal gas and a real gas (2 marks)
 - iii) Molar enthalpy and Molar entropy (2 marks)
- b) Using relevant examples and equations, explain the molar enthalpy, heat capacity and molar entropies of real gases (9 marks)