University of Swaziland

Faculty of Science and Engineering

Department of Chemistry

Re-sit Examination 2017/2018

Title of Paper	:	Applied thermodynamics
Course code	:	CHE 242
Time	:	3 hours
Instructions	:	Each question is worth 25% Answer question 1 and any other 3 questions Data sheets are provided with this examination

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Question 1 – Compulsory [25 Marks]

a) At 27.0 °C, the vapor pressure of pure water is 23.76 mmHg and that of an aqueous solution of urea is 22.97 mmHg. Calculate the molality of urea in this solution. [10]

b) Write short notes on the following;

i. Osmotic pressure [5]

ii. Boiling point elevation [5]

iii. Vapour pressure lowering [5]

Question 2 [25 marks]

a) An aqueous solution of an unknown solute freezes at -3.55 °. At what temperature would you expect it to boil given that K_f= 1.86 °C kg/mol and K_b= 0.52 °C kg/mol. [8]

b) The analysis of gases is done under real or perfect conditions. Derive an expressions $\Delta_r G$ for real gases [6]

c) Write short notes on the following;

a. Triple point [2]
b. van't Hoff factor [2]
c. Standard chemical potential [4]

d) Show your understanding of colligative properties by using 1 real life examples to show the use of any two scenarios of your choice. [3]

Question 3 [25 marks]

a) Write short notes on the following;

a. Henry's law [3]

b. Osmotic pressure [3]

c. Vapour pressure lowering [3]

b) What mass of urea CON_2H_4, must be added to 450 g H_2O to get a solution with a vapour pressure of 298 mmHg given that the vapour pressure of pure H_2O is 31.8 mmHg at this temperature. [4]

c) Using a rough sketch, show the important components of a phase diagram. [5]

d) Illustrate the schematic temperature dependence of the chemical potential with temperature for the three phases of a chemical substance [7]

Question 4 [25 Marks]

a) Draw a sketch of the phase diagram of water and explain briefly the slopes and curvature of the liquid-solid and the liquid-gas boundaries, respectively. [15]

b)

i) Using an appropriate fundamental thermodynamic equation derive the Clausius - Clapeyron equation for evaporation in the form

$$\ln P_2 = \ln P_1^* - \frac{\overline{\Delta H}_{vap}}{\overline{R}}\left(\frac{1}{T_2} - \frac{1}{T_1}\right). \quad [5]$$

ii) What change in the boiling point of water at 1 atm is brought by 1 10 torr increase in pressure ? [5]

Question 5 [25 Marks]

a) Calculate the freezing point and the boiling point of a solution that contains 15.0 grams of urea (CH_4N_2O) in 250 g of water. Urea is a covalently bounded compound (K_f=1.86 and K_b=0.52 °C kg mol-1). [8]

b) Derive the Gibbs energy of mixing for solutions under ideal conditions;

$$\Delta_{mix}G = nRT(x_A \ln x_A + x_B \ln x_B)$$ [17]

Question 6 [25 Marks]

a) Using a rough sketch, show the important components of a phase diagram. [8]

b) Illustrate the schematic temperature dependence of the chemical potential with temperature for the three phases of a chemical substance [8]

c) For the chemical equation (Question 5d), derive 4 equations for the chemical potential and use them with Hess' law to find an equation for $\Delta_r G$ (given that $\Delta_r G = \Delta\mu$) [9]