University of Swaziland

Faculty of Science and Engineering

Department of Chemistry

Main 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

Question 1 -- Compulsory [25 Marks]

a) Write short notes on the following

i. Partial molar volume [2]

ii. Raoult's Law [3]

b) What is the approximate osmotic pressure of a 0.118 mol and 1.00 g/mL solution of LiCl at 10.0 °C? The freezing point of this solution is -0.415 °C. [8]

c) Solid $CaCO_3$ degenerates into CaO and CO_2 at certain conditions, determine if this reaction will proceed under standard conditions given that $\Delta_r G°$ of $CaCO_3$, CaO and CO_2 are -1128, -603.5 and -137.2 kJ mol^{-1}, respectively. [6]

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

Question 2 [25 Marks]

a) Write short notes on the following;

i. Triple point [2]

ii. van't Hoff factor [2]

iii. Standard chemical potential [4]

b) Show your understanding of colligative properties by using 2 real life examples to show the use of any two scenarios of your choice. [6]

c) The vapour pressure of pure acetone is 4.00×10^3 mmHg. A solution is prepared by dissolving 1.00 g of a non-volatile compound sulfanilamide ($C_6H_8O_2N_2S$) in 10.00 g of acetone (CH_3COCH_3):

i. Find the vapour pressure of acetone in the solution. [7]

ii. Given that the solution is prepared in a 200 ml container, what is the osmotic pressure of the solution at 0 °C. [4]

Question 3 [25 Marks]

a) Write short notes on the following;

i. Henry's law [3]

ii. Osmotic pressure [3]

iii. Vapour pressure lowering [3]

b) Calculate the partial molar volume of pure liquid water when the density is given by 0,997 g/cm^3 at 25 °C. By how much would the molar volume change if the sample is increased by 2 g. [4]

c) 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]

d) Derive the vapor pressure of a pressurized liquid, with an aid of diagrams where necessary. [8]

Question 4 [25 Marks]

a) At 286 K, the osmotic pressure of a glucose solution is 9.97 atm. What is the freezing point depression (given the density of the solution is 1.12 g/mL) given that K_f = 1.86 °C kg/mol? [10]

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

c) Estimate the vapour pressure of a liquid benzene at 20 °C when its normal boiling point is 80 °C at a vapour pressure of is 101 kPa, given that $\Delta_{vap}H$=30.8 kJ/mol. [5]

d) Explain how Raoults law and Henry's law are used to specify the chemical potential of a component of a mixture [5]

Question 5 [25 Marks]

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

b) Derive the equation for the vapor pressure lowering [4]

c) Give brief explanation of the following observations;

i. Freezing –point constants are typically larger than boiling point constants of a solvent,

ii. There is a difference in the boiling point constants of water and benzene. [6]

d) Derive that equation of the equilibrium constant for the generic chemical equation

$$aA(g) + bB(g) \rightarrow cC(g) + dD(g)$$ [7]

Question 6 [25 Marks]

a) Determine the molecular formula of a compound given that when 7.85 g sample of the compound having an empirical formula C_5H_4 is dissolved in 301 g of benzene, the freezing point of the solution is 1.04 °C below that of pure benzene. K_f is given by 5.12 °C kg/mol. [6]

b) 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]

c) Calculate the difference in slope of the chemical potential against pressure on either side of (a) the normal freezing point of water and (b) the normal boiling point of water. Given that the densities of ice and water at 0°C are 0.917 gcm^{-3} and 1.00 gcm^{-3} and those of water and water vapour at 100°C are 0.958 gcm^{-3} and 0.598 gcm^{-3}, respectively. By how much does the chemical potential of water exceed that of liquid water at 1.2 atm and 100°C? [10]