ALUPE UNIVERSITY COLLEGE
Bastion of Knowledge...
P. O.Box 845-50400 Busia(K)
principal@auc.ac.ke
Tel: +254 741 217 185
+254 736 044 469
off Busia-Malaba road

OFFICE OF THE DEPUTY PRINCIPAL
ACADEMICS, STUDENT AFFAIRS AND RESEARCH

UNIVERSITY EXAMINATIONS

2018/2019 ACADEMIC YEAR

SECOND YEAR SECOND SEMESTER REGULAR EXAMINATION

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE

COURSE CODE: **CHE 202**

COURSE TITLE: **CHEMICAL THERMODYNAMICS AND PHASE EQUILIBRIA**

DATE: 24TH APRIL, 2019 **TIME: 2.00 PM – 5.00 PM**

INSTRUCTION TO CANDIDATES

- **SEE INSIDE**

THIS PAPER CONSISTS OF 4 PRINTED PAGES **PLEASE TURN OVER**

CHE 202: CHEMICAL THERMODYNAMICS AND PHASE EQUILIBRIA

STREAM: BED (Science) **DURATION: 3 Hours**

INSTRUCTIONS TO CANDIDATES

i. *Answer **ALL** questions.*

ii. *Diagrams may be used whenever they serve to illustrate the answer.*

iii. *Do not write on the question paper.*

Physical Constants

Physical Constants: $R=0.08206$ L atm mol K^{-1}, $R=8.314$ J K^{-1} mol^{-1}, $C_v=12.48$

Question One

a) Explain why the entropy of a gas increases with volume and with temperature. (1 Mark)

b) Calculate the change in entropy (ΔS) when pressure of a perfect gas is changed isothermally from an initial pressure of 2 atm to a final pressure of 5 atm. (3 Marks)

c) Calculate the temperature of a cold sink in the Carnot system having hot source at 300 K with $q_h=260$ J connected to the cold sink at $q_c=180$ J. (3 Marks)

d) Calculate entropy change in the surroundings when 1.0 moles of H_2O (liquid) is formed from its elements under standard conditions at 298 K given $\Delta H^{\theta}= -286$ kJ mol^{-1}. Comment on the increase or decrease in entropy and give reasons for that change. (4 Marks)

e) State the Clausius inequality. (1 Mark)

f) Justify Trouton's rule. What are the sources of discrepancies? (3 Marks)

g) Explain why water has a large entropy of vapourization compared to other liquids such as benzene, carbon tetrachloride, cyclohexane, hydrogen sulphide and methane. (2 Marks)

h) Predict the standard molar enthalpy of vapourisation of ethane (C_2H_6) from its boiling point -88.6°C and the standard molar entropy of vapourization $\Delta S^{\theta}_{vap}= 88.9$ $JK^{-1}mol^{-1}$. (3 Marks)

Question Two

a) State the 1st law of thermodynamics. (1 Mark)

b) Define the Clausius-Clapeyron equation. (1 Mark)

c) What is a phase? (1 Mark)

d) The vapour pressure of water is 1.0 atm at 373 K, and the enthalpy of vaporization is 40.7 kJ mol^{-1}. Estimate the vapour pressure at temperature of 363 K and 383 K, respectively. (4 Marks)

e) Methane (CH_4) and benzene (C_6H_6) form an ideal dilute solution. The pressure of pure benzene is P_{benz} = 300 Torr at 298 K. Henry's Law constant of the solute (methane) is $K_{meth} = 4.27 \times 10^4$ Torr at 298 K. If the mole fraction of CH_4 in the liquid phase is $x_{meth} = 1.01 \times 10^{-2}$, find:

i) The partial pressure of CH_4 at 298 K (3 Marks)

ii) The partial pressure of C_6H_6 (3 Marks)

iii) The mole fraction of CH_4 in the gaseous phase. (3 Marks)

Question Three

a) Explain the importance of studying phase equilibria and phase diagrams in chemistry (1 Mark)

b) Write and define all the terms in the Gibbs phase rule (2 Marks)

c) Find degrees of freedom, *f* for a system consisting of solid sucrose in equilibrium with an aqueous solution of sucrose. (2 Marks)

d) One mole of an ideal gas expands at T = 298 K from 24.79 L to 49.58 L in a reversible process. Calculate the change in entropy. (3 Marks)

e) Calculate the entropy change in the surroundings when 1.00 mol $N_2O_4(g)$ is formed from 2.00 moles $NO_2(g)$ under standard conditions at 298 K. (3 Marks)

f) Show the 4 reversible processes in the carnot cycle diagrammatically and calculate the ΔS around the cycle. (3 Marks)

g) Show that for an irreversible adiabatic change, $dS \geq \frac{d_q}{T}$ (3 Marks)

Question Four

a) Derive and explain the significance of the Clapeyron equation (3 Marks)

b) Explain and justify colligative property for nonvolatile solutes for the vapour pressure

(1 Mark)

c) Calculate the entropy change when argon at 25°C and 1.00 bar in a container of volume 0.500 dm^3 is compressed to 0.05 dm^3 and is simultaneously cooled to -25°C. (4 Marks)

d) Calculate the standard reaction entropy for the combustion of methane to carbon dioxide and liquid water at 25°C. Standard reaction entropies are; methane(g)= 186.3 J K^{-1} mol^{-1}, Carbon dioxide(g)=213.7 J K^{-1} mol^{-1}, Water (l)=69.9 J K^{-1} mol^{-1} and $O_{2(g)}$=205.138 J K^{-1} mol^{-1} (3 Marks)

e) Construct a boiling point/composition diagram for two liquids with different boiling points. (2 Marks)

f) Using the concept in (d) above, explain how fractional distillation of oil is carried out. (2 Marks)

g) Explain how the Clausius-Clapeyron equation can be used to construct the entire vaporization/freezing curve for a particular liquid. (2 Marks)

****