MACHAKOS UNIVERSITY

University Examinations 2019/2020Academic year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE ANALYTICAL CHEMISTRY

SCH 201: CHEMICAL THERMODYNAMICS AND PHASE EQUILIBRIA

DATE: **TIME:**

INSTRUCTIONS TO CANDIDATES

1. This paper contains **two sections**, **A** and **B**
2. Question number one (**Section A**) is **compulsory**
3. Choose **any** other **two** questions from section **B**.

Useful constants

R=8.314J/mol k or R=0.08206L.atm/mol k

$C_p=\frac{5}{2}R$ $C_v=\frac{3}{2}R$(monoatomic ideal gases)

$C_p=\frac{7}{2}R$ $C_v=\frac{5}{2}R$(Diatomic ideal gases)

STP (T=273.15K, 1atm=101325Nm^{-2}, V=22.415dm^3)

$\Delta U=nC_vdT$

$\Delta H=nC_PdT$

SECTION A (COMPULSORY)

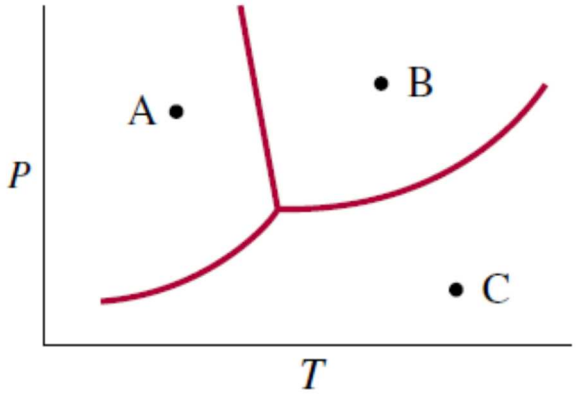
QUESTION 1 (30 MARKS)

a) State and give a mathematical expression for the first law of thermodynamics (3 marks)

b) Using $Cv = \frac{dE}{dT}$ and $Cp = \frac{\delta q_p}{dT}$ show that for a perfect ideal gas $C_p = C_v + R$ (3 marks)

c) The vapor pressure of ethyl ether is 405 mmHg at 18°C. Calculate its vapor pressure at 32°C, given its ΔH=26kJ/mol (3 marks)

d) The figure below shows a phase diagram of water. Predict what would happen as a result of the following changes:



i. Starting at A, the temperature is raised at constant pressure (1 mark)

ii. Starting at C, the temperature is lowered at constant pressure (1 mark)

iii. Starting at B, the pressure is lowered at a constant temperature (1 mark)

e) Using the generalized expression for clausius inequality, derive an alternative criterion for spontaneity at constant temperature and volume (3 marks)

f) Differentiate between heat and work (2 marks)

g) Classify the following as isolated, closed or open system (3 marks)

i. Nitrogen and hydrogen reacting in a sealed tube to form ammonia

ii. A glass vial containing Sulphuric acid is broken inside water in a beaker

iii. Thermos flask

h) A certain gas expands from 500 mL to 1500 mL very slowly at 25°C. If there is one mole of the gas in the chamber, calculate the work involved when the gas behaves ideally (3 marks)

i) Critical temperature of methane and carbon dioxide are -81.9°C and 31.1°C respectively. Determine which of these gases has stronger intermolecular forces and why. (3 marks)

j) Differentiate between enthalpy and entropy (2 marks)

k) Explain how adding a solute affects the freezing point of a solvent (2 marks)

SECTION B (Answer any TWO questions)

QUESTION TWO (20 MARKS)

a) If the normal boiling point of a substance is 335 k and its enthalpy of vaporization is 92.1 kJ/mol. Using Clausius Clapeyron equation $\ln \frac{P_1}{P_2} = -\frac{\Delta H_{vap}}{R}(\frac{1}{T_2} - \frac{1}{T_1})$ calculate;

i) Its boiling point when pressure is increased to 5 atm (5 marks)

ii) What is the vapor pressure of the substance at 300 k? (5 marks)

b) i) Define standard enthalpy of formation (2 marks)

ii) Given the following standard enthalpies of formation, calculate the $\Delta H^o_{Combustion}$ of benzene and change in the internal energy of the system at 298 k (8 marks)

Compound	ΔH^o_f(kj/mol)
$CO_2(g)$	-393.51
$C_6H_6(l)$	+48.7
$H_2O(l)$	-285.83

QUESTION THREE (20 MARKS)

a) A 4 L sample of hydrogen gas at 15 atm and 25°c is allowed to expand to a final pressure of 1atm. Calculate q, w, ΔU and ΔH if the gas expands adiabatically and irreversibly given $\frac{T_2}{T_1} = \frac{\frac{C_v}{R}+\frac{P_2}{P_1}}{\frac{C_v}{R}+1}$ (10 marks)

b) Show that change in internal energy (ΔU) is the same whether a system undergoes isochoric or isobaric process as long as the ΔT is the same. (5 marks)

c) Using Gibbs phase rule, state and identify the number of intensive variables that must be defined when;

i. Pure ice water is melted (2 marks)

ii. When pure water boils (2 marks)

iii. At the triple point (1 mark)

QUESTION FOUR (20 MARKS)

a) Define the following terms

i. Specific heat capacity (2 marks)

ii. Molar heat capacity. (2 marks)

b) Describe the boundary conditions in;

i. Open system (2 marks)

ii. Closed system (2 marks)

iii. Isolated system (2 marks)

c) The standard molar enthalpy of formation of ammonia is -56.25kJ/mol. Using the heat capacity data given below, calculate the standard molar heat of formation of ammonia at 1000k (10 marks)

$C_pN_{2(g)}$ J/mol. k=26.98+(5.912×10^{-3}) T

$C_pNH_{3(g)}$ J/mol. k=25.89+(32.58×10^{-3}) T

$C_pH_{2(g)}$ J/mol. k=29.07-(0.837×10^{-3}) T

QUESTION FIVE (20 MARKS)

a) Sample of 1 mole of silver at 150^{o}C is placed in contact with 1 mole of silver at 0^{o}C forming an isolated system at constant pressure. Assuming the specific heat capacity of silver is 25.85J/mol k, Calculate

i. The final temperature of both the silver samples (4 marks)

ii. Calculate ΔS for the hot silver (2 marks)

iii. Calculate ΔS for the cold silver (2 marks)

iv. The total ΔS of the system (1 marks)

v. Is the process spontaneous (1 marks)

b) Two Carnot engines operate with a temperature difference of 250K between their hot and cold reservoirs. If engine A's hot reservoir is maintained at 1000K, while that of engine B is maintained at 1250K, which is the more efficient engine? (5 marks)

c) Differentiate between state and non-state functions and give two examples in each case (5 marks)