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 EDUCATION

SCH 201: CHEMICAL THERMODYNAMICS

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

$\Delta U=nC_vdT$

$\Delta H=nC_PdT$

SECTION A (COMPULSORY)

QUESTION ONE (30 MARKS)

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

b) Differentiate between extensive and intensive properties of matter and give an example for each (3 marks)

c) Explain why $Cp>C_v$ (3 marks)

d) What is the heat required to vaporize 1 mole of water ($H_2O_{(l)}$) at 25°C and 1 atmospheric pressure given H_{vap} =50.68kJ/mol K, Cp of $H_2O_{(l)}$ =95.45J/mol K and Cp of $H_2O_{(g)}$ =23.75J/mol K? (3 marks)

e) Two Carnot engines operate with a temperature difference of 300 K between their hot and cold reservoirs. If engine A's hot reservoir is maintained at 1200 K, while that of engine B is maintained at 750 K, determine the most efficient engine. (3 marks)

f) Using second law of thermodynamics show that for a cyclic engine with no cold reservoir the conversion of all heat to equivalent work is non-spontaneous. (3 marks)

g) Calculate the change in free energy when 11.21dm^3 of a perfect gas at 0°C and 760mmHg pressure expands isothermally until its pressure is 190mmHg (3 marks)

h) The 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)

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

j) Determine the entropy of the following reaction using information below (3 marks)

Substance	**S^o($Jmol^{-1}K^{-1}$)**
$C_2H_{2(g)}$	200.82
$H_{2(g)}$	130.59
$C_2H_{4(g)}$	219.45

$C_2H_{2(g)}+H_{2(g)} \longrightarrow C_2H_{4(g)}$

SECTION B (ANSWER ANY TWO QUESTIONS)

QUESTION TWO (20 MARKS)

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

b) Describe the boundary conditions in;

i) Open system (2 marks)

ii) Closed system (2 marks)

iii) Isolated system (2 marks)

c) Define the following terms

i) Specific heat capacity (2 marks)

ii) Molar heat capacity (2 marks)

QUESTION THREE (20 MARKS)

a) Sample of 1 mole of silver at 150ºC is placed in contact with 1mole of silver at 0ºC forming an isolated system at constant pressure. Assuming the specific heat capacity of silver is 28.85J/mol k, Calculate

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

ii) ΔS for the hot silver. (2 marks)

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

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

v) Is the process above spontaneous. (1 mark)

b) Provide an expression for work done by a gas as it expands by volume ΔV against an external pressure P_{ext}. (2 marks)

c) Give an expression for the change in internal energy of the system as it expands by volume ΔV against an external pressure P_{ext} on absorbing q joules of heat. (3 marks)

d) A sample of gas changes in volume from 6 Litres to 8 Litres against an external pressure of 2.5 atm and simultaneously absorbs 1000 J of heat. What is the change in the internal energy of the system? (5 marks)

QUESTION FOUR (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 isothermally and reversibly. (10 marks)

b) A certain gas expands from 400 mL to 1200 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. (5 marks)

c) Given the following standard enthalpies of formation, calculate the standard enthalpy of combustion ($\Delta H^{o}_{combustion}$) of benzene at 298 k. (5 marks)

Compound	$\Delta H^{o}f$ (kJ/mol k)
CO_2	-393.51
C_6H_6	+48.7
H_2O	-285.83

QUESTION FIVE (20 MARKS)

a) State the Hess's law. (2 marks)

b) Calculate the enthalpy of the reaction, $C_2H_{4(g)}+H_{2(g)} \longrightarrow C_2H_{6(g)}$ at 298 k using the information given below. (6 marks)

$C_2H_{4(g)}+3O_{2(g)} \longrightarrow 2CO_{2(g)}+2H_2O_{(g)}$ ΔH=-1395 kJ

$C_2H_{6(g)}+{}^{7}/_{2}O_{2(g)} \longrightarrow 2CO_{2(g)}+3H_2O_{(g)}$ ΔH=-1550 kJ

$H_{2(g)}+{}^{1}/_{2}O_{2(g)} \longrightarrow H_2O_{(g)}$ ΔH=-243 kJ

c) The volume of a sample of an ideal gas at 0°C is 44.83 litres. To what volume must the gas be compressed adiabatically to attain a temperature of 30°C. (6 marks)

d) State and explain the physical concept of entropy and its variation with temperature. (6 marks)