MACHAKOS UNIVERSITY COLLEGE

(A Constituent College of Kenyatta University)
University Examinations for 2015/2016 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION (SCIENCE)

SCH 201: CHEMICAL THERMODYNAMICS

DATE: 12/8/2016 **TIME: 2:00 – 4:00 PM**

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory**.
- Answer any **two** questions from section **B**.

Useful information

- Gas Constant, R = 8.314 $JK^{-1}mol^{-1}$ = 0.08206 L atm K^{-1} mol^{-1}
- 1 atm = 760 mmHg = 101325 Nm^{-2}

SECTION A - COMPULSORY.

1. a) Define each of the following terms as used in thermodynamics;

   i) System

   ii) Surrounding

   iii) State function

   iv) Intensive property

   v) Closed system (5 marks)

   b) i) State Hess's law of constant heat summation. (2 marks)

   ii) Calculate the enthalpy of the reaction;

   $C_2H_{4(g)} + H_{2(g)} \rightarrow C_2H_{6(g)}$
   at 298 K from the following data:

   i) $C_2H_{4(g)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 2H_2O_{(g)}$ $\Delta H = -1395$ kJ
   ii) $C_2H_{6(g)} + 7/2O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(g)}$ $\Delta H = -1550$ kJ

   iii) $H_{2(g)} + 1/2O_{2(g)} \rightarrow H_2O(g)$ $\Delta H = -243$ kJ

   (4 marks)

   c) i) Define an isothermal change (2 marks)

   ii) 0.2 moles of an ideal gas was expanded isothermally at 273 K from 8 dm^3 to 10 dm^3. Determine the energy (q) absorbed from the surroundings.

   (4 marks)

   d) Calculate the Gibb's Free Energy change (ΔG), at 25 °C for the reaction:

   $C_2H_5OH_{(l)} + O_{2(g)} \rightarrow CH_3COOH_{(l)} + H_2O_{(l)}$

   from the following data.

   i. $H_{2(g)} + ½\ O_{2(g)} \rightarrow H_2O_{(l)}$ $\Delta G = -238$kJ

   ii. $2C_{(graphite)} + 3H_2O_{(g)} + 1/2\ O_{2(g)} \rightarrow C_2H_5OH_{(l)}$ $\Delta G = -176$kJ

   iii. $2C_{(graphite)} + 2H_2O_{(g)} + O_{2(g)} \rightarrow CH_3COOH_{(l)}$ $\Delta G = -394$kJ

   (5 marks)

   e) i) From the First Law of thermodynamics, derive the equation $C_p - C_v = R$ (4 marks)

   ii) The volume of a sample of an ideal monatomic gas at 20 °C is 65.2 litres. To what volume must the gas be compressed adiabatically so as to attain a temperature of 50 °C? (4 marks)

SECTION B

ANSWER ANY TWO QUESTIONS

2. a) i) Define adiabatic change (2 marks)

ii) 6 moles of an ideal monatomic gas at 400 K are compressed adiabatically to one quarter of the original volume. Calculate the temperature of the gas after compression. (4 marks)

b) i) Derive the Kirchhoff's equation (5 marks)

ii) For the reaction

$$N_{2(g)} + 3H_{2(g)} \leftrightarrow 2NH_{3(g)}$$

The value of ΔH^0_{298} is - 92.29 kJ at 25 °C. The molar heat capacities at constant pressure of nitrogen, hydrogen and ammonia are given as:

$C_{H2} = (29.038 - 0.0836 \times 10^{-3} T + 20.097 \times 10^{-7} T^2) JK^{-1}$

$C_{N2} = (26.957 + 5.906 \times 10^{-3} T - 3.373 \times 10^{-7} T^2) JK^{-1}$

$C_{NH3} = (25.870 + 32.968 \times 10^{-3} T - 30.430 \times 10^{-7} T^2) JK^{-1}$

Calculate the standard enthalpy of reaction at 125 °C. (5 marks)

c) When one mole of liquid benzene was completely burnt in oxygen to form liquid water and CO_2 gas, ΔH was found to be -3250 kJ at 298 K. Calculate the enthalpy of reaction at constant volume at the same temperature. (4 marks)

3. a) i) Define the third law of thermodynamics (2 marks)

ii) Calculate the entropy change for the reaction:

$$2C_{(graphite)} + 2H_{2(g)} \rightarrow 2C_2H_{4(g)}$$

Given the following standard entropies at 25 °C in units $J\ K^{-1}mole^{-1}$;

$C_{(graphite)}$	5.7
$H_{2(g)}$	131.2
$C_2H_{4(g)}$	221.0

(5 marks)

b) The enthalpy of transition from rhombic to monoclinic sulphur at the transition temperature of 95.6 °C is 0.361 kJ/mole. Determine the entropy of transition. (4 marks)

c) The boiling point of water at a pressure of 50 atmospheres is 265 °C and at 1 atmosphere is 100 °C. Assuming the temperature of the sink is 40 °C, compare the theoretical efficiencies of a steam engine operating between the boiling point of water and that of the sink at: a) 1 atmosphere b) 50 atmospheres. (5 marks)

d) Calculate the change in free energy when 11.21 dm^3 of a perfect gas at 0 °C and 760 mmHg pressure expands isothermally until its pressure is 190 mmHg. (4 marks)

4. a) i) Derive the Clapeyron - Clausius Equation. (5 marks)

ii) Determine the enthalpy of vaporization of water from the following data, expressing the results in J/mol.

Boiling Temperature of water = 373 K

The rate of change of pressure with temperature = 2.717 cmHg/K

Density of water = 0.962 g/ml

Density of water vapour = 5.973 x 10^{-4} g/ml

Density of mercury = 13.59 g /ml

Acceleration due to gravity = 981 cm/s^2 (5 marks)

b) i) Derive the Gibb's - Helmholtz equation. (5 marks)

ii) For the reversible reaction

$N_2 + 3H_2 \leftrightarrow 2NH_3$

At 773 K, the value of K_P, with partial pressures in atmospheres, is 1.44 x 10^{-5} at low pressures where the gases behave ideally. Determine the corresponding value of K_C with concentrations in mole $litre^{-1}$. (5 marks)

5. a) Calculate the change in free energy when 11.21 dm^3 of a perfect gas at 0 °C and 760 mmHg pressure expands isothermally until its pressure is 190 mmHg. (5 marks)

b) i) Derive the Van't Hoff Equation (5 marks)

ii) The equilibrium constant K_P for the reaction:

$N_2 + 3H_2 \leftrightarrow 2NH_3$

is 1.64 x 10^{-4} at 673K and 1.44 x 10^{-5} at 773 K. Determine the mean enthalpy of formation, ΔH_V, for one mole of ammonia from its elements in this temperature range. (5 marks)

c) i) Define entropy of a system (1 mark)

ii) One mole of an ideal monatomic gas at standard temperature and pressure was heated at constant volume to a temperature of 353 K. Determine the change in entropy for the process. (4 marks)