MACHAKOS UNIVERSITY

University Examinations 2023/2024

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF EDUCATION SCIENCE TELECOMMUNICATION AND INFORMATION TECHNOLOGY

BACHELOR OF EDUCATION SCIENCE (SPECIAL NEEDS)

BACHELOR OF EDUCATION SCIENCE MATHEMATICS

BACHELOR OF EDUCATION (SCIENCE)

SCH 201: CHEMICAL THERMODYNAMICS

DATE: **TIME:**

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks).

Useful information:

1 atm = 101325 Nm^{-2}

R = 8.314 $Jmole^{-1}K^{-1}$

= 0.08206 *litre-atm* $mole^{-1}K^{-1}$

0 ^oC = 273.15K

SECTION A

QUESTION ONE (30 MARKS)

a) Distinguish between (i) an isothermal and (ii) an adiabatic change, extensive and intensive properties. (4marks).

b) Explain the term system and distinguishing between open, closed and isolated systems. (6marks)

c) Express the First law of thermodynamics, in mathematical form, explaining what the various terms represent. (5marks)

d) A sample of an ideal monatomic gas at $30\ ^oC$ expands reversibly and adiabatically from 1.5 x 10^{-3} m^3 to 5.5 x 10^{-3} m^3. Determine the final temperature of the gas. Given the Cv/R=1.5. (5 marks)

e) A gas held in a cylinder fitted with a weightless piston expands against a constant external pressure of atm from volume of 5 dm^3 to 10 dm^3. In the process it absorbs 400 J thermal energy from its surrounding. Determine change in internal energy (5marks)

f) When one mole (18cm^3) of water at $100\ ^oC$ and 1atm pressure is converted to steam at $100\ ^oC$, the amount of heat absorbed is 40670 j. Calculate energy change for the reaction (5marks)

SECTION B

QUESTION TWO (20 MARKS).

a) State Hess's law (2 marks)

b) Given the following data:

$2\ C_2H_6(g) + 7\ O_2(g) \rightarrow 4\ CO_2(g) + 6\ H_2O(l)$ $\Delta H = -3120$ kJ

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H = -394$ kJ

$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(l)$ $\Delta H = -572$ kJ

Using cycle diagram, calculate ΔH for the following reaction.

$2C(s) + 3\ H_2(g) \rightarrow C_2H_6(g)$ (6 marks)

c) Derive the Kirchhoff's law (6 marks)

d) Given the following enthalpies of combustion of diborane (B_2H_6), Boron, and Hydrogen has -194 kj/mol, -236 kj/mol and -241 kj/mol respectively. Using cycle diagram, determine enthalpy of formation of diborane. (6 marks)

QUESTION THREE (20 MARKS).

a) The equilibrium constant at 400 °C for the reaction

$\frac{3}{2}H_2 + \frac{1}{2}N2 \rightarrow NH_3$ is 0.0129. calculate ΔG^O for the reaction. Assume gases behave ideally (5 marks)

b) Determine pressure that must give a volume of an ideal gas, originally at $100\ ^oC$ and 1 atm pressure, be adiabatically compressed in order to raise its temperature to $400\ ^oC$. ($C_p/R = 1.4$, for the gas). (6 marks)

c) Calculate the entropy change for the reaction: (5 marks)

$2\ C(s) + 3H_2(g) \rightarrow C_2H_6(g)$;

given the following standard entropies at $25\ ^oC$:

Substance	$S^o(JK^{-1}$ mole $^{-1})$
C(s)	5.68
$C_2H_6(g)$	229.5
$H_2(g)$	130.5

d) One mole of ideal monoatomic at STP is heated at constant volume to a temperature of 323 K. determine the change in entropy for the process (cp=5/2R) (6 marks)

QUESTION FOUR (20 MARKS).

a) Determine the change in free energy when 11.21 dm^3 of a perfect gas at $0\ ^oC$ and 1 atm pressure expands isothermally until its pressure is 190 mmHg. (5 marks)

b) The vapor pressure of chloroform at $30\ ^oC$ is 248 mmHg while at $25\ ^oC$ the vapor pressure is 535 mmHg. Determine the molar enthalpy of vaporization, ΔHv. (5 marks)

c) Given that dE= -dw and CvdT =-PdV show that

$$\left[\frac{T2}{T1}\right] = \left[\frac{V1}{V2}\right]^{R/Cv}$$ (5 marks)

d) A balloon filled with gas absorbs 1.0 Kj of heat and expands from 20 dm^3 to 22 dm^3 a against 1 atm pressure. Calculate change in internal energy and enthalpy. (5 marks)

QUESTION FIVE (20 MARKS).

a) Derive an equation to show that work done by the gas in reversible expansion is given by

$$W = -nRT \ln\left(\frac{V_2}{V_1}\right)$$

(5 marks)

b) Calculate the free energy change when 3 moles of an ideal gas which occupies one litre is isothermally compressed at $0\ ^oC$ to a volume of 250 cm^3. (5 marks)

c) Calculate the entropy change when one kilogram of water at $27\ ^oC$ is converted to super-heated steam at $200\ ^oC$ under constant atm. Give that Shc of liquid water 4180J/kg, Shc steam (1670 + 0.49T) J/kg at T^O K and latent heat of vapouration 2.3×10^5 J/kg.(10 marks)