MACHAKOS UNIVERSITY

University Examinations for 2022/2023 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF EDUCATION (SCIENCE)

BACHELOR OF EDUCATION (SPECIAL NEEDS)

BACHELOR OF SCIENCE (MATHEMATICS).

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 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

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Explain why satisfying the first law of thermodynamics does not guarantee that a process will occur. (3 marks)

b) Classify the following as isolated, closed or open system. (4 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) The universe.

iv) A thermometer.

c) Given the following standard enthalpies of formation, calculate the standard enthalpy of combustion ($\Delta H^{o}_{combustion}$) of benzene at 298 K (4 marks)

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

d) Explain why $Cp > C_v$. (3 marks)

e) Calculate the heat required to vaporize 1 mole of water ($H_2O_{(l)}$) at 25^{o}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. (4 marks)

f) The Critical temperature of methane and carbon dioxide are -81.9^{o}C and 31.1^{o}C respectively. Identify with a reason which between these two gases has stronger intermolecular forces. (3 marks)

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

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

i) State and give mathematical expression for the third law of thermodynamics. (3 marks)

SECTION B

QUESTION TWO (20 MARKS)

a) A 4L sample of hydrogen gas at 15atm 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 reversibly given $\frac{T_2}{T_1} = \frac{P_2}{P_1}^{\frac{\gamma-1}{\gamma}}$ and $\gamma = \frac{C_p}{C_v}$ (10 marks)

b) I) State the Hess's law. (2 marks)

II) 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 (4 marks)

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

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

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

c) State and explain the physical concept of entropy and its variation with temperature (4 marks)

QUESTION THREE (20 MARKS)

a) 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 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 as used in thermodynamics

i) Specific heat capacity. (2 marks)

ii) Molar heat capacity. (2 marks)

QUESTION FOUR (20 MARKS)

a) A Sample of 1 mole of silver at 150^{o}C is placed in contact with 1mole of silver at 0^{o}C 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) A sample of gas changes in volume from 6 litres to 8 litres against an external pressure of 2.5atm and simultaneously absorbs 1000J of heat. Calculate the change in the internal energy of the system (4 marks)

c) 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 (4 marks)

d) Differentiate between extensive and intensive properties of matter. (2 marks)

QUESTION FIVE (20 MARKS)

a) Given that $Cv = \frac{dE}{dT}$ and $Cp = \frac{\delta q_p}{dT}$ show that for a perfect gas $C_p = C_v + R$. (6 marks)

b) Using the generalized expression for clausius inequality ($dU + pdV - TdS \leq O$), derive an alternative criterion for spontaneity at constant temperature and pressure. (4 marks)

c) A certain gas expands from 250 mL to 750 mL very slowly at 25^{o}C. If there is one mole of the gas in the chamber, calculate the work done when the gas behaves ideally. (5 marks)

d) Provide an expression for the following.

i) Work done by a gas as it expands by volume ΔV against an external pressure P_{ext} (2 marks)

ii) The change in internal energy of the system as it expands by volume ΔV against an external pressure P_{ext} after absorbing q joules of heat. (3 marks)