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(*University of Choice*)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY EXAMINATIONS

2021/2022 ACADEMIC YEAR

SECOND YEAR FIRST SEMESTER SPECIAL /SUPPLEMENTARYEXAMINATIONS

FOR THE DEGREE

OF

BACHELOR OF SCIENCE (CHEMISTRY)

BACHELOR OF EDUCATION (SCIENCE)

COURSE CODE: **SCH 240**

COURSE TITLE: **BASIC CHEMICAL THERMODYNAMICS**

DATE: 29/07/2022 **TIME:** 8-10 a.m.

INSTRUCTIONS TO CANDIDATES

Answer all the Questions

TIME: 2 Hours

Useful Data

$R = 8.314\ Jmol^{-1}K^{-1}$ or $0.08206\ L\ atm\ K^{-1}mol^{-1}$ $1atm = 1.01325 \times 10^5\ Pa$, $1\ Pa\ m^3 = 1J$

$\int x^n dx = x^{n+1}/n+1 + C$, $PV = nRT$, $q = (sp)\ m\Delta T$, $q = C\Delta T$, $\Delta U = q + w$, $w = -p_{ex}\Delta V$,
$w = -nRT \ln (V_f/V_i)$, $\Delta U = nC_{v,m}\Delta T$, $\Delta H = \Delta U + \Delta(PV)$, $C_{p,m} - C_{v,m} = R$, $Cv,m = 3/2R$,
$Cp,m = 5/2R$, $(V_1/V_2)^{\gamma} = P_2/P_1$, $dS = dq_{rev}/T$, $\Delta S_{sys} = \int_{V1}^{V2} P/T\ dV$,

$$\Delta H = \int_{T1}^{T2} nCPmdT, \Delta rH = \sum v\Delta Hf(products) - \sum v\Delta Hf(reactants)$$

$\Delta S = n \int_{T1}^{T2} Cv\ dT/T + nR \int_{V1}^{V2} dV/V$, $\Delta S = n \int_{T1}^{T2} C_p\ dT/T - nR \int_{P1}^{P2} dp/P$

$\Delta G^o = -RT\ln K$, $\Delta G^O = \Delta H^O - T\Delta S^O$, $\Delta A = \Delta U - T\Delta S$, $d\ln P/dT = \Delta H_{vap}/RT^2$,

$\ln P = -\Delta H_{vap}/RT$ + Constant f= c-p +2, $\int_1^2 d\Delta H = \Delta H_2 - \Delta H_1 = \int_{T1}^{T2} \Delta CPdT$

QUESTION ONE (20 MARKS)

a) Explain the difference between expansion work against constant pressure and work of reversible expansion and their consequences (6 marks)

b) A quantity of 0.2590 g of benzoic acid was burned in a constant- volume bomb calorimeter. Consequently, the temperature of the water in the inner jacket rose from 20.17°C to 22.22°C. If the effective heat capacity of the bomb calorimeter plus water is 5267.8 J/K, Calculate ΔU and ΔH for the combustion of benzoic acid in kJ/mol (6 marks)

c) Crystallization of sodium acetate from a supersaturated solution occurs spontaneously. What can you deduce about the signs of ΔS and ΔH? (4 marks)

d) Explain the difference between the change in internal energy and the change in enthalpy of a chemical or physical process (4marks)

QUESTION TWO (15 MARKS)

a) Calculate the enthalpy change for the formation of methane from the given data

Reaction	ΔH (kJ)
$C(s) + O_2(g) \rightarrow CO_2(g)$	-393
$H_2(g) + ½O_2(g) \rightarrow H_2O(l)$	-285
$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2\ H_2O(l)$	-890

(5 marks)

b) Explain, citing examples, the significance of a physical observable being a state

c) A cube of 59g of iron was heated to 70°C and transferred to a beaker containing 100 g of water at 20°C, what is the heat capacity, specific heat capacity and molar heat capacity of the iron cube (Cs_{H2O} is $4.184JK^{-1}g^{-1}$ M_{Fe} is 55.85 g mol^{-1})

(6 marks)

QUESTION THREE (20 MARKS)

a) A quantity of 4.5 g of CaC_2 is reacted with an excess of water at 298 K and atmospheric pressure: $CaC_2(s) + 2H_2O(l) \rightarrow Ca(OH)(aq) + C_2H_2(g)$.

Calculate the work done in joules by the acetylene gas against the atmospheric pressure.

(4 marks)

b) Calculate the value of ΔS in heating 3.5 moles of monoatomic ideal gas from 50°C to 77°C at constant pressure. (5 marks)

c) Consider the following reaction
$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$. The heat evolved is 367.5 kJ. Calculate q, ΔH and ΔU. The volume of 1 mole of H_2 generated at 1 atm is 24.5 L Comment on the difference in value between ΔH and ΔU. (6 marks)

d) A quantity of 0.850 mole of a monoatomic ideal gas initially at a pressure of 15.0 atm and 300K is allowed to expand until its final pressure is 1.00 atm. Calculate the work done in joules if the expansion is carried out adiabatically and reversibly (5 marks)

QUESTION FOUR (15 MARKS)

4. a) Calculate the maximum non-expansion work per mole that may be obtained from a fuel cell in which the chemical reaction is the combustion of propane.
$\Delta_f G^o(CO_2, g) = -394.36$ kJ mol^{-1}, $\Delta_f G^o(H_2O, l) = -237.13$ kJ mol^{-1}, $\Delta_f G^o(C_3H_8\ g) = -23.49$ kJ mol^{-1} (5 marks)

b) Show that $Cp = Cv + nR$ (5 marks)

c) Derive the Clausius-Clapeyron equation given that $dG = -SdT + VdP$. (5 marks)