NATIONAL OPEN UNVERSITY OF NIGERIA
PLOT 91, CADASTRAL ZONE, NNAMDI AZIKIWE EXPRESSWAY, JABI - ABUJA
FACULTY OF SCIENCES
DEPARTMENT OF PURE & APPLIED SCIENCES
OCTOBER/NOVEMBER 2019_2 EXAMINATION

COURSE CODE: CHM405
COURSE TITLE: CHEMICAL THERMODYNAMICS
CREDIT: 2 UNIT
TIME ALLOWED: 2 HOURS
INSTRUCTION: Answer question one and any other three questions

Q1

(a)(i) State Boyle's Law. Show graphically that the pressure of an ideal gas varies inversely with its volume and the variation of pressure with volume according to Boyle's law**. (6 marks)**

(ii). State the third law of thermodynamics. **(2 marks)**
(iii) When is reaction said to be spontaneous? **(2 marks)**
(iv) State Zeroth Law of thermodynamics and to what extend is it important? **(4 marks)**

(b) A given system consists of 1 cm^3 matter with a mass of 1 g, equivalent to 20 g/mol. If the system consists of 3 x 10^{23} identical atoms at 0 K and one atom absorb a photon of wavelength of 1 cm. Calculate
(i The entropy change for the system (**4 marks)**
(ii The energy change of the system due to absorption of one mole **(2 marks)**
(iii The expected rise in the temperature of the system (**2 marks)**

C). State the first law of thermodynamics **(3 marks)**
Q2.

(i) What is the relation between heat absorbed and gas constant? **(1 mark)**
(ii) What is entropy? **(½ mark)**
(iii) With reference to Gibbs free energy change, give the condition for a chemical reaction to be spontaneous, nonspontaneous and at equilibrium. **(1 ½ marks)**

(b) A tire with a volume of 11.41 litre reads 44PSI on the tire gauge. What is the new tire pressure when you compress the tire and its new volume is 10.6? **(3 marks)**

(ii) A syringe has a volume of 10 cubic centimeter, the pressure is 1 atm, if you plug the end

so that no gas can escape and push the plunger down, what must the final volume be to change the pressure to 3.5 atm. **(3 marks)**

(iv) Differentiate between inter molecular and intramolecular forces **(1 mark)**

(v) Highlight the effect of 'inter' and 'intra' molecular forces on the various physical states of water. **(1 mark)**

(c) Derive an expression for isothermal expansion of an ideal gas **(4 marks)**

Q3

(a) Define the term heat capacity of a close system. **(5 marks)**

(b) Show that for n moles of a gas, the C_P is always greater than C_V by multiple of R (where R is the gas constant). **(5 marks)**

(c) Show that the heat absorbed at constant pressure is equal to change in enthalpy **(5 marks)**

Q4

(a) Given that in a Joule-Thompson apparatus, the total work done is the sum of the work done in the first and second chamber, that is, $\mu_{JT,}$,show that the process is isoenthalpy **(2 marks)**

(ii) Define the term, Joule-Thompson coefficient. Hence show that**,**

$$\mu_{JT} = \frac{\partial T}{\partial P} = \frac{T\left(\frac{\partial V}{\partial T}\right)_P - V}{C_P}$$

(5 marks)

(b) (i) Calculate the enthalpy change for the combustion of propane, which occurs according to the following equation, **(4 marks)**

$$C_3H_{8(g)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(g)}$$

Given: $\Delta H_f^0(C_3H_{8(g)}) = -104.63\ kJ/mol$, $\Delta H_f^0(CO_{2(g)}) = -393.67\ kJ/mol$

$\Delta H_f^0(4H_2O_{(l)}) = -287.20\ kJ/mol$

(ii) Given the following thermochemical equations,

$$S_{(s)} + \frac{3}{2}O_{2(g)} \rightarrow SO_{3(g)} \quad \Delta H^\theta = -396\ kJ/mol$$

$$SO_{2(g)} + \frac{1}{2}O_2 \rightarrow SO_{3(g)} \quad \Delta H^\theta = -99\ kJ/mol$$

Calculate the standard enthalpy change for the reaction below: **(4 marks)**

$$S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$$

Q5

(a) What is entropy? Hence state the second law of thermodynamics with respect to entropy change of natural processes. **(1 mark)**

(ii) If the volume of an ideal gas changes from 0.2 to 0.4 m3 at stp, calculate the entropy change associated with the process**. (2 mark)**

(b) If the pressure of an ideal gas under adiabatic process changes from 50662.50 to 101325 Pa and corresponding entropy change is 8.0J/mol/K, calculate the heat capacity at constant volume. **(4 marks)**

(ii) If the same gas in b(i) above undergoes isochoric change at initial temperature of 298 K, what will be its final temperature? **(5 marks)**

(C) Given that ΔH = 10 Kg/mol, ΔS= 2 Kg/ mol, calculate the free energy change and state if the reaction is spontaneous. (Temperature= 200k) **(3 marks)**