



NATIONAL OPEN UNIVERSITY 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 extent 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 3×10^{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

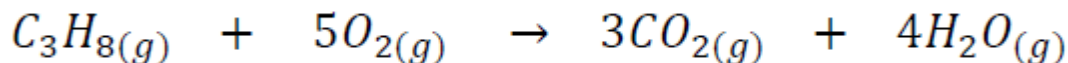
- (a) Define the term heat capacity of a close system. (5 marks)
- (b) Show that for n moles of a gas, the C_P is always greater than C_V by multiple of R (where R is the gas constant). (5 marks)
- (c) Show that the heat absorbed at constant pressure is equal to change in enthalpy (5 marks)

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, μ_{JT} , show that the process is isoenthalpy (2 marks)
- (ii) Define the term, Joule-Thompson coefficient. Hence show that,

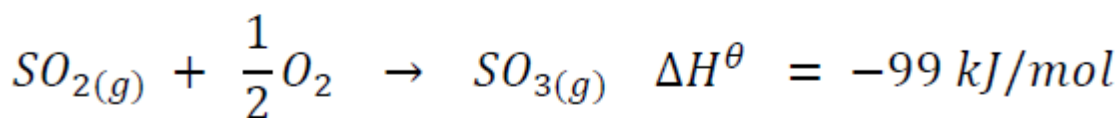
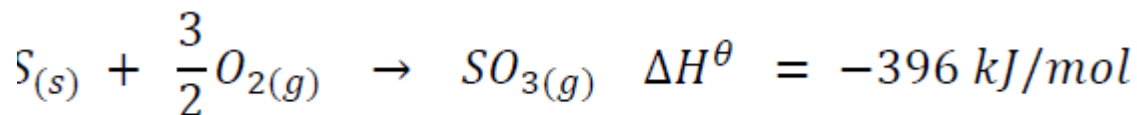
$$\mu_{JT} = \frac{\partial T}{\partial P} = \frac{T \left(\frac{\partial V}{\partial T} \right)_P - V}{C_P} \quad (5 \text{ marks})$$

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

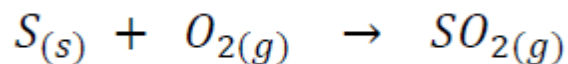


Given: $\Delta H_f^0(C_3H_8(g)) = -104.63 \text{ kJ/mol}$, $\Delta H_f^0(CO_2(g)) = -393.67 \text{ kJ/mol}$
 $\Delta H_f^0(4H_2O(l)) = -287.20 \text{ kJ/mol}$

- (ii) Given the following thermochemical equations,



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



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 $\Delta H = 10 \text{ KJ/mol}$, $\Delta S = 2 \text{ KJ/mol}$, calculate the free energy change and state if the reaction is spontaneous. (Temperature= 200k) **(3 marks)**