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**NATIONAL OPEN UNVERSITY OF NIGERIA**
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**FACULTY OF SCIENCES**
**DEPARTMENT OF PURE & APPLIED SCIENCES**
**APRIL/MAY, 2019 EXAMINATIONS**
**CHM 405** CHEMICAL THERMODYNAMICS (2 UNITS)

## Instruction: answer question 1 and any other three questions

## Time allowed: 2 hours

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**. (4 ½ marks)**
(ii)State the third law of thermodynamics. Highlight the most essential application of the law and its limitations**. (6 ½ marks)**

(iii) State the Zeroth Law of thermodynamics and to what extend is it important? **(2 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 consist 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 (**1 ½ mark)**

(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 (**1 marks)**

(c) Derive an expression for the Maxwell equations. **(6 ½ marks)**

Q2.

(a) (i)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 litres? **(3 marks)**

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

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

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

(b)(i) Show that under adiabatic expansion of an ideal gas, the heat capacity at constant pressure (CP) and at constant volume (CV) are related to the pressure and volume in an exponential manner. **(4 ½ marks)**

(ii) Calculate the ratio, for an ideal gas if the volume changes from 0.2 to 0.4 m3 with a corresponding change in pressure from 101325 to 50663 Pa**. (2 ½ marks)**

Q3

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

(b) Show that for n moles of a gas, the CP is always greater than CV by multiple of R (where R is the gas constant). **(10 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 ½ mark)**

(ii) Define the term, Joule-Thompson coefficient. Hence show that**, (7 ½ marks)**

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

(b) (i) Calculate the enthalpy change for the combustion of propane, which occurs according to the following equation, **(3 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,

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

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

Calculate the standard enthalpy change for the reaction below: **(2 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**. (3 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. **(5 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? **(6 marks)**