

**NATIONAL OPEN UNVERSITY OF NIGERIA**

**PLOT 91, CADASTRAL ZONE, NNAMDI AZIKIWE EXPRESSWAY, JABI - ABUJA**

**FACULTY OF SCIENCES**

**DEPARTMENT OF PURE & APPLIED SCIENCES**

**NOV. 2018\_2 EXAMINATION QUESTIONS**

**COURSE CODE: CHM 301**

**COURSE TITLE: PHYSICAL CHEMISTRY III**

**COURSE UNIT: 3**

**INSTRUCTION: Answer question 1 and any other four questions.**

**Time: 2½ hours**

**QUESTION 1**

1a.What is inversion temperature **(1 mark)**

(b) Define the following thermodynamics terms:

 (i) System **(0.5 mark)**

(ii) Surrounding **(0.5 mark)**

(iii) Boundary **(0.5 mark)**

(c) Based on exchange of matter and energy between the system and the surrounding, highlight the three basic types of thermodynamic system **(1.5marks)**

(d) (i) Calculate the value of the gas constant for an ideal gas at standard temperature and pressure (stp) **(3 marks)**

ii. Write down the van der Waals equation of state and define all symbols use in developing the equation **(1 mark)**

iii 4 moles of an ideal gas occupies a volume of 44. 8 m3 at a temperature of 300 K Calculate the pressure exerted by the ideal gas **(1.5 mark)**

(e) State two properties of state function **(1 mark)**

(f) State the following laws of thermodynamics,

 i. Zeroth law **(1 mark)**

 ii First law **(0.5 mark)**

 iii. Second law **(0.5 mark)**

 iv. Third law **(0.5 mark)**

(g) When is a thermodynamic process considered to be adiabatic, isothermal, isochoric, isobaric and cyclic? **(3 marks)**

(h) A gas expands at constant pressure (3 Pa) from initial volume of 100 to 200 m3, calculate the work done **(1 mark)**

(i) State phase rule and write a mathematical equation for the defined rule**(1 mark)**

(j) 2 moles of an ideal gas expands isothermally from 100 to 200 m3 at 400 K. Calculate the work done **(2 marks)**

(k) State the four basic stages of a Carnot cycle **(2 marks)**

**QUESTION 2**

2(a) Derive an expression for the work done during isothermal expansion of an ideal gas **(6 marks)**

(b) If the volume of 2 moles of an ideal gas changes from 200 to 400 cm3 at 296 K, calculate the work done during the isothermal expansion of the gas. **(3 marks)**

(c) Calculate the free energy change for a reaction whose equilibrium constant at 300 K is 8.21. Hence is the reaction spontaneous? **(3 marks)**

**QUESTION 3**

3(a) What is the significant of zero, positive and negative values of Joule-Thompson coefficient **(3 marks)**

(b) Explain what happened when a gas is expanded below or above its inversion temperature **(2 marks)**

(c) Show that the heat capacity at constant pressure (for one mole of a gas) is greater than the heat absorb at constant volume by an amount equal to the gas constant (i.eCp = CV + R) **(7 marks)**

**QUESTION 4**

4. (a) Show that adiabatic expansion of an ideal gas, $C\_{V}ln\left(\frac{T\_{2}}{T\_{1}}\right)=Rln\left(\frac{V\_{1}}{V\_{2}}\right)$ **(6 marks)**

 (b) Consider the following chemical reaction,

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If the pressure of SO2, O2 and SO3­ are 2.1, 4.2 and 18.2 Pa respectively, Calculate the equilibrium constant for the reaction. **(4 marks)**

(c) Calculate the standard free energy change (at 300 K) for the reaction given in ‘b’ above. Hence state with reason, if the reaction is spontaneous **(2 marks)**

**QUESTION 5**

5(a) Consider the reaction given below,

$$CH\_{4}+ 4O\_{2} \rightarrow CO\_{2}+ 2H\_{2}O$$

Given the following bond energies data, calculate the enthalpy change for the reaction[C-H = 412 kJ/mol, O=O = 497 kJ/mol, C=O = 745 kJ/mol, H-O = 463 kJ/mol) **(7 marks)**

(b) What is Carnot Cycle. Hence Calculate the efficiency of a Carnot engine that operates between 440 and 560 K **(5 marks)**

**QUESTION 6**

6 (a) What is a spontaneous reaction? **(2 marks)**

(b) Write an expression that relates free energy change and change in Helmholtz work function tochange in internal energy change, enthalpy change and entropy change. hence state whether the reaction is spontaneous or not when these functions (change in free energy and Helmholtz work function) are zero, positive and negatives **(5 marks)**

(c) The enthalpy change for the atomization of ethane is -2828380 J/molwhile the entropy change is 299890 J/mol. Calculate the free energy change for the reaction at 303 K. Hence is the reaction spontaneous? (Give reason for your answer) **(3 marks)**

(d) What is the significant of Kirchhoff’ s equation in thermodynamics **(2 marks)**