



NATIONAL OPEN UNIVERSITY OF NIGERIA
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FACULTY OF SCIENCES
DEPARTMENT OF PURE & APPLIED SCIENCES
2020_1 EXAMINATION QUESTIONS

COURSE CODE: CHM 301

COURSE TITLE: PHYSICAL CHEMISTRY III

INSTRUCTION: Answer question 1 and any other four questions.

Duration 3 hours

QUESTION 1

- (a) In one sentence for each, describe the three types of thermodynamic systems that you know **(3 marks)**
- (b) Under what condition is the state of a system defined **(1 mark)**
- (c) State the zeroth law of thermodynamics **(3 mark)**
- (d) Differentiate between extensive and intensive properties of a system **(2 marks)**
- (e) How does a state of a system give rise to process? **(1 mark)**
- (f) Define the following processes
- i. Isothermal process **(1 mark)**
 - ii. Adiabatic process **(1 mark)**
 - iii. Isochoric process **(1 mark)**
 - (iv) Isobaric process **(1 mark)**
- (g) Show that the heat absorbed at constant volume is equal to change in internal energy **(3 marks)**
- (h) What is bond enthalpy **(1 mark)**
- (i) List the four steps involved in the operation of the Carnot cycle **(4 marks)**

QUESTION 2

- (a) What is entropy, hence, calculate the entropy of mixing of 1.00 mol of H_2 with 2.00 mol of O_2 assuming that no chemical reaction occurs **(6 marks)**
- (b) State the first law of thermodynamics and write a mathematical expression for the law, hence show that the heat absorbed at constant pressure is equal to change in enthalpy **(6 marks)**

QUESTION 3

- (a) The molar heat of transition of an atom is 20.12 kJ/mol at 298 K. Calculate the entropy change of transition **(3 marks)**
- (b) Why is it difficult to use entropy data to test for spontaneity of a chemical reaction **(4 marks)**

- (c) What is a spontaneous process and what aspect of nature is spontaneous **(2 marks)**
(d) Calculate the molar volume of water **(3 marks)**

QUESTION 4

- (a) Consider the following reaction, $SO_{2(g)} + 2O_{2(g)} = 2SO_{3(g)}$. Answer the following questions
- (i) Write expression for equilibrium constant in terms of pressure **(1 marks)**
(ii) If the equilibrium pressures are $P_{SO_2} = 3.42 Pa$, $P_{SO_3} = 3.58 Pa$ and $P_{O_2} = 3.31$, calculate the equilibrium constant for the reaction. **(2 marks)**
(iii) Calculate the free energy change for the reaction at 1000K and state whether the reaction is spontaneous or not **(3 marks)**
(b) Calculate the heat necessary to raise the temperature of 3.00 mol of butane from 298 to 573 K at constant pressure. ($C_p = (19.41+0.233T)J/mol/K$) **(6 marks)**

QUESTION 5

- (a) What is the contribution of heat and work done on internal energy hence state the implication positive and negative value of heat (dq) and work on the internal energy and the system respectively. **(5 marks)**
(b) In one sentence define isothermal, isobaric and isochoric thermodynamic processes **(3 marks)**
(c) Assume that pressure of the gas is P and the external pressure is P_{ext} which is slightly less than the gas pressure. Derive expression for the work done on the system given that the change in distance is dx and the surface area and the applied force are A and F respectively. **(4 marks)**

QUESTION 6

- (a) A gas expands from $10 m^3$ to $12 m^3$ against a constant [pressure of $102325 Nm^{-2}$ at 298 K. What is the work done on the gas? **(3 marks)**
(b) Calculate the number of moles of an ideal gas that will exert a pressure of 102.325 Pa at a volume of $22.4 dm^3$ and temperature of 273 K. What can you deduce from your result? **(4 marks)**
(c) Using the value of change in free energy, under what conditions will you conclude that a reaction is spontaneous, non-spontaneous and at equilibrium **(3 marks)**
(d) Given that work done in isothermal expansion of an ideal gas is given as, $W = -PdV$, derive an integrated equation for the work done in isothermal expansion of an ideal gas **(5 marks)**