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University Examinations 2024/2025

FIRST YEAR FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE, BACHELOR OF SCIENCE BIOCHEMISTRY, BACHELOR OF SCIENCE IN BIOTECHNOLOGY

SCH 3101: PHYSICAL CHEMISTRY I

DATE: JANUARY 2025 **TIME: 2 HOURS**

INSTRUCTIONS: *Answer question **one** and any other **two** questions*

QUESTION ONE (30 MARKS)

a) The ideal gas law equation can be rearranged in different ways to take the form of Boyle's law, Charles's law, or Avogadro's law. Write the three forms of the law according to Boyle's law, Charles's law, and Avogadro's law. (6 marks)

b) Calculate the value of the gas constant in (L.atm)/(K.mol) from knowledge of the standard molar volume of a gas since 1 mol of a gas occupies a volume of 22.414 L at 0^{o}C and 1 atm pressure. (4 marks)

c) (i) Explain the terms effusion and give it formular (3 marks)

(ii) Discuss how Graham's Law of effusion can be used to determine molar mass of a substance. (6 marks).

d) To describe real gas behaviour more accurately, we need to adjust the ideal gas equation according to the van der Waals Equation. Write the equation and explain all the terms. (5 marks)

(1)

(2) $2NO(g)+O_2(g) \rightleftharpoons 2NO_2(g)$

(e) Methane, the main constituent of natural gas, burns in oxygen to yield carbon dioxide and water:

$CH_4(g) + 2O_2(g) \rightarrow CO_2(s) + 2\ H_2O\ (1)$

Use the following information to calculate AH O in kilojoules for the combustion of methane:

(6 marks)

$CH_4(g) + O_2(g) \rightarrow CH_2O(g) + H_2O(g)$ $\Delta H^o = -275.6$ kJ

$CH_2O(g) + O_2(g) \rightarrow CO_2(g) + H_2O(g)$ $\Delta H^o = -526.7$ kJ

$H_2O(1) \rightarrow H_2O(g)$ $\Delta H^o = 44.0$ kJ

QUESTION TWO (20 MARKS)

a) In a car engine, the mixture of gasoline and air in a cylinder is compressed from 1.0 atm to 9.5 atm prior to ignition. If the uncompressed volume of the cylinder is 410 mL, what is the volume in milliliters when the mixture is fully compressed? (4 marks)

b) Sketch a graph to express Boyle's law as the relationship between the volume and pressure of a gas. (4 marks).

c) Explain the term 'partial pressure' and explain why Dalton's law is a limiting law (6 marks)

d) Sketch a graph with three curves to depict the distribution of molecular speeds u m/s for N_2 gas at three temperatures. (6 marks).

QUESTION THREE (20 MARKS)

a) Define the following terms (6 marks)

(i) Brønsted - Lowry acid

(ii) State function

(iii) Perfect/ldeal gas

b) Explain two types of electrochemical cells (4 marks)

c) Nitrogen dioxide is a toxic pollutant that contributes to photochemical smog. One way it forms is through the following sequence:

(1) $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ $Kc_1 = 4.3\times10^{-25}$

(2) $2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$ $Kc_2 = 6.4\times10^9$

i) Show that the overall Qc for this reaction sequence is the same as the product of the Qc's for the individual reactions. (6 marks)

(ii) Given that both reactions occur at the same temperature, find Kc for the overall reaction. (4 marks).

QUESTION FOUR (20 MARKS)

a) A steel tank has a volume of 438 L and is filled with 0.885 kg of O_2. Calculate the pressure of O_2 at 21 ^{O}C. (6 marks)

b) The Kinetic-Molecular Theory is based on three postulates: Discuss each of them. (9 marks).

c) For an hypothetical reaction between A and B below, write its equilibrium constant expression: (5 marks)

$aA + bB \rightleftharpoons cC + dD$