MULTIMEDIA UNIVERSITY OF KENYA

FACULTY OF SCIENCE AND TECHNOLOGY

UNIVERSITY EXAMINATIONS 2017/2018

FIRST YEAR SECOND SEMESTER EXAMINATION FOR THE DEGREE OF

BACHELOR OF SCIENCE IN INDUSTRIAL CHEMISTRY AND BACHELOR OF SCIENCE IN ANALYTICAL CHEMISTRY

CHE 2103: INTRODUCTION TO PHYSICAL CHEMISTRY

DATE: THURSDAY 23RD AUGUST 2018 TIME: 2 HOURS

INSTRUCTIONS:

ANSWER YOUR QUESTIONS IN ANSWER BOOKLET PROVIDED.

ANSWER QUESTION ONE [COMPULSORY] AND ANY OTHER TWO QUESTIONS.

Important data

$R = 8.314\ J\ Mol^{-1}\ deg^{-1}$

$R = 0.0821\ L\ atm.\ Mol^{-1}\ K^{-1}$

$1\ cal = 4.184\ J$

$1\ L\ atm = 101.3\ J$

$N = 14$
$O = 16$
$Ar = 40$

$P = 1\ atm$
$T = 0^{\circ}C$ (14)
$273\ 11K$
$273.$
273.1 $K =$

QUESTION ONE (THIRTY MARKS) COMPULSORY

a) 56 g of nitrogen gas were reacted with hydrogen gas to form ammonia gas at STP. What is the volume of NH_3 gas formed? **[3 Marks]**

b) (i) State the Avogadro's law of gases. **[1 Mark]**

(ii) Derive the Avogadro's law from the Kinetic gas equation. **[2 marks]**

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c) The mass percentage composition of dry air at sea level is approximately N_2: 75.5, O_2: 23.2 and Ar:1.3. What is the partial pressure of each component when the total pressure is 1.2 atm? **[3 Marks]**

d) (i) State the Le Châteliers principle of chemical equilibrium. **[1 Mark]**

(ii) Discuss the factors that affect chemical equilibrium. **[4 Marks]**

(iii) The synthesis of ammonia in the Haber process is represented by the equation

$$3H_2(g) + N_2(g) \rightarrow 2NH_3(g) + 92.05\ kJ$$

Explain the conditions required for securing maximum yield of the products in the industrial process. **[3 Marks]**

e) A mixture of 0.500 mol of hydrogen and 0.500 mol of iodine was placed in 1.0 L stainless steel flask at 430° C. The equilibrium constant for the reaction;

$$H_2(g) + I_2(g) \leftrightharpoons 2HI(g)$$

is 54.3 at this temperature. Calculate the concentration of H_2, I_2 and HI at equilibrium. **[4 Marks]**

f) (i) Define a buffer solution. **[1 Mark]**

(ii) Calculate the pH of a buffer system containing 1.0 M CH_3COOH and CH_3COONa.

(iii) What would be the pH of the buffer system in (ii) above after adding 1.0 mol of gaseous HCl to 1 L of the solution? Assume volume doesn't change upon addition of 1 mole HCl gas. **[8 Marks]**

QUESTION TWO (TWENTY MARKS)

a) Compare the pressures predicted for 0.8 dm^3 of chlorine gas weighing 17 5 g at 273.15 K when;

(i) the gas behaves ideal and

(ii) when the gas behaves like a real gas van der Waals equation.

For chlorine the Van der Waals constants are a = 6.493 atm L^{-2} mol^{-2} and b = 0.0562 L mol^{-1}. **[5 Marks]**

b) (i) Define the term 'most probable velocity' as used to describe velocity of gas molecules. **[1 Mark]**

(ii) Sketch and explain the distribution of molecular velocities in a sample of a gas at 273 K, 400 K and 800 K **[4 Marks]**

c) Calculate the concentration of aqueous ammonia necessary to initiate the precipitation of iron (II) hydroxide from a 0.0030 M solution of iron (II) chloride. Ksp for iron (II) hydroxide is 1.6×10^{-14} and K_b for ammonia is 1.8×10^{-5}. **[7 Marks]**

d) The pH of 0.10 M solution of formic acid (HCOOH) is 2.39. What is the K_a of the acid? **[3 Marks]**

QUESTION THREE – 20 MARKS

a) Briefly describe four assumptions of the kinetic molecular theory of gases. **[2 Marks]**

b) What is the pressure exerted by 16.256 g of oxygen gas in 15.0 L container at 30° C

c) What is the pH of 0.500 M aqueous ammonia solution? **[5 Marks]**

d) (i) Distinguish between solubility and molar solubility. **[1 Marks]**

(ii) The solubility of calcium sulphate is found experimentally to be 0.67 g/L. calculate the solubility product constant for this sparingly soluble salt.

[6 Marks]

e) Calculate the solubility of silver chloride in g/L in a 6.5×10^{-3} M silver nitrate solution. Solubility product constant for silver chloride is 1.6×10^{-10} **[6 Marks]**

QUESTION FOUR – 20 MARKS

a) In a chemical reaction used in automotive airbag safety systems, nitrogen gas is produced by the decomposition of sodium azide

$2NaN_3(s) \longrightarrow 3N_2(g) + 2\ Na(l)$

What volume of nitrogen measured at 25°C and 0.980 atm is produced by the decomposition of 62.5 g sodium azide? **[3 Marks]**

b) Hydrogen gas produced by the following reaction is collected over water at 23° C and 742 mmHg barometric pressure.

$2Al(s) + 6HCl(aq) \longrightarrow 1AlCl_3(aq) + 3H_2(g)$

What volume of the gas will be collected in the reaction of 1.50 g solid Al with excess aqueous HCl. The vapour pressure of water at this temperature 19.8 mmHg

[4 Marks]

c) One percent of a measured amount of Argon escapes through a pin hole in 77.3 s. One percent of same amount of an unknown gas escapes through the same pin hole under similar conditions in 97.6 s. Calculate the molar mass of the unknown gas. **[3 Marks]**

d) For the reaction; $H_2(g) + I_2(g) \leftrightharpoons 2HI(g)$, the initial concentrations of H_2, I_2 and HI are 0.00623 M, 0.00414 M and 0.0224 respectively. Equilibrium constant for the reaction is 54.3. Calculate the concentration of these species at equilibrium. **[7 Mark]**

e) The equilibrium constant of the reaction; $3H_2(g) + N_2(g) \leftrightharpoons 2NH_3(g)$ at 375°C is 1.2. At the start of reaction there are 0.249 mol N_2, 3.21×10^{-2} mol H_2 and 6.42×10^{-4} mol of NH_3 in a 3.5 L reaction vessel. Predict the direction the reaction will proceed. **[3 Mark]**

QUESTION FIVE – 20 MARKS

a) A 452 ml sample of fluorine gas is heated from 22° C to 187° C at a constant pressure. What is its final volume? **[2 Mark]**

b) Argon gas is used in lightbulbs to retard the vaporization of the filament. A certain lightbulb containing argon having a pressure of 1.2 atm at 20° C is heated to 85° C at constant volume. What is the final pressure of the gas in the bulb assuming the number or moles remains the same? **[2 Marks]**

c) The solubility product constant of copper (II) hydroxide is 2.2×10^{-20} at 25° C. Determine its solubility in g/L. **[5 Mark]**

d) Exactly 200 mL of 0.0040 M $BaCl_2$ are added to 600 mL of 0.0080 M K_2SO_4. Will a precipitate form upon mixing the two solutions? $K_{sp} = 1.1 \times 10^{-10}$ **[5 Mark]**

e) $CH_2ClCOOH$ is a weak acid. What is the pH of a 0.0020 M $CH_2ClCOOH$ aqueous solution? $K_a = 1.8 \times 10^{-3}$ **[5 Marks]**

f) Explain the periodic trends in strength of binary acids. **[1 Mark]**

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