UNIVERSITY OF SWAZILAND

FINAL EXAMINATION – 2018, MAY

TITLE OF PAPER : Introductory Chemistry II

COURSE NUMBER : CHE 152

TIME : Three Hours

INSTRUCTIONS :

1. **Answer all questions in Section A** (Total 40 marks)
2. **Answer any three questions in Section B** (each question is 20 marks)

NB: Non-programmable electronic calculators may be used
A data sheet, a periodic table and answer sheet (for **Section A**) are attached

Useful data and equations:

1 atm = 760 Torr = 760 mmHg

1 atm = 101325 Pa

Arrhenius equation: $k = Ae^{-E_a/RT}$ or $lnk = lnA - \frac{E_a}{RT}$

Van der Walls equation: $P = \frac{nRT}{V-nb} - \frac{n^2a}{V^2}$

This Examination Paper Contains Twelve Printed Pages Including This Page

You are not supposed to open the paper until permission to do so has been granted by the Chief Invigilator.

Question 1

a. What is the kinetic energy, in J, of one mole of Ar atoms moving at 650 m/s?

(5)

b. Calculate ΔH for the reaction (10)

$$NO(g) + O(g) \quad NO_2(g)$$

given the following information:

$$NO(g) + O_3(g) \longrightarrow NO_2(g) + O_2(g) \qquad \Delta H = -198.9\ kJ$$
$$O_3(g) \longrightarrow \tfrac{3}{2} O_2(g) \qquad \Delta H = -142.3\ kJ$$
$$O_2(g) \longrightarrow 2\,O(g) \qquad \Delta H = 495.0\ kJ$$

c. Calculate the enthalpy change for the combustion of 1 mol of ethanol: (10)

$$C_2H_5OH(l) + 3\,O_2(g) \longrightarrow 2\,CO_2(g) + 3\,H_2O(l)$$

Given the following $\Delta H°f$ values:

$C_2H_5OH_{(l)}$ → -277.7 kj/mol

$CO_{2(g)}$ → -393.5 kj/mol

$H_2O_{(l)}$ → -285.8 kj/mol

Question 2

a) Calculate the pH of each of the following solutions: (12)

i) 0.15 M solution of HNO_3

ii) 0.025 M solution of $Ba(OH)_2$

iii) 0.15 M solution of CH_3COOH

iv) 0.38 M solution of NH_3

b) If it takes 53.5 mL of a 0.200 M solution of NaOH to exactly neutralize 30.15 mL of HCl solution, calculate the molarity of the HCL solution. (10)

c) Reconstruct the following table on your scripts sheet and fill in the blanks. (3)

Solution	pH	[H+]	[OH-]	pOH
#1				4.44
#2			3.8×10^{-3} M	

Question 3

a. Write the equilibrium-constant expression for the following reaction. (12)

i. $CO_{2(s)} + H_2O_{(l)} \longrightarrow H^+_{(aq)} + HCO_3^-{}_{(aq)}$

ii. $Cr_{(s)} + 3Ag^+_{(aq)} \longrightarrow Cr^{3+}_{(aq)} + 3Ag_{(s)}$

iii. $3\,Fe_{(s)} + 4H_2O_{(g)} \longrightarrow Fe_3O_{4(s)} + 4H_{2(g)}$

iv. $(NH_4)_2Se\ (s) \longrightarrow 2NH_3\ (g) + H_2Se\ (g)$

b. For the reaction:

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b. For the reaction:

$$N_2(g) + O_2(g) \rightleftharpoons 2\,NO(g)$$

that is run at 25 °C, $K_c = 1 \times 10^{-30}$. Use this information to write the equilibrium-constant expression and calculate the equilibrium constant for the reaction:

$$2\,NO(g) \rightleftharpoons N_2(g) + O_2(g)$$ (3)

c. Sulphur trioxide decomposes at high temperature in a sealed container:

$$2\,SO_3(g) \rightleftharpoons 2\,SO_2(g) + O_2(g)$$

Initially, the vessel is charged at 1000 K with $SO_3(g)$ at a partial pressure of 0.500 atm. At equilibrium the SO_3 partial pressure is 0.200 atm. Calculate the value of K_p at 1000 K.

(10)

Question 4

a. Nitrous oxide can be formed by thermal decomposition of ammonium nitrate.

$$NH_4NO_{3(s)} \longrightarrow N_2O_{(g)} + 2H_2O_{(g)}$$

What mass of ammonium nitrate would be required to produce 115 L of N_2O at 2800 Torr and 42°C (8)

b. In the first step in the industrial process for making nitric acid, ammonia reacts with oxygen in the presence of a suitable catalyst to form nitric oxide and water vapor:

$$4\,NH_{3(g)} + 5\,O_{2(g)} \rightarrow 4\,NO_{(g)} + 6H_2O_{(g)}$$

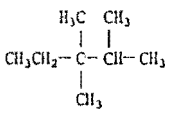
How many liters of $NH_{3(g)}$ at 850 °C and 5.00 atm are required to react with 1.00 mol of $O_2(g)$ in this reaction? (10)

c. The pressure in a natural-gas tank is maintained at 2.20 atm. On a day when the temperature is –15 °C, the volume of gas in the tank is 3.25×10^3 m^3. What is the volume of the same quantity of gas on a day when the temperature is 51 °C? (7)

Question 5

a. Write the names of the following compounds: (2 each)

i.



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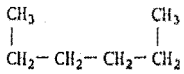
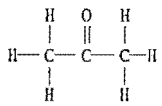


iii.



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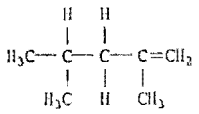
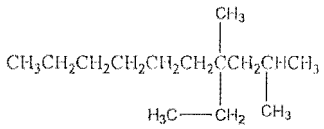
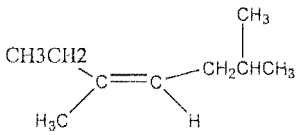
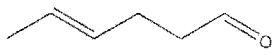
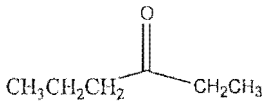


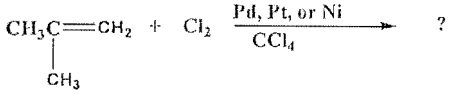
v. 

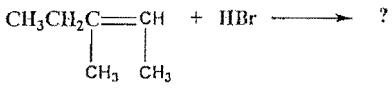
vi. 

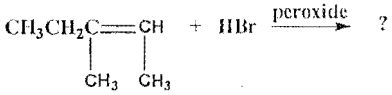
vii. 

viii. 

b. Complete the following reactions (9)

i) 

ii) 

iii) 

Question 6

a. Nitrogen dioxide decomposes to nitric oxide and oxygen via the reaction:

$$2NO_2 \rightarrow 2NO + O_2$$

In a particular experiment at 300 °C, $[NO_2]$ drops from 0.0100 to 0.00650 M in 100 s. What is the rate of disappearance of NO_2. (3)

b. The following data were measured for the reaction of nitric oxide with hydrogen:

$$2\ NO(g) + 2\ H_2(g) \rightarrow N_2(g) + 2\ H_2O(g)$$

Experiment Number	[NO] (*M*)	[H_2] (*M*)	Initial Rate (*M*/s)
1	0.10	0.10	1.23×10^{-3}
2	0.10	0.20	2.46×10^{-3}
3	0.20	0.10	4.92×10^{-3}

i. Determine the rate law for this reaction. (5)

ii. Calculate the rate constant. (5)

iii. Calculate the rate when [NO] = 0.050 *M* and [H_2] = 0.150 *M*. (5)

c. The following data were obtained for the gas-phase decomposition of nitrogen dioxide at 300°C,

Time (s)	$[NO_2]$ (*M*)
0.0	0.01000
50.0	0.00787
100.0	0.00649
200.0	0.00481
300.0	0.00380

a. Is the reaction first or second order in NO_2? (7)

SI Units and Conversions

Unit	Symbol	SI units
Newton	N	$kg.m.s^{-2}$
Pascal	Pa	$kg.m^{-1}.s^{-2}$ or $N.m^{-2}$
Joule	J	$kg.m^{2}.s^{-2}$ or N.m or AVs
Watt	W	$kg.m^{2}.s^{-3}$ or $J.s^{-1}$
Coulomb	C	A.s
Volt	V	$kg.m^{2}.s^{-3}.A^{-1}$ or $J.C^{-1}$
Ohm	Ω	$kg.m^{2}.s^{-3}.A^{-2}$ or $v.A^{-1}$
Amp	A	$1Cs^{-1}$

Pressure Units and conversion factors

Pa	I Pa = 1 $N.m^{-2}$
Bar	1 bar = 10^{5} Pa
Atmosphere	1 atm = 101.325 kPa
Torr	760 Torr = 1 atm
	760 Torr = 760 mmHg= 101.325 kPa

General data and Fundamental Constants

Gas constant	R	8.314 51 $J.K^{-1}.mol^{-1}$ 8.314 51 x 10^{-2} $L.bar.K^{-1}.mol^{-1}$ 8.205 78 x 10^{-2} $L.atm.K^{-1}.mol^{-1}$ 62.364 $L.Torr.K^{-1}.mol^{-1}$
Avogadro constant	N_A	6.022169 x 10^{23} mol^{-1}
Molar volume of an ideal gas at 0°C and 1 atm	V_m	22.414 dm^3

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Department of Chemistry