UNIVERSITY OF SWAZILAND

RE-SIT EXAMINATION – 2018, JULY

TITLE OF PAPER : Introductory Chemistry II

COURSE NUMBER : CHE 152

TIME : Three Hours

INSTRUCTIONS :

1. **Answer all questions in Section A** (Total 50 marks)
2. **Answer any two questions in Section B** (each question is 25 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. Differentiate between effusion and diffusion of gas molecules. (5)

b. At 25°C, 0.350 moles of $CH_{4(g)}$, 0.240 mole of $H_{2(g)}$ and 0.500 mole of $N_{2(g)}$ are contained in a 10.0 L flask. Evaluate the partial pressure (in atm), of each of the components of the gaseous mixture in the flask, and the overall pressure in the flask. (10)

c. 8.0 grams of argon and 25.0 grams of neon are placed in a 1200.0 ml container at 25.0°C. Calculate the partial pressures of both gases. (10)

Question 2

a. Write the thermochemical equations that give values of the standard enthalphies of formation for the following: (10)

i. $Al_2O_{3(s)}$

ii. $C_2H_5OH_{(l)}$

iii. $CH_6N_{2(l)}$

iv. $C_6H_5OH_{(l)}$

v. $CaCO_{3(s)}$

b. Calculate ΔH for the reaction (10)

$$2\,C(s) + H_2(g) \longrightarrow C_2H_2(g)$$

given the following chemical equations and their respective enthalpy changes:

$$\begin{aligned} C_2H_2(g) + \tfrac{5}{2}O_2(g) &\longrightarrow 2\,CO_2(g) + H_2O(l) & \Delta H &= -1299.6\text{ kJ} \\ C(s) + O_2(g) &\longrightarrow CO_2(g) & \Delta H &= -393.5\text{ kJ} \\ H_2(g) + \tfrac{1}{2}O_2(g) &\longrightarrow H_2O(l) & \Delta H &= -285.8\text{ kJ} \end{aligned}$$

c. The combustion of methylhydrazine (CH_6N_2), a liquid rocket fuel, produces $N_2(g)$, $CO_2(g)$, and $H_2O(l)$:

$$2\,CH_6N_2(l) + 5\,O_2(g) \longrightarrow 2\,N_2(g) + 2\,CO_2(g) + 6\,H_2O(l)$$

When 6.00 g of methylhydrazine is combusted in a bomb calorimeter, the temperature of the calorimeter increases from 25.00°C to 39.50°C. In a separate experiment the heat capacity of the calorimeter was measured to be 7.794 kJ/°C. Calculate the heat of reaction for the combustion of a mole of CH_6N_2. (5)

Question 3

a. A household cleaning reagent has a hydroxide concentration of 0.0032 M. Calculate the [H_3O+], pH and pOH for this solution. (9)

b. A student prepared a 0.10 M solution of formic acid (HCOOH) and found its pH at 25°C to be 2.38. Calculate K_a for formic acid at this temperature. (10)

c. In a sample of lemon juice, $[H^+] = 3.8 \times 10^{-4}\ M$. What is the pH? (6)

Question 4

a. The data in the table below were obtained for the reaction: (9)

A + B → P

Experiment Number	[A] (M)	[B] (M)	Initial Rate (M/s)
1	0.273	0.763	2.83
2	0.273	1.526	2.83
3	0.819	0.763	25.47

i. What is the order of the reaction in [A]

ii. What is the order of the reaction in [B]

iii. Write the rate law for the reaction.

iv. What is the overall order of this reaction?

b. For the reaction

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g) \qquad \Delta H^\circ = 87.9 \text{ kJ}$$

in which direction will the equilibrium shift when

i. $Cl_2(g)$ is added,

ii. the temperature is increased,

iii. the volume of the reaction system is increased,

iv. $PCl_3(g)$ is removed? (8)

c. If the rate of decomposition of N_2O_5 in the reaction $2\ N_2O_5(g) \rightarrow 4\ NO_2(g) + O_2(g)$ at a particular instant is 4.2×10^{-7} *M*/s, what is the rate of appearance of

i. NO_2 and

ii. O_2 at that instant? (8)

Question 5

a. Draw the structures of the following compounds: (20)

i. 2,4-dimethyl-1-pentene

ii. 3-ethyl-2-methylpentane

iii. 2,4-dichloro-2-pentyne

iv. 2,5,6-trimethylnonane

v. 3-bromocyclohexanone

vi. 2,4-dimethyl-hexanoic acid

vii. 3-ethoxy-5-methyl-octanal

viii. Methyl-cyclobutylamine

ix. Isopropyl-butyl ether

x. 3-bromo-6-ethyl-4,4,5-trimethyl-8-nonanol

b. Draw the structure and give the name of the product of the reaction of 4-ethyl-2-methyl-1-heptene which HBr. (5)

Question 6

a. Write the equilibrium expression for K_c for the following reactions: (10)

i. $2\ O_3(g) \rightleftharpoons 3\ O_2(g)$

ii. $2\ NO(g) + Cl_2(g) \rightleftharpoons 2\ NOCl(g)$

$Ag^+(aq) + 2\ NH_3(aq) \rightleftharpoons Ag(NH_3)_2^+(aq)$

iii.

iv. $Cd^{2+}(aq) + 4\,Br^{-}(aq) \rightleftharpoons CdBr_4^{2-}(aq)$

v. $H_2(g) + I_2(g) \rightleftharpoons 2\,HI(g)$

b. For the reaction:

$H_2(g) + I_2(g) \rightleftharpoons 2\,HI(g)$,

K_p = 794 at 298 K and K_p = 55 at 700 K. Is the formation of HI favoured more at the higher or lower temperature? (2)

c. After a mixture of hydrogen and nitrogen gases in a reaction vessel is allowed to attain equilibrium at 472°C, it was found to contain 7.38 atm H_2, 2.46 atm N_2, and 0.166 atm NH_3. From these data, calculate the equilibrium constant K_p for the reaction

$N_2(g) + 3\,H_2(g) \rightleftharpoons 2\,NH_3(g)$ (8)

d. Given the reactions

$$HF(aq) \rightleftharpoons H^{+}(aq) + F^{-}(aq) \qquad K_c = 6.8 \times 10^{-4}$$

$$H_2C_2O_4(aq) \rightleftharpoons 2\,H^{+}(aq) + C_2O_4^{2-}(aq) \qquad K_c = 3.8 \times 10^{-6}$$

Determine the value of K_c for the reaction

$2\,HF(aq) + C_2O_4^{2-}(aq) \rightleftharpoons 2\,F^{-}(aq) + H_2C_2O_4(aq)$ (5)

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^{o}C and 1 atm	V_m	22.414 dm^{3}

UNIVERSITY OF SWAZILAND

Department of Chemistry

Atomic Number — 2 **He** 4.0026 — Atomic Weight

1 **H** 1.0079																	2 **He** 4.0026
3 **Li** 6.941	4 **Be** 9.0122											5 **B** 10.811	6 **C** 12.011	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.179
11 **Na** 22.990	12 **Mg** 24.305											13 **Al** 26.982	14 **Si** 28.086	15 **P** 30.974	16 **S** 32.064	17 **Cl** 35.453	18 **Ar** 39.948
19 **K** 39.098	20 **Ca** 40.078	21 **Sc** 44.956	22 **Ti** 47.88	23 **V** 50.942	24 **Cr** 51.996	25 **Mn** 54.938	26 **Fe** 55.847	27 **Co** 58.933	28 **Ni** 58.69	29 **Cu** 63.546	30 **Zn** 65.39	31 **Ga** 69.723	32 **Ge** 72.61	33 **As** 74.922	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.906	40 **Zr** 91.224	41 **Nb** 92.906	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.75	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	57 **La** 138.91	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.85	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** 226.03	89 **Ac** 227.03															

58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** 146.92	62 **Sm** 150.36	63 **Eu** 151.97	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.04	71 **Lu** 174.97
90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** 237.05	94 **Pu** (244)	95 **Am** (234)	96 **Cm** (247)	97 **Bk** 247	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)