Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2021/2022

COURSE NAME	:	CHEMISTRY
COURSE CODE	:	DAM 13102
PROGRAMME CODE	:	DAM
EXAMINATION DATE	:	JANUARY / FEBRUARY 2022
DURATION	:	2 HOURS AND 30 MINUTES
INSTRUCTION	:	1. ANSWER **ALL** QUESTIONS IN SECTION A
		2. ANSWER **TWO (2)** QUESTIONS ONLY IN SECTION B
		3. THIS FINAL EXAMINATION IS AN **ONLINE** ASSESSMENT AND CONDUCTED VIA **CLOSE BOOK**

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

SECTION A

Q1 (a) A mixture containing 0.84 mol of PCl_5 and 0.18 mol of PCl_3 was allowed to achieve equilibrium in a closed container of capacity 1.0 dm^3 at 300 °C. It was found that 0.72 mol of PCl_5 remains. Calculate *K*c for the decomposition of PCl_5.

(5 marks)

(b)

$$CH_3COOH + C_2H_5OH \rightleftharpoons CH_3COOC_2H_5 + H_2O$$

A mixture containing 1.0 mol of ethanoic acid and 5.0 mol of ethanol was allowed to achieve equilibrium at room temperature. The amount of ethanoic acid left requires 289 cm^3 of 0.2 M NaOH to complete reaction.

(i) Find the number of moles of ethanoic acid reacted for the reaction.

(4 marks)

(ii) Determine the value of K_c for the reaction.

(8 marks)

(c)

$$CS_2\,(g) + 4H_2\,(g) \rightleftharpoons CH_4\,(g) + 2H_2S\,(g) \quad \Delta H = \text{negative}$$

State and explain the effect of the following changes (if any) on the K_p and the amount of methane, CH_4 in the equilibrium mixture of the given reaction.

(i) Increasing the temperature

(2 marks)

(ii) Increasing the pressure

(2 marks)

(iii) Adding more hydrogen gas

(2 marks)

(iv) Addition of a suitable catalyst

(2 marks)

Q2 (a) Differentiate the acid and base according to Lewis and Bronsted Lowry theory.

(4 marks)

(b) Identify the acid-base conjugate pairs in each of the following reactions. Justify your answer.

(i) $CH_3COO^- + HCN \leftrightarrow CH_3COOH + CN^-$

(2 marks)

(ii) $H_2PO_4^{2-} + NH_3 \leftrightarrow HPO_4^{2-} + NH_4^+$

(2 marks)

(c) Identify the Lewis acid and Lewis base in each of the following reactions. Justify your answer.

(i) $Ag^+_{(aq)} + 2NH_{3\,(aq)} \leftrightarrow Ag(NH_3)^+_{2\,(aq)}$

(2 marks)

(ii) $SnCl_{4(s)} + 2Cl^-_{(aq)} \leftrightarrow SnCl^{2-}_{6\,(aq)}$

(2 marks)

(d) A 0.056 g quantity of acetic acid is dissolved in distilled water to make 50 ml solution. The acetic acid dissolves in distilled water according to the following equations. (Molar mass of acetic acid = 60.052 g/mol).

$$CH_3COOH + H_2O \leftrightarrow CH_3COO^- + H_3O^+ \qquad K_a = 1.8 \times 10^{-5}$$

(i) Calculate the concentration of acetic acid solution in Molar (M).

(2 marks)

(ii) Determine the concentration of CH_3COOH, CH_3COO^- and H_3O^+ at equilibrium.

(9 marks)

(iii) Calculate the pH of the solution.

(2 marks)

SECTION B

Q3 (a) The density of water at 4°C is 1.00 gcm^{-3}. Determine the number of water molecules in 4.5 cm^3 of water at the same temperature.

(5 marks)

(b) Pitchblende is the most important compound of uranium. Mass analysis of an 84.2 g sample shows that it contains 71.4 g of uranium, with oxygen the only other element. Determine the amount of uranium (in grams) are in 102 kg of pitchblende.

(5 marks)

(c) In mammals, lactose (milk sugar) is metabolized to glucose, $C_6H_{12}O_6$, the key nutrient for generating chemical potential energy. Determine the mass percent of each element in glucose.

(7 marks)

(d) During excessive physical activity, lactic acid forms in muscle tissue and it is responsible for muscle soreness. Elemental analysis shows that this compound contains 40.0 mass % C, 6.71 mass % H, and 53.3 mass % O.

(i) Determine the empirical formula of lactic acid.

(5 marks)

(ii) Determine the molecular formula of lactic acid.
(Given: Molecular mass of lactic acid is 90.08 g/mol)

(3 marks)

Q4 (a) Classify the following substances as ionic or covalent compounds. Justify your answer.

(i) MgO

(3 marks)

(ii) CS_2

(3 marks)

(iii) KF

(3 marks)

(iv) $SiCl_4$

(3 marks)

(b) Show the steps to draw the Lewis structure for NO_2^+ ion.

(5 marks)

(c) A polyatomic ion HCO_2^- has two (2) resonance structures.

(i) Draw the possible resonance structures for HCO_2^-

(4 marks)

(ii) Determine the formal charge for each atom in both resonance structures.

(4 marks)

Q5 (a) Sodium azide (NaN_3) decomposes according to the equation:

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

Determine the volume of nitrogen produced at 21 °C and 120 kPa on the decomposition of 60.0 g of sodium azide.

(7 marks)

(b) A chemical engineer uses waste CO_2 from a manufacturing process, instead of chlorofluorocarbons, as a "blowing agent" in the production of polystyrene. Find the density (in g/L) of CO_2 and the number of molecules per liter:

(i) at standard temperature and pressure

(7 marks)

(ii) at 20.0 °C and 1.00 atm

(3 marks)

(c) Acetylene (C_2H_2), an important fuel in welding, is produced in the laboratory when calcium carbide (CaC_2) reacts with water:

$$CaC_2\,(s) + 2H_2O\,(l) \longrightarrow C_2H_2\,(g) + Ca(OH)_2\,(aq)$$

For a sample of acetylene collected over water, total gas pressure (adjusted to barometric pressure) is 738 torr and the volume is 523 mL. At the temperature of the gas (23 °C), the vapor pressure of water is 21 torr. Calculate mass (grams) of acetylene that are collected.

(8 marks)

Q6 (a) A 250 g of water is heated from 22 °C to 98 °C. Calculate the amount of heat (q) absorbed by the water. Given the specific heat of water is 4.18 $Jg^{-1}\,{}^oC^{-1}$.

(4 marks)

(b) A quantity of 1.922 g of methanol (CH_3OH) was burned in a constant-volume bomb calorimeter. Consequently, the temperature of the water rose by 4.20°C. If the quantity of water surrounding the calorimeter was exactly 2000 g and the heat capacity of the calorimeter was 2.02 kJ/°C, calculate the heat released (kJ) by the burning of 1 mol methanol. Given the specific heat of water is 4.18 $Jg^{-1}\,{}^oC^{-1}$.
(Molar mass of CH_3OH = 32 g/mol).

(7 marks)

(c) Consider the following two reactions:

$$A \rightarrow 2B \qquad \Delta H^o_{rxn} = \Delta H_1$$
$$A \rightarrow C \qquad \Delta H^o_{rxn} = \Delta H_2$$

Write the thermochemical equation for

(i) the formation of $\frac{1}{2}B$

(2 marks)

(ii) the dissociation of 4 moles of C

(2 marks)

(iii) the process of $2B \rightarrow C$

(2 marks)

(d) Calculate ΔH^o for the reaction of $H_{(g)} + Br_{(g)} \rightarrow HBr_{(g)}$ using the following data:

$$H_{2(g)} \rightarrow 2H_{(g)} \qquad \Delta H^o = 436.4\ kJ$$
$$Br_{2(g)} \rightarrow 2Br_{(g)} \qquad \Delta H^o = 192.5\ kJ$$
$$H_{2(g)} + Br_{2(g)} \rightarrow 2HBr_{(g)} \qquad \Delta H^o = -72.4\ kJ$$

(8 marks)

Q7 (a) Write the reaction rate expression for the following reactions.

(i) $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$

(1 marks)

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

(1 marks)

(b) Consider the reaction below:

$$2NO_{(g)} + O_{2\,(g)} \rightarrow 2NO_{2(g)}$$

Suppose that at a particular moment during the reaction, nitric oxide (NO) is reacting at the rate of 0.066 M/s. Determine:

(i) at what rate NO_2 is being formed.

(2 marks)

(ii) at what rate O_2 is reacting.

(2 marks)

(c) The following data were obtained from the reaction of

$$2H_{2\,(g)} + 2NO_{(g)} \rightarrow 2H_2O_{(g)} + N_{2(g)}$$

Experiment	$[H_2]$	$[NO]$	Initial Rate (M/s)
1	0.010	0.025	2.4×10^{-6}
2	0.0050	0.025	1.2×10^{-6}
3	0.010	0.0125	0.60×10^{-6}

(i) Write the rate law for the reaction.

(2 marks)

(ii) Determine the overall order of the reaction.

(6 marks)

(iii) Calculate the rate constant.

(2 marks)

(d) The thermal decomposition of phosphine (PH_3) into phosphorus and hydrogen is a first order reaction.

$$4PH_{3\,(g)} \rightarrow P_{4\,(g)} + 6H_{2(g)}$$

The half-life of the reaction is 35.0 s at 680°C.

(i) Calculate the rate constant for the reaction.

(3 marks)

(ii) If the initial concentration of phosphine is 0.25 M, find the concentration of phosphine after 5.0 minutes of reaction.

(3 marks)

(iii) The time required for 95% of the phosphine to decompose.

(3 marks)

-END OF QUESTIONS-

FINAL EXAMINATION

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List of chemical elements

Atomic No.	*Atomic Weight*	*Name*	*Sym.*	*Atomic No.*	*Atomic Weight*	*Name*	*Sym*
1	1.0	Hydrogen	H	31	69.72	Gallium	Ga
2	4.0	Helium	He	32	72.64	Germanium	Ge
3	6.9	Lithium	Li	33	74.92	Arsenic	As
4	9.0	Beryllium	Be	34	78.96	Selenium	Se
5	10.81	Boron	B	35	79.90	Bromine	Br
6	12.01	Carbon	C	36	83.80	Krypton	Kr
7	14.01	Nitrogen	N	37	85.47	Rubidium	Rb
8	16.00	Oxygen	O	38	87.62	Strontium	Sr
9	19.00	Fluorine	F	39	88.91	Yttrium	Y
10	20.18	Neon	Ne	40	91.22	Zirconium	Zr
11	22.99	Sodium	Na	41	92.91	Niobium	Nb
12	24.31	Magnesium	Mg	42	95.94	Molybdenum	Mo
13	26.98	Aluminum	Al	43	98.00	Technetium	Tc
14	28.09	Silicon	Si	44	101.07	Ruthenium	Ru
15	30.97	Phosphorus	P	45	102.91	Rhodium	Rh
16	32.07	Sulfur	S	46	106.42	Palladium	Pd
17	35.45	Chlorine	Cl	47	107.87	Silver	Ag
18	39.95	Argon	Ar	48	112.41	Cadmium	Cd
19	39.10	Potassium	K	49	114.82	Indium	In
20	40.08	Calcium	Ca	50	118.71	Tin	Sn
21	44.96	Scandium	Sc	51	121.76	Antimony	Sb
22	47.87	Titanium	Ti	52	127.60	Tellurium	Te
23	50.94	Vanadium	V	53	126.90	Iodine	I
24	52.00	Chromium	Cr	54	131.29	Xenon	Xe
25	54.94	Manganese	Mn	55	132.91	Cesium	Cs
26	55.85	Iron	Fe	56	137.33	Barium	Ba
27	58.93	Cobalt	Co	57	138.91	Lanthanum	La
28	58.69	Nickel	Ni	58	140.12	Cerium	Ce
29	63.55	Copper	Cu	59	140.91	Praseodymiu	Pr
30	65.39	Zinc	Zn	60	144.24	Neodymium	Nd