Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2021/2022

COURSE NAME	:	PHYSICAL CHEMISTRY
COURSE CODE	:	BWK 10103
PROGRAMME CODE	:	BWK
EXAMINATION DATE	:	JANUARY / FEBRUARY 2022
DURATION	:	3 HOURS 30 MINUTES
INSTRUCTION	:	1. ANSWER **ALL** QUESTIONS
		2. THIS FINAL EXAMINATION IS AN **ONLINE** ASSESSMENT AND CONDUCTED VIA **OPEN BOOK**

THIS QUESTION PAPER CONSIST OF **SIX (6)** PAGES

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Q1 (a) In one experiment, a big chunk of ice absorbed 6.00 kJ of heat at 16 °C until it melted. Briefly describe the minimum value entropy change of ice to ensure that the process is spontaneous.

(4 Marks)

(b) The atomic number and atomic mass of elements is systematically sorted in **Table Q1(b)**. With the aid of the tabulated values, predict the temperature of 83.68 g of carbon dioxide at a pressure of 1830 torr contained in a 3920 cm^3 vessel.

(6 Marks)

(c) 0.0746 g of KCl was accurately dissolved in 200 cm^3 of distilled water. Calculate the ionic strength of solution when the prepared KCl solution is homogenously mixed with 0.008 M $AlCl_3$.

(5 Marks)

(d) 1 mol of phosphorus pentachloride are heated to 500 K in a sealed vessel. The reaction proceeds as below:

$$PCl_{5\,(g)} \rightleftharpoons PCl_{3\,(g)} + Cl_{2\,(g)}$$

The equilibrium mixture at a total pressure of 625 atm contains 0.6 mol of chlorine gas. The gas constant values are tabulated in **Table Q1(d)**. Determine the Kc of the reaction by employing the suitable gas constant provided.

(5 Marks)

Q2 (a) 319.998 g of oxygen gas are allowed to expend isothermally at 27 °C from an initial volume of 10 L. Infer the work done by the gas to the piston if the gas expends up to three times from its initial volume.

(3 Marks)

(b) Two cylinders A and B are connected by a tube with negligible volume. The initial volume and pressure of cylinder A are 2.5 x 10^3 cm^3 and 3.4 x 10^5 Pa. The initial temperature of cylinder A is 300 K while the number of mol of gas in cylinder B is 0.2 mol. When the barrier between the tube is removed and both gaseous are allowed to mixed homogenously, the pressure in both cylinder reaches 3.9 x 10^5 Pa. The temperature gas mixture increases to 82.5618 °C when it reaches equilibrium. Determine the initial volume of cylinder B (in mL) if no thermal energy enters or leaves the gas.

(7 Marks)

(c) During winter, ice on roadways is probably the most serious meteorological hazard which may lead to serious injuries and several tragic deaths.

(i) Suggest **THREE (3)** chemicals that can be used to minimize this problem by employing the colligative theory.

(4 Marks)

(ii) Distinguish the most economical chemical among the chemicals that you have suggested. Given that the molal freezing point depression constant of water is equal to -1.86 $°C/m$. Show your detail calculation.

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(6 Marks)

(d) Consider a vessel with 3 compartments. Each compartment has different type of gas namely chlorine, helium and argon gas. The mass of the gaseous are 3.2 g, 1.2 g and 4.5 g respectively. The barrier between the compartment is then removed and the gaseous are allowed to mixed homogeneously. Point out the specific variable that should be controlled to ensure that the mixing of these gaseous are non-spontaneous. Show your detail calculation.

(10 Marks)

Q3 (a) List down the different types of potentiometric titration.

(4 Marks)

(b) Briefly describe the basic laws of photochemistry.

(6 Marks)

(c) 1 mol of xenon took 225 seconds to effuse through a tiny hole.

(i) Predict how long would it take for 1 mol of oxygen gas to effuse under the same condition.

(4 Marks)

(ii) Briefly explain why the phenomenon goes as predicted.

(1 Mark)

(d) Ammonia (NH_3) burns in oxygen to form nitrogen oxide and water. At a particular moment, the rate at which oxygen reacts with ammonia to produce product is 0.40 M. Calculate the rate at which water is formed.

(5 Marks)

Q4 (a) The pH of a 0.2 M solution of an unknown weak acid at equilibrium is 3.7. Estimate the Ka of this acid.

(3 Marks)

(b) Explain **TWO (2)** methods that can be used to determine the average translational kinetic energy (rms) of 63 g of bromine gas at 127 °C.

(7 Marks)

(c) The enzyme carbonic anhydrase catalyses the reversible reaction of carbon dioxide and water to form carbonic acid. When the concentration of carbon dioxide in the body is too high, carbonic anhydrase catalyses the following reaction:

$$CO_2 + H_2 \rightleftharpoons H_2CO_3$$

The rate constant of the reaction at 36.1 °C and 37.2 °C was found to be 5.03 x 10^{-5} $m^{-1}s^{-1}$ and 6.71 x 10^{-3} $m^{-1}s^{-1}$ respectively.

(i) By analysing the data given, point out the minimum energy needed to produce carbonic acid.

(4 Marks)

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(ii) Provide a hypothesis on the rate of reaction if the reaction is conducted at elevated temperature with the presence of carbonic anhydrase

(6 Marks)

(d) The reaction between ethyl ethanoate and potassium hydroxide follows the second order reaction.

$$CH_3COOC_2H_5 + KOH \rightarrow CH_3COOK + C_2H_5OH$$

An aqueous solution containing equimolar amount of ethyl ethanoate and potassium hydroxide were mixed at 298 K. Initially, 112.2112 g of potassium hydroxide was dissolved in 200 cm^3 water before it was being reacted with ethyl ethanoate. At 300 seconds, its concentration drops to 6.25 M. When the chemist repeated the experiment the next day, it was found that the half-life of the reaction is 352 s. Provide a hypothesis on why the phenomenon is such.

(10 Marks)

-END OF QUESTIONS-

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FINAL EXAMINATION

SEMESTER/SESSION : SEMESTER I 2021/2022 PROGRAMME : BWK
COURSE NAME : PHYSICAL CHEMISTRY COURSE CODE : BWK 10103

Table Q1(b): Atomic Number and Atomic Mass of Elements

Element	Symbol	Atomic number (Z)	Atomic mass (A)	Element	Symbol	Atomic number (Z)	Atomic mass (A)
Actinium	Ac	89	227.0278	Mercury	Hg	80	200.59
Aluminum	Al	13	26.98154	Molybdenum	Mo	42	95.94
Americium	Am	95	~243	Neodymium	Nd	60	144.24
Antimony	Sb	51	121.75	Neon	Ne	10	20.179
Argon	Ar	18	39.948	Neptunium	Np	93	237.0482
Arsenic	As	33	74.9216	Nickel	Ni	28	58.7
Astatine	At	85	~210	Niobium	Nb	41	92.9064
Barium	Ba	56	137.33	Nitrogen	N	7	14.0067
Berkelium	Bk	97	~247	Nobelium	No	102	~259
Beryllium	Be	4	9.01218	Osmium	Os	76	190.2
Bismuth	Bi	83	208.9804	Oxygen	O	8	15.9994
Boron	B	5	10.81	Palladium	Pd	46	106.4
Bromine	Br	35	79.904	Phosphorus	P	15	30.97376
Cadmium	Cd	48	112.41	Platinum	Pt	78	195.09
Calcium	Ca	20	40.08	Plutonium	Pu	94	~244
Californium	Cf	98	~251	Polonium	Po	84	~209
Carbon	C	6	12.011	Potassium	K	19	39.0983
Cerium	Ce	58	140.12	Praseodymium	Pr	59	140.9077
Cesium	Cs	55	132.9054	Promethium	Pm	61	~145
Chlorine	Cl	17	35.453	Protactinium	Pa	91	231.0359
Chromium	Cr	24	51.996	Radium	Ra	88	226.0254
Cobalt	Co	27	58.9332	Radon	Rn	86	~222
Copper	Cu	29	63.546	Rhenium	Re	75	186.207
Curium	Cm	96	~247	Rhodium	Rh	45	102.9055
Dysprosium	Dy	66	162.5	Rubidium	Rb	37	85.4678
Einsteinium	Es	99	~254	Ruthenium	Ru	44	101.07
Erbium	Er	68	167.26	Samarium	Sm	62	150.4
Europium	Eu	63	151.96	Scandium	Sc	21	44.9559
Fermium	Fm	100	~257	Selenium	Se	34	78.96
Fluorine	F	9	18.998403	Silicon	Si	14	28.0855
Francium	Fr	87	~223	Silver	Ag	47	107.868
Gadolinium	Gd	64	157.25	Sodium	Na	11	22.98977
Gallium	Ga	31	69.72	Strontium	Sr	38	87.62
Germanium	Ge	32	72.59	Sulfur	S	16	32.06
Gold	Au	79	196.9665	Tantalum	Ta	73	180.9479
Hafnium	Hf	72	178.49	Technetium	Tc	43	~97
Helium	He	2	4.0026	Tellurium	Te	52	127.6
Holmium	Ho	67	164.9304	Terbium	Tb	65	158.9254
Hydrogen	H	1	1.0079	Thallium	Tl	81	204.37
Indium	In	49	114.82	Thorium	Th	90	232.0381
Iodine	I	53	126.9045	Thulium	Tm	69	168.9342
Iridium	Ir	77	192.22	Tin	Sn	50	118.69
Iron	Fe	26	55.847	Titanium	Ti	22	47.9
Krypton	Kr	36	83.8	Tungsten	W	74	183.85
Lanthanum	La	57	138.9055	Uranium	U	92	238.029
Lawrencium	Lr	103	~260	Vanadium	V	23	50.9414
Lead	Pb	82	207.2	Xenon	Xe	54	131.3
Lithium	Li	3	6.941	Ytterbium	Yb	70	173.04
Lutetium	Lu	71	174.97	Yttrium	Y	39	88.9059
Magnesium	Mg	12	24.305	Zinc	Zn	30	65.38
Manganese	Mn	25	54.938	Zirconium	Zr	40	91.22

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Table Q1(d): Gas constant (R) at different unit

Value	Unit
0.0821	$LatmK^{-1}mol^{-1}$
8.3145	$JK^{-1}mol^{-1}$
8.3145×10^{3}	$LPamol^{-1}K^{-1}$
8.3145	$M^{3}PaK^{-1}mol^{-1}$
0.008314	$kJK^{-1}mol^{-1}$

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