

**UNIVERSITY OF SWAZILAND**  
**MAIN EXAMINATION -- 2019, JUNE**

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**TITLE OF PAPER** : Introductory Chemistry II

**COURSE NUMBER** : CHE152

**TIME** : Three Hours

**INSTRUCTIONS** :

1. Answer Question I (compulsory) and any other three questions (each question is 25 marks)

**NB:** Non-programmable electronic calculators may be used  
A data sheet and a periodic table are attached

**Useful data and equations:**

1 atm = 760 Torr = 760 mmHg

1 atm = 101325 Pa

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

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

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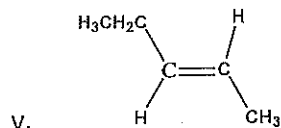
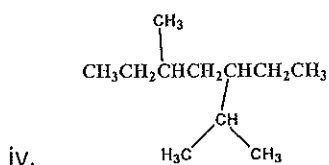
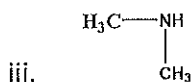
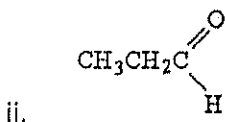
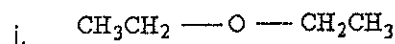
This Examination Paper Contains **Six** Printed Pages Including This Page

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

### Question 1 (Compulsory)

a. Name the following compounds:

(10)

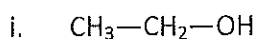


b. Draw the structures of the following compounds:

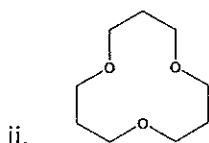
(10)

- 3-chloro-3-cyclohexenone
- 2,3,3-trimethyl-4-octyne
- 3-chloro-3-methyl-1-pentene
- 3-methyl-5-hexen-3-ol
- 3-methyl-3-hydroxybutanoic acid

c. Identify the functional groups in each of the following compounds:

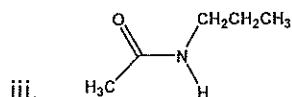


(1)



ii.

(2)



iii.

(2)

### Question 2

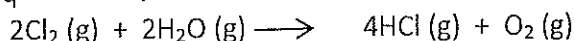
a. Write the equilibrium-constant expression for the following reactions:

(8)

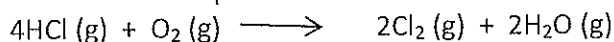
- $\text{CO}_2(\text{g}) + 2\text{H}_2(\text{g}) \longrightarrow \text{CH}_3\text{OH}(\text{g})$
- $\text{CO}_2(\text{s}) + \text{H}_2\text{O}(\text{l}) \longrightarrow \text{H}^+(\text{aq}) + \text{HCO}_3^-(\text{aq})$
- $\text{Cr}(\text{s}) + 3\text{Ag}^+(\text{aq}) \longrightarrow \text{Cr}^{3+}(\text{aq}) + 3\text{Ag}(\text{s})$



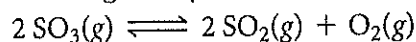
- b. The  $K_{\text{eq}}$  for the equilibrium below is  $7.52 \times 10^{-2}$  at  $480.0^\circ\text{C}$ . (3)



What is the value of  $K_{\text{eq}}$  at this temperature for the following reaction?

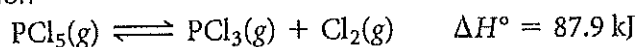


- c. Sulfur trioxide decomposes at high temperature in a sealed container:



Initially, the vessel is charged at 1000 K with  $\text{SO}_3(g)$  at a partial pressure of 0.500 atm. At equilibrium the  $\text{SO}_3$  partial pressure is 0.200 atm. Calculate the value of  $K_p$  at 1000 K. (9)

- d. For the reaction



in which direction will the equilibrium shift when

- $\text{Cl}_2(g)$  is added
- the temperature is increased
- the volume of the reaction system is decreased
- $\text{PCl}_3(g)$  is removed? (5)

### Question 3

- a. The pressure in a natural-gas tank is maintained at 2.20 atm. On a day when the temperature is  $-25^\circ\text{C}$ , the volume of gas in the tank is  $3.25 \times 10^3 \text{ m}^3$ . What is the volume of the same quantity of gas on a day when the temperature is  $53^\circ\text{C}$ ? (7)
- b. A 0.75-mol sample of oxygen gas is confined at  $0^\circ\text{C}$  and 1.0 atm in a cylinder with a movable piston. The piston compresses the gas so that the final volume is a quarter of the initial volume and the final pressure is 5.2 atm. What is the final temperature of the gas in degrees Celsius? (10)
- c. Sodium bicarbonate (2.00 kg) is reacted with excess concentrated hydrochloric acid at  $37.0^\circ\text{C}$  and 1.00 atm. What volume of  $\text{CO}_2$  will be produced. (8)

### Question 4

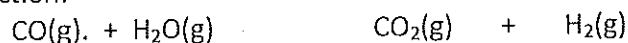
- a) What is the conjugate base of  $\text{HClO}_4$ ,  $\text{H}_2\text{S}$ ,  $\text{PH}_4^+$ ,  $\text{HCO}_3^-$ ? (4)
- b) What is the conjugate acid of  $\text{CN}^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{H}_2\text{O}$ ,  $\text{HCO}_3^-$ ? (4)
- c) A solution is made by mixing 27.3 mL of 0.28 M HCl and 25.0 mL of 0.35 M NaOH. Calculate the pH of this solution. (10)
- d) Calculate the concentration of  $\text{OH}^-(aq)$  in a solution in which (7)

i)  $[H^+] = 3 \times 10^{-6} M$ ;

ii)  $[H^+] = 50 \times [OH^-]$

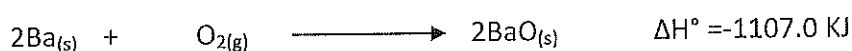
### Question 5

- a) In the coal-gasification process, carbon monoxide is converted to carbon dioxide via the following reaction:



In an experiment, 0.35 mol of CO and 0.40 mol of H<sub>2</sub>O were placed in a 1 L reaction vessel. At equilibrium, there were 0.19 mol of CO remaining. Calculate  $K_{eq}$  at this temperature. (10)

- a) Given the following reaction:

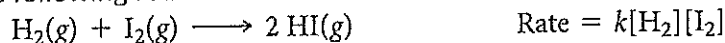


How many KJ of heat are released when:

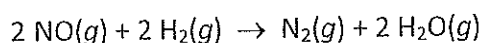
- i. 4.98 g of BaO<sub>(s)</sub> is produced (8)
- ii. 10.66 g of Ba<sub>(s)</sub> reacts completely with oxygen to form BaO<sub>(s)</sub>? (7)

### Question 6

- a. Consider the following reaction:



- i. What is the reaction order of the reactant H<sub>2</sub>? (4)
- ii. What are the units of the rate constant? (6)
- b. The following data were measured for the reaction of nitric oxide with hydrogen:



Experiment Number	[NO] (M)	[H <sub>2</sub> ] (M)	Initial Rate (M/s)
1	0.10	0.10	$1.23 \times 10^{-3}$
2	0.10	0.20	$2.46 \times 10^{-3}$
3	0.20	0.10	$4.92 \times 10^{-3}$

- 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<sub>2</sub>] = 0.150 M. (5)

### SI Units and Conversions

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

### Pressure Units and conversion factors

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

UNIVERSITY OF SWAZILAND  
Department of Chemistry

Atomic Number		Atomic Weight		
1	H	1.0079	He	
2	He	4.0026		
3	Li	6.941	Be	
4	Be	9.0122		
11	Na	22.990	Mg	
12	Mg	24.305		
19	K	39.098	Ca	
20	Ca	40.078		
37	Rb	85.47	Sr	
38	Sr	87.62		
55	Cs	132.91	Ba	
56	Ba	137.33		
87	Fr	(223)	Ra	
88	Ra	226.03		
21	Sc	44.956	Y	
22	Ti	47.88	Zr	
23	V	50.942	Nb	
24	Cr	51.996	Mo	
25	Mn	54.938	Tc	
26	Fe	55.847	Ru	
27	Co	58.933	Rh	
28	Ni	58.69	Pd	
29	Cu	63.546	Ag	
30	Zn	65.39	Cd	
39	Y	88.906	La	
40	Zr	91.224	Hf	
41	Nb	92.906	Ta	
42	Mo	95.94	W	
43	Tc	(98)	Re	
44	Ru	101.07	Os	
45	Rh	102.91	Ir	
46	Pd	106.42	Pt	
47	Ag	107.87	Au	
48	Cd	112.41	Hg	
57	La	138.91	Pr	
58	Ce	140.12	Nd	
59	Pr	140.91	Pm	
60	Nd	144.24	Sm	
61	Pm	146.92	Eu	
62	Sm	150.36	Gd	
63	Eu	151.97	Tb	
64	Gd	157.25	Dy	
65	Tb	158.93	Ho	
66	Dy	162.50	Er	
67	Ho	164.93	Tm	
68	Er	167.26	Yb	
69	Tm	168.93	Lu	
70	Yb	173.04		
71	Lu	174.97		
72	Hf	178.49	Th	
73	Ta	180.95	Pa	
74	W	183.85	U	
75	Re	186.2	Np	
76	Os	190.2	Pu	
77	Ir	192.22	Am	
78	Pt	195.08	Cm	
79	Au	196.97	Bk	
80	Hg	200.59	Cf	
81	Tl	204.38	Es	
82	Pb	207.2	Fm	
83	Bi	208.98	Md	
84	Po	(209)	No	
85	At	(210)	Lr	
86	Rn	(222)		
87	Fr	(223)		
88	Ra	226.03		
89	Ac	227.03		
90	Th	232.04	Pa	
91	Pa	231.04	U	
92	U	238.03	Np	
93	Np	237.05	Pu	
94	Pu	(244)	Am	
95	Am	(243)	Cm	
96	Cm	(247)	Bk	
97	Bk	247	Cf	
98	Cf	(251)	Es	
99	Es	(252)	Fm	
100	Fm	(257)	Md	
101	Md	(258)	No	
102	No	(259)	Lr	
103	Lr	(260)		
5	B	10.811	6	C
6	C	12.011	7	N
7	N	14.007	8	O
8	O	15.999	9	F
9	F	18.998	10	Ne
13	Al	26.982	14	Si
14	Si	28.086	15	P
15	P	30.974	16	S
16	S	32.064	17	Cl
17	Cl	35.453	18	Ar
18	Ar	39.948	19	K
19	K	39.098	20	Ca
31	Ga	69.723	32	Ge
32	Ge	72.61	33	As
33	As	74.922	34	Se
34	Se	78.96	35	Br
35	Br	79.904	36	Kr
36	Kr	83.80	37	Rb
37	Rb	85.47	38	Sr
49	In	114.82	50	Sn
50	Sn	118.71	51	Sb
51	Sb	121.75	52	Te
52	Te	127.60	53	I
53	I	126.90	54	Xe
54	Xe	131.29	55	Cs
55	Cs	132.91	56	Ba
81	Tl	204.38	82	Pb
82	Pb	207.2	83	Bi
83	Bi	208.98	84	Po
84	Po	(209)	85	At
85	At	(210)	86	Rn
86	Rn	(222)	87	Fr
87	Fr	(223)	88	Ra
88	Ra	226.03	89	Ac
89	Ac	227.03	90	Th
90	Th	232.04	91	Pa
91	Pa	231.04	92	U
92	U	238.03	93	Np
93	Np	237.05	94	Pu
94	Pu	(244)	95	Am
95	Am	(243)	96	Cm
96	Cm	(247)	97	Bk
97	Bk	247	98	Cf
98	Cf	(251)	99	Es
99	Es	(252)	100	Fm
100	Fm	(257)	101	Md
101	Md	(258)	102	No
102	No	(259)	103	Lr
103	Lr	(260)		