UNIVERSITY OF SWAZILAND
FINAL EXAMINATION 2008/2009

TITLE OF PAPER	:	**Introductory Chemistry II**
COURSE CODE	:	**C112**
TIME ALLOWED	:	**Three (3) Hours.**
INSTRUCTIONS	:	**There are Six questions. Each question is worth 25 marks. Answer any Four (4) Questions. Non-programmable electronic calculators may be used.**

DO NOT OPEN THIS QUESTION PAPER UNTIL PERMISSION TO DO SO HAS BEEN GRANTED BY THE CHIEF INVIGILATOR.

Question 1 (25 marks)

(a)

(i) Give a summary of the statement that described the Kinetic molecular theory of ideal gases. [4]

(ii) How does the Kinetic molecular theory explain Dalton's law of partial pressures ? [3]

(b) From the ideal gas equation, obtain an expression for the molar mass of a gas M in terms of its mass, m , pressure, P, volume, V, temperature, T and the gas constant, R. [3]

(c)

(i) Differentiate between 'diffusion' and 'effusion' of gas molecules. [2]

(ii) Sate Graham's law and give its mathematical expression. Define all the parameters in the expression. [4]

(d) At 100°C and 1.0 atm, a 0.124g of a volatile compound evaporates to give 45.3cm^3 of vapour. Evaluate the molar mass, M, of this substance. [4]

(e) A 200.0 mL sample of $H_{2(g)}$ effuses through a porous container four times as rapidly as an unknown gas, X. Calculate the molar mass of X, given that $M_{H_2} = 2.0$ g/mol. Identify X. [5]

Question 2 (25 marks)

(a)

(i) Differentiate between the initial rate and instantaneous rate of a reaction. Show how they can evaluated for a given reaction. [8]

(ii) For a given real or hypothetical first order reaction, show graphically the variation of initial rate with initial concentration. [3]

(b) The reaction:

$$CS_2 \rightarrow CS + S$$

is first order with $k = 10^{-7}s^{-1}$ at 1000°C

(i) Calculate the half-life for this reaction. [3]

(ii) How many days will it take a 2.00g sample of CS_2 to decompose and reduce to 0.75g of CS_2? [4]

(iii) Referring to (ii), how many grams of CS would be formed after this length of time? [3]

(iv) How much of the 2.00g CS_2 would remain after 45.0 days? [4]

uestion 3 (25 marks)

(a) Define or explain the term 'thermochemical standard state of a substance'. Give two examples of substances in their standard states. [3]

(b)

(i) Define the term 'standard molar enthalpy of formation', ΔH^{O}_{f}: Explain the significance of 'o' in the superscript. [3]

(ii) Write the thermochemical equations that give values of the standard enthalpies of formation of $Al_2O_{3(s)}$ and $C_2H_5OH_{(l)}$. [4]

(iii) 10.0g of lithium was burnt in excess oxygen at constant atmosphric pressure to form Li_2O. The reaction mixture was then brought back to 25°C. In the process, 420KJ of heat was given off. Calculate the standard molar enthalpy of formation of Li_2O. [5]

(c)

(i) Sate Hess' Law of heat summation. [1]

(ii) Given the following equations and their ΔH^{O} values thus :

	ΔH (KJ)
$C_2H_5OH_{(l)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(l)}$	-1367.0
$C_2H_{4(g)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 2H_2O_{(l)}$	-1411.0

Calculate the heat of reaction at 298K for the following reaction.

$C_2H_{4(g)} + H_2O_{(l)} \rightarrow C_2H_5OH_{(l)}$ [3]

(iii) Given that the standard enthalpy of formation of $SO_{2(g)}$ is -296.83 KJ/mol while that of $SO_{3(g)}$ is -395.72 KJ/mol, calculate the enthalpy of reaction of the oxidation of 5.0g of SO_2 in the reaction :

$$2SO_{2(g)} + O_{2(g)} \rightarrow 2SO_{3(g)}$$ [6]

Question 4 (25 marks)

(a) The household cleaning reagent solution has a hydroxide concentration of 0.0032M. Calculate the $[H_3O^+]$, pH and pOH for this solution. [6]

(b) HA is a newly discovered monoprotic acid. A 0.20M solution of this acid is found to have a ph of 3.22.

(i) What is the K_a value for this acid? [4]

(ii) Evaluate the K_b for its conjugate base. [3]

(c) An aqueous ammonia solution has $K_b = 1.8 \times 10^{-5}$.

(i) Calculate the [OH^-] and pH for this solution. [6]

(d)

(i) For a diprotic acid, state the expression that relates the K_a, (the overall ionization constant) K_{a1} and K_{a2} (the stepwise ionization constant s). [1]

(ii) Calcualte the pH of a 1.0 x10^{-2}M $H_2SO_{3(aq)}$ at 25°C for which K_{a1} = 1.5 x10^{-2} and K_{a2} = 1.2 x10^{-7}. [5]

Question 5 (25 marks)

(a) Give the ground state electron configuration for each of the following atoms:

(i) Nitrogen [1½ marks]

(ii) Oxygen [1½ marks]

(iii) Silicon [2 marks]

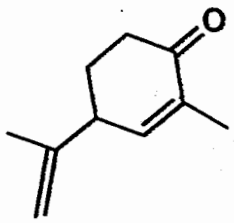
(iv) Sulphur [2 marks]

(b) (i) What is the importance of knowledge of electron configuration of an atom? [3 marks]

(ii) Phosphine, an organic compound made up of hydrogen and phoisphorus has atomic connectivity PH. How many hydrogen atoms does phosphorus bond to in forming phosphine? [2 marks]

(iii) Draw a three dimensional structure for a molecule of chloroform, using solid, wedge, and dashed lines to indicate its tetrahedral geometry. [4 marks]

(c) Carrone, a substance responsible for the odour of spearmint, has the following structure:



Carrone

(i) Indicate in the structure, how many hydrogen atoms are bonded to each carbon atom. [5 marks]

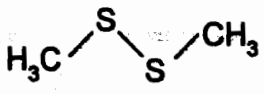
(ii) Give the molecular formular of carrone. [4 marks]

Question 6 (25 marks)

(a) (i) Commonly used in biology as a tissue preservative, formaldehyde, CH_2O, contains a carbon oxygen double bond. Draw the line-bond structure of formaldehyde, and indicate the hybridization of the carbon and oxygen atoms. [2 marks]

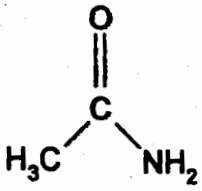
(ii) Draw the following structures and fill in any non bonding valence electrons that are missing.

(1)



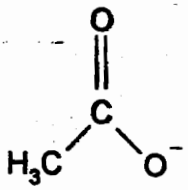
Dimethyl disulphide [2 marks]

(2)



[2 marks]

(3)



[2 marks]

(b) (i) Use the δ^+/δ^- convention to show the direction of expected polarity for each of the bonds indicated. [3 marks]

(1)	$H_3C–Cl$	(2)	$H_3C–NH_2$
(3)	$H_2N–H$	(4)	$H_3C–SH$
(5)	$H_3C–MgBr$	(6)	$H_3C–F$

(ii) Draw the resonance forms for the acetate ion CH_3COO^-. [1 mark]

(iii) Explain what these resonance structures (forms) predict for:

(1) The carbon-oxygen bond lengths in the acetate ion. [2 marks]

(2) The electrical charge on the oxygen atoms. [2 marks]

(c) Write the dot structure, the dash structure, and the bond-line (or the skeletal) structure for each of the following molecules:

(i) $CH_3CH_2NH_2$ [3 marks]

(ii) CH_3SCH_3 [3 marks]

(iii) $(CH_3)_2CHCH_2CH_2OH$ [3 marks]

General data and fundamental constants

Quantity	Symbol	Value
Speed of light	c	$2.997\,924\,58 \times 10^{8}$ m s^{-1}
Elementary charge	e	$1.602\,177 \times 10^{-19}$ C
Faraday constant	$F = N_A e$	9.6485×10^{4} C mol^{-1}
Boltzmann constant	k	$1.380\,66 \times 10^{-23}$ J K^{-1}
Gas constant	$R = N_A k$	8.314 51 J K^{-1} mol^{-1}
		$8.205\,78 \times 10^{-2}$ dm^3 atm K^{-1} mol^{-1}
		6.2364×10 L Torr K^{-1} mol^{-1}
Planck constant	h	$6.626\,08 \times 10^{-34}$ J s
	$\hbar = h/2\pi$	$1.054\,57 \times 10^{-34}$ J s
Avogadro constant	N_A	$6.022\,14 \times 10^{23}$ mol^{-1}
Atomic mass unit	u	$1.660\,54 \times 10^{-27}$ Kg
Mass		
electron	m_e	$9.109\,39 \times 10^{-31}$ Kg
proton	m_p	$1.672\,62 \times 10^{-27}$ Kg
neutron	m_n	$1.674\,93 \times 10^{-27}$ Kg
Vacuum permittivity	$\varepsilon_o = 1/c^2\mu_o$	$8.854\,19 \times 10^{-12}$ J^{-1} C^2 m^{-1}
	$4\pi\varepsilon_o$	$1.112\,65 \times 10^{-10}$ J^{-1} C^2 m^{-1}
Vacuum permeability	μ_o	$4\pi \times 10^{-7}$ J s^2 C^{-2} m^{-1}
		$4\pi \times 10^{-7}$ T^2 J^{-1} m^3
Magneton		
Bohr	$\mu_B = e\hbar/2m_e$	$9.274\,02 \times 10^{-24}$ J T^{-1}
nuclear	$\mu_N = e\hbar/2m_p$	$5.050\,79 \times 10^{-27}$ J T^{-1}
g value	g_e	2.002 32
Bohr radius	$a_o = 4\pi\varepsilon_o\hbar/m_e e^2$	$5.291\,77 \times 10^{-11}$ m
Fine-structure constant	$\alpha = \mu_o e^2 c/2h$	$7.297\,35 \times 10^{-3}$
Rydberg constant	$R_\infty = m_e e^4/8h^3 c\varepsilon_o^2$	$1.097\,37 \times 10^{7}$ m^{-1}
Standard acceleration of free fall	g	9.806 65 m s^{-2}
Gravitational constant	G	$6.672\,59 \times 10^{-11}$ N m^2 Kg^{-2}

Conversion factors

1 cal	=	4.184 joules (J)	1 erg	=	1×10^{-7} J
1 eV	=	$1.602\,2 \times 10^{-19}$ J	1 eV/molecule	=	96 485 kJ mol^{-1}

Prefixes

f	p	n	μ	m	c	d	k	M	G
femto	pico	nano	micro	milli	centi	deci	kilo	mega	giga
10^{-15}	10^{-12}	10^{-9}	10^{-6}	10^{-3}	10^{-2}	10^{-1}	10^{3}	10^{6}	10^{9}

PERIODIC TABLE OF ELEMENTS

PERIODS	GROUPS 1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIIIB	9 VIIIB	10 VIIIB	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1.008 H 1																	4.003 He 2
2	6.941 Li 3	9.012 Be 4											10.811 B 5	12.011 C 6	14.007 N 7	15.999 O 8	18.998 F 9	20.180 Ne 10
3	22.990 Na 11	24.305 Mg 12	TRANSITION ELEMENTS										26.982 Al 13	28.086 Si 14	30.974 P 15	32.06 S 16	35.453 Cl 17	39.948 Ar 18
4	39.098 K 19	40.078 Ca 20	44.956 Sc 21	47.88 Ti 22	50.942 V 23	51.996 Cr 24	54.938 Mn 25	55.847 Fe 26	58.933 Co 27	58.69 Ni 28	63.546 Cu 29	65.39 Zn 30	69.723 Ga 31	72.61 Ge 32	74.922 As 33	78.96 Se 34	79.904 Br 35	83.80 Kr 36
5	85.468 Rb 37	87.62 Sr 38	88.906 Y 39	91.224 Zr 40	92.906 Nb 41	95.94 Mo 42	98.907 Tc 43	101.07 Ru 44	102.91 Rh 45	106.42 Pd 46	107.87 Ag 47	112.41 Cd 48	114.82 In 49	118.71 Sn 50	121.75 Sb 51	127.60 Te 52	126.90 I 53	131.29 Xe 54
6	132.91 Cs 55	137.33 Ba 56	138.91 *La 57	178.49 Hf 72	180.95 Ta 73	183.85 W 74	186.21 Re 75	190.2 Os 76	192.22 Ir 77	195.08 Pt 78	196.97 Au 79	200.59 Hg 80	204.38 Tl 81	207.2 Pb 82	208.98 Bi 83	(209) Po 84	(210) At 85	(222) Rn 86
7	223 Fr 87	226.03 Ra 88	(227) **Ac 89	(261) Rf 104	(262) Ha 105	(263) Unh 106	(262) Uns 107	(265) Uno 108	(266) Une 109	(267) Uun 110								

Atomic mass → 10.811
Symbol → B
Atomic No. → 5

*Lanthanide Series	140.12 Ce 58	140.91 Pr 59	144.24 Nd 60	(145) Pm 61	150.36 Sm 62	151.96 Eu 63	157.25 Gd 64	158.93 Tb 65	162.50 Dy 66	164.93 Ho 67	167.26 Er 68	168.93 Tm 69	173.04 Yb 70	174.97 Lu 71
**Actinide Series	232.04 Th 90	231.04 Pa 91	238.03 U 92	237.05 Np 93	(244) Pu 94	(243) Am 95	(247) Cm 96	(247) Bk 97	(251) Cf 98	(252) Es 99	(257) Fm 100	(258) Md 101	(259) No 102	(260) Lr 103

( ) indicates the mass number of the isotope with the longest half-life.