UNIVERSITY OF SWAZILAND
SUPPLEMENTARY EXAMINATION, 2009/2010

TITLE OF PAPER : **INTRODUCTORY CHEMISTRY II**

COURSE CODE : **C112**

TIMEALLOWED ; **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.

SECTION A

Question 1 (25 marks)

(a) Use an appropriate diagram or graph with specific examples, to show the influence of temperature and molecular weight on the distribution of gaseous molecular speeds in a given system. Briefly explain the shapes of the curves. [6]

(b) A 350.0mL sample of oxygen gas exerts a pressure of 830 torr at 22°C.
- (i) Calculate the temperature during which it exerts a pressure of 600 torr in a volume of 500.0mL. [4]
- (ii) What volume will $O_{2(g)}$ occupy at STP? [3]

© (i) State Dalton's law of partial pressures. [1]
- (ii) At 25°C, 0.200 mole of $CH_{4(g)}$, 0.300 mole of $H_{2(g)}$ and 0.400 mole of $N_{2(g)}$ are contained in a 10.0L 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. [5]
- (iii) Suppose the temperature of the flask in question c(ii) above is raised from 25°C to 75°C, evaluate the ratio of the total pressures in the flask at the two temperatures. [3]
- (iv) Calculate the volume of 0.65 mole of an ideal gas at 365 torr and 97°C. [3]

(Use: R = 0.0821 $L.atm.mol^{-1}K^{-1}$)

Question 2 (25 marks)

(a) What is the difference between initial rate and instantaneous rate of a reaction? Show how each of them can be estimated for a reaction. [8]

(b) Using a real or hypothetical reaction, show graphically the variation of initial rates with initial concentrations for a first order reaction. [3]

© Given that $k = 10^{-7}s^{-1}$ at 1000°C for the following first order reaction:

$$CS_2 \rightarrow CS + S$$

- (i) Evaluate the half – life for this reaction. [3]
- (ii) Calculate the number of days it would 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]

Question 3 (25 marks)

(a) For the standard enthalpy of formation of a substance, ΔH^o_f:
- (i) Define it and state its S.I. units
- (ii) Illustrate it with an example without giving its actual value.
- (iii) What is its value for an element in its thermochemical standard state?

[4]

(b) **Give a statement of Hess' law of heat summation.** **[2]**

© **Given the following standard enthalpy changes of formation, calculate the standard enthalpy change of combustion of silane, SiH_4, at 298K:**

$$SiH_{4(g)} + 2O_{2(g)} \rightarrow SiO_{2(g)} + 2H_2O_{(l)}$$

Substance	$SiH_{4(g)}$	$SiO_{2(g)}$	$H_2O_{(l)}$
ΔH^o_f(KJ/mol)	+34.0	-910.9	-285.8

[6]

(d) **From the following equations and their corresponding standard enthalpy changes, calculate the ΔH^o_{rxn}, for the following reaction at 298K.**

$$C_{(s)} + 2H_{2(g)} \rightarrow CH_{4(g)}$$

Given:

Reaction	ΔH^o (KJ)
$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$	-393.5
$H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)}$	-285.8
$CO_{2(g)} + 2H_2O_{(l)} \rightarrow CH_{4(g)} + 2O_{2(g)}$	+890.3

[8]

(e) **Given the following reaction:**

$$2Ba_{(s)} + O_{2(g)} \rightarrow 2BaO_{(s)} \quad \Delta H^o = -1107.0 \text{ KJ}$$

How many KJ of heat are released when:

(i) **5.75g of $BaO_{(s)}$ is produced?**

(ii) **15.75g of $Ba_{(s)}$ reacts completely with oxygen to form $BaO_{(s)}$?** **[5]**

SECTION B: Structure and Bonding

Question 4 (25 marks)

(a) Name any five elements in the periodic table which are most commonly associated with the majority of organic compounds. (5 marks)

(b) Using the principles and rules that govern the distribution of electrons in atomic orbitals, write the ground state electron configuration for each atom named in (a) above. (5 marks)

(c) Why is knowledge of electron configuration of an element important in the study of molecular structure and properties of carbon compounds? (5 marks)

(d) With the aid of suitable diagrams and formulas, explain the following terms:

(i) An Orbital (4 marks)
(ii) Lewis Structure (3 marks)
(iii) Chemical Bond (3 marks)

Question 5 (25 marks)

(a) Briefly describe the structure and bonding characteristics of ammonia molecule (NH_3) in terms of the following three modes of bonding:

(i) The Lewis Model (3 marks)
(ii) Valence Shell Electron Pair Repulsion (VSEPR) Theory (3 marks)
(iii) Orbital Hybridization (3 marks)

(b) (i) Write two resonance structures for the formate ion $HC\bar{O}_2$. (3 marks)

(ii) Explain what these structures predict for:

(1) The carbon-oxygen bond lengths of the formate 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 formular for each of the following molecules:

(i) $(CH_3)_2\ CHOH$ (3 marks)
(ii) $(CH_3)_2CH\ CH_2CH_2CH_2OH$ (3 marks)
(iii) $CH_3\ \ddot{O}\ CH_3$ (3 marks)

Question 6 (25 marks)

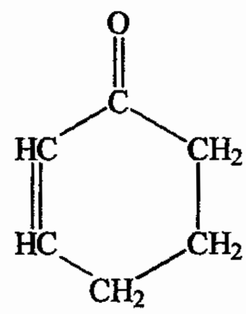
(a) Write an equation for the Lewis acid / Lewis base reaction between boron trifluoride and dimethyl sulphide [$(CH_3)2S$]. Use curved arrows to track the flow of electrons and show formal charges if present. (8 marks)

(b) Write a bond line formula for each of the following: (8 marks)

(i) $(CH_3)_2N\ CH_2CH_3$

(ii)
$$\begin{array}{l} \quad\ \ CH_3 \\ \quad\ \ \ | \\ CH_3\ CH\ CH_2CH_2CH_2OH \end{array}$$

(iii) $CH_2{=}CH\,CH_2CH_2CH{=}CHCH_3$

(iv) 

(c) Draw the three-dimensional structures for each of the following molecules.
(9 marks)

(i) $CH_3\,Cl$

(ii) $CH_2\,Br\,Cl$

(iii) CH_4

PERIODIC TABLE OF ELEMENTS

PERIODS	GROUPS 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1	1.008 **H** 1																	4.003 **He** 2
2	6.941 **Li** 3	9.012 **Be** 4										Atomic mass → **Symbol** → Atomic No. →	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								

***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.

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	$F = N_Ae$	9.6485×10^{4} C mol^{-1}
Boltzmann constant	k	$1.380\,66 \times 10^{-23}$ J K^{-1}
Gas constant	$R = N_Ak$	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	$a_o = 4\pi\varepsilon_o\hbar/m_ee^2$	$5.291\,77 \times 10^{-11}$ m
Fine-structure constant	$\alpha = \mu_oe^2c/2h$	$7.297\,35 \times 10^{-3}$
Rydberg constant	$R_\infty = m_ee^4/8h^3c\varepsilon_o^2$	$1.097\,37 \times 10^{7}$ 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}