UNIVERSITY OF SWAZILAND

SUPPLIMENTARY EXAMINATION 2005

TITLE OF PAPER:	GENERAL CHEMISTRY
COURSE NUMBER:	C101
TIME:	THREE (3) HOURS
INSTRUCTIONS:	There are six (6) questions each worth 25 marks. Answer any four (4) questions. A data sheet and periodic table are attached. Non-programmable calculators may be used.

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Question 1

(a) Give the set of four quantum numbers of the electron that is removed when nickel forms Ni^{+}.

[2]

(b) There are four elements which have the number of electrons indicated in paranthesis

A(2), B(8), C(15), D (17)

(i) Arrange the elements in order of increasing size. Explain your order. *[2]*

(ii) Draw the Lewis structures of BA_2, CD_3, CD_5 and CBD_3. *[2]*

(iii) Draw the VSEPR models of all the compounds in (ii) above. *[2]*

(c) Ammonia gas is synthesized from the reaction of nitrogen gas and hydrogen gas. If the rate of formation of ammonia is reported as 1.15 mol NH_3/L.h, what is the rate of disappearance of H_2?

[3]

(d) (i) What is Lassaigne sodium fusion test and what is the importance of the test?

(ii) Name any five elements that are most commonly present in organic compounds.

(iii) Describe to show the presence of any three of the elements named above.

[12]

Question 2

(a) Outline a Corey-Hause synthesis of the following compounds;

(i) $CH_3CH_2CH_2CH_2CH_3$

(ii) $CH_3CH_2CH(CH_3)_2$

[6]

(b) (i) Name any six classes of organic compounds.

(ii) Give the functional group and a named example for each of the classes of compounds named above.

[9]

(c) (i) What is hybridization?

(ii) Name the types of hybridization occurring in organic compounds.

(iii) Describe briefly how each type of hybridization named above is formed.

[10]

Question 3

(a) A solution is made by mixing 17.3 mL of 0.25 M HCl and 15.0 mL of 0.33 M NaOH. Calculate the pH of this solution. *[5]*

(b) White phosphorus, P_4, can be prepared by the following reaction:

$$2Ca_3(PO_4)_2(s) + 6SiO_2(s) + 10C(s) \rightarrow P_4(s) + 6CaSiO_3(s) + 10CO(g)$$

A reaction vessel contains 25.00 g of each of the reactant. Determine

(i) the limiting reagent *[3]*

(ii) the mass of white phosphorus, P_4, obtained from this reaction mixture if the reaction proceeds with a 72.6% yeield. *[3]*

(c) A 50.0 mL sample of 0.25 M methylamine CH_3NH_2 (aq), solution is titrated with 0.35 M HCl solution. The K_b for methylamine is 3.6×10^{-4}.

(i) What is the initial pH of the 0.25 M CH_3NH_2? *[6]*

(ii) What volume of the HCl solution is required to reach the stiochiometric point of the titration? *[3]*

(iii) Calculate the pH of the solution at the stoichiometric point. *[5]*

Question 4

(a) The density of silver metal at 25°C is 10.5g/cm^3. Calculate the number of silver atoms in a cube of silver that measures 3.00 cm on each side. *[3]*

(b) Consider the elements silicon, sodium and chlorine.

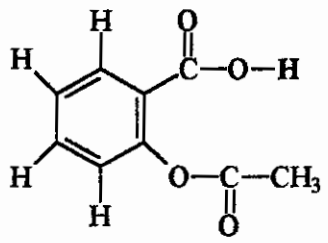
(i) Write the electronic configuration of each element. *[1½]*

(ii) Arrange the elements in order of increasing atomic size, from smallest to the largest. *[1½]*

(iii) The energy needed to ionize a sodium atom is 8.24×10^{-19}J. Calculate the wavelength of light that will ionize a sodium atom. *[2]*

(iv) Do you expect the wavelength of light that will ionize a chlorine atom to be longer or shorter than that for sodium? Explain. *[2]*

(c) A B.Sc. student dissolves an aspirin tablet in 0.500 L of water at 25°C. The tablet is known to contain 0.32g of acetylsalicyclic acid, $HC_9H_7O_4$ whose structure is given below



acetylsalicyclic acid

(i) Write the equilibrium expression for the ionization of acetylsalicyclic acid in water. *[1]*

(ii) Given that $K_a = 3.3 \times 10^{-4}$ for acetylsalicyclic acid at 25°C, Calculate the pH of the aspirin solution. *[5]*

(d) Nitrous oxide can be formed by thermal decomposition of ammonium nitrate.

$$NH_4NO_3(s) \xrightarrow{\Delta} N_2O(g) + 2H_2O(g)$$

What mass of ammonium nitrate would be required to produce 145L of N_2O at 2850 Torr and 42^oC?

[3]

(e) With reasons, state which direction will each of the following reactions shift after the specified stress is applied.

(i) $N_2O_4(g) \quad 2NO_2(g)$
a decrease in total pressure

(ii) $2Cl_2(g) + 2H_2O(l) \quad 4HCl(g) + O_2(g) \quad \Delta H^o = -113kJ$,
an increase in temperature

(iii) $CaCO_3(s) \quad CaO(s) + CO_2(g)$
removal of some of the CO_2 formed.

[6]

Question 5

(a) Define the following terms

(i) Electronegativity

(ii) Ionization energy

(iii) Hydrogen bonding

[3]

(b) Naturally occurring magnesium is a mixture of three isotopes: 78.99% ^{24}Mg and 11.01% ^{26}Mg. The atomic masses are respectively 23.9850 amu, 24.9858 amu and 25.9826. Calculate the average molar mass of magnesium

[4]

(c) A compound used in the manufacture of Saran is found to have 247% C, 2.1% H and 73.2% Cl by mass.

(i) Deduce the empirical formulae of the compound.

[2]

The storage of 3.557 g of the compound in a 750 mL vessel at $0^{O}C$ results in a pressure of 1.10 atm after the substance has vaporized.

(ii) What is the molecular formulae of the compound.

[2]

(iii) Draw the Lewis structure of the compound and show which bonds are polar. On the polar bonds, designate the σ^{+} and σ^{-} element.

[2]

(d) Suggest, giving reasons, which substance in each pair is likely to have the higher normal boiling point.

(i) CH_4 or SiH_4
(ii) HF or HCl
(iii) H_2O or CH_3OH

[6]

(e) The valence shell electronic configuration of a certain periodic group is ns^2np^3.

(i) write the electronic configurations of the first two members of the group.

[2]

(ii) which element in the group has the smallest size? Smallest first ionization energy? Smallest electronegativity? Most metallic character?

[4]

Question 6

(a) The reaction of nitric acid, NO, with bromine gas gives nitrosyl bromide NOBr. The reaction reaches the dynamic equilibrium.

$$2NO(g) + Br_2(g) \qquad 2NOBr(g)$$

(i) In your own words explain what is meant by 'dynamic equilibrium'.

[2]

(ii) Suggest two ways in which you can increase the yield of NOBr once the reaction has reached equilibrium.

[2]

A sample of 0.0873 mol NO with 0.0437 mol Br_2 in a 2.00 L flask gives an equilibrium mixture containing 0.0518 mol NOBr.

(iii) Calculate the equilibrium constant K_C for this reaction at 25°C.

[5]

(iv) Calculate the equilibrium constant K_p for this reaction at 25°C.

[3]

(b) Beer was brewed by ancient Egyptians and is thought to have been of the rations of the builders of pyramids.

The energy content of beer comes from glucose and ethanol. The ethanol and glucose composition of a beer is given below.

Constituent	Concentration (g/dm^3)
Ethanol, C_2H_5OH	20
Glucose, $C_6H_{12}O_6$	20

Ethanol is food as well as a drug. Like glucose it burns to give carbon dioxide and water.

(i) Write balanced chemical equations for the complete combustion of ethanol and glucose.

[2]

(ii) given that the standard enthalpy change of combustion for ethanol and glucose are -1370 kJ mol^{-1} and -3000 kJ mol^{-1} respectively, calculate the enthalpy change per gram for both glucose and ethanol.

[4]

(iii) Hence or otherwise, calculate the total energy available per dm^3 of beer.

[2]

(c) For the compound SF_2

(i) Write the Lewis structure

(ii) Using the USEPR theory, predict the shape of the molecule

(iii) Predict whether or not the molecule is polar.

[5]

PERIODIC TABLE OF ELEMENTS

GROUPS

PERIODS	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIIIB	10	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											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								

TRANSITION ELEMENTS

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.

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	ge	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}