

**THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES**

**2013 ACADEMIC YEAR
FINAL EXAMINATIONS**

CHE1000: INTRODUCTION TO CHEMISTRY

TIME: THREE (3) HOURS

INSTRUCTIONS TO THE CANDIDATES

1. Indicate your **student ID number** and **TG number** on **ALL** your answer booklets.
2. This examination paper consists of two (2) sections: **A** and **B**
3. Section **A** has ten (10) short answer questions. Questions carry equal marks. (Total marks = 40).
ANSWER ALL QUESTIONS IN SECTION A IN THE MAIN ANSWER BOOKLET
4. Section **B** has five (5) long answer questions. Questions carry equal marks. (Total marks = 60).
ANSWER QUESTION B1 and ANY THREE QUESTIONS, EACH IN A SEPARATE ANSWER BOOKLET.
6. **YOU ARE REMINDED OF THE NEED TO ORGANISE AND PRESENT YOUR WORK CLEARLY AND LOGICALLY.**
7. **ENSURE** that you have nine (9) printed pages and Periodic Table.

ADDITIONAL INFORMATION TO THE CANDIDATES:

Useful data is provided on page 9 and 10.

SECTION A

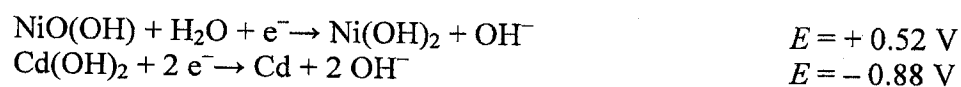
ANSWER ALL QUESTIONS

Question A1

- (a) Show using Lewis structures the reaction between fluorine and nitrogen leading to the formation of NF_3 .
- (b) Draw the molecular geometry of the resultant product in (a) and give the name of the shape.

Question A2

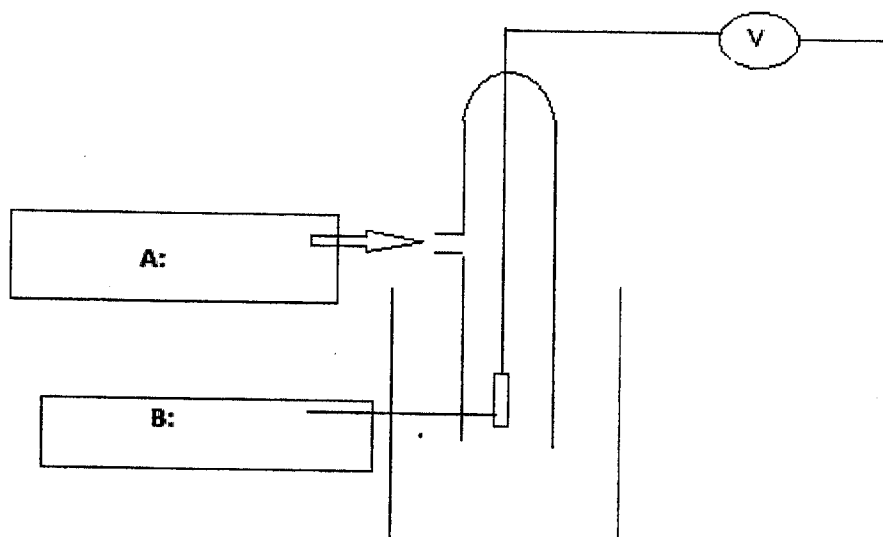
Nickel-cadmium cells are used to power electrical equipment such as drills and shavers. The electrode reactions are shown below.



- (a) Calculate the e.m.f. of a nickel-cadmium cell.
- (b) Deduce an overall equation for the reaction that occurs in the cell when it is used.

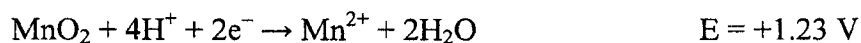
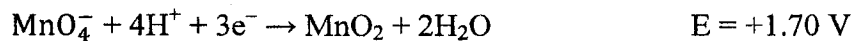
Question A3

- (a) Define the term **standard electrode potential**.
- (b) Identify A and B on the diagram of the **standard hydrogen electrode**.



Question A4

- (a) What is meant by disproportionation?
- (b) Use the following data to deduce whether MnO_2 will disproportionate in acidic solution.

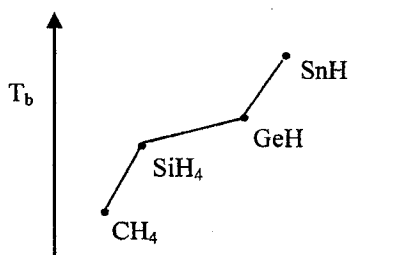


Question A5

- (a) Explain why carbonated (containing carbon dioxide) drinks must be stored in sealed container.
- (b) Once a beverage has been opened, why does it maintain carbonation when refrigerated than at room temperature?

Question A6

The diagram below shows the *boiling point trend of Group 14 hydrides*.



- (a) What is an instantaneous dipole?
- (b) Use the concept of polarizability to explain the trend observed in the diagram above.

Question A7

Consider a substance, X, which has the following properties

ΔH_{vap}	20 kJ/mol
ΔH_{fus}	5 kJ/mol
b.pt	75 °C
m.pt	- 15

Sketch a heating curve for the substance X starting at - 50 °C

Question A8

Some water is placed in a sealed glass container connected to a vacuum pump and the pump turned on reducing the pressure inside. The water appears to boil and then freezes.

- (a) Draw a phase diagram of water to explain these changes
- (b) What would happen if the vacuum pump was left on indefinitely?

Question A9

Compounds with representative formula C_nH_{2n} may be alkenes or cycloalkanes. Some of these compounds exhibit geometrical isomerism. Write down the geometrical isomers and give IUPAC names of:

- (a) 2-Butene
- (b) 1,3-Dimethylcyclobutane

Question A10

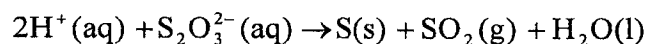
Draw structures of the compounds with the following descriptions

- (a) A straight chain primary alcohol with molecular formula $C_5H_{12}O$
- (b) A cyclic tertiary amine molecular $C_5H_{11}N$
- (c) An allylic alcohol with three carbons only. What is the molecular formula of this compound?

SECTION B**ANSWER QUESTION B1 AND ANY THREE QUESTIONS**

Question B1

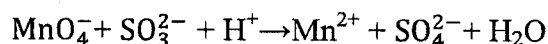
In CHE1000 laboratory you performed an experiment on the effect of temperature on the reaction rate. The reaction studied at different temperatures was of sulphuric acid with sodium thiosulphate as given in a reaction:



- (a) Write an expression of the rate of reaction involving all the species in the above reaction. **[2 marks]**
- (b) According to the experimental conditions, the initial rate of disappearance of sodium thiosulphate at 298.15 K was $1.29 \times 10^{-3} \text{ mol dm}^{-3} \text{ s}^{-1}$.
- (i) Calculate the initial rate of disappearance of H_2SO_4 . **[2 marks]**
- (ii) Determine the rate of production of sulphur dioxide. **[2 marks]**
- (iii) Calculate the rate of reaction. **[2 marks]**
- (c) A plot of $-\ln t$ versus $1/T$ gave a slope of $-3.9392 \times 10^3 \text{ K}$.
- (i) Make a sketch of a plot of $-\ln t$ versus $1/T$ **[2 marks]**
- (ii) What is the activation energy of the reaction? **[5 marks]**

Question B2

Pure sodium sulfite is difficult to get. One method of assessing its purity is by the reaction of potassium manganate (VII), KMnO_4 , in acidic solution according to the **unbalanced ionic** equation shown



Sodium sulphite, Na_2SO_3 , is slowly oxidized in air to sodium sulphate, Na_2SO_4 . 1.75 g of an impure sample of sodium sulphite was dissolved in water and made up to 250 cm^3 with distilled water. 25.0 cm^3 of this solution required 22.8 cm^3 of $0.0216 \text{ mol dm}^{-3}$ potassium manganate(VII) solution for complete oxidation. (Molar mass of sodium sulphite = 126.05 g/mol)

- (a) Balance the equation in acidic media **[4 marks]**
- (b) Calculate the change in oxidation number of sulphur in the reaction of sulphite ions with manganate(VII) ions. **[2 marks]**

- (c) Calculate the number of moles of manganate(VII) ions used in the titration. [2 marks]
- (d) Calculate the number of moles of sodium sulphite present in 25.0 cm³ of the solution. [3 marks]
- (e) Calculate the total mass of pure sodium sulphite in 250 cm³ of the solution. [2 marks]
- (f) Calculate the percentage purity of the sample of sodium sulphite. [2 marks]

Question B3

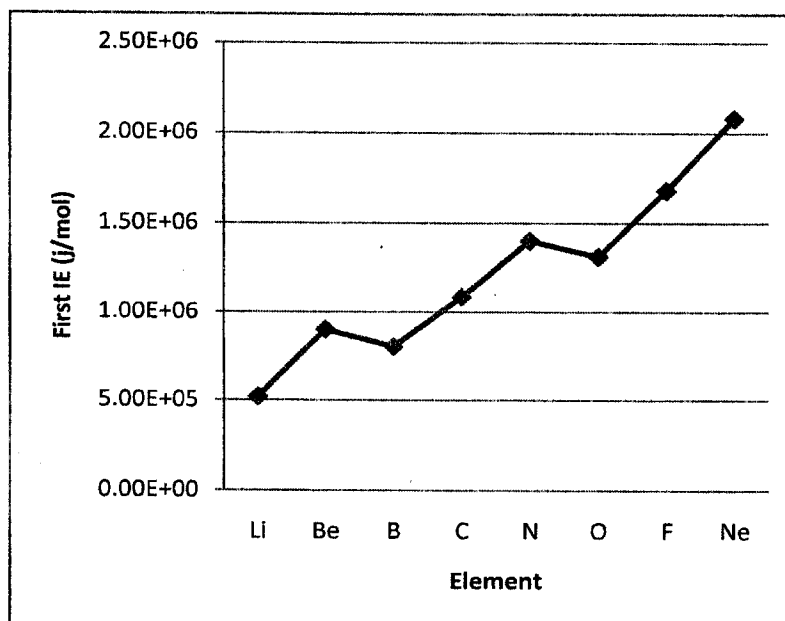
At elevated temperatures, SbCl₅(g) decomposes into SbCl₃(g) and Cl₂(g) as shown by the following equation:



- (a) An 89.7 g sample of SbCl₅ (molecular mass 299.0 g mol⁻¹) is placed in an evacuated 15.0 dm³ container at 182 °C.
- (i) What is the concentration in moles dm⁻³ of SbCl₅ in the container before any decomposition occurs? [2 marks]
- (ii) What is the pressure in atmospheres of SbCl₅ in the container before any decomposition occurs? [2 marks]
- (b) If the SbCl₅ is 29.2 percent decomposed when equilibrium is established at 182 °C, calculate the value for equilibrium constant K_p and K_c, for this decomposition reaction. [11 marks]

Question B4

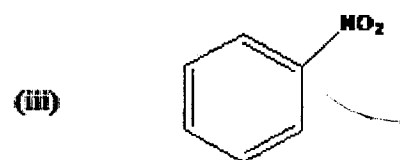
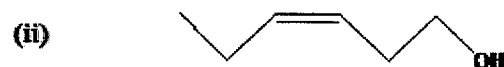
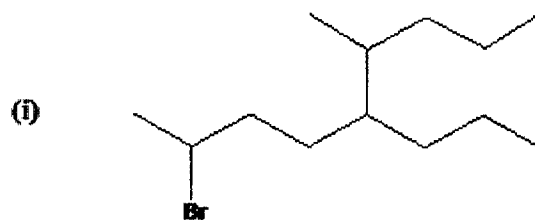
- (a) Define *Ionization Energy*. [1 mark]
- (b) Why do you think energy has to be added to pull an electron away from an atom? [2 marks]
- (c) An electron in H atom in 1s ground electronic state has an energy of -2.18×10^{-18} J. Calculate the ionization energy of H atoms in J mol^{-1} . [6 marks]
- (d) The first ionization energies of period 2 elements show a trend indicated in a graph below.
- (i) Write the ground state electronic configuration of Be and B. [2 marks]
- (ii) Draw an electron energy diagram of Be and B. [2 marks]
- (iii) Explain why ionization energy of B is lower than that of Be. [2 marks]



Question B5

(a) Write IUPAC names for the following given structures.

[7 marks]



(b) Draw the structures whose IUPAC names are given

[8 marks]

(i) 2-Pentanone

(ii) 5-Oxohexanenitrile

(iii) Butyl butanoate

(iv) N-methylbenzamide

(v) Methylbenzene

USEFUL DATA

Physical constants

Avogadro constant, N_A	$6.022 \times 10^{23} \text{ mol}^{-1}$
Acceleration due to gravity	9.8 m s^{-2}
Faraday's constant, F	96485 C mol^{-1}
Mass of electron, m_e	$9.11 \times 10^{-31} \text{ kg}$
Planck's constant, h	$6.626 \times 10^{-34} \text{ J s}$
Rydberg constant, R_H	$1.097 \times 10^7 \text{ m}^{-1}$
Speed of light, c	$3.00 \times 10^8 \text{ m s}^{-1}$
Universal gas constant, R	$8.3145 \text{ J mol}^{-1} \text{ K}^{-1}$ $0.083145 \text{ L bar mol}^{-1} \text{ K}^{-1}$ $0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1}$ $62.364 \text{ L torr mol}^{-1} \text{ K}^{-1}$ $62.364 \text{ L mmHg mol}^{-1} \text{ K}^{-1}$

Pressure conversions

$$1 \text{ atm} = 1.01325 \times 10^5 \text{ Pa} = 1.01325 \times 10^5 \text{ N m}^{-2} = 760 \text{ torr} = 760 \text{ mmHg} \\ = 1.01325 \text{ bar}$$

$$1 \text{ bar} = 1.00000 \times 10^5 \text{ Pa} \\ = 1.00000 \times 10^5 \text{ N m}^{-2}$$

Other conversion factors

$$V = J C^{-1} \quad 1 \text{ eV} = 1.602 \times 10^{-19} \text{ J} \\ 1 \text{ J} = 1 \text{ kg m}^2 \text{ s}^{-2}$$

PERIODIC TABLE OF THE ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
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KEY

Atomic number X Atomic mass Name of the element X

1 H 1.01 Hydrogen	2 He 4.00 Helium																	3 Li 6.94 Lithium	4 Be 9.01 Beryllium	5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon	11 Na 23.00 Sodium	12 Mg 24.31 magnesium	13 Al 26.98 Aluminum	14 Si 28.09 Silicon	15 P 30.99 Phosphorus	16 S 32.07 Sulphur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon	19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.88 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 71.61 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton	37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc 97.91 Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.91 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.87 Silver	48 Cd 112.41 Cadmium	49 In 114.82 Indium	50 Sn 118.71 Tin	51 Sb 121.76 Antimony	52 Te 127.60 Tellurium	53 I 126.90 Iodine	54 Xe 131.29 Xenon	55 Cs 132.91 Caesium	56 Ba 137.33 Barium	57-71 Lanthanum 138.91	57 La 138.91 Lanthanum	58 Ce 140.12 Cerium	59 Pr 140.91 Praseodymium	60 Nd 144.24 Neodymium	61 Pm 144.91 Promethium	62 Sm 150.36 Samarium	63 Eu 151.97 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.93 Terbium	66 Dy 162.50 Dysprosium	67 Ho 164.93 Holmium	68 Er 167.26 Erbium	69 Tm 168.93 Thulium	70 Yb 173.04 Ytterbium	71 Lu 174.97 Lutetium	87 Fr (223.02) Francium	88 Ra 226.03 Radium	89-103 Actinium 227.03	89 Ac 227.03 Actinium	90 Th 232.04 Thorium	91 Pa 231.04 Protactinium	92 U 238.03 Uranium	93 Np 237.05 Neptunium	94 Pu 244.0 Plutonium	95 Am 243.06 Americium	96 Cm 247.07 Curium	97 Bk 247.07 Berkelium	98 Cf 251.08 Californium	99 Es 252.08 Einsteinium	100 Fm 257.10 Fermium	101 Md 260 Mendelevium	102 No 259.10 Nobelium	103 Lr 262.11 Lawrencium
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