



UNIVERSITY OF SWAZILAND  
Faculty of Health Sciences  
Department of Environmental Health Science  
BACHELOR OF SCIENCE IN ENVIRONMENTAL HEALTH

MAIN EXAMINATION PAPER 2018

TITLE OF PAPER : CHEMISTRY FOR HEALTH SCIENCES

COURSE CODE : EHS111

DURATION : 2 HOURS

MARKS : 100

INSTRUCTIONS :

- : READ THE QUESTIONS & INSTRUCTIONS CAREFULLY
- : ANSWER **ANY FOUR** QUESTIONS
- : EACH QUESTION **CARRIES 25** MARKS.
- : WRITE NEATLY & CLEARLY
- : NO PAPER SHOULD BE BROUGHT INTO OR OUT OF THE EXAMINATION ROOM.
- : BEGIN EACH QUESTION ON A SEPARATE SHEET OF PAPER.

DO NOT OPEN THIS QUESTION PAPER UNTIL PERMISSION IS GRANTED BY THE INVIGILATOR.

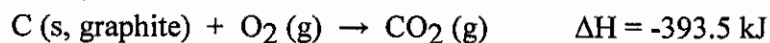
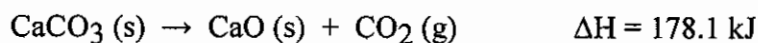
## QUESTION ONE

- a. The element X has three naturally occurring isotopes. The masses (amu) and % abundances of the isotopes are given in the table below. The average atomic mass of the element is \_\_\_\_\_ amu.

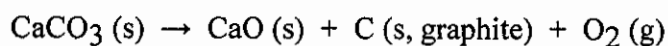
Isotope	Abundance (%)	Mass (amu)
$^{15}\text{X}$	28.60	15.33
$^{17}\text{X}$	13.30	17.26
$^{16}\text{X}$	58.10	18.11

[6 Marks]

- b. State the first law of thermodynamics. [3 Marks]
- c. Osmium has a density of  $22.6 \text{ g/cm}^3$ . The mass of a block of osmium that measures  $1.01 \text{ cm} \times 0.233 \text{ cm} \times 0.648 \text{ cm}$  is \_\_\_\_\_ g. [4 Marks]
- d. An iron mine produces  $1.67 \times 10^4$  tons of raw ore per day. If the ore is 26.39% elemental iron, the mine produces \_\_\_\_\_ pounds of elemental iron per year. (Assume the mine operates 365 days per year.) [6 Marks]
- e. Given the following reactions



the enthalpy of the reaction;



is \_\_\_\_\_ kJ.

[6 Marks]

## QUESTION TWO

- a.
- A reaction that is spontaneous has a \_\_\_\_\_.
  - When a system is at equilibrium, the \_\_\_\_\_.
  - The thermodynamic quantity that expresses the degree of disorder in a system is \_\_\_\_\_.
  - The phrase "like dissolves like" refers to the fact that \_\_\_\_\_.

- (v) The halogens, alkali metals, and alkaline earth metals have \_\_\_\_, \_\_\_\_, and \_\_\_\_ valence electrons, respectively.
- (vi) Of all the groups in the periodic table, only group \_\_\_\_\_ contains examples of elements that are gas, liquid, and solid at room temperature.
- (vii) Chlorine is much more apt to exist as an anion than is sodium. This is because \_\_\_\_\_.
- (viii) A nonpolar bond will form between two \_\_\_\_\_ atoms of \_\_\_\_\_ electronegativity
- (ix) A coordinate covalent bond is \_\_\_\_\_.
- (x) Brønsted-Lowry base is a \_\_\_\_\_ and has a \_\_\_\_\_.

[2 × 10 Marks]

- b. The  $K_a$  of hypochlorous acid (HClO) is  $3.0 \times 10^{-8}$  at  $25.0^\circ\text{C}$ . Calculate the pH of a 0.0335 M hypochlorous acid solution.

[5 Marks]

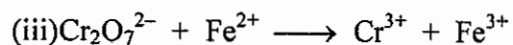
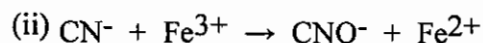
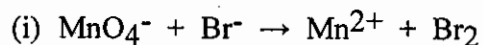
### QUESTION THREE

- a. Write the full electron configuration of the following ions

- (i)  $\text{Mn}^{4+}$   
(ii)  $\text{I}^-$   
(iii)  $\text{S}^{2-}$

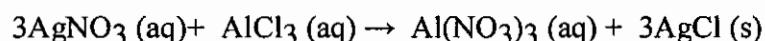
[2 × 3 Marks]

- b. For each of the following redox reaction equations, identify oxidizing and reducing agents and assign oxidation numbers of all atoms involved in the redox reaction.



[3 × 4 Marks]

- c. Silver nitrate and aluminum chloride react with each other by exchanging anions:



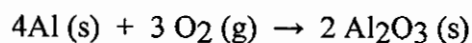
What mass in grams of AgCl is produced when 4.22 g of AgNO<sub>3</sub> react with 7.73 g of AlCl<sub>3</sub>? [7 Marks]

#### QUESTION FOUR

- a. A compound was found to contain 90.6% lead (Pb) and 9.4% oxygen. The empirical formula for this compound is \_\_\_\_\_. [7 Marks]
- b. The pH of a 0.60 M aqueous solution of formic acid, HCHO<sub>2</sub>, at 25.0°C is 1.98. What is the value of K<sub>a</sub> for formic acid? [6 Marks]
- c. A certain alcohol contains only three elements, carbon, hydrogen, and oxygen. Combustion of a 30.00 gram sample of the alcohol produced 57.30 grams of CO<sub>2</sub> and 35.22 grams of H<sub>2</sub>O. What is the empirical formula of the alcohol? [9 Marks]
- d. With reference to enthalpy changes, what does the term "standard conditions" mean? [3 Marks]

#### QUESTION FIVE

- a. Solid aluminum and gaseous oxygen react in a combination reaction to produce aluminum oxide:



In a particular experiment, the reaction of 2.5 g of Al with 2.5 g of O<sub>2</sub> produced 3.5 g of Al<sub>2</sub>O<sub>3</sub>. What is the % yield of the reaction?

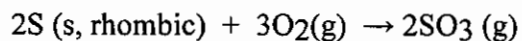
[9 Marks]

- b. Use the table below to answer the questions that follow.

Thermodynamic Quantities for Selected Substances at 298.15 K (25 °C)

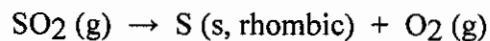
Substance	$\Delta H^\circ_f$ (kJ/mol)	$\Delta G^\circ_f$ (kJ/mol)	S (J/K-mol)
<b>Calcium</b>			
Ca (s)	0	0	41.4
CaCl <sub>2</sub> (s)	-795.8	-748.1	104.6
Ca <sup>2+</sup> (aq)	226.7	209.2	200.8
<b>Chlorine</b>			
Cl <sub>2</sub> (g)	0	0	222.96
Cl <sup>-</sup> (aq)	-167.2	-131.2	56.5
<b>Oxygen</b>			
O <sub>2</sub> (g)	0	0	205.0
H <sub>2</sub> O (l)	-285.83	-237.13	69.91
<b>Phosphorus</b>			
P <sub>2</sub> (g)	144.3	103.7	218.1
PCl <sub>3</sub> (g)	-288.1	-269.6	311.7
POCl <sub>3</sub> (g)	-542.2	-502.5	325
<b>Sulfur</b>			
S (s, rhombic)	0	0	31.88
SO <sub>2</sub> (g)	-269.9	-300.4	248.5
SO <sub>3</sub> (g)	-395.2	-370.4	256.2

- (i) The value of  $\Delta S^\circ$  for the oxidation of solid elemental sulfur to gaseous sulfur trioxide,



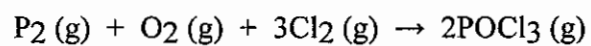
is \_\_\_\_\_ J/K·mol.

- (ii) The value of  $\Delta S^\circ$  for the decomposition of gaseous sulfur dioxide to solid elemental sulfur and gaseous oxygen,



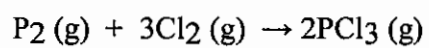
is \_\_\_\_\_ J/K·mol.

(iii) The value of  $\Delta S^\circ$  for the formation of  $\text{POCl}_3$  from its constituent elements,



is \_\_\_\_\_ J/K·mol.

(iv) The value of  $\Delta S^\circ$  for the formation of phosphorous trichloride from its constituent elements,



is \_\_\_\_\_ J/K·mol.

**[4×4 Marks]**

## General data and fundamental constants

Quantity	Symbol	Value
Speed of light	$c$	$2.997\,924\,58 \times 10^8 \text{ m s}^{-1}$
Elementary charge	$e$	$1.602\,177 \times 10^{-19} \text{ C}$
Faraday constant	$F = N_A e$	$9.6485 \times 10^4 \text{ C mol}^{-1}$
Boltzmann constant	$k$	$1.380\,66 \times 10^{-23} \text{ J K}^{-1}$
Gas constant	$R = N_A k$	$8.314\,51 \text{ J K}^{-1} \text{ mol}^{-1}$ $8.205\,78 \times 10^{-2} \text{ dm}^3 \text{ atm K}^{-1} \text{ mol}^{-1}$ $6.2364 \times 10 \text{ L Torr K}^{-1} \text{ mol}^{-1}$
Planck constant	$h$ $\hbar = h/2\pi$	$6.626\,08 \times 10^{-34} \text{ J s}$ $1.054\,57 \times 10^{-34} \text{ J s}$
Avogadro constant	$N_A$	$6.022\,14 \times 10^{23} \text{ mol}^{-1}$
Atomic mass unit	$u$	$1.660\,54 \times 10^{-27} \text{ Kg}$
Mass		
electron	$m_e$	$9.109\,39 \times 10^{-31} \text{ Kg}$
proton	$m_p$	$1.672\,62 \times 10^{-27} \text{ Kg}$
neutron	$m_n$	$1.674\,93 \times 10^{-27} \text{ Kg}$
Vacuum permittivity	$\epsilon_0 = 1/c^2 \mu_0$ $4\pi\epsilon_0$	$8.854\,19 \times 10^{-12} \text{ J}^{-1} \text{ C}^2 \text{ m}^{-1}$ $1.112\,65 \times 10^{-10} \text{ J}^{-1} \text{ C}^2 \text{ m}^{-1}$
Vacuum permeability	$\mu_0$	$4\pi \times 10^{-7} \text{ J s}^2 \text{ C}^{-2} \text{ m}^{-1}$ $4\pi \times 10^{-7} \text{ T}^2 \text{ J}^{-1} \text{ m}^3$
Magneton		
Bohr	$\mu_B = e\hbar/2m_e$	$9.274\,02 \times 10^{-24} \text{ J T}^{-1}$
nuclear	$\mu_N = e\hbar/2m_p$	$5.050\,79 \times 10^{-27} \text{ J T}^{-1}$
g value	$g_e$	2.002 32
Bohr radius	$a_0 = 4\pi\epsilon_0\hbar/m_e e^2$	$5.291\,77 \times 10^{-11} \text{ m}$
Fine-structure constant	$\alpha = \mu_0 e^2 c/2h$	$7.297\,35 \times 10^{-3}$
Rydberg constant	$R_\infty = m_e e^4/8h^3 c \epsilon_0^2$	$1.097\,37 \times 10^7 \text{ m}^{-1}$
Standard acceleration of free fall	$g$	$9.806\,65 \text{ m s}^{-2}$
Gravitational constant	$G$	$6.672\,59 \times 10^{-11} \text{ N m}^2 \text{ Kg}^{-2}$

## Conversion factors

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

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

GROUPS

PERIODS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
	IA	IIA	IIIB	IVB	VB	VIB	VII B	VIII B	IB	IIB	IIIA	IIIB	IIIA	IVA	VA	VIA	VIIA	VIIIA	
1	1.008 H																		4.003 He
2	6.941 Li	9.012 Be											10.811 B	12.011 C	14.007 N	15.999 O	18.998 F	20.180 Ne	
3	22.990 Na	24.305 Mg											26.982 Al	28.086 Si	30.974 P	32.06 S	35.453 Cl	39.948 Ar	
4	39.098 K	40.078 Ca	44.956 Sc	47.88 Ti	50.942 V	51.996 Cr	54.938 Mn	55.847 Fe	58.933 Co	58.69 Ni	63.546 Cu	65.39 Zn	69.723 Ga	72.61 Ge	74.922 As	78.96 Se	79.904 Br	83.80 Kr	
5	85.468 Rb	87.62 Sr	88.906 Y	91.224 Zr	92.906 Nb	95.94 Mo	98.907 Tc	101.07 Ru	102.91 Rh	106.42 Pd	107.87 Ag	112.41 Cd	114.82 In	118.71 Sn	121.75 Sb	127.60 Te	126.90 I	131.29 Xe	
6	132.91 Cs	137.33 Ba	138.91 *La	178.49 Hf	180.95 Ta	183.85 W	186.21 Re	190.2 Os	192.22 Ir	195.08 Pt	196.97 Au	200.59 Hg	204.38 Tl	207.2 Pb	208.98 Bi	(209) Po	(210) At	(222) Rn	
7	223 Fr	226.03 Ra	(227) **Ac	(261) Rf	(262) Ha	(263) Unh	(262) Uns	(265) Uno	(266) Une	(267) Uun									

TRANSITION ELEMENTS

140.12 Ce	140.91 Pr	144.24 Nd	(145) Pm	150.36 Sm	151.96 Eu	157.25 Gd	158.93 Tb	162.50 Dy	164.93 Ho	167.26 Er	168.93 Tm	173.04 Yb	174.97 Lu
232.04 Th	231.04 Pa	238.03 U	237.05 Np	(244) Pu	(243) Am	(247) Cm	(247) Bk	(251) Cf	(252) Es	(257) Fm	(258) Md	(259) No	(260) Lr

\*Lanthanide Series

\*\*Actinide Series

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