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}X	28.60	15.33
^{17}X	13.30	17.26
^{16}X	58.10	18.11

[6 Marks]

b. State the first law of thermodynamics. **[3 Marks]**

c. Osmium has a density of 22.6 g/cm^3. The mass of a block of osmium that measures 1.01 cm × 0.233 cm × 0.648 cm is _____ g. **[4 Marks]**

d. An iron mine produces 1.67 x 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

$$CaCO_3\,(s) \rightarrow CaO\,(s) + CO_2\,(g) \qquad \Delta H = 178.1\ kJ$$

$$C\,(s, graphite) + O_2\,(g) \rightarrow CO_2\,(g) \qquad \Delta H = -393.5\ kJ$$

the enthalpy of the reaction;

$$CaCO_3\,(s) \rightarrow CaO\,(s) + C\,(s, graphite) + O_2\,(g)$$

is _____ kJ. **[6 Marks]**

QUESTION TWO

a.

(i) A reaction that is spontaneous has a _____.

(ii) When a system is at equilibrium, the _____.

(iii) The thermodynamic quantity that expresses the degree of disorder in a system is _____.

(iv) 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) Brontsed-Lowry base is a _____ and has a _____.

[2 × 10 Marks]

b. The K_a of hypochlorous acid (HClO) is 3.0×10^{-8} at 25.0°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) Mn^{4+}

(ii) I^-

(iii) 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.

(i) $MnO_4^- + Br^- \rightarrow Mn^{2+} + Br_2$

(ii) $CN^- + Fe^{3+} \rightarrow CNO^- + Fe^{2+}$

(iii) $Cr_2O_7^{2-} + Fe^{2+} \longrightarrow Cr^{3+} + Fe^{3+}$ **[3 × 4 Marks]**

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

$3AgNO_3\ (aq) + AlCl_3\ (aq) \rightarrow Al(NO_3)_3\ (aq) + 3AgCl\ (s)$

What mass in grams of AgCl is produced when 4.22 g of $AgNO_3$ react with 7.73 g of $AlCl_3$? **[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, $HCHO_2$, at 25.0°C is 1.98. What is the value of K_a 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_2 and 35.22 grams of H_2O. 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:

$4Al\ (s) + 3\ O_2\ (g) \rightarrow 2\ Al_2O_3\ (s)$

In a particular experiment, the reaction of 2.5 g of Al with 2.5 g of O_2 produced 3.5 g of Al_2O_3. 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	$\Delta H°_f$ (kJ/mol)	$\Delta G°_f$ (kJ/mol)	S (J/K-mol)
Calcium			
Ca (s)	0	0	41.4
$CaCl_2$ (s)	-795.8	-748.1	104.6
Ca_2^+ (aq)	226.7	209.2	200.8
Chlorine			
Cl_2 (g)	0	0	222.96
Cl- (aq)	-167.2	-131.2	56.5
Oxygen			
O_2 (g)	0	0	205.0
H_2O (l)	-285.83	-237.13	69.91
Phosphorus			
P_2 (g)	144.3	103.7	218.1
PCl_3 (g)	-288.1	-269.6	311.7
$POCl_3$ (g)	-542.2	-502.5	325
Sulfur			
S (s, rhombic)	0	0	31.88
SO_2(g)	-269.9	-300.4	248.5
SO_3(g)	-395.2	-370.4	256.2

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

$2S\ (s, rhombic) + 3O_2(g) \rightarrow 2SO_3\ (g)$

is _____ J/K· mol.

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

$SO_2\ (g) \rightarrow S\ (s, rhombic) + O_2\ (g)$

is _____ J/K· mol.

(iii) The value of $\Delta S°$ for the formation of $POCl_3$ from its constituent elements,

$P_2 (g) + O_2 (g) + 3Cl_2 (g) \rightarrow 2POCl_3 (g)$

is _____ J/K· mol.

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

$P_2 (g) + 3Cl_2 (g) \rightarrow 2PCl_3 (g)$

is _____ J/K· mol.

[4×4 Marks]

General data and fundamental constants

Quantity	Symbol	Value
Speed of light	c	$2.997\ 924\ 58 \times 10^{8}$ 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
	$\hbar = h/2\pi$	$1.054\ 57$ X-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}

GROUPS

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