UNIVERSITY OF SWAZILAND CHEMISTRY DEPARTMENT

RE-SIT EXAMINATIONS 2017/2018

TITLE OF PAPER: INTRODUCTORY CHEMISTRY I

COURSE CODE: CHE151

TIME ALLOWED: THREE (3) HOURS

INSTRUCTIONS: THERE ARE TWO SECTIONS: SECTION A AND SECTION B. ANSWER ALL THE QUESTIONS IN SECTION A AND ANY THREE QUESTIONS FROM SECTION B.

SECTION A IS WORTH 25 MARKS AND EACH QUESTION IN SECTION B IS WORTH 25 MARKS.

THE **ANSWER SHEET** FOR SECTION A IS ATTACHED TO THE QUESTION PAPER.GIVE YOUR ANSWERS TO SECTION A QUESTIONS BY RECORDING ON THE ANSWER SHEET THE LETTER CORRESPONDING TO THE CORRECT ANSWER.

AT THE END OF THE EXAM, BEFORE YOU LEAVE, PLACE THE ANSWER SHEET INSIDE THE UNISWA ANSWER BOOKLET CONTAINING YOUR ANSWERS TO SECTION B

A PERIODIC TABLE AND A TABLE OF CONSTANTS HAVE BEEN PROVIDED WITH THIS EXAMINATION PAPER.

PLEASE DO NOT OPEN THIS PAPER UNTIL AUTHORISED TO DO SO BY THE CHIEF INVIGILATOR.

SECTION A: ANSWER ALL THE QUESTIONS (25 MARKS)

1. The mass of a sample is 550 milligrams. Which of the following expresses that mass in kilograms?

   A. 5.5×10^{8} kg
   B. 5.5×10^{5} kg
   C. 5.5×10^{-4} kg
   D. 5.5×10^{-6} kg
   E. 5.5×10^{-1} kg

2. Given that 1 inch = 2.54 cm, 1 cm^3 is equal to

   A. 16.4 in^3
   B. 6.45 in^3
   C. 0.394 in^3
   D. 0.155 in^3
   E. 0.0610 in^3

3. Acetone, which is used as a solvent and as a reactant in the manufacture of Plexiglas®, boils at 56.1°C. What is the boiling point in degrees Fahrenheit?

   A. 159°F
   B. 133°F
   C. 101°F
   D. 69.0°F
   E. 43.4°F

4. The result of $(3.8621 \times 1.5630) - 5.98$ is properly written as

   A. 0.06
   B. 0.056
   C. 0.0565
   D. 0.05646
   E. 0.056462

5. Bromine is the only nonmetal that is a liquid at room temperature. Consider the isotope bromine-81, $^{81}_{35}Br$. Select the combination which lists the correct atomic number, neutron number, and mass number, respectively.

A. 35, 46, 81
B. 35, 81, 46
C. 81, 46, 35
D. 46, 81, 35
E. 35, 81, 116

6. Silicon, which makes up about 25% of Earth's crust by mass, is used widely in the modern electronics industry. It has three naturally occurring isotopes, ^{28}Si, ^{29}Si, and ^{30}Si. Calculate the atomic mass of silicon.

Isotope	Isotopic Mass (amu)	Abundance %
^{28}Si	27.976927	92.23
^{29}Si	28.976495	4.67
^{30}Si	29.973770	3.10

A. 29.2252 amu
B. 28.9757 amu
C. 28.7260 amu
D. 28.0855 amu
E. 27.9801 amu

7. Which of the following is the empirical formula for hexane, C_6H_{14}?

A. $C_{12}H_{28}$
B. C_6H_{14}
C. C_3H_7
D. $CH_{2.3}$
E. $C_{0.43}H$

8. The substance, $CoCl_2$, is useful as a humidity indicator because it changes from pale blue to pink as it gains water from moist air. What is its name?

A. cobalt dichloride
B. cobalt(II) chloride
C. cobalt chloride
D. cobaltic chloride
E. copper(II) chloride

9. Magnesium fluoride is used in the ceramics and glass industry. What is the mass of 1.72 mol of magnesium fluoride?

   A. 43.3 g
   B. 62.3 g
   C. 74.5 g
   D. 92.9 g
   E. 107 g

10. Lead (II) nitrate is a poisonous substance which has been used in the manufacture of special explosives and as a sensitizer in photography. Calculate the mass of lead in 139 g of $Pb(NO_3)_2$.

   A. 107 g
   B. 90.8 g
   C. 87.0 g
   D. 83.4 g
   E. 62.6 g

11. Household sugar, sucrose, has the molecular formula $C_{12}H_{22}O_{11}$. What is the % of carbon in sucrose, by mass?

   A. 26.7 %
   B. 33.3 %
   C. 41.4 %
   D. 42.1 %
   E. 52.8 %

12. Terephthalic acid, used in the production of polyester fibers and films, is composed of carbon, hydrogen, and oxygen. When 0.6943 g of terephthalic acid was subjected to combustion analysis it produced 1.471 g CO_2 and 0.226 g H_2O. What is its empirical formula?

   A. $C_2H_3O_4$
   B. $C_3H_4O_2$
   C. $C_4H_3O_2$
   D. $C_5H_{12}O_4$
   E. C_2H_2O

13. Select the net ionic equation for the reaction between sodium chloride and mercury(I) nitrate.

$2NaCl(aq) + Hg_2(NO_3)_2(aq) \rightarrow NaNO_3(aq) + Hg_2Cl_2(s)$

A. $Na^+(aq) + NO_3^-(aq) \rightarrow NaNO_3(aq)$
B. $Hg_2^{2+}(aq) + 2Cl^-(aq) \rightarrow Hg_2Cl_2(s)$
C. $NaCl(aq) \rightarrow Na^+(aq) + Cl^-(aq)$
D. $Hg_2(NO_3)_2(aq) \rightarrow Hg_2^{2+}(aq) + 2NO_3^-(aq)$
E. $Hg_2^{2+}(aq) \rightarrow Hg_2(s)$

14. Which of the following is a strong acid?

A. H_3PO_4
B. HNO_3
C. HF
D. CH_3COOH
E. H_2O

15. Automobile batteries use 3.0 *M* H_2SO_4 as an electrolyte. How much 1.20 *M* NaOH will be needed to neutralize 225 mL of battery acid?

$H_2SO_4(aq) + 2NaOH(aq) \rightarrow 2H_2O(l) + Na_2SO_4(aq)$

A. 0.045 L
B. 0.28 L
C. 0.56 L
D. 0.90 L
E. 1.1 L

16. Vinegar is a solution of acetic acid, CH_3COOH, dissolved in water. A 5.54-g sample of vinegar was neutralized by 30.10 mL of 0.100 *M* NaOH. What is the percent by weight of acetic acid in the vinegar?

A. 0.184%
B. 1.63%
C. 3.26%
D. 5.43%
E. 9.23%

17. The size of an atomic orbital is associated with

A. the principal quantum number (n).
B. the angular momentum quantum number (l).
C. the magnetic quantum number (m_l).
D. the spin quantum number (m_s).
E. the angular momentum and magnetic quantum numbers, together.

18. The energy of an electron in the hydrogen atom is determined by

A. the principal quantum number (n) only.
B. the angular momentum quantum number (l) only.
C. the principal and angular momentum quantum numbers (n & l).
D. the principal and magnetic quantum numbers (n & m_l).
E. the principal, angular momentum and magnetic quantum numbers.

19. Which one of the following sets of quantum numbers can correctly represent a $3p$ orbital?

a.	b.	c.	d.	e.
$n = 3$	$n = 1$	$n = 3$	$n = 3$	$n = 3$
$l = 1$	$l = 3$	$l = 2$	$l = 1$	$l = 0$
$m_l = 2$	$m_l = 3$	$m_l = 1$	$m_l = -1$	$m_l = 1$

A. a
B. b
C. c
D. d
E. e

20. Which one of the following equations correctly represents the process involved in the electron affinity of X?

A. $X(g) \rightarrow X^+(g) + e^-$
B. $X^+(g) \rightarrow X^+(aq)$
C. $X^+(g) + e^- \rightarrow X(g)$
D. $X(g) + e^- \rightarrow X^-(g)$
E. $X^+(g) + Y^-(g) \rightarrow XY(s)$

21. Select the element with the greatest metallic character.

A. Li
B. Ca
C. Al
D. Pb
E. Cs

22. Consider the set of isoelectronic atoms and ions A^{2-}, B^{-}, C, D^{+}, and E^{2+}. Which arrangement of relative radii is correct?

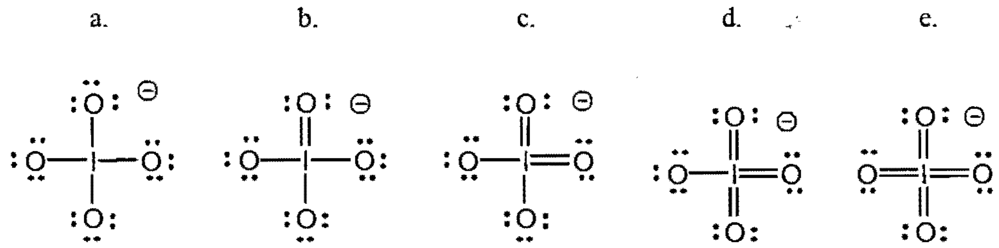
A. $A^{2-} > B^{-} > C > D^{+} > E^{2+}$
B. $E^{2+} > D^{+} > C > B^{-} > A^{2-}$
C. $A^{2-} > B^{-} > C < D^{+} < E^{2+}$
D. $A^{2-} < B^{-} < C > D^{+} > E^{2+}$
E. None of these is correct.

23. Which one of the following Lewis structures is definitely incorrect?

a. BF_3 b. XeO_3 c. N_2 d. $AlCl_4^-$ e. NH_4^+

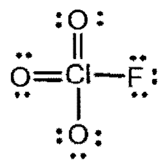
A. a
B. b
C. c
D. d
E. e

24. Select the Lewis structure in which formal charges are minimized for the periodate anion, IO_4^-.



A. a
B. b
C. c
D. d
E. e

25. What is the electron pair geometry of ClO_3F, whose Lewis structure is given below?



A. trigonal pyramidal
B. square planar
C. square pyramidal
D. tetrahedral
E. octahedral

SECTION B: ANSWER ANY THREE QUESTIONS (75 MARKS)

Q.1. (a) Perform the following calculations, paying special attention to significant figures, rounding and units:

i) $\frac{16.3521\ cm^2 - 1.448\ cm^2}{7.085\ cm}$ **[2]**

ii) $V = \pi r^2 h$, where r = 6.23 cm, h = 4.630 cm **[2]**

iii) $(6.022 x\ 10^{23}$ atoms/mol$)(2.18 x 10^{-18}$ J/atom$)(\frac{1}{2^2} - \frac{1}{3^2})$ **[2]**

b) A certain element X has two naturally occurring isotopes, ^{10}X and ^{11}X. Find the percentage abundances of ^{10}X and ^{11}X given that the atomic mass of X = 10.81amu, the isotopic mass of ^{10}X= 10.0129, and the isotopic mass of ^{11}X= 11.0093 amu.

[5]

c) In each of the following, something is wrong with part of the statement. Provide the correct name or formula:

i) $BaCl_2$ is called barium dichloride
ii) Sodium sulphide has the formula $(Na)_2SO_3$
iii) Iron(II) sulphate has the formula $Fe_2(SO_4)_3$
iv) Dicesium carbonate has the formula Cs_2CO_3

[6]

d) Name each of the following:

i) SF_4 ii) Cl_2O_7 iii) S_2Cl_2 iv) IF_7

[8]

Q.2. (a) Vitamin C (MM = 176.12 g/mol) is a compound that contains C, H and O atoms only. When a 1.000-gram sample is placed in a combustion chamber and burned, the following data are obtained:

Mass of CO_2 absorber after combustion = 85.35 g
Mass of CO_2 absorber before combustion = 83.85 g
Mass of H_2O absorber after combustion = 37.96 g
Mass of H_2O absorber before combustion = 37.55 g

(i) Determine the empirical formula of vitamin C.
(ii) What is the molecular formula of vitamin C?

[15]

Q.2. (b) Copper is sometimes obtained from an ore containing copper(I) sulphide by a multi-step process. After initial grinding, the first step is to "roast" the ore (heat it strongly in the presence of oxygen gas) to form powdered copper(I) oxide and gaseous sulphur dioxide. The balanced reaction equation involved is,

$$Cu_2S(s) + 2O_2(g) \rightarrow 2CuO(s) + SO_2(g)$$

(i) How many moles of oxygen are required to roast 10.0 mol of copper(I) sulphide?
(ii) How many grams of sulphur dioxide are formed when 10.0 mol of the ore is roasted?
(iii) How many kilograms of oxygen are required to form 2.86 kg of copper(I) oxide?

[10]

Q.3. (a) When two liquids hydrazine, N_2H_4, and dinirogen tetroxide, N_2O_4, are mixed, an explosive reaction takes place to form dinitrogen and water vapour. The balanced reaction equation is,

$$2N_2H_4(l) + N_2O_4(l) \rightarrow 3N_2(g) + 4H_2O(g)$$

(i) Determine which one of the reactants is the limiting reagent when 1.00×10^2 g of N_2H_4 and 2.00×10^2 g of N_2O_4 are mixed.
(ii) How many grams of nitrogen gas form?

[8]

Q.3. (b) Sand (silicon dioxide, SiO_2) reacts with powdered carbon at high temperature to form silicon carbide and carbon monoxide. When 100.0 kg of sand is processed, 51.4 kg of SiC is recovered. What is the percentage yield of SiC from this process? The balanced reaction equation is

$$SiO_2(s) + 3C(s) \rightarrow SiC(s) + 2CO(g)$$

[6]

Q.3. (c) Using appropriate calculations, briefly describe how you would prepare 800 mL of a 0.15 M aqueous solution from a 6.0 M stock solution. **[5]**

Q.3. (d) Because of their toxicity, soluble mercury compounds such as mercury(II) nitrate must be removed from industrial waste water. One removal method involves reacting waste water with sodium sulphide to produce solid mercury(II) sulphide and sodium nitrate solution.

$$Hg(NO_3)_2(aq) + Na_2S(aq) \rightarrow HgS(s) + 2NaNO_3(aq)$$

Consider a laboratory simulation, where 50 mL of 0.010 M mercury(II) nitrate reacts with 20 mL of 0.10 M sodium sulphide.How many grams of mercury(II) sulphide form? **[6]**

Q.4. (a) What are the n, ℓ, and m_ℓ values for the 5f subshell? **[2]**

Q.4. (b) What feature of an orbital is related to each of the following quantum numbers?

(i) Principal quantum number (n)

(ii) Angular momentum q. number (ℓ)

(iii) Magnetic q. number (m_ℓ)

[3]

Q.4. (c) Using the periodic table, rank each set of the main group elements in order of decreasing atomic size:

(i) K, Ga, Ca ii) I, Xe, Ba **[2]**

Q.4. (d) Give condensed electron configurations, and box orbital diagrams showing valence electrons for the following species:

(i) Mo^{3+} (iii) As^{3-}

[8]

Q.4. (e) For each of the following, give the Lewis structure, the electron pair geometry, the molecular geometry and the hybridization of the central atom:

(i) SbF_5 (ii) BrF_5

[10]

CHE151 RE-SIT EXAM SECTION A ANSWER SHEET – JULY 2018.

Stud ID No.....................................Programme:..........................

Ques No.	Letter corresponding to the correct answer
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PERIODIC TABLE OF THE ELEMENTS

GROUPS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
PERIODS	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII			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											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	28.0855 Si 14	30.9738 P 15	32.06 S 16	35.453 Cl 17	39.948 Ar 18
4	39.0983 K 19	40.078 Ca 20	44.956 Sc 21	47.88 Ti 22	50.9415 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	92.9064 Nb 41	95.94 Mo 42	98.907 Tc 43	101.07 Ru 44	102.906 Rh 45	106.42 Pd 46	107.868 Ag 47	112.41 Cd 48	114.82 In 49	118.71 Sn 50	121.75 Sb 51	127.60 Te 52	126.904 I 53	131.29 Xe 54
6	132.905 Cs 55	137.33 Ba 56	138.906 *La 57	178.49 Hf 72	180.948 Ta 73	183.85 W 74	186.207 Re 75	190.2 Os 76	192.22 Ir 77	195.08 Pt 78	196.967 Au 79	200.59 Hg 80	204.383 Tl 81	207.2 Pb 82	208.980 Bi 83	(209) Po 84	(210) At 85	(222) Rn 86
7	(223) Fr 87	226.025 Ra 88	(227) **Ac 89	(261) Rf 104	(262) Ha 105	(263) Unh 106	(262) Uns 107	(265) Uno 108	(266) Une 109									

* Lanthanide series	140.115 Ce 58	140.908 Pr 59	144.24 Nd 60	(145) Pm 61	150.36 Sm 62	151.96 Eu 63	157.25 Gd 64	158.925 Tb 65	162.50 Dy 66	164.930 Ho 67	167.26 Er 68	168.934 Tm 69	173.04 Yb 70	174.967 Lu 71
** Actinide series	232.038 Th 90	231.036 Pa 91	238.029 U 92	237.048 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

Numbers below the symbol of the element indicates the atomic numbers. Atomic masses, above the symbol of the element, are based on the assigned relative atomic mass of ^{12}C = exactly 12; ( ) indicates the mass number of the isotope with the longest half-life.

SOURCE: International Union of Pure and Applied Chemistry, I. Mills, ed., *Quantities, Units, and Symbols in Physical Chemistry*, Blackwell Scientific Publications, Boston, 1988, pp 86-98.

Fundamental Physical Constants (six significant figures)

Avogadro's number	N_A	$= 6.02214\times10^{23}$/mol
atomic mass unit	amu	$= 1.66054\times10^{-27}$ kg
charge of the electron (or proton)	e	$= 1.60218\times10^{-19}$ C
Faraday constant	F	$= 9.64853\times10^{4}$ C/mol
mass of the electron	m_e	$= 9.10939\times10^{-31}$ kg
mass of the neutron	m_n	$= 1.67493\times10^{-27}$ kg
mass of the proton	m_p	$= 1.67262\times10^{-27}$ kg
Planck's constant	h	$= 6.62607\times10^{-34}$ J·s
speed of light in a vacuum	c	$= 2.99792\times10^{8}$ m/s
standard acceleration of gravity	g	$= 9.80665$ m/s^2
universal gas constant	R	$= 8.31447$ J/(mol·K)
		$= 8.20578\times10^{-2}$ (atm·L)/(mol·K)

Rydberg constant = 1.097 x 10^7 m^{-1}

SI Unit Prefixes

p	n	μ	m	c	d	k	M	G
pico-	nano-	micro-	milli-	centi-	deci-	kilo-	mega-	giga-
10^{-12}	10^{-9}	10^{-6}	10^{-3}	10^{-2}	10^{-1}	10^{3}	10^{6}	10^{9}

Conversions and Relationships

Length
SI unit: meter, m

1 km	= 1000 m
	= 0.62 mile (mi)
1 inch (in)	= 2.54 cm
1 m	= 1.094 yards (yd)
1 pm	= 10^{-12} m = 0.01 Å

Volume
SI unit: cubic meter, m^3

1 dm^3	= 10^{-3} m^3
	= 1 liter (L)
	= 1.057 quarts (qt)
1 cm^3	= 1 mL
1 m^3	= 35.3 ft^3

Pressure
SI unit: pascal, Pa

1 Pa	= 1 N/m^2
	= 1 kg/m·s^2
1 atm	= 1.01325×10^5 Pa
	= 760 torr
1 bar	= 1×10^5 Pa

Mass
SI unit: kilogram, kg

1 kg	= 10^3 g
	= 2.205 lb
1 metric ton (t)	= 10^3 kg

Energy
SI unit: joule, J

1 J	= 1 kg·m^2/s^2
	= 1 coulomb·volt (1 C·V)
1 cal	= 4.184 J
1 eV	= 1.602×10^{-19} J

Math relationships

$\pi = 3.1416$

volume of sphere = $\frac{4}{3}\pi r^3$

volume of cylinder = $\pi r^2 h$

Temperature
SI unit: kelvin, K

0 K	= −273.15°C
mp of H_2O	= 0°C (273.15 K)
bp of H_2O	= 100°C (373.15 K)
T (K)	= T (°C) + 273.15
T (°C)	= [T (°F) − 32]$\frac{5}{9}$
T (°F)	= $\frac{9}{5}T$ (°C) + 32