

UNIVERSITY OF SWAZILAND
SUPPLEMENTARY EXAMINATIONS **2015/2016**

TITLE OF PAPER: **INTRODUCTORY CHEMISTRY**

COURSE NUMBER: **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. DETATCH THE ANSWER SHEET FROM THE QUESTION PAPER AND FILL IN ALL THE INFORMATION REQUIRED

For Section A, record the letter corresponding to the correct answer on the Section A answer sheet which is attached

AT THE END OF THE EXAM, BEFORE YOU LEAVE, PLACE THE ANSWER SHEET INSIDE THE UNISWA ANSWER BOOKLET CONTAINING YOUR ANSWERS TO SECTION B. DO NOT FORGET

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

1. Isopropyl alcohol, commonly known as rubbing alcohol, boils at 82.4°C. What is the boiling point in kelvins?
- A. 387.6 K
 - B. 355.6 K
 - C. 323.6 K
 - D. 190.8 K
 - E. -190.8 K

2. Select the answer with the correct number of decimal places for the following sum:

$$13.914 \text{ cm} + 243.1 \text{ cm} + 12.00460 \text{ cm} =$$

- A. 269.01860 cm
 - B. 269.0186 cm
 - C. 269.019 cm
 - D. 269.02 cm
 - E. 269.0 cm
3. Which of the following correctly expresses 0.000007913 g in scientific notation?
- A. $7.913 \times 10^6 \text{ g}$
 - B. $7.913 \times 10^5 \text{ g}$
 - C. $7.913 \times 10^{-5} \text{ g}$
 - D. $7.913 \times 10^{-6} \text{ g}$
 - E. $7.913 \times 10^{-9} \text{ g}$

4. 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.

<u>Isotope</u>	<u>Isotopic Mass (amu)</u>	<u>Abundance %</u>
^{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
5. Which of the following compounds is covalent?
- A. CaCl_2
B. MgO
C. Al_2O_3
D. Cs_2S
E. PCl_3
6. The compound, BaO , absorbs water and carbon dioxide readily and is used to dry gases and organic solvents. What is its name?
- A. barium oxide
B. barium(II) oxide
C. barium monoxide
D. baric oxide
E. barium peroxide
7. What is the formula for magnesium sulfide?
- A. MgS
B. MgS_2
C. Mg_2S
D. Mg_2S_3
E. MgSO_4

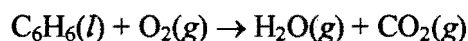
8. Sulfur trioxide can react with atmospheric water vapor to form sulfuric acid that falls as acid rain. Calculate the mass in grams of 3.65×10^{20} molecules of SO_3 .

- A. 6.06×10^{-4} g
- B. 2.91×10^{-2} g
- C. 4.85×10^{-2} g
- D. 20.6 g
- E. 1650 g

9. A compound containing chromium and silicon contains 73.52 mass percent chromium. Determine its empirical formula.

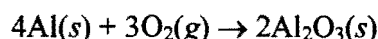
- A. CrSi_3
- B. Cr_2Si_3
- C. Cr_3Si
- D. Cr_3Si_2
- E. Cr_2S

10. Balance the following equation for the combustion of benzene:



- A. $\text{C}_6\text{H}_6(l) + 9\text{O}_2(g) \rightarrow 3\text{H}_2\text{O}(g) + 6\text{CO}_2(g)$
- B. $\text{C}_6\text{H}_6(l) + 9\text{O}_2(g) \rightarrow 6\text{H}_2\text{O}(g) + 6\text{CO}_2(g)$
- C. $2\text{C}_6\text{H}_6(l) + 15\text{O}_2(g) \rightarrow 6\text{H}_2\text{O}(g) + 12\text{CO}_2(g)$
- D. $\text{C}_6\text{H}_6(l) + 15\text{O}_2(g) \rightarrow 3\text{H}_2\text{O}(g) + 6\text{CO}_2(g)$
- E. $2\text{C}_6\text{H}_6(l) + 9\text{O}_2(g) \rightarrow 6\text{H}_2\text{O}(g) + 12\text{CO}_2(g)$

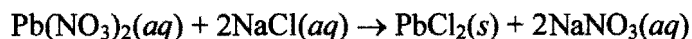
11. Aluminum reacts with oxygen to produce aluminum oxide which can be used as an adsorbent, desiccant or catalyst for organic reactions.



A mixture of 82.49 g of aluminum ($\mathcal{M} = 26.98$ g/mol) and 117.65 g of oxygen ($\mathcal{M} = 32.00$ g/mol) is allowed to react. Identify the limiting reactant and determine the mass of the excess reactant present in the vessel when the reaction is complete.

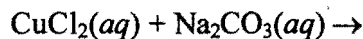
- A. Oxygen is the limiting reactant; 19.81 g of aluminum remain.
- B. Oxygen is the limiting reactant; 35.16 g of aluminum remain.
- C. Aluminum is the limiting reactant; 16.70 g of oxygen remain.
- D. Aluminum is the limiting reactant; 35.16 g of oxygen remain.
- E. Aluminum is the limiting reactant; 44.24 g of oxygen remain.

12. In the following reaction, what ions, if any, are spectator ions?



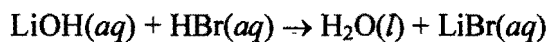
- A. $\text{Pb}^{2+}(\text{aq})$, $\text{Cl}^{-}(\text{aq})$
- B. $\text{Na}^{+}(\text{aq})$, $\text{NO}_3^{-}(\text{aq})$
- C. $\text{Pb}^{2+}(\text{aq})$, $\text{NO}_3^{-}(\text{aq})$
- D. $\text{Na}^{+}(\text{aq})$, $\text{Cl}^{-}(\text{aq})$
- E. There are no spectator ions

13. Select the correct name and chemical formula for the precipitate that forms when the following reactants are mixed.



- A. copper(I) carbonate, Cu_2CO_3
- B. copper(II) carbonate, Cu_2CO_3
- C. copper(I) carbonate, CuCO_3
- D. copper(II) carbonate, CuCO_3
- E. sodium chloride, NaCl

14. Select the net ionic equation for the reaction between lithium hydroxide and hydrobromic acid.



- A. $\text{LiOH}(\text{aq}) \rightarrow \text{Li}^{+}(\text{aq}) + \text{OH}^{-}(\text{aq})$
- B. $\text{HBr}(\text{aq}) \rightarrow \text{H}^{+}(\text{aq}) + \text{Br}^{-}(\text{aq})$
- C. $\text{H}^{+}(\text{aq}) + \text{OH}^{-}(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$
- D. $\text{Li}^{+}(\text{aq}) + \text{Br}^{-}(\text{aq}) \rightarrow \text{LiBr}(\text{aq})$
- E. $\text{Li}^{+}(\text{aq}) + \text{OH}^{-}(\text{aq}) + \text{H}^{+}(\text{aq}) + \text{Br}^{-}(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{LiBr}(\text{aq})$

15. A standard solution of 0.243 M NaOH was used to determine the concentration of a hydrochloric acid solution. If 46.33 mL of NaOH is needed to neutralize 10.00 mL of the acid, what is the molar concentration of the acid?

- A. 0.0524 M
- B. 0.888 M
- C. 1.13 M
- D. 2.26 M
- E. 2.43 M

16. Select the arrangement of electromagnetic radiation which starts with the lowest wavelength and increases to greatest wavelength.

- A. radio, infrared, ultraviolet, gamma rays
- B. radio, ultraviolet, infrared, gamma rays
- C. gamma rays, radio, ultraviolet, infrared
- D. gamma rays, infrared, radio, ultraviolet
- E. gamma rays, ultraviolet, infrared, radio

17. According to the Bohr theory of the hydrogen atom, the minimum energy (in J) needed to ionize a hydrogen atom from the $n = 2$ state is

- A. 2.18×10^{-18} J
- B. 1.64×10^{-18} J
- C. 5.45×10^{-19} J
- D. 3.03×10^{-19} J
- E. None of these choices is correct.

18. Which of the following is a correct set of quantum numbers for an electron in a $3d$ orbital?

- A. $n = 3, l = 0, m_l = -1$
- B. $n = 3, l = 1, m_l = +3$
- C. $n = 3, l = 2, m_l = 3$
- D. $n = 3, l = 3, m_l = +2$
- E. $n = 3, l = 2, m_l = -2$

19. In the quantum mechanical treatment of the hydrogen atom, which one of the following combinations of quantum numbers is not allowed?

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

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

20. The electronic structure $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$ refers to the ground state of

- A. Kr
- B. Ni
- C. Fe
- D. Pd
- E. None of these choices is correct.

21. Which of the following elements has the greatest atomic radius?

- A. Li
- B. Ne
- C. Rb
- D. Sr
- E. Xe

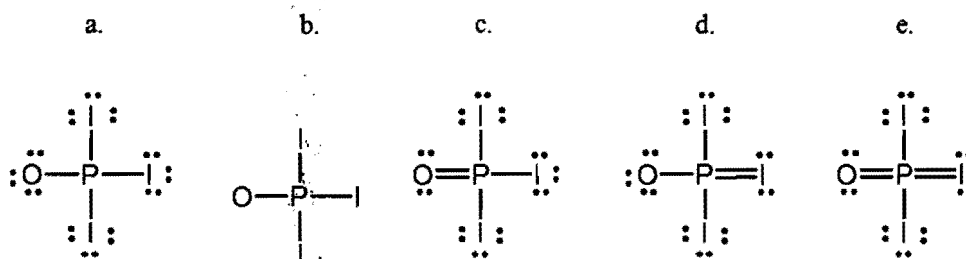
22. Select the element with the least metallic character.

- A. Sn
- B. Sr
- C. Tl
- D. Ge
- E. Ga

23. Select the correct formula for a compound formed from calcium and chlorine.

- A. CaCl
- B. CaCl₂
- C. Ca₂Cl
- D. Ca₂Cl₂
- E. CaCl₃

24. Phosphoryl iodide is used in the preparation of organophosphorus derivatives and phosphate esters. Select the Lewis' structure for POI_3 which minimizes formal charges.



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

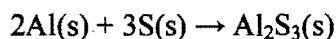
25. In which one of the following species is the central atom (the first atom in the formula) likely to violate the octet rule?

- A. BF_4^-
- B. NO_5
- C. SiCl_4
- D. NH_3
- E. CH_2Cl_2

SECTION B: ANSWER ANY THREE QUESTIONS

- Q.1. a) Write the following numbers in scientific notation:
i) 281.0 ii) 0.00380 iii) 4279.8 iv) 58 200.9 [2]
- b) Write the following numbers in standard notation. Use a terminal decimal point when needed.
i) 5.55×10^3 ii) 1.0070×10^4 iii) 8.85×10^{-7} iv) 3.004×10^{-4} [2]
- c) Argon has three naturally occurring isotopes, ^{36}Ar , ^{38}Ar and ^{40}Ar .
i) What is the mass number of each?
ii) How many protons, neutrons and electrons are present in each? [6]
- d) What monatomic ions do the following elements form? In each case, give the Lewis symbol of the atom and the corresponding ion.
i) Iodine; ii) Calcium; iii) selenium [9]
- e) Name the following anions and give the names and formulas of the acids derived from them:
i) Br^- ii) ClO_3^- iii) CN^- iv) SO_4^{2-} [6]
- Q.2. (a) A dry-cleaning solvent (MW = 146.99 g/mol) that contains C, H and Cl is suspected to be a cancer-causing agent. When a 0.250-g sample was studied by combustion analysis, 0.451 g of CO_2 and 0.0617 g of H_2O formed. Find the molecular formula of the substance. [16]
- (b) Thermite is a mixture of iron(III) oxide and aluminium powders that was once used to weld railroad tracks. It undergoes a spectacular reaction to yield solid aluminium oxide and molten iron.
- $$\text{Fe}_2\text{O}_3(\text{s}) + 2\text{Al}(\text{s}) \rightarrow \text{Al}_2\text{O}_3(\text{s}) + 2\text{Fe}(\text{l})$$
- (i) How many grams of iron form when 135 g of aluminium react?
(ii) How many atoms of aluminium react for every 1.00 g of aluminium oxide formed? [9]

- Q.3. (a) How many grams of solid aluminium sulphide can be prepared by the reaction of 10.0 g of aluminium and 15.0 g of sulphur? How much of the nonlimiting reactant is in excess? The balanced reaction is as follows:



[8]

- (b) Marble (calcium carbonate) reacts with hydrochloric acid solution to form calcium chloride solution, water, and carbon dioxide. What is the percentage yield of carbon dioxide if 3.5 g of the gas is collected when 10.0 g of marble reacts with excess acid? The reaction equation is,

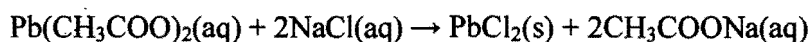


[5]

- (c) To prepare a fertilizer, a technician dilutes a stock solution of sulphuric acid by adding 25.0 m³ of 7.50 M acid to enough water to make 500.0 mL of a dilute solution. What is the mass (in g) of sulphuric acid per milliliter of the diluted solution?

[5]

- (d) Consider a 1.5 M aqueous solution of lead(II) acetate. When 267 mL reacts with 125 mL of 3.40 M sodium chloride, how many grams of solid lead(II) chloride can form? The required reaction equation is,



[7]

- Q.4. (a) What values of the angular momentum (l) and magnetic (m_l) quantum numbers are allowed for a principal quantum number (n) of 4? How many orbitals exist for $n=4$?

[10]

- Q.4. (c) Rank the ions in each set in order of increasing size:

- (i) Se^{2-} , Rb^+ , Br^-
 (ii) O^{2-} , F^- , N^{3-}
 (iii) Tl^{2+} , Cs^+ , I^-
 (iv) Sr^{2+} , Cs^+ , Ba^{2+}

[4]

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

- (i) Sn^{2+} (iii) Se^{2-}

[5]

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

- (i) SF_4 (ii) XeF_2

[6]

PERIODIC TABLE OF THE ELEMENTS

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			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	(268) Une 109									

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
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

* Lanthanide series

** Actinide series

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 ¹²C = 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	$N_A = 6.02214 \times 10^{23} / \text{mol}$
atomic mass unit	$\text{amu} = 1.66054 \times 10^{-27} \text{ kg}$
charge of the electron (or proton)	$e = 1.60218 \times 10^{-19} \text{ C}$
Faraday constant	$F = 9.64853 \times 10^4 \text{ C/mol}$
mass of the electron	$m_e = 9.10939 \times 10^{-31} \text{ kg}$
mass of the neutron	$m_n = 1.67493 \times 10^{-27} \text{ kg}$
mass of the proton	$m_p = 1.67262 \times 10^{-27} \text{ kg}$
Planck's constant	$h = 6.62607 \times 10^{-34} \text{ J}\cdot\text{s}$
speed of light in a vacuum	$c = 2.99792 \times 10^8 \text{ m/s}$
standard acceleration of gravity	$g = 9.80665 \text{ m/s}^2$
universal gas constant	$R = 8.31447 \text{ J}/(\text{mol}\cdot\text{K})$ $= 8.20578 \times 10^{-2} \text{ (atm}\cdot\text{L)} / (\text{mol}\cdot\text{K})$

$$\text{Rydberg constant} = 1.097 \times 10^7 \text{ m}^{-1}$$

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 ₂ O	= 0°C (273.15 K)
bp of H ₂ O	= 100°C (373.15 K)
T (K)	= T (°C) + 273.15
T (°C)	= $[T (\text{°F}) - 32] \frac{5}{9}$
T (°F)	= $\frac{9}{5}T (\text{°C}) + 32$

CHE151 FINAL EXAM ANSWER SHEET FOR SECTION A

Student ID # _____ Degree Program (BSc, BEd, etc): _____

Date: _____

Question No.	Letter corresponding to the correct answer
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