UNIVERSITY OF BOTSWANA

DEPARTMENT OF CHEMISTRY

B.Sc Year I: GENERAL CHEMISTRY (C110) SEMESTER I EXAMINATION

Date: December 10, 2001
Duration: 3 hours

Instructions:

- * WRITE ALL ANSWERS ON THIS QUESTION PAPER
- * The Paper has Three Parts
- * For Multiple Choice Questions (Section A & B), circle the letter for the correct answer for each question.
- For questions in <u>Section C</u>, use the space provided to write your answers. If you need additional space, write on the back of the printed pages.

Important:

It is the student's responsibility to check that no page is missing in this paper!

Data:					
	Avo	gadro constant		=	6.022 x 10 ²³ mol ⁻¹
R	= `	8.314 J. K ⁻¹ . mol ⁻¹		=	0.08206 L. atm. K ⁻¹ . mol ⁻¹ .
1 atm	=	760 mm Hg.	1m	=	10° nm
R_{H}	=	1.097 x 10 ⁷ m ⁻¹ ;	c	=	$3.00 \times 10^8 \text{ m/s}.$
	=	6.63 x 10 ⁻³⁴ J.s		=	6.63 x 10 ⁻³⁴ kg m ² /s
Rydbe	erg Co	ont (R)		=	3.29 x 10 ¹⁵ Hz
•	_			=	$3.29 \times 10^{15} \text{ s}^{-1}$

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Do not write in this table.								
MC A	MC B	1	2	3	4	5	6	Total

Page 2 of 15 pages

SECTION A: Multiple Choice [30 %, 2 Marks Each]

Circle the letter for the correct answer in each question.

1.	Wri	te the nuclear symbol for the species that has 36 neutrons and 28 electrons.
	a)	$^{66}\mathrm{Ge^{2+}}$
	b)	$^{66}\mathrm{Ni}^{2^+}$
	c)	$^{66}Zn^{2+}$
	d)	$^{66}\text{Fe}^{2^{+}}$
	e)	$^{66}\text{Fe}^{2+}$ $^{66}\text{Kr}^{6+}$
2.		ch one of the following Name-Formula combinations is NOT CORRECT ? (Which ver is FALSE ?)
	a)	Lithium aluminum sulfate, LiAlSO ₄
	b)	Chloric acid, HClO ₃ (aq)
	c)	Cobalt (II) bromide tetrahydrate, CoBr ₂ .4H ₂ O
	d)	Dinitrogen pentoxide, N ₂ O ₅
	e)	Potassium hydrogen phosphate, K ₂ HPO ₄
3.		udent carries out an oxidation reaction with element Z, which is in Group 13. What e general formula of the expected oxide?
	a)	ZO
	b)	Z_2O
	c)	Z_2O_3
	d)	Z_3O_4
	e)	Z_3O_2

Page 3 of 15 pages

4.	The maxin	num dri	ving speed limit in Botswana is 120 km/hr.	What is this	speed in m/s?
	a)	20.0	m/s		
	b)	0.0333	m/s		
	c)	200	m/s		
	d)	33.3	m/s		
	e)	100	m/s		
5.	How many	oxygei	n (O) atoms are there in 175 g of Na ₂ S ₂ O ₃ .2	H ₂ O? The	molar mass is

- 5. How many oxygen (O) atoms are there in 175 g of Na₂S₂O₃.2H₂O? The molar mass is 194.13 g/mol
 - a) 5.43 x 10²⁴
 b) 1.63 x 10²⁴
 - c) 2.71×10^{24}
 - d) 1.09 x 10²⁴
 - e) 1.20 x 10²⁴
- **6.** A sample of a compound of chlorine and oxygen contains 59.63 % Cl by mass. Determine the empirical formula.
 - a) Cl₂O
 - b) Cl₂O₃
 - c) ClO₂
 - d) Cl₂O₅
 - e) Cl₂O₇

Page 4 of 15 pages

7. When the equation

$$H_3PO_4$$
 + $Ca(OH)_2$ \rightarrow $Ca_3(PO_4)_2$ + H_2O

is balanced, the proper sequence of stoichiometric coefficients is

- a) 3, 2, 1, 6
- b) 2, 3, 1, 6
- c) 2, 3, 6, 1
- d) 2, 3, 3, 1
- e) 3, 2, 6,1

8. In the following reaction

$$Zn\left(s\right)$$
 + $CuSO_{4}\left(aq\right)$ $ightarrow$ $ZnSO_{4}\left(aq\right)$ + $Cu\left(s\right)$

identify the reducing and oxidising agent, respectively

- a) Zn^{2+} and Cu^{2+}
- b) Zn and CuSO₄
- c) Zn and Cu
- d) ZnSO₄ and CuSO₄
- e) Zn²⁺ and CuSO₄

9. Calculate the oxidation numbers for the S atoms in the two species:

	HS	O ₃ -	and	Na ₂ S
a)	+ 4	and	- 2	
b)	+6	and	- 1	
c)	+ 4	and	- 0.5	
d)	+ 6	and	+ 0.5	
e)	+4	and	- 1	

10.	Magnesium	carbonate reacts	with	phos	ohoric	acid	according	to t	he eo	uation

 $2H_3PO_4$ (aq) + $3MgCO_3$ (s) \rightarrow $Mg_3(PO_4)_2 + 3CO_2$ (g) + $3H_2O$ (l)

How many gram of carbon dioxide will be produced when 50.0 g of MgCO $_3$ (Molar mass = 84.31 g/mol) reacts completely with $\rm H_3PO_4$?

- a) 52.2 g
- b) 13.1 g
- c) 26.1 g
- d) 50.0 g
- e) 33.3 g

11. A given mass of hydrogen occupies 40.0 L at 700 torr. What volume will it occupy at 5.00 atm pressure and at the same temperature? (1 atm = 760 torr)

- a) 7.37 L
- b) 18.3 L
- c) 217 L
- d) 153 L
- e) 76.8 L

- i) n = 3, l = -2, $m_l = 0$, $m_s = +\frac{1}{2}$;
- ii) $n = 2, l = 2, m_{l1} = -1, m_s = -\frac{1}{2};$
- iii) n = 6, l = 2, $m_l = +2$, $m_s = +\frac{1}{2}$;
- iv) n = 4, l = 0, $m_l = 0$, $m_s = -\frac{1}{2}$;
- v) $n = 3, l = 2, m_l = -3, m_s = +\frac{1}{2}$
- a) i) and ii)
- b) iii) and v)
- c) ii) and iv)
- d) iv) and v)
- e) iii) and iv)

Page 6 of 15 pages

13. How many unpaired electrons are in the electron structure of 24Cr?

	u)	
	b)	4
	c)	3
	d)	6
	e)	5
14.	Whic	ch one of the following statements is FALSE?
	a)	Expanded octet requires a large atom with nd orbitals
	b)	Electronegativity decreases down the group
	c)	Formal charge can be used to evaluate stability of resonance structures
	d)	Ionic radius of cations decrease down the group
	e)	Electronegativity affects the polarity of a chemical bond
15.	Whic	Electronegativity affects the polarity of a chemical bond the one of the following compounds is expected to have the most favourable (largest) the energy?
15.	Whic	ch one of the following compounds is expected to have the most favourable (largest)
15.	Whice lattice	ch one of the following compounds is expected to have the most favourable (largest) the energy?
15.	Whice lattice a)	ch one of the following compounds is expected to have the most favourable (largest) the energy? LiF
15.	Whice lattice a) b)	ch one of the following compounds is expected to have the most favourable (largest) the energy? LiF KF

Page 7 of 15 pages

SECTION B: Multiple Choice [30 %, 3 Marks Each]

1.	At 25 °C the average speed for molecules of an unknown gas is 2.77 times that for Xe
	(g). What could be the formula of this unknown gas?

- a) SF_6
- b) BeF₂
- c) UF₆
- d) NO₂
- e) NH₃

2. If 250 mL of 0.150 M $CaCl_2$ (aq) solution is mixed with 250 mL of 0.150 M $AlCl_3$ (aq) solution, what is the molarity of Cl-, in the resulting mixed solution?

- a) 0.150 M
- b) 0.375 M
- c) 0.250 M
- d) 0.188 M
- e) 0.225 M

3. Which of the following is TRUE regarding the number of un-paired electrons in

	₁₆ S	33As	₂₅ Mn ²
a)	2	3	5
b)	3	2	5
c)	2	5	3
d)	4	3	7
e)	5	2	3

Page 8 of 15 pages

4. An impure sample of CuSO₄ weighing 5.52 g was dissolved in water and allowed to react with excess zinc according to equation to the equation:

 $CuSO_4 (aq) + Zn (s) \rightarrow ZnSO_4 (aq) + Cu (s)$

What is the percent $CuSO_4$ (molar mass = 159.61 g/mol) in the sample if 1.49 g of Cu was produced?

- a) 71.8 %
- b) 67.8%
- c) 83.4 %
- d) 59.3 %
- e) 90.6 %

5. Calculate the energy, in kJ/mol, for the photon emission associated with the second Balmer line of hydrogen (H).

- a) 246 kJ/mol
- b) 312 kJ/mol
- c) 433 kJ/mol
- d) 381 kJ/mol
- e) 345 kJ/mol

6. Given the following Lewis dot structure, calculate the Formal Charge on the F, S, and N atoms, respectively:

$$F - S = N$$

- a) 0, 0, 0
- b) -1, +1, 0
- c) 0, +1, -1
- d) -1, +2, -1
- e) 0, -1, +1

Page 9 of 15 pages

Which one of the following molecules is polar (has a dipole moment, $\mu \neq 0$)?

The geometry of the ${\rm IF_4}^+$ cation is best described as:

Tetrahedral See saw molecule

Square planar Octahedral Square pyramidal

 BF_3

PCl₃

CF₄

 SF_6

7.

8.

a) b)

c) d) e)

a) b)

c)

d)

e)

9.		number of sigma s in the CNO anio		ls, pi (π) bonds, and unshared/lone pairs of valence	
	a)	2 σ,	2 π,	and	4 lone pairs	
	b)	1 σ,	3 π,	and	4 lone pairs	
	c)	4 σ,	0 π,	and	8 lone pairs	
	d)	0 σ,	4 π,	and	4 lone pairs	
	e)	2 σ,	0π,	and	0 lone pairs	
10.	What is	the hydridization o	of the Br	atom in	the BrF ₃ molecule?	
		p				
		p ²				
		p^3 p^3 d				
		p^3d^2				
	•					

Page 10 of 15 pages

SECTION C:[40 %]

Answer each question in the space provided. If you require more space use the back of the page. You may do your rough work on the back of the printed page, but cross it out before submitting your paper.

- 1. Write the, i) Balanced chemical equation, ii) Complete ionic equation,
 - iii) Net ionic equation; for each of the following reactions (a & b):
 - a) Hydrochloric acid added to an aqueous solution of silver nitrate [3 marks]

b) Aqueous acetic acid reacted with a solution of barium hydroxide

[3 marks]

Page 11 of 15 pages

2. Use the method of half-reactions to balance the following ionic equation in basic solution:

$$\text{ClO}_2^-(\text{aq})$$
 + $\text{SO}_3^{-2-}(\text{aq})$ \rightarrow $\text{Cl}^-(\text{aq})+$ $\text{SO}_4^{-2-}(\text{aq})$ [6 marks]

Page 12 of 15 pages

					[4 marks
	₄₂ Mo,	₃₄ Se,	₅₀ Sn ⁴⁺ ,	45Rh ⁺	
	-	ving in order o	f increasing ele	ctronegativity:	
P, Se,	Si, Cl, S				[1 marl
					[
	_	ving in order o	f decreasing me	etallic character:	
Sb, Ba	ı, F, Sr				[1 mar
					[

Page 13 of 15 pages

- **4.** For the following molecules and ions:
 - i) Write the Lewis dot structures;
 - ii) Describe by name the overall geometry of valence electron pairs;
 - iii) Describe by name the geometry of the molecule or ion;
 - iv) Describe the bond angles expected in the structures.

[8 marks]

a) IF₅

b) NO₂

Page 14 of 15 pages

5. Write three different non-equivalent resonance structures for H_2PO_4 as $(HO)_2PO_2$ with a central P atom. Determine the most reasonable structure by calculating the formal charges on each of the differently bonded atoms.

[8 marks]

Page 15 of 15 pages

6. A piece of Cu metal 3.31 cm x 1.84 cm x 1.0 cm reacts with 157 mL of 1.35 M nitric acid solution. The density of copper is 8.92 g/cm³. From the following equation:

$$4HNO_{3}\left(aq\right) \ + \ Cu\left(s\right) \qquad \boldsymbol{\rightarrow} \qquad Cu(NO_{3})_{2}\left(aq\right) \ + \ 2NO_{2}\left(g\right) \ + \ 2H_{2}O\left(l\right)$$

What volume of NO_2 at 1.01 atm and 297 K will be formed?

[7 marks]

PERIODIC TABLE OF THE ELEMENTS http://www.chem.gmw.ac.ub/inpsc/atw/table.html

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twt/table.ht								11	29	C	63.546	47	Ag	107.868	62	Ψn	196.967	111	Unn	(272)
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nttp://www.chem.qmw.ac.uk/ıupac/atwt/table.html								6	27	ပိ	58.9332	45	Rh	102.906	LL	Ir	192.22	109	Mt	(268)
p://www.ch								8	26	Fe	55.847		Ru	101.07	92	SO	190.2	108	Hs	(265)
Ħ								7	25	Mn	54.9380	43	Tc	(98)	75	Re	186.207	107	Bh	(264)
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Lanthanides:	57	28	59	09	61	62	63	49	65	99	29	89	69	70
	La	ပီ	Pr	PZ	Pm	Sm	Εn	В	Tb	Dy	Ho	Er	Tm	ΧÞ
	138.906	140.12	140.908	144.24	(145)	150.36	151.96	151.96 157.25	158.925	162.50	161.930	167.26	166.934	173.04

	La	ပီ	Pr	PZ	Pm	Sm	En	В	T	Dy	La Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb	Εŗ	Tm	$\mathbf{X}\mathbf{p}$
	138.906	140.12	140.908	144.24	(145)	150.36	151.96	157.25	158.925	162.50	161.930	167.26	166.934	173.0
Actinides:	68	06	16	92	93	94	<u> 56</u>	96	26	86	66	100	101	102
	Ac Th Pa U Np Pu Am Cm Bk Cf Es Fm Md No	Th	Pa	n	a Z	Pu	Am	Cm	Bk	Ç	Es	Fm	Md	ž
	227 028	232 038	231 036	920 886	237 048	(244)	(243)	(747)	(747)	(751)	(252)	(757)	(258)	(050)