UNIVERSITY OF SWAZILAND

FINAL EXAMINATIONS 2014/2015

TITLE OF PAPER: INTRODUCTORY CHEMISTRY

COURSE NUMBER: C111

TIME ALLOWED: THREE (3) HOURS

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

SECTION A IS WORTH 50 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 ON THE ANSWER SHEET BY MAKING A CROSS OVER THE LETTER CORRESPONDING TO THE CORRECT ANSWER. DETATCH THE ANSWER SHEET FROM THE QUESTION PAPER AND FILL IN ALL THE INFORMATION REQUIRED IN THE SPACES PROVIDED

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

1) Which one of the following is often easily separated into its components by simple techniques such as filtering or decanting?
A) heterogeneous mixture
B) compounds
C) homogeneous mixture
D) elements
E) solutions

2) Which states of matter are significantly compressible?
A) gases only
B) liquids only
C) solids only
D) liquids and gases
E) solids and liquids

3) For which of the following can the composition vary?
A) pure substance
B) element
C) both homogeneous and heterogeneous mixtures
D) homogeneous mixture
E) heterogeneous mixture

4) If matter is uniform throughout and cannot be separated into other substances by physical means, it is _____.
A) a compound
B) either an element or a compound
C) a homogeneous mixture
D) a heterogeneous mixture
E) an element

5) An element cannot _____.
A) be part of a heterogeneous mixture
B) be part of a homogeneous mixture
C) be separated into other substances by chemical means
D) interact with other elements to form compounds
E) be a pure substance

6) Homogeneous mixtures are also known as
A) solids
B) compounds
C) elements
D) substances
E) solutions

7) There are _____ electrons, _____ protons, and _____ neutrons in an atom of $^{132}_{54}Xe$.

A) 132, 132, 54
B) 54, 54, 132
C) 78, 78, 54
D) 54, 54, 78
E) 78, 78, 132

8) An atom of the most common isotope of gold, ^{197}Au, has _____ protons, _____ neutrons, and _____ electrons.

A) 197, 79, 118
B) 118, 79, 39
C) 79, 197, 197
D) 79, 118, 118
E) 79, 118, 79

9) Which combination of protons, neutrons, and electrons is correct for the isotope of copper, $^{63}_{29}Cu$?

A) 29 p^+, 34 n°, 29 e^-
B) 29 p^+, 29 n°, 63 e^-
C) 63 p^+, 29 n°, 63 e^-
D) 34 p^+, 29 n°, 34 e^-
E) 34 p^+, 34 n°, 29 e^-

10) Which isotope has 45 neutrons?

A) $^{80}_{36}Kr$
B) $^{80}_{35}Br$
C) $^{78}_{34}Se$
D) $^{34}_{17}Cl$
E) $^{103}_{45}Rh$

11) The formula weight of a substance is _____.

A) identical to the molar mass
B) the same as the percent by mass weight
C) determined by combustion analysis
D) the sum of the atomic weights of each atom in its chemical formula
E) the weight of a sample of the substance

12) The formula weight of calcium nitrate ($Ca(NO_3)_2$), rounded to one decimal place, is _____ amu.
A) 102.1
B) 164.0
C) 204.2
D) 150.1
E) 116.1

13) The formula weight of magnesium fluoride (MgF_2), rounded to one decimal place, is _____ g/mol.
A) 86.6
B) 43.3
C) 62.3
D) 67.6
E) 92.9

14) The formula weight of lead nitrate ($Pb(NO_3)_2$) is _____ g/mol.
A) 269.2
B) 285.2
C) 317.2
D) 331.2
E) 538.4

15) The mass % of C in methane (CH_4) is _____.
A) 25.13
B) 133.6
C) 74.87
D) 92.26
E) 7.743

16) The mass % of F in the binary compound KrF_2 is _____.
A) 18.48
B) 45.38
C) 68.80
D) 81.52
E) 31.20

17) Calculate the percentage by mass of nitrogen in $PtCl_2(NH_3)_2$.
A) 4.67
B) 9.34
C) 9.90
D) 4.95
E) 12.67

18) Calculate the percentage by mass of lead in $Pb(NO_3)_2$.
A) 38.6
B) 44.5
C) 62.6
D) 65.3
E) 71.2

19) Calculate the percentage by mass of nitrogen in $Pb(NO_3)_2$.
A) 4.2
B) 5.2
C) 8.5
D) 10.4
E) 12.6

20) Calculate the percentage by mass of lead in $PbCO_3$.
A) 17.96
B) 22.46
C) 73.05
D) 77.54
E) 89.22

21) Calculate the percentage by mass of oxygen in $Pb(NO_3)_2$.
A) 9.7
B) 14.5
C) 19.3
D) 29.0
E) 33.4

22) Which one of the following is a triprotic acid?
A) nitric acid
B) chloric acid
C) phosphoric acid
D) hydrofluoric acid
E) sulfuric acid

23) Which one of the following solutions will have the greatest concentration of hydroxide ions?
A) 0.100 M rubidium hydroxide
B) 0.100 M sodium hydroxide
C) 0.100 M ammonia
D) 0.100 M barium hydroxide
E) 0.100 M hydrochloric acid

24) Which one of the following is a weak acid?
A) HNO_3
B) HCl
C) HI
D) HF
E) $HClO_4$

25) Which of the following are weak acids?
A) HCl, HBr
B) HI, HBr
C) HI, H_2SO_4
D) HNO_3, $HClO_4$
E) none of the above

26) A compound was found to be soluble in water. It was also found that addition of acid to an aqueous solution of this compound resulted in the formation of carbon dioxide. Which one of the following cations would form a precipitate when added to an aqueous solution of this compound?
A) NH_4^+
B) K+
C) Ba^{2+}
D) Rb^+
E) Na^+

27) Which hydroxides are weak bases?
A) KOH, $Ba(OH)_2$
B) $Sr(OH)_2$, KOH, NaOH, $Ba(OH)_2$
C) KOH, NaOH
D) KOH, NaOH, $Ba(OH)_2$
E) None of these is a weak base.

28) The balanced reaction between aqueous potassium hydroxide and aqueous acetic acid is _____.
A) $KOH\,(aq) + HC_2H_3O_2\,(aq) \rightarrow OH^-\,(l) + H\,C_2H_3O_2^+\,(aq) + K\,(s)$
B) $KOH\,(aq) + HC_2H_3O_2\,(aq) \rightarrow H_2O\,(l) + KC_2H_3O_2\,(aq)$
C) $KOH\,(aq) + HC_2H_3O_2\,(aq) \rightarrow H_2C_2H_3O_3\,(aq) + K\,(s)$
D) $KOH\,(aq) + HC_2H_3O_2\,(aq) \rightarrow KC_2H_3O_3\,(aq) + H_2\,(g)$
E) $KOH\,(aq) + HC_2H_3O_2\,(aq) \rightarrow H_2KC_2H_3O\,(aq) + O_2\,(g)$

29) The balanced reaction between aqueous nitric acid and aqueous strontium hydroxide is _____.

A) HNO_3 (aq) + $Sr(OH)_2$ (aq) → $Sr(NO_3)_2$ (aq) + H_2 (g)
B) HNO_3 (aq) + $Sr(OH)_2$ (aq) → H_2O (l) + $Sr(NO_3)_2$ (aq)
C) HNO_3 (aq) + SrOH (aq) → H_2O (l) + $SrNO_3$ (aq)
D) $2HNO_3$ (aq) + $Sr(OH)_2$ (aq) → $2\,H_2O$ (l) + $Sr(NO_3)_2$ (aq)
E) $2HNO_3$ (aq) + $Sr(OH)_2$ (aq) → $Sr(NO_3)_2$ (aq) + $2\,H_2$ (g)

30) In which reaction does the oxidation number of oxygen increase?
A) $Ba(NO_3)_2$ (aq) + K_2SO_4 (aq) → $BaSO_4$ (s) + 2 KNO_3 (aq)
B) HCl (aq) + NaOH (aq) → NaCl (aq) + H_2O (*l*)
C) MgO (s) + H_2O (*l*) → $Mg(OH)_2$ (s)
D) 2 SO_2 (g) + O_2 (g) → 2 SO_3 (g)
E) 2 H_2O (*l*) → 2 H_2 (g) + O_2 (g)

31) In which reaction does the oxidation number of hydrogen change?
A) HCl (aq) + NaOH (aq) → NaCl (aq) + H_2O (*l*)
B) 2 Na (s) + 2 H_2O (*l*) → 2 NaOH (aq) + H_2 (g)
C) CaO (s) + H_2O (*l*) → $Ca(OH)_2$ (s)
D) 2 $HClO_4$ (aq) + $CaCO_3$ (s) → $Ca(ClO_4)_2$ (aq) + H_2O (*l*) + CO_2 (g)
E) SO_2 (g) + H_2O (*l*) → H_2SO_3 (aq)

32) Which one of the following is <u>not</u> a valid value for the magnetic quantum number of an electron in a 5d subshell?
A) 2
B) -3
C) 0
D) 1
E) -1

33) Which of the subshell below does <u>not</u> exist due to the constraints upon the angular momentum quantum number?
A) 2d
B) 2s
C) 2p
D) all of the above
E) none of the above

34) Which of the subshells below do not exist due to the constraints upon the angular momentum quantum number?
A) 4f
B) 4d
C) 4p
D) 4s
E) All of the above do exist

35) An electron cannot have the quantum numbers n = _____, ℓ = _____, m_ℓ = _____.
A) 2, 0, 0
B) 2, 1, -1
C) 3, 1, -1
D) 1, 1, 1
E) 3, 2, 1

36) An electron cannot have the quantum numbers n = _____, ℓ = _____, m_ℓ = _____.
A) 6, 1, 0
B) 3, 2, 3
C) 3, 2, -2
D) 1, 0, 0
E) 3, 2, 1

37) Which one of the following is an incorrect subshell notation?
A) 4f
B) 2e
C) 3s
D) 2p
E) 3d

38) Which one of the following is an incorrect orbital notation?
A) 2s
B) $3p_y$
C) 3f
D) $4d_{xy}$
E) 4s

39) Which quantum number determines the energy of an electron in a hydrogen atom?
A) n
B) E
C) m_l
D) l
E) n and l

40) Which one of the quantum numbers does <u>not</u> result from the solution of the Schrodinger equation?
A) principal
B) azimuthal
C) magnetic
D) spin
E) angular momentum

41) Which quantum numbers must be the same for the orbitals that they designate to be degenerate in a one-electron system (such as hydrogen)?
A) n, l, and m_l
B) n and l only
C) l and m_l
D) m_l only
E) n only

42) In a p_x orbital, the subscript x denotes the _____ of the electron.
A) energy
B) spin of the electrons
C) probability of the shell
D) size of the orbital
E) axis along which the orbital is aligned

43) The _____ orbital is degenerate with $5p_y$ in a many-electron atom.
A) 5s
B) $5p_x$
C) $4p_y$
D) $5d_{xy}$
E) $5d^2$

44) At maximum, an f-subshell can hold _____ electrons, a d-subshell can hold _____ electrons, and a p-subshell can hold _____ electrons.
A) 14, 10, 6
B) 2, 8, 18
C) 14, 8, 2
D) 2, 12, 21
E) 2, 6, 10

45) If an electron has a principal quantum number (n) of 3 and an angular momentum quantum number (l) of 2, the subshell designation is _____.
A) 3p
B) 3d
C) 4s
D) 4p
E) 4d

46) Which one of the following represents an acceptable set of quantum numbers for an electron in an atom? (arranged as n, l, m_l, and m_s)

A) 2, 2, -1, -1/2
B) 1, 0, 0, 1/2
C) 3, 3, 3, 1/2
D) 5, 4,- 5, 1/2
E) 3, 3, 3, -1/2

47) Which one of the following represents an acceptable possible set of quantum numbers (in the order n, l, m_l, m_s) for an electron in an atom?

A) 2, 1, -1, 1/2
B) 2, 1, 0, 0
C) 2, 2, 0, 1/2
D) 2, 0, 1, -1/2
E) 2, 0, 2, +1/2

48) Which one of the following orbitals can hold two electrons?

A) $2p_x$
B) 3s
C) $4d_{xy}$
D) all of the above
E) none of the above

49) Which quantum numbers must be the same for the orbitals that they designate to be degenerate in a many-electron system?

A) n, l, and m_l
B) n only
C) n, l, m_l, and m_s
D) m_s only
E) n and l only

50) The effective nuclear charge of an atom is primarily affected by _____.

A) inner electrons
B) outer electrons
C) nuclear charge
D) electron distribution
E) orbital radial probability

SECTION B: Answer any TWO of the three questions

Question One

a) Consider solutions in which 0.1 mol of each of the following compounds is dissolved in 1 L of water $Ca(NO_3)_2$ (calcium nitrate), $C_6H_{12}O_6$ (glucose), $Al(NO_3)_3$ (aluminium nitrate), and $NaNO_3$ (sodium nitrate). Rank the solutions in order of increasing electrical conductivity, based on the fact that the greater the number of ions in solution, the greater the conductivity. **[4]**

b) For the reaction between aqueous solutions of sodium sulphate, Na_2SO_4, and barium chloride, $BaCl_2$, write (**a**) the balanced molecular equation, (**b**) the complete ionic equation, (**c**) the net ionic equation. **[6]**

c) Determine the oxidation state of the boldfaced element in **(a)** $NaHSO_4$, **(b)** BaO_2, **(c)** S_8, **[3]**

d) Calculate the molarity of a solution made by dissolving 23.4 g of sodium sulfate (Na_2SO_4) in enough water to form 125 mL of solution. **[4]**

c) Complete and balance the following equation for an oxidation-reduction reaction that occurs in basic solution:

$$Cr(OH)_3(s) + ClO^-(aq) \rightarrow CrO_4^{2-}(aq) + Cl_2(g)$$

[8]

Question Two

a) Predict the number of subshells in the fourth shell, that is, for $n = 4$. (**b**) Give the label for each of these subshells. (**c**) Give the orbitals that are in each of these subshells. **[8]**

b) Write the electron configuration of a chromium atom, atomic number 24. How many unpaired electrons does an chromium atom possess? **[5]**

c) What is the characteristic valence electron configuration of the group 17 elements, the halogens? Illustrate your answer with two examples. **[7]**

d) Write the electron configuration for (**a**) Ga, (**b**) Cu, and (**c**) As^{3-}. **[6]**

Question Three

a) In the isoelectronic series Rb^+, Sr^{2+}, Y^{3+}, which ion is largest? **[2]**

b) Referring to a periodic table, arrange the atoms Ne, Na, P, Ar, K in order of increasing first ionization energy. **[3]**

c) Write the balanced chemical equation for the reaction of solid selenium dioxide, $SeO_2(s)$, with water **[2]**

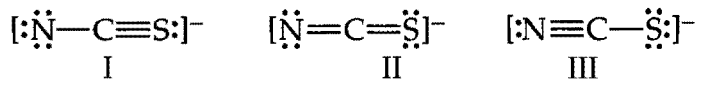
d) Write a balanced equation for the reaction of cesium metal with $O_2(g)$. **[2]**

e) Arrange the ionic compounds NaF, CsI, and CaO in order of increasing lattice energy. **[3]**

f) Predict the ion generally formed by **(a)** Sr, **(b)** S, **(c)** Al. **[3]**

g) Write the Lewis structure of XeF_4. Give the overall geometry of the molecule. **[5]**

h) Three possible Lewis structures for the thiocyanate ion, NCS^-, are



I II III

Determine the formal charges in each structure. Based on the formal charges, suggest which Lewis structure is the best. **[5]**

Useful relations

At 298.15 K, $RT = 2.4790$ kJ mol^{-1} and $RT/F = 25.693$ mV

1 atm = 101.325 kPa = 760 Torr (exactly)

1 bar = 10^5 Pa

1 eV = $1.602\,18 \times 10^{-19}$ J = 96.485 kJ mol^{-1} = 8065.5 cm^{-1}

1 cm^{-1} = 1.986×10^{-23} J = 11.96 J mol^{-1} = 0.1240 meV

1 cal = 4.184 J (exactly)

1 D (debye) = $3.335\,64 \times 10^{-30}$ C m

1 T = 10^4 G

1 Å (ångström) = 100 pm

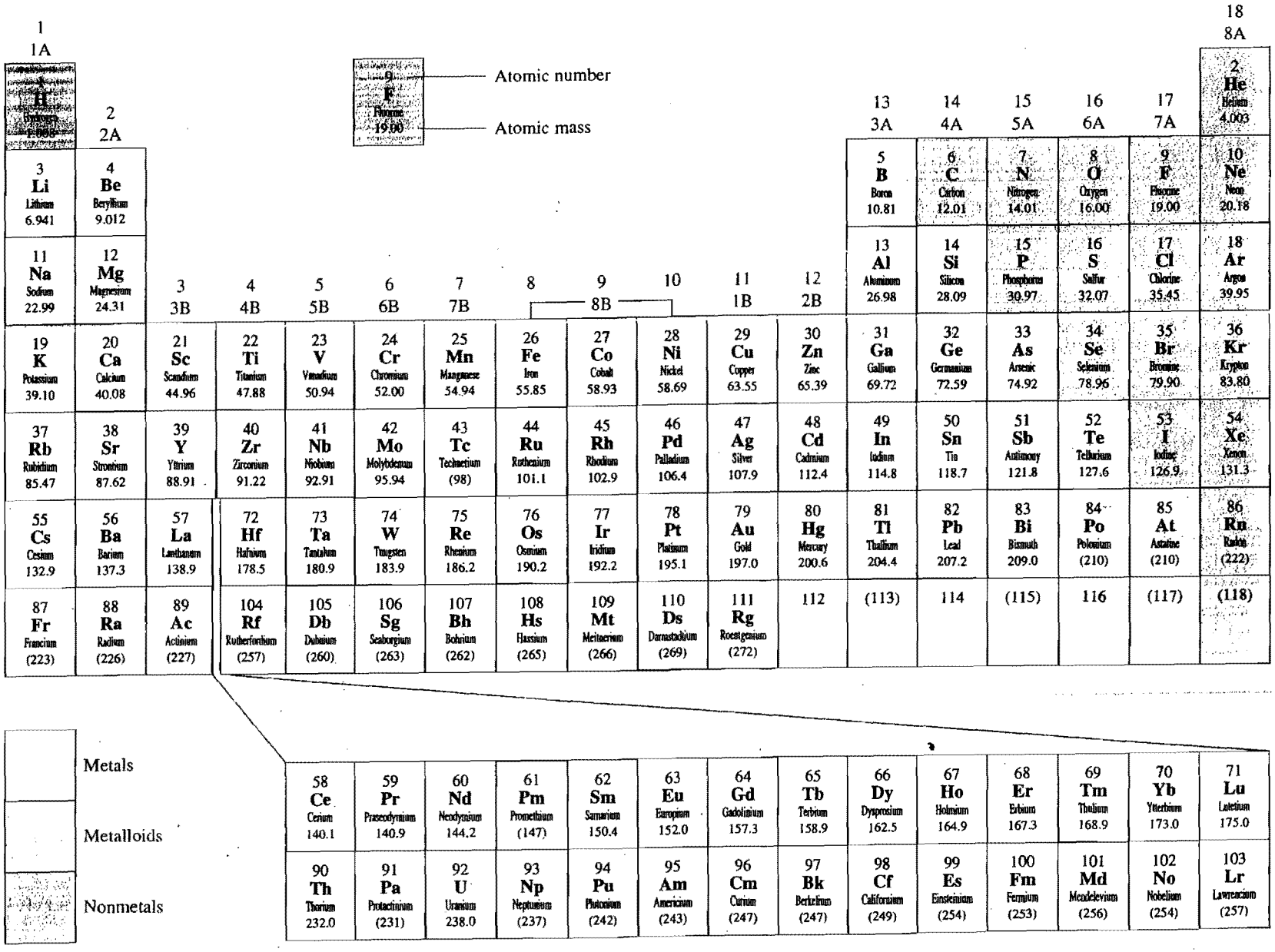
1 M = 1 mol dm^{-3}

General data and fundamental constants

	Quantity	Symbol	Value
*	Speed of light	c	$2.997\,925 \times 10^8$ m s^{-1}
*	Elementary charge	e	$1.602\,177 \times 10^{-19}$ C
	Faraday constant	$F = eN_A$	9.6485×10^4 C mol^{-1}
	Boltzmann constant	k	$1.380\,66 \times 10^{-23}$ J K^{-1} 8.6174×10^{-5} eV K^{-1}
*	Gas constant	$R = kN_A$	8.314 51 J K^{-1} mol^{-1} $8.205\,78 \times 10^{-2}$ dm^3 atm K^{-1} mol^{-1}
*	Planck constant	h	$6.626\,08 \times 10^{-34}$ J s
		$\hbar = h/2\pi$	$1.054\,57 \times 10^{-34}$ 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 of electron	m_e	$9.109\,39 \times 10^{-31}$ kg
*	Vacuum permittivity	ε_0	$8.854\,19 \times 10^{-12}$ J^{-1} C^2 m^{-1}
		$4\pi\varepsilon_0$	$1.112\,65 \times 10^{-10}$ J^{-1} C^2 m^{-1}
	Bohr magneton	$\mu_B = e\hbar/2m_e$	$9.274\,02 \times 10^{-24}$ J T^{-1}
*	Bohr radius	$a_0 = 4\pi\varepsilon_0\hbar^2/m_e e^2$	$5.291\,77 \times 10^{-11}$ m
*	Rydberg constant	$R_\infty = m_e e^4/8h^3 c\varepsilon_0^2$	~~$1.097\,37 \times 10^5$ cm^{-1}~~ $= 1.09737 \times 10^7$ m^{-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



The 1–18 group designation has been recommended by the International Union of Pure and Applied Chemistry (IUPAC) but is not yet in wide use. In this text we use the standard U.S. notation for group numbers (1A–8A and 1B–8B). No names have been assigned for elements 112, 114, and 116. Elements 113, 115, 117, and 118 have not yet been synthesized.

UNIVERSITY OF SWAZILAND

C111 MAIN EXAMINATION	DATE: December 2014
Course Title: Introductory Chemistry **ANSWER SHEET FOR SECTION A OF EXAM**	**Stud.** **ID No.**

INSTRUCTION: Place an X over the "box" corresponding to the correct answer

Q. No.							
1	A	B	C	D	E		
2	A	B	C	D	E		
3	A	B	C	D	E		
4	A	B	C	D	E		
5	A	B	C	D	E		
6	A	B	C	D	E		
7	A	B	C	D	E		
8	A	B	C	D	E		
9	A	B	C	D	E		
10	A	B	C	D	E		
11	A	B	C	D	E		
12	A	B	C	D	E		
13	A	B	C	D	E		
14	A	B	C	D	E		
15	A	B	C	D	E		
16	A	B	C	D	E		
17	A	B	C	D	E		
18	A	B	C	D	E		
19	A	B	C	D	E		
20	A	B	C	D	E		
21	A	B	C	D	E		
22	A	B	C	D	E		
23	A	B	C	D	E		
24	A	B	C	D	E		
25	A	B	C	D	E		

Q. No.							
26	A	B	C	D	E		
27	A	B	C	D	E		
28	A	B	C	D	E		
29	A	B	C	D	E		
30	A	B	C	D	E		
31	A	B	C	D	E		
32	A	B	C	D	E		
33	A	B	C	D	E		
34	A	B	C	D	E		
35	A	B	C	D	E		
36	A	B	C	D	E		
37	A	B	C	D	E		
38	A	B	C	D	E		
39	A	B	C	D	E		
40	A	B	C	D	E		
41	A	B	C	D	E		
42	A	B	C	D	E		
43	A	B	C	D	E		
44	A	B	C	D	E		
45	A	B	C	D	E		
46	A	B	C	D	E		
47	A	B	C	D	E		
48	A	B	C	D	E		
49	A	B	C	D	E		
50	A	B	C	D	E		