UNIVERSITY OF SWAZILAND

FINAL EXAMINATION 2013/14

TITLE OF PAPER: INTRODUCTORY CHEMISTRY I

COURSE NUMBER: C111

TIME: THREE (3) HOURS

INSTRUCTIONS:

(i) Answer **all questions** in section A (total 50 marks)
(ii) Answer **any 2 questions** in section B (Each question is 25 marks)

Non-programmable electronic calculators may be used.

A data sheet, a periodic table and answer sheet for section A are attached

DO NOT OPEN THIS PAPER UNTIL PERMISSION TO DO SO IS GRANTED BY THE CHIEF INVIGILATOR.

SECTION A (50 Marks)

This section consists of multiple choice questions. Correct answer must be indicated by putting a circle around the letter for that answer on the answer sheet provided. If you change your answer, please cancel the wrong answer with a cross and then put a circle around the correct one. If more than one option has a circle around it a zero will be given for that question. Attempt all 50 questions.

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1. A small amount of oil added to water is an example of a _____.
   (A) homogeneous mixture (B) heterogeneous mixture (C) compound
   (D) pure substance (E) solid

2. Which one of the following has the element name and symbol correctly matched?
   (A) S, sodium (B) Tn, tin (C) Ir, iron (D) Ne, neon (E) B, bromine

3. 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) be a pure substance
   (E) interact with other elements to form compounds

4. Which of the following has the same number of significant figures as the number 1.00310?
   (A) 1×10^6 (B) 199.791 (C) 8.66 (D) 5.1149 (E) 100

5. Consider the following selected postulates of Dalton's atomic theory:
   (i) Each element is composed of extremely small particles called atoms.
   (ii) Atoms are indivisible.
   (iii)Atoms of a given element are identical.
   (iv)Atoms of different elements are different and have different properties.
   Which of the postulates is(are) no longer considered valid?
   (A) (i) and (ii) (B) (ii) only (C) (ii) and (iii) (D) (iii) only (E) (iii) and (iv)

6. The gold foil experiment performed in Rutherford's lab _____.
   (A) confirmed the plum-pudding model of the atom
   (B) led to the discovery of the atomic nucleus
   (C) was the basis for Thomson's model of the atom
   (D) utilized the deflection of beta particles by gold foil
   (E) proved the law of multiple proportions

7. All atoms of a given element have the same _____.
   (A) mass (B) number of protons (C) number of neutrons
   (D) number of electrons and neutrons (E) density

8. 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

9. In the symbol ${}^{x}_{6}C$, x is _____.
(A) the number of neutrons (B) the atomic number (C) the mass number
(D) the isotope number (E) the elemental symbol

10. Isotopes are atoms that have the same number of ___ but differing number of ____.
(A) protons, electrons (B) neutrons, protons (C) protons, neutrons
(D) electrons, protons (E) neutrons, electrons

11. Elements _____ exhibit similar physical and chemical properties.
(A) with similar chemical symbols (B) in the same period of the periodic table
(C) with similar atomic masses (D) on opposite sides of the periodic table
(E) in the same group of the periodic table

12. Which pair of elements is most apt to form a molecular compound with each other?
(A) aluminum, oxygen (B) magnesium, iodine (C) sulfur, fluorine
(D) potassium, lithium (E) barium, bromine

13. Which species below is the nitride ion?
(A) Na^+ (B) NO_3^- (C) NO_2^- (D) NH_4^+ (E) N^{3-}

14. Barium reacts with a polyatomic ion to form a compound with the general formula $Ba_3(X)_2$. What would be the most likely formula for the compound formed between sodium and the polyatomic ion X?
(A) NaX (B) Na_2X (C) Na_2X_2 (D) Na_3X (E) Na_3X_2

15. Which one of the following compounds is chromium(III) oxide?
(A) Cr_2O_3 (B) CrO_3 (C) Cr_3O_2 (D) Cr_3O (E) Cr_2O_4

16. The correct name for MgF_2 is _____.
(A) monomagnesium difluoride (B) magnesium difluoride
(C) manganese difluoride (D) manganese bifluoride (E) magnesium fluoride

17. When the following equation is balanced, the coefficients are _____.
$C_8H_{18} + O_2 \rightarrow CO_2 + H_2O$
(A) 2, 3, 4, 4 (B) 1, 4, 8, 9 (C) 2, 12, 8, 9 (D) 4, 4, 32, 36
(E) 2, 25, 16, 18

18. The formula weight of aluminum sulfate ($Al_2(SO_4)_3$) is _____u.
(A) 342.15 (B) 123.04 (C) 59.04 (D) 150.14 (E) 273.06

19. The mass % of Al in aluminum sulfate ($Al_2(SO_4)_3$) is _____.
(A) 7.886 (B) 15.77 (C) 21.93 (D) 45.70 (E) 35.94

20. A 30.5 gram sample of glucose ($C_6H_{12}O_6$) contains _____ mol of glucose.
(A) 0.424 (B) 0.169 (C) 5.90 (D) 2.36 (E) 0.136

21. A 30.5 gram sample of glucose ($C_6H_{12}O_6$) contains _____ atoms of carbon.
(A) 1.02×10^{23} (B) 6.12×10^{23} (C) 6.02×10^{23} (D) 2.04×10^{23} (E) 1.22×10^{24}

22. How many sulfur dioxide molecules are there in 0.180 mol of sulfur dioxide?
(A) 1.80×10^{23} (B) 6.02×10^{24} (C) 6.02×10^{23} (D) 1.08×10^{24}
(E) 1.08×10^{23}

23. Which of the following is insoluble in water at 25 °C?
(A) $Mg_3(PO_4)_2$ (B) Na_2S (C) $(NH_4)_2CO_3$ (D) $Ca(OH)_2$ (E) $Ba(C_2H_3O_2)_2$

24. Which combination will produce a precipitate?
(A) $NaC_2H_3O_2(aq)$ and $HCl(aq)$ (B) $NaOH(aq)$ and KCl aq)
(C) $AgNO_3(aq)$ and $Ca(C_2H_3O_2)_2(aq)$ (D) KOH aq) and $Mg(NO_3)_2(aq)$
(E) $NaOH(aq)$ and $HCl(aq)$

25. The reaction between strontium hydroxide and chloric acid produces _____.
(A) a molecular compound and a weak electrolyte (B) two weak electrolytes
(C) two strong electrolytes (D) a molecular compound and a strong electrolyte
(E) two molecular compounds

26. Which of the following are weak acids?
(A) HF, HBr (B) HI, HNO_3, HBr (C) HI, HF (D) HF

(E) none of the above

27. The balanced reaction between aqueous potassium hydroxide and aqueous acetic acid is _____.
(A) $KOH(aq) + HC_2H_3O_2(aq) \rightarrow OH^-(l) + HC_2H_3O_2^+(aq) + K(s)$
(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) $KOH(aq) + HC_2H_3O_2(aq) \rightarrow H_2KC_2H_3O(aq) + O_2(g)$

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

29. In which species does nitrogen have the highest oxidation number?
(A) N_2 (B) NH_3 (C) HNO_2 (D) NO_2^- (E) $NaNO_3$

30. What are the respective concentrations (M) of Mg^{+2} and $C_2H_3O_2^-$ afforded by dissolving 0.600 mol $Mg(C_2H_3O_2)_2$ in water and diluting to 135 mL?
(A) 0.444 and 0.889 (B) 0.0444 and 0.0889 (C) 0.889 and 0.444
(D) 0.444 and 0.444 (E) 4.44 and 8.89

31. A 0.100 M solution of _____ will contain the highest concentration of potassium ions.
(A) potassium phosphate (B) potassium hydrogen carbonate
(C) potassium hypochlorite (D) potassium iodide
(E) potassium oxide

32. The wavelength of light that has a frequency of $1.20 \times 10^{13} s^{-1}$ is _____ m.
(A) 25.0 (B) 2.50×10^{-5} (C) 0.0400 (D) 12.0 (E) 2.5

33. The wavelength of a photon that has an energy of 6.33×10^{-18} J is _____ m.
(A) 3.79×10^{-7} (B) 3.10×10^{-8} (C) 2.38×10^{23} (D) 4.21×10^{-24} (E) 9.55×10^{15}

34. Calculate the energy (J) change associated with an electron transition from n = 2 to n = 5 in a hydrogen atom.
(A) 6.5×10^{-19} (B) 5.5×10^{-19} (C) 8.7×10^{-20} (D) 4.6×10^{-19}
(E) 5.8×10^{-53}

35. The de Broglie wavelength of an electron is 8.7×10^{-11} m. The mass of an electron is 9.1×10^{-31} kg. The velocity of this electron is _____ m/s.
(A) 8.4×10^{-3} (B) 1.2×10^{-7} (C) 6.9×10^{-5} (D) 8.4×10^{6} (E) 8.4×10^{-3}

36. The _____ quantum number defines the shape of an orbital.
(A) spin (B) magnetic (C) principal (D) angular momentum (E) psi

37. The n = 1 shell contains _____ p orbitals. All the other shells contain _____ p orbitals.
(A) 3, 6 (B) 0, 3 (C) 6, 2 (D) 3, 3 (E) 0, 6

38.) Each d-subshell can accommodate a maximum of _____ electrons.
(A) 6 (B) 2 (C) 10 (D) 3 (E) 5

39. $[Ar]4s^2 3d^{10} 4p^3$ is the electron configuration of a(n) _____ atom.

(A) As (B) V (C) P (D) Sb (E) Sn

40. The correct ground-state electron configuration for molybdenum is _____.

(A) $[Kr]5s^1 4d^{10}$ (B) $[Kr]5s^2 4d^4$ (C) $[Kr]5s^1 4d^5$ (D) $[Kr]5s^2 4d^5$
(E) $[Kr]5s^2 4d^9$

41. Which group in the periodic table contains elements with the valence electron configuration of $ns^2 np^1$?
(A) 1 (B) 2 (C) 13 (D) 14 (E) 18

42. In which set of elements would all members be expected to have very similar chemical properties?
(A) O, S, Se (B) N, O, F (C) Na, Mg, K (D) S, Se, Si (E) Ne, Na, Mg

43. Electrons in the 1s subshell are much closer to the nucleus in Ar than in He due to the larger _____ in Ar.
(A) nuclear charge (B) paramagnetism (C) diamagnetism
(D) Hund's rule (E) azimuthal quantum number

44. The atomic radius of main-group elements generally increases down a group because _____.
(A) effective nuclear charge increases down a group
(B) effective nuclear charge decreases down a group
(C) effective nuclear charge zigzags down a group
(D) the principal quantum number of the valence orbitals increases
(E) both effective nuclear charge increases down a group and the principal quantum number of the valence orbitals increases

45. Which one of the following atoms has the largest radius?
(A) O (B) F (C) S (D) Cl (E) Ne

46. Of the choices below, which gives the order for first ionization energies?
(A) Cl > S > Al > Ar > Si (B) Ar > Cl > S > Si > Al
(C) Al > Si > S > Cl > Ar (D) Cl > S > Al > Si > Ar
(E) S > Si > Cl > Al > Ar

47. Which of the following correctly represents the second ionization of aluminum?
(A) $Al^+(g) + e^- \rightarrow Al(g)$ (B) $Al(g) \rightarrow Al^+(g) + e^-$
(C) $Al^-(g) + e^- \rightarrow Al^{2-}(g)$ (D) $Al^+(g) + e^- \rightarrow Al^{2+}(g)$
(E) $Al^+(g) \rightarrow Al^{2+}(g) + e^-$

48. Which ion below has the largest radius?
(A) Cl^- (B) K^+ (C) Br^- (D) F^- (E) Na^+

49. In the Lewis symbol for a sulfur atom, there are ____ paired and ____ unpaired electrons.
(A) 2, 2 (B) 4, 2 (C) 2, 4 (D) 0, 6 (E) 5, 1

50. The central atom in _____ violates the octet rule.
(A) NH_3 (B) SeF_2 (C) BF_3 (D) AsF_3 (E) CF_4

Please insert your answer sheet inside the answer book used for section B.

SECTION B (50 Marks)

There are three questions in this section. Each question is worth 25 marks. Answer any two questions. In all calculations answers must have the correct number of significant figures and correct units.

Question 1 (25 marks)

(a) Consider the following molecules: BF_3, KrF_2 and PF_5. Draw the Lewis structure of each molecule and use VSEPR theory to predict the shape. [9]

(b) Use VSEPR theory to predict the shape of the following oxoanions: ClO_3^-, ClO_4^- and ClO_2^-. [9]

(c) Draw three resonance structures of the cyanate anion, NCO^-, (C is central atom). Calculate the formal charge on each atom in each structure and hence indicate which is the most important structure. [7]

Question 2 (25 marks)

(a) Sulfur and oxygen react to produce sulfur trioxide. In a particular experiment, 7.9 grams of SO_3 are produced by the reaction of 5.0 grams of O_2 with 6.0 grams of S. What is the % yield of SO_3 in this experiment?

$$S(s) + O_2(g) \rightarrow SO_3(g) \text{ (not balanced)}$$ [9]

(b) What is the empirical formula of a compound that contains 49.4% K, 20.3% S, and 30.3% O by mass? [6]

(c) Combustion of a 1.031-g sample of a compound containing only carbon, hydrogen, and oxygen produced 2.265 g of CO_2 and 1.236 g of H_2O. What is the empirical formula of the compound? [10]

Question 3 (25 marks)

(a) Write the molecular equation and the net ionic equation for the formation of an aqueous solution of NiI_2 and evolution of CO_2 gas when solid $NiCO_3$ is mixed with aqueous hydriodic acid. [4]

(b) Suggest two aqueous solutions that can be used to prepare iron(II) phosphate. Write the net ionic equation for the precipitation reaction. [4]

(c) What mass (g) of AgBr is formed when 35.5 mL of 0.184 M $AgNO_3$ is treated with an excess of aqueous hydrobromic acid? [5]

(d) What volume (L) of 0.250 M H_2SO_4 is required to neutralize a solution prepared by dissolving 17.5 g of NaOH in 350 mL of water? [5]

(e) Pure acetic acid ($HC_2H_3O_2$) is a liquid and is known as glacial acetic acid. Calculate the molarity of a solution prepared by dissolving 10.00 mL of glacial acetic acid at 25 °C in sufficient water to give 500.0 mL of solution. The density of glacial acetic acid at 25 °C is 1.05 g/mL. [7]

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
	$\hbar = h/2\pi$	$1.054\ 57 \times 10^{-34}$ 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		
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}

PERIODIC TABLE OF ELEMENTS

GROUPS

PERIODS	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIIIB	10	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											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

TRANSITION ELEMENTS

*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.

UNIVERSITY OF SWAZILAND

C111 SECTION A ANSWER SHEET

STUDENT ID NUMBER:_____

Correct answer must be indicated by putting a circle around the letter for that answer on the answer sheet provided. If you change your answer, please cancel the wrong answer with a cross and then put a circle around the correct one. If more than one option has a circle around it a zero will be given for that question.

1	A	B	C	D	E		26	A	B	C	D	E
2	A	B	C	D	E		27	A	B	C	D	E
3	A	B	C	D	E		28	A	B	C	D	E
4	A	B	C	D	E		29	A	B	C	D	E
5	A	B	C	D	E		30	A	B	C	D	E
6	A	B	C	D	E		31	A	B	C	D	E
7	A	B	C	D	E		32	A	B	C	D	E
8	A	B	C	D	E		33	A	B	C	D	E
9	A	B	C	D	E		34	A	B	C	D	E
10	A	B	C	D	E		35	A	B	C	D	E
11	A	B	C	D	E		36	A	B	C	D	E
12	A	B	C	D	E		37	A	B	C	D	E
13	A	B	C	D	E		38	A	B	C	D	E
14	A	B	C	D	E		39	A	B	C	D	E
15	A	B	C	D	E		40	A	B	C	D	E
16	A	B	C	D	E		41	A	B	C	D	E
17	A	B	C	D	E		42	A	B	C	D	E
18	A	B	C	D	E		43	A	B	C	D	E
19	A	B	C	D	E		44	A	B	C	D	E
20	A	B	C	D	E		45	A	B	C	D	E
21	A	B	C	D	E		46	A	B	C	D	E
22	A	B	C	D	E		47	A	B	C	D	E
23	A	B	C	D	E		48	A	B	C	D	E
24	A	B	C	D	E		49	A	B	C	D	E
25	A	B	C	D	E		50	A	B	C	D	E