UNIVERSITY OF SWAZILAND

SUPPLEMENTARY 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.

1. The law of constant composition applies to __________.
   (A) solutions (B) heterogeneous mixtures (C) compounds
   (D) homogeneous mixtures (E) solids

2. Which one of the following has the element name and symbol correctly matched?
   (A) Ti, tin (B) C, copper (C) Mn, manganese
   (D) Si, silver (E) Sn, silicon

3. Which one of the following is not an intensive property?
   (A) density (B) temperature (C) melting point (D) mass (E) boiling point

4. Precision refers to __________.
   (A) how close a measured number is to other measured numbers
   (B) how close a measured number is to the true value
   (C) how close a measured number is to the calculated value
   (D) how close a measured number is to zero
   (E) how close a measured number is to infinity

5. A molecule of water contains hydrogen and oxygen in a 1:8 ratio by mass. This is a statement of __________.
   (A) the law of multiple proportions (B) the law of constant composition
   (C) the law of conservation of mass (D) the law of conservation of energy
   (E) none of the above

6. Which one of the following is not true concerning cathode rays?
   (A) They originate from the negative electrode.
   (B) They travel in straight lines in the absence of electric or magnetic fields.
   (C) They impart a negative charge to metals exposed to them.
   (D) They are made up of electrons.
   (E) The characteristics of cathode rays depend on the material from which they are emitted.

7. 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

8. 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

9. In the symbol , $^{x}_{6}C$, $x =$ __________.
   (A) 19 (B) 13 (C) 6 (D) 7 (E) not enough information to determine

10. In the periodic table, the elements are arranged in __________.
(A) alphabetical order
(B) order of increasing atomic number
(C) order of increasing metallic properties
(D) order of increasing neutron content
(E) reverse alphabetical order

11. Which pair of elements would you expect to exhibit the greatest similarity in their physical and chemical properties?
(A) O, S (B) C, N (C) K, Ca (D) H, He (E) Si, P

12. Which pair of elements is most apt to form an ionic compound with each other?
(A) barium, bromine (B) calcium, sodium (C) oxygen, fluorine
(D) sulphur, fluorine (E) nitrogen, hydrogen

13. Which species below is the sulphite ion?
(A) HSO_3^{-2} (B) SO_3^{-2} (C) S^{2-} (D) SO_4^{-2} (E) HS^-

14. Aluminium reacts with a certain non-metallic element to form a compound with the general formula Al_2X_3. Element X must be from Group __________ of the Periodic Table of Elements.
(A) 13 (B) 14 (C) 15 (D) 16 (E) 17

15. Which one of the following compounds is copper(I) chloride?
(A) $CuCl$ (B) $CuCl_2$ (C) Cu_2Cl (D) Cu_2Cl_3 (E) Cu_3Cl_2

16. The correct name for $NaHCO_3$ is __________.
(A) sodium hydride (B) persodium carbonate (C) persodium hydroxide
(D) sodium hydrogen carbonate (E) carbonic acid

17. When the following equation is balanced, the coefficients are __________.
$NH_3(g) + O_2(g) \rightarrow NO_2(g) + H_2O$
(A) 1, 1, 1, 1 (B) 4, 7, 4, 6 (C) 2, 3, 2, 3 (D) 1, 3, 1, 2
(E) 4, 3, 4, 3

18. The formula weight of potassium dichromate ($K_2Cr_2O_7$) is __________ u.
(A) 107.09 (B) 255.08 (C) 242.18 (D) 294.18 (E) 333.08

19. What is the mass % of carbon in dimethylsulfoxide (C_2H_6SO) rounded to three significant figures?
(A) 60.0 (B) 20.6 (C) 30.7 (D) 7.74 (E) 79.8

20. One million argon atoms is __________ mol (rounded to two significant figures) of argon atoms.
(A) 3.0 (B) 1.7×10^{-18} (C) 6.0×10^{23} (D) 1.0×10^{-6} (E) $1.0 \times 10^{+6}$

21. A sample of CH_2F_2 with a mass of 19 g contains __________ atoms of F.
(A) 2.2×10^{23} (B) 38 (C) 3.3×10^{24} (D) 4.4×10^{23} (E) 9.5

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

23. Which of the following is soluble in water at 25 °C?
(A) $Fe_3(PO4)_2$ (B) $Fe(OH)_2$ (C) $Fe(NO_3)_2$ (D) $FeCO_3$ (E) FeS

24. Which combination will produce a precipitate?
(A) $NH_4OH(aq)$ and $HCl(aq)$ (B) $AgNO_3(aq)$ and $Ca(C_2H_3O_2)_2(aq)$
(C) $NaOH(aq)$ and $HCl(aq)$ (D) $NaCl(aq)$ and $HC_2H_3O_2(aq)$
(E) $NaOH(aq)$ and $Fe(NO_3)_2(aq)$

25. The net ionic equation for the reaction between aqueous sulphuric acid and aqueous sodium hydroxide is _________.
(A) $H^+(aq) + HSO_4^-(aq) + 2OH^-(aq) \rightarrow 2\,H_2O(l) + SO_4^{2-}(aq)$
(B) $H^+(aq) + HSO_4^-(aq) + 2\,Na^+(aq) + 2OH^-(aq) \rightarrow 2\,H_2O(l) + 2Na^+(aq) + SO_4^{2-}(aq)$
(C) $SO_4^{2-}(aq) + 2Na^+(aq) \rightarrow 2Na^+(aq) + SO_4^{2-}(aq)$
(D) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$
(E) $2H^+(aq) + SO_4^{2-}(aq) + 2Na^+(aq) + 2OH^-(aq) \rightarrow 2\,H_2O(l) + 2Na^+(aq) + SO_4^{2-}(aq)$

26. 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.

27. The balanced reaction between aqueous nitric acid and aqueous strontium hydroxide is__
(A) $HNO_3(aq) + Sr(OH)_2(aq) \rightarrow Sr(NO_3)_2(aq) + H_2(g)$
(B) $HNO_3(aq) + Sr(OH)_2(aq) \rightarrow H_2O(l) + Sr(NO_3)_2(aq)$
(C) $HNO_3(aq) + SrOH(aq) \rightarrow H_2O(l) + SrNO_3(aq)$
(D) $2HNO_3(aq) + Sr(OH)_2(aq) \rightarrow 2\,H_2O(l) + Sr(NO_3)_2(aq)$
(E) $2HNO_3(aq) + Sr(OH)_2(aq) \rightarrow Sr(NO_3)_2(aq) + 2\,H_2(g)$

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

29. In which species does sulphur have the highest oxidation number?
(A) S_8 (elemental form of sulphur) (B) H_2S (C) SO_2 (D) H_2SO_3 (E) K_2SO_4

30. Which one of the following is not true concerning 2.00 L of 0.100 M solution of $Ca_3(PO_4)_2$?
(A) This solution contains 0.200 mol of $Ca_3(PO_4)_2$.
(B) This solution contains 0.800 mol of oxygen atoms.
(C) 1.00 L of this solution is required to furnish 0.300 mol of Ca^{2+} ions.
(D) There are 6.02×10^{22} phosphorus atoms in 500.0 mL of this solution.
(E) This solution contains 0.600 mol of Ca^{2+}.

31. Which solution contains the largest number of moles of chloride ions?
(A) 10.0 mL of 0.500M $BaCl_2$ (B) 4.00 mL of 1.000M NaCl
(C) 7.50 mL of 0.500M $FeCl_3$ (D) 25.00 mL of 0.400M KCl
(E) 30.00 mL of 0.100M $CaCl_2$

32. What is the frequency (s^{-1}) of electromagnetic radiation that has a wavelength of 0.53 m?
(A) 5.7×10^{8} (B) 1.8×10^{-9} (C) 1.6×10^{8} (D) 1.3×10^{-33} (E) 1.3×10^{33}

33. The wavelength of a photon that has an energy of 5.25×10^{-19} J is __________ m.
(A) 3.79×10^{-7} (B) 2.64×10^{6} (C) 2.38×10^{23} (D) 4.21×10^{-24} (E) 3.79×10^{7}

34. The frequency of electromagnetic radiation required to promote an electron from n = 2 to n = 4 in a hydrogen atom is __________ Hz.
(A) 4.13×10^{-19} (B) 6.17×10^{14} (C) 5.46×10^{-19} (D) 8.22×10^{14} (E) 4.13×10^{19}

35. At what speed (m/s) must a 3.0-mg object be moving in order to have a de Broglie wavelength of 5.4×10^{-29} m?
(A) 1.6×10^{-28} (B) 3.9×10^{-4} (C) 2.0×10^{12} (D) 4.1 (E) 6.3

36. The __________ subshell contains only one orbital.
(A) 5d (B) 6f (C) 4s (D) 3d (E) 1p

37. The total number of orbitals in a shell is given by __________.
(A) l^2 (B) n^2 (C) 2n (D) 2n + 1 (E) $2l + 1$

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

39. [Ne] $3s^23p^3$ is the electron configuration of a(n) __________ atom.
(A) As (B) V (C) P (D) Sb (E) Sn

40. The ground state electron configuration for Zn is __________.
(A) [Kr]$4s^23d^{10}$ (B) [Ar]$4s^23d^{10}$ (C) [Ar]$4s^13d^{10}$ (D) [Ar]$3s^23d^{10}$ (E) [Kr]$3s^23d^{10}$

41. Elements in group __________ have a np^6 electron configuration in the outer shell.
(A) 14 (B) 16 (C) 17 (D) 18 (E) 15

42. In which set of elements would all members be expected to have very similar chemical properties?
(A) P, Se, I (B) Cl, Br, Na (C) Si, As, Te (D) Ne, Na, Mg (E) Br, I, At

43. Screening of the nuclear charge by core electrons in atoms is __________.
(A) less efficient than that by valence electrons
(B) more efficient than that by valence electrons
(C) essentially identical to that by valence electrons
(D) responsible for a general decrease in atomic radius going down a group
(E) both essentially identical to that by valence electrons and responsible for a general decrease in atomic radius going down a group

44. Atomic radius generally increases as we move _________.
(A) down a group and from right to left across a period
(B) up a group and from left to right across a period
(C) down a group and from left to right across a period
(D) up a group and from right to left across a period
(E) down a group; the period position has no effect

45. ________ is isoelectronic with argon and _________ is isoelectronic with neon.
(A) Cl^-, F^- (B) Cl^-, Cl^+ (C) F^+, F^- (D) Ne^-, Kr^+ (E) Ne-, Ar^+

46. _________ have the lowest first ionization energies of the groups listed.
(A) Alkali metals (B) Transition elements (C) Halogens
(D) Alkaline earth metals (E) Noble gases

47. Which equation correctly represents the first ionization of phosphorus?
(A) $P(g) + e^- \rightarrow P^-(g)$ (B) $P(g) \rightarrow P^-(g) + e^-$
(C) $P(g) \rightarrow P^+(g) + e^-$ (D) $P^-(g) \rightarrow P(g) + e^-$
(E) $P^+(g) + e^- \rightarrow P(g)$

48. Of the following species, _________ has the largest radius.
(A) Rb^+ (B) Sr^{2+} (C) Br^- (D) Kr (E) Ar

49. The central atom in _________ does not violate the octet rule.
(A) SF_4 (B) KrF_2 (C) CF_4 (D) XeF_4 (E) ICl_4^-

50. What is the maximum number of double bonds that a hydrogen atom can form?
(A) 0 (B) 1 (C) 2 (D) 3 (E) 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) Draw Lewis structures of the following species and use VSEPR theory to predict their shapes; SO_2, SO_3 and SeF_4. [9]

(b) Draw the Lewis structure of NO_2, NO_2^+, and NO_2^-. In each case calculate the formal charge on the central N atom. [9]

(c) Determine whether the following molecules are polar or non-polar: AsH_3, SF_6, HI, [7]

Question 2 (25 marks)

(a) Propane (C_3H_8) reacts with oxygen in the air to produce carbon dioxide and water. In a particular experiment, 38.0 grams of carbon dioxide are produced from the reaction of 22.05 grams of propane with excess oxygen. What is the % yield in this reaction? [9]

(b) What is the empirical formula of a compound that contains 29% Na, 41% S, and 30% O by mass? [6]

(c) Combustion of a 0.9835-g sample of a compound containing only carbon, hydrogen, and oxygen produced 1.900 g of CO_2 and 1.070 g of H_2O. What is the empirical formula of the compound? [10]

Question 3 (25 marks)

(a) Write the molecular and the net ionic equation for the formation of an aqueous solution of $Al(NO_3)_3$ when solid $Al(OH)_3$ is mixed with aqueous nitric acid. [4]

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

(c) What mass (g) of CaF_2 is formed when 47.8 mL of 0.334 M NaF is treated with an excess of aqueous calcium nitrate? [5]

(d) An aliquot (28.7 mL) of a KOH solution required 31.3 mL of 0.118 M HCl for neutralization. What mass (g) of KOH was in the original sample? [5]

(e) A solution is prepared by adding 1.60 g of solid NaCl to 50.0 mL of 0.100 M $CaCl_2$. What is the molarity of chloride ion in the final solution? Assume that the volume of the final solution is 50.0 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	$F = N_A e$	$9.6485 \times 10^{4}\ C\ mol^{-1}$
Boltzmann constant	k	$1.380\,66 \times 10^{-23}\ J\ K^{-1}$
Gas constant	$R = N_A k$	$8.314\,51\ J\ K^{-1}\ mol^{-1}$
		$8.205\,78 \times 10^{-2}\ dm^{3}\ atm\ K^{-1}\ mol^{-1}$
		$6.2364 \times 10\ L\ Torr\ K^{-1}\ mol^{-1}$
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	=	$1 \times 10^{-7}\ J$
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	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB			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										Atomic mass → **Symbol** → Atomic No. →	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	28.086 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								

*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