UNIVERSITY OF SWAZILAND

SUPPLEMENTARY EXAMINATION 2012/13

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. The symbol for the element tungsten is __________.
   (A) At (B) Tn (C) W (D) Ta (E) none of these

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

3. Which one of the following has the element name and symbol correctly matched?
   (A) S, sodium (B) Sn, tin (C) Ir, iron (D) N, neon (E) Fl, fluorine

4. Which one of the following is a pure substance?
   (A) blood (B) sea water (C) sweetened water (D) liquid mercury
   (E) beer

5. Which of the following are chemical processes?
   1. burning hydrogen
   2. melting ice
   3. decomposition of calcium carbonate
   4. dissolving salt in water

   (A) 2, 3, 4 (B) 1, 3, 4 (C) 1, 3 (D) 1, 2 (E) 1, 4

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

7. Which atom has the smallest number of neutrons?
   (A) carbon-14 (B) nitrogen-14 (C) oxygen-16 (D) fluorine-19
   (E) neon-20

8. There are __________ electrons, __________ protons, and __________ neutrons in an atom of ${}^{34}_{16}S$.
   (A) 16,16,34 (B) 16,16,18 (C) 18,18, 34 (D) 18, 18, 16
   (E) 16,16,20

9. The element X has two naturally occurring isotopes. The masses (amu) and % abundances of the isotopes are given in the Table below. The average atomic mass of the element is __________ amu.

Isotope	Abundance (%)	Mass (amu)
^{79}Br	50.54	78.9183
^{81}Br	49.46	80.9163

(A) 78.91 (B) 79.87 (C) 79.91 (D) 80.92 (E) 79.19

10. Of the following, only __________ is **not** a metal.
(A) Rb (B) Zn (C) Si (D) Pb (E) Li

11. An element in the bottom left corner of the periodic table __________.
(A) is either a metal or metalloid (B) is definitely a metal
(C) is either a metalloid or a non-metal (D) is definitely a non-metal
(E) is definitely a metalloid

12. Which one of the following molecular formulas is also an empirical formula?
(A) $C_{12}H_{12}O_4$ (B) H_2O (C) C_4H_8 (D) $C_{10}H_8$ (E) Hg_2Cl_2

13. Which species has largest number of electrons?
(A) $^{118}_{50}Sn^{2+}$ (B) $^{114}_{49}In$ (C) $^{126}_{52}Te^{2-}$ (D) $^{112}_{48}Cd$ (E) $^{132}_{54}Xe^{2+}$

14. Which of the following compounds would you expect to be ionic?
(A) C_4H_8 (B) $FeSO_4$ (C) $SiCl_4$ (D) Cl_2O (E) SO_3

15. Which species below is the sulphide ion?
(A)PO_3^{3-} (B) S^{2-} (C) SO_3^{2-} (D) P^{3-} (E) SO_4^{2-}

16. Which formula/name pair is **incorrect**?
(A) $Fe_3(PO_4)_2$ iron(II) phosphate (B) $Fe_2(SO_3)_3$ iron(III) sulphite
(C) $Fe_3(PO_3)_2$ iron(II) phosphide (D) $FeSO_3$ iron(II) sulphite
(E) $FePO_4$ iron(III) phosphate

17. When the following equation is balanced, the coefficients are __________.

$NH_3\ (g) + O_2\ (g) \rightarrow NO_2\ (g) + H_2O\ (g)$

(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. There are __________ sulphur atoms in 25 molecules of $C_4H_4S_2$.
(A) 50 (B) 3.8×10^{24} (C) 6.0×10^{25} (D) 100 (E) 1.5×10^{25}

19. The formula of ammonium sulphate is $(NH_4)_2SO_4$. The molecular weight of this compound is ______ amu.
(A) 128.02 (B) 132.14 (C) 114.09 (D) 118.07 (E) 98.64

20. The mass % of H in methane C_2H_8 is __________.
(A) 25.13 (B) 4.032 (C) 74.87 (D) 92.26 (E) 7.743

21. One mole of __________ contains the largest number of atoms.
(A) $(NH_4)_2SO_4$ (B) C_6H_6 (C) $Al(NO_3)_3$ (D) Na_3PO_4 (E) H_2O_2

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

23. How many grams of sodium carbonate contain 0.100 mol carbon atoms?
(A) 21.2 g (B) 106 g (C) 5.30 g (D) 212 g (E) 10.6 g

24. Which of the following are weak electrolytes?
HCl, $HC_2H_3O_2$, NH_3, KCl
(A) HCl, KCl (B) HCl, NH_3, KCl (C) $HC_2H_3O_2$, NH_3
(D) HCl, $HC_2H_3O_2$, KCl (E) $HC_2H_3O_2$, KCl

25. What are the spectator ions in the reaction between $Ba(OH)_2(aq)$ and $HClO_3(aq)$
(A) Ba^{2+} and H^+ (B) H^+ and OH^- (C) Ba^{2+} and ClO_3^- (D) H^+ and ClO_3^-
(E) OH^- only

26. The balanced net ionic equation for precipitation of $CaCO_3$ when aqueous solutions of Na_2CO_3 and $CaCl_2$ are mixed is __________.
(A) $2Na^+(aq) + CO_3^{2-}(aq) \rightarrow Na_2CO_3\ (aq)$ (B) $2\ Na^+(aq) + 2Cl^-(aq) \rightarrow 2NaCl\ (aq)$
(C) $Na^+(aq) + Cl^-(aq) \rightarrow NaCl\ (aq)$ (D) $Ca^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)$
(E) $Na_2CO_3(aq) + CaCl_2\ (aq) \rightarrow 2NaCl\ (aq) + CaCO_3(s)$

27. The concentration (M) of an aqueous methanol produced when 0.250 L of a 5.00 M solution was diluted to 1.00 L is __________M.
(A) 2.50 (B) 0.0500 (C) 20.0 (D) 1.25 (E) 0.800

28. A radio station broadcasts at 103.5 MHz. The wavelength of the signal is __________ m.
(A) 3.10 (B) 2.90 (C) 4.71 (D) 2.75 (E) 3.84

29. What is the de Broglie wavelength (m) of a 2.0 mg object moving at a speed of 500 m/s?
(A) $6.6\ x10^{-31}$ (B) $1.5\ x10^{30}$ (C) $5.3\ x10^{-28}$ (D) $2.6\ x10^{-30}$ (E) $3.8\ x10^{29}$

30. All of the orbitals in a given subshell have the same value of the ____ quantum number.
(A) principal (B) azimuthal (C) magnetic (D) A and B (E) B and C

31. Which of the subshells below **do not** exist due to the constraints upon the azimuthal quantum number?
(A) 4 f (B) 4 d (C) 4 p (D) 4 s (E) none of these

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

33. Which set of three quantum numbers (n, l, m$_l$) corresponds to a 3d orbital?

(A) 3, 2, 2 (B) 3, 1, 1 (C) 3, 2, 3 (D) 2, 1, 0 (E) 2, 3, 3

34. Which of the following is a valid set of four quantum numbers?(n, l, m$_l$, m$_s$)

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

35. Which electron configuration denotes an atom in its ground state?

	1s	2s	2p		
(A)	↑	↑↓			
(B)	↑↑	↑↓			
(C)	↑↓	↑↓	↑↓		
(D)	↑↓	↑↓	↑		↑
(E)	↑	↑	↑	↓	↑

36. The ground state electron configuration of P is __________.

(A) $1s^22s^22p^63s^23p^3$ (B) $1s^22s^22p^63s^23p^5$ (C) $1s^22s^22p^63s^23p^63d^{10}4s^24p^1$
(D) $1s^22s^22p^63s^23p^64s^1$ (E) $1s^22s^22p^63s^23p^64s^24p^3$

37. The ground state configuration of bromine is __________.

(A) $[Ar]2s^22p^5$ (B) $[Ar]\ 3d^{10}4s^24p^5$ (C) $[Ar]4s^24p^5$
(D) $He]2s^22p^5$ (E) $[Kr]4d^{10}5s^25p^5$

38. Which two elements have the same ground-state electron configuration?

(A) Pd and Pt (B) Cu and Ag (C) Fe and Cu (D) Cl and Ar
(E) No two elements have the same ground-state electron configuration.

39. Which element would be expected to have chemical and physical properties closest to those of argone?

(A) S (B) K (C) Ne (D) F (E) Cl

40. Of the following, which gives the correct order for atomic radius for Mg, Na, P, Si and Ar?
(A) Na > Mg > Si > P > Ar   (B) Mg > Na > P > Si > Ar
(C) Ar > Si > P > Na > Mg   (D) Ar > P > Si > Mg > Na
(E) Si > P > Ar > Na > Mg

41. Which of the following is an isoelectronic series?
(A) $B^{5-}, Sr^{4-}, As^{3-}, Te^{2-}$ (B) S^{2-}, Cl^-, Ar, K^+ (C) S, Cl, Ar, K
(D) $Si^{2-}, P^{2-}, S^{2-}, Cl^{2-}$ (E) F^-, Cl^-, Br^-, I^-

42. Of the following atoms, which has the largest <u>first</u> ionization energy?
(A) Cl   (B) F   (C) C   (D) P   (E) Br

43. The ion with the smallest diameter is ________.
(A) Br^- (B) Cl^- (C) N^{3-} (D) F^- (E) O^{2-}

44. The acidity of carbonated water is due to the ________.
(A) presence of sulphur   (B) reaction of CO_2 and H_2O (C) addition of acid
(D) nonmetal oxides   (E) none of the above

45. Based on the octet rule, phosphorus most likely forms a ________ ion.
(A) P^{3+} (B) P^{3-} (C) P^{5+} (D) P^{5-} (E) P^+

46. Which of the following would have to gain two electrons in order to achieve a noble gas electron configuration?
S   Ca   Na   Se   Br
(A) Br   (B) Ca   (C) Na   (D) S, Se   (E) Ca, S, Se

47. What is the electron configuration for the Co^{2+} ion?
(A) $[Ar]4s^23d^5$ (B) $[Ar]3d^7$ (C) $[Ar]3d^5$ (D) $[Ar]4s^23d^9$
(E) $[Ne]3s^23p^{10}$

48. The Lewis structure of PF_3 shows that the central phosphorus atom has ________ nonbonding and ________ bonding electron pairs.
(A) 2, 2   (B) 1, 3   (C) 3, 1   (D) 1, 2   (E) 3, 3

49. The molecular geometry of the $BeCl_2$ molecule is ________.
(A) linear   (B) bent   (C) tetrahedral   (D) trigonal planar   (E) T-shaped

50. Of the molecules below, only ________ is polar.
(A) SbF_5 (B) AsH_3 (C) I_2 (D) SF_6 (E) CH_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.

Question 1 (25 marks)

(a) Name the following compounds

(i) $NiF_2 \cdot 4H_2O$ (ii) Hg_2Cl_2 (iii) S_2Cl_2 (iv) $HIO(aq)$ (8)

(b) Give the chemical formulas of the following species:

(i) copper(II) perchlorate hexahydrate (ii) vanadium(V) oxide (4)

(c) The mass composition of a compound used to generate O_2 in the laboratory is: 31.91% K, 28.93% Cl, the remainder being oxygen. Determine the empirical formula of the compound. (4)

(d) Octane, C_8H_{18}, is typical of the molecules found in petrol.

(i) Calculate the mass (in grams) of one octane molecule.

(ii) Determine the number of octane molecules in 1 mL of octane, the mass of which is 0.82 g. (6)

(e) Determine the molar mass of $NiF_2 \cdot 4H_2O$ (3)

Question 2 (25 marks)

(a) The contents of Beaker 1 are mixed with those of Beaker 2. If a reaction occurs, write the net ionic reaction and identify the spectator ions. (6)

Beaker 1	Beaker 2
(i) $NiSO_4(aq)$	$(NH_4)_2CO_3(aq)$
(ii) $H_3PO_4(aq)$	$CuCl_2(aq)$
(iii) $K_2S(aq)$	$AgNO_3(aq)$

(b) Name the salt that is produced and write the full molecular equation for the acid-base neutralization reaction between:

(i) Potassium hydroxide and acetic acid, CH_3COOH

(ii) Ammonia and Hydrochloric acid. (6)

(c) Identify the oxidizing agent and reducing agent in each of the following reactions:

(i) $2\ Al(s) + Cr_2O_3(s) \rightarrow Al_2O_3(s) + 2Cr(s)$

(ii) $6\ Li(s) + N_2(g) \rightarrow 2Li_3N(s)$

(iii) $NO(g) + O_3(g) \rightarrow NO_2(g) + O_2(g)$ (6)

(d) A mixture of 7.45 g iron(II) oxide and 0.111 mol of aluminum metal is placed in a crucible and heated in a high temperature oven, where the reduction of the oxide occurs:

(i) Write the balanced equation for the reduction (products are Fe and Al_2O_2).

(ii) Determine the maximum amount of iron (in moles of Fe) that can be produced.

(iii) Calculate the mass of excess reactant remaining in the crucible. (7)

Question 3 (25 marks)

(a) Ultraviolet radiation has wavelengths less than about 350 nm. What is the energy accompanying the emission of 1.00 mol of photons at this wavelength? (3)

(b) Calculate the wavelength of an electron with a velocity of 3.0×10^7 m/s. (3)

(c) Explain why the lattice enthalpy of magnesium oxide (3850 kJ/mol) is greater than that of magnesium sulphide (3405 kJ/mol). (3)

(d) Write the Lewis structure of the following species and state the number of lone pairs on the central atom.

(i) ClO_2^- (ii) ClF_3 (4)

(e) Write the Lewis structures and predict the shapes of

(i) IF_4^- (ii) $OSbCl_3$ (Sb central atom) (6)

(f) Write the Lewis structure of each reactant, identify the Lewis acid and the Lewis base and then write the Lewis formula of the product (complex):

(i) $SO_2 + Cl^- \rightarrow$

(ii) $AlCl_3 + Cl^- \rightarrow$ (6)

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	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