UNIVERSITY OF SWAZILAND

FINAL EXAMINATION 2011/12

TITLE OF PAPER: INTRODUCTORY CHEMISTRY I

COURSE NUMBER: C111

TIME: THREE (3) HOURS

INSTRUCTIONS:

(i) Answer **all questions** in section A (total 40 marks)
(ii) Answer **any 3 questions** in section B (Each question is 20 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 (40 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 40 questions.

1. The chemical symbol of manganese is
   (A) Mg (B) Mn (C) Mo (D) Md (E) Ma

2. The number of protons, neutrons, and electrons, respectively in a neutral atom of this ^{19}F (Z=9) is
   (A) 9 protons, 19 neutrons, and 9 electrons
   (B) 10 protons, 9 neutrons, and 10 electrons
   (C) 9 protons, 10 neutrons, and 9 electrons
   (D) 9 protons, 9 neutrons, and 9 electrons
   (E) 19 protons, 10 neutrons, and 19 electrons

3. All the following have 36 electrons except
   (A) $^{87}Sr^{2+}$ (Z=38) (B) $^{79}Se^{2-}$ (Z=34) (C) $^{85}Rb^{+}$ (Z=37)
   (D) $^{84}Kr^{2+}$ (Z=36) (E) $^{80}Br^{-}$ (Z=35)

4. Which of the following is an alkali metal?
   (A) Ca (B) Sc (C) Be (D) K (E) Ba

5. Which of the following elements is most likely to form a cation?
   (A) Be (B) P (C) S (D) N (E) I

6. All of the following are heterogeneous mixtures except
   (A) milk (B) a rock (C) Vinegar
   (D) yogurt (E) a precipitate in water

7. An example of a physical property is
   (A) The reaction of rubidium with water to form rubidium hydroxide
   (B) The reaction of caesium with oxygen to form caesium superoxide
   (C) The density of boron
   (D) The energy content of liquid sodium
   (E) The burning of sulphur to form sulphur dioxide.

8. A solution of iron(III) chlorate contains the ions
   (A) Fe^{3+} and ClO_4^- (B) Fe^{3+} and ClO^- (C) Fe^{3+} and ClO_3^-
   (D) Fe^{3+} and ClO_2^- (E) Fe^{2+} and ClO_4^-

9. Which of the following is the phosphide ion?
   (A) PO_3^{3-} (B) PO_4^{3-} (C) P^{3-} (D) P^{2-} (E) P^-

10. The formula for sulphurous acid is
(A) H_2SO_3 (B) H_3PO_3 (C) H_2SO_4 (D) HSO (E) H_2S

11. Which of the following is boron nitride?
(A) BN (B) B_2N (C) B_3N_2 (D) BC (E) B_2N_3

12. Which of the following is calcium phosphate?
(A) $Ca_3(PO_3)_2$ (B) $Ca_3(PO_4)_2$ (C) Ca_3PO_4 (D) $CaPO_4$ (E) Ca_2PO_4

13. A bottle of cola purchased in Europe gave the volume as 50 cL. What is the volume in mL?
(A) 0.005 mL (B) 5 000 mL (C) 500 mL (D) 0.05 mL (E) 50 mL

14. Chlorine has two naturally occurring isotopes; Cl-35 and Cl-37, with a natural abundance of 75.77 % and 24.23 %, respectively. The mass of an atom of Cl-35 is 5.807×10^{-23} g and that of Cl-37 is 6.139×10^{-23} g. What is the average molar mass of Chlorine?
(A) 36.97 g/mol (B) 35.45 g/mol (C) 36.48 g/mol
(D) 35.97 g/mol (E) 34.97 g/mol

15. How many moles of nitrogen are contained in 10.62 g of nitrogen gas, N_2?
(A) 1.319 mol (B) 148.8 mol (C) 0.3790 mol (D) 2.638 mol
(E) 0.7580 mol

16. When aqueous solutions of cadmium nitrate and sodium sulphide are mixed, what are the "spectator ions'?
(A) S^{2-} and NO_3^- (B) Cd^{2+} and S^{2-} (C) Cd^{2+} and NO_3^-
(D) Na^+ and NO_3^- (E) Na^+ and S^{2-}

17. Which of the following is soluble in water?
(A) lead(II) sulphate (B) Mercury(I) chloride (C) lead(II) iodide
(D) barium carbonate (E) mercury(I) nitrate

18. What type of reagent is required to convert NO_2^- to HNO_2?
(A) acid (B) base (C) reducing agent (D) oxidizing agent
(E) neutralization reagent

19. Which of the following oxides gives a basic solution when dissolved in water?
(A)selenium trioxide (B) dinitrogen pentoxide (C) calcium oxide
(D) sulphur dioxide (E) carbon dioxide

20. What is the oxidation number of chlorine in HOCl?
(A) +1 (B) -1 (C) +2 (D) +3 (E) 0

21. When aluminium metal is dissolved in perchloric acid, aluminium(III) percholrate and hydrogen gas are formed. In the balanced equation for the reaction, what is the coefficient of hydrogen gas?
(A) 3 (B) 2 (C) 1 (D) 4 (E) 5

22. The following equation is unbalanced

$F_2 + H_2O \rightarrow O_3 + HF$

In the balanced equation, the coefficient of HF is

(A) 6 (B) 3 (C) 2 (D) 4 (E) 8

23. Which of the following pairs of solutions will give a precipitate when mixed?

(A) $AgNO_3(aq)$ and $LiClO_4(aq)$ (B) $Pb(NO_3)_2(aq)$ and $KI(aq)$
(C) $K_2SO_4(aq)$ and $Cu(NO_3)_2$ (D) $NaCH_3COO(aq)$ and $CaCl_2(aq)$
(E) $Ca(CH_3COO)_2(aq)$ and $NH_4Cl(aq)$

24. Consider the following reaction:

$Cd(s) + 2\,AgCl(s) \rightarrow Cd^{2+}(aq) + 2\,Ag(s) + 2Cl^{-}(aq)$

In this reaction

(A)The oxidizing agent is Cd(s)
(B) The reducing agent is AgCl(s)
(C)No electrons are transferred since the oxidation number of Cl is unchanged
(D) Electrons are transferred from Ag in Agcl(s) to Cd(s)
(E) Electrons are transferred from Cd(s) to Ag in AgCl(s)

25. Calculate the wavelength of blue light of frequency 6.40×10^{14} Hz.

(A) 468 nm (B) 311 nm (C) 214 nm (D) 640 nm (E) 936 nm

26. Calculate the energy per photon of microwaves of frequency 3.00×0^{11} Hz.

(A) 2.21×10^{-45} J (B) 1.99×10^{-22} J (C) 4.52×10^{44} J
(D) 5.97×10^{-14} J (E) 120 J

27. An electron in a hydrogen atom has the quantum numbers $n = 4$, $l = 1$, $m_l = 0$. In what type of orbital is the electron located

(A) 3p (B) 3d (C) 4s (D) 4d (E) 4p

28. How many orbitals are there in a shell with n = 3?

(A) 9 (B) 18 (C) 4 (D) 8 (E) 3

29. Which subshell can hold the greatest number of electrons?

(A) 6p (B) 3d (C) 4f (D) 4d (E) 5d

30. What is the ground state electron configuration of an aluminium atom?

(A) $[Ne]3s^23p^1$ (B) $[Ne]3s^13p^2$ (C) $[Ne]3s^2$
(D) $[Ne]3s^23p^2$ (E) $[Ne]3s^23p^3$

31. How many unpaired electrons are there in the ground state of Cu^+?

(A) 0 (B) 1 (C) 6 (D) 3 (E) 5

32. What is the electron configuration of Ni^{4+}?

(A) $[Ar]3d^64s^2$ (B) $[Ar]3d^6$ (C) $[Ar]3d^8$ (D) $[Ar]3d^64s^1$
(E) $[Ar]3d^44s^2$

33. Which of the following would have the smallest radius?

(A) oxygen (B) sulphur (C) carbon (D) silicon (E) lithium

34. Which of the following has the highest first ionization energy?

(A) P (B) Mg (C) S (D) Al (E) Si

35. The lattice enthalpy of potassium iodide is the energy change for the reaction

(A) $KI(s) \rightarrow K(g) + I(g)$
(B) $KI(s) \rightarrow K^+(g) + I^-(g)$
(C) $K(g) + I(g) \rightarrow KI(s)$
(D) $K(s) + \frac{1}{2}I_2(s) \rightarrow KI(s)$
(E) $KI(s) \rightarrow K(g) + \frac{1}{2}I_2(g)$

36. How many lone pairs of electrons does the oxygen atom possess in the Lewis structure of H_2O?

(A) 2 (B) 4 (C) 3 (D) 1 (E) 0

37. Which of the following is most volatile?

(A) CBr_3H (B) CCl_4 (C) CCl_3H (D) CBr_4 (E) CBr_2H_2

38. Which of the following has the highest boiling point?

(A) n-butane, $CH_3(CH_2)_2CH_3$
(B) n-hexane, $CH_3(CH_2)_4CH_3$
(C) n-heptane, $CH_3(CH_2)_5CH_3$
(D) n-propane, $CH_3CH_2CH_3$
(D) n-pentane, $CH_3(CH_2)_3CH_3$

39. The boiling point of HF is higher than that of HCl due to

(A) ion-dipole forces (B) Hydrogen bonding (C) London forces
(D) dipole-dipole forces (E) ion-ion forces.

40. For which of the following substances would hydrogen bonding be most important?

(A) NH_3 (B) HI (C) CH_4 (D) H_2 (E) GeH_4

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

SECTION B (60 Marks)

There are four questions in this section. Each question is worth 20 marks. Answer any three questions. In all calculations answers must have the correct number of significant figures and units.

Question 1 (20 marks)

(a) You know that an unlabelled bottle contains a solution of one of the following: $AgNO_3$, $CaCl_2$ or $Al_2(SO_4)_3$. A friend suggests you test a portion of each solution with $Ba(NO_3)_2$ and then with NaCl solutions. Explain, with supporting equations, how these two tests together would be sufficient to determine which salt is present in the solution. [6]

(b) Which of the following are redox reactions? For those that are, indicate which element is oxidized and which is reduced. For those that are not indicate whether they are precipitation or acid-base reactions.

(i) $Cu(OH)_2(s) + 2\,HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2\,H_2O(l)$

(ii) $Fe_2O_3(s) + 3\,CO(g) \rightarrow 2\,Fe(s) + 3\,CO_2(g)$

(iii) $Sr(NO_3)_2(aq) + H_2SO_4(aq) \rightarrow SrSO_4(s) + 2\,HNO_3(aq)$

(iv) $Zn(s) + 10H^+(aq) + 2NO_3^-(aq) \rightarrow 4Zn^{2+}(aq) + N_2O(g) + 5H_2O(l)$ [6]

(c) A sample of 1.50 g of lead(II) nitrate is mixed with 125 mL of 0.100 M sodium sulphate solution.

(i) Write the chemical equation for the reaction that occurs.
(ii) Which is the limiting reactant in the reaction?
(iii) What is the concentration of sulphate ions that remain in solution after the reaction is complete? [8]

Question 2 (20 marks)

(a) Metal chlorides, such as praseodymium chloride, $PrCl_3$, can be prepared by heating praseodymium oxide, Pr_2O_3, with ammonium chloride to yield the chloride, $PrCl_3$, plus water and ammonia.

(i) Write a balanced equation for the reaction.
(ii) If 50.0 g Pr_2O_3 is used, what mass of $PrCl_3$ will be produced? [8]

(b) Antimony reacts with oxygen as follows

$$4\,Sb(s) + 3\,O_2(g) \rightarrow 2\,Sb_2O_3(s)$$

(i) What type of reaction is this?

(ii) What is the limiting reactant when 5.0 mol Sb(s) and 5.0 mol $O_2(g)$ react?

(iii) How many moles of the excess reactant remain if reaction is complete?

(iv) How many moles of product can be formed?

(v) If 2.0 mol Sb_2O_3 forms, what is the percentage yield? [12]

Question 3 (20 marks)

(a) Draw Lewis structures of the following species. Identify those that do not obey the octet rule and explain why they do not.

(i) SO_3^{2-} (ii) AlH_3 (iii) SbF_5 [9]

(b) Give the VSEPR model shape of the species in (a) [6]

(c) Indicate whether he species in (a) is polar or none polar [3]

(d) Calculate the formal charge of the central atom in each the species in (a) [2]

Question 4 (20 marks)

(a) Consider the compound $NiSO_4 \cdot 6H_2O$

(i) Name the compound

(ii) Calculate the molar mass of the compound

(iii) How many moles are there in 5.00 g of the compound?

(iv) How many oxygen atoms are present in one molecule of the compound?

(v) How many moles of hydrogen atoms are present in 4.2×10^{-3} mol of the compound? [8]

(b) The molar mass of boron atoms in a sample of naturally occurring ore is 10.81 g/mol. The sample is known to consist of ^{10}B (of mass 10.013 **u**) and ^{11}B (of mass 10.093 **u**). What are the abundances of the two isotopes? [6]

(c) Name the following compounds

(i) $CuCl_2 \cdot 2H_2O$

(ii) $CrPO_4$

(iii) V_2O_5 [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	$F = N_A e$	$9.6485 \times 10^{4}\ C\ mol^{-1}$
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	=	1×10^{-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.

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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)		21.	(A)	(B)	(C)	(D)	(E)
2	(A)	(B)	(C)	(D)	(E)		22	(A)	(B)	(C)	(D)	(E)
3	(A)	(B)	(C)	(D)	(E)		23	(A)	(B)	(C)	(D)	(E)
4	(A)	(B)	(C)	(D)	(E)		24	(A)	(B)	(C)	(D)	(E)
5	(A)	(B)	(C)	(D)	(E)		25	(A)	(B)	(C)	(D)	(E)
6	(A)	(B)	(C)	(D)	(E)		26	(A)	(B)	(C)	(D)	(E)
7	(A)	(B)	(C)	(D)	(E)		27	(A)	(B)	(C)	(D)	(E)
8	(A)	(B)	(C)	(D)	(E)		28	(A)	(B)	(C)	(D)	(E)
9	(A)	(B)	(C)	(D)	(E)		29	(A)	(B)	(C)	(D)	(E)
10	(A)	(B)	(C)	(D)	(E)		30	(A)	(B)	(C)	(D)	(E)
11	(A)	(B)	(C)	(D)	(E)		31	(A)	(B)	(C)	(D)	(E)
12	(A)	(B)	(C)	(D)	(E)		32	(A)	(B)	(C)	(D)	(E)
13	(A)	(B)	(C)	(D)	(E)		33	(A)	(B)	(C)	(D)	(E)
14	(A)	(B)	(C)	(D)	(E)		34	(A)	(B)	(C)	(D)	(E)
15	(A)	(B)	(C)	(D)	(E)		35	(A)	(B)	(C)	(D)	(E)
16	(A)	(B)	(C)	(D)	(E)		36	(A)	(B)	(C)	(D)	(E)
17	(A)	(B)	(C)	(D)	(E)		37	(A)	(B)	(C)	(D)	(E)
18	(A)	(B)	(C)	(D)	(E)		38	(A)	(B)	(C)	(D)	(E)
19	(A)	(B)	(C)	(D)	(E)		39	(A)	(B)	(C)	(D)	(E)
20	(A)	(B)	(C)	(D)	(E)		40	(A)	(B)	(C)	(D)	(E)