UNIVERSITY OF SWAZILAND

FINAL EXAMINATION 2010/11

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 symbol for the element lead is _____.
   (A) Ld (B) Pb (C) Sn (D) Hg (E) none of these

2. A combination of sand, salt, and 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) P, potassium (B) C, copper (C) Mg, manganese
   (D) Ag, silver (E) Sn, silicon

4. 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

5. Of the following, only _____ is a chemical reaction.
   (A) melting of lead (B) dissolving sugar in water (C) tarnishing of silver
   (D) crushing of stone (E) dropping a penny into a glass of water

6. 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) 5.119 (E) 100

7. Which atom has the largest number of neutrons?
   (A) phosphorus-30 (B) chlorine-37 (C) potassium-39
   (D) argon-40 (E) calcium-40

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. The element X has three 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)
^{15}X	28.60	15.33
^{17}X	13.30	17.26
^{16}X	58.10	18.11

(A) 17.20 (B) 16.90 (C) 17.65 (D) 17.11 (E) 16.90

10. Which one of the following is a nonmetal?
(A) W (B) Sr (C) Os (D) Ir (E) Br

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

12. Which compounds do not have the same empirical formula?
(A) C_2H_2, C_6H_6 (B) CO, CO_2 (C) C_2H_4, C_3H_6
(D) $C_2H_4O_2$, $C_6H_{12}O_6$ (E) $C_2H_5COOCH_3$, CH_3CHO

13. Which species has 16 protons?
(A) ^{31}P (B) $^{34}S^{2-}$ (C) ^{36}Cl (D) $^{80}Br^-$ (E) ^{16}O

14. Which of the following compounds would you expect to be ionic?
(A) H_2O (B) CO_2 (C) $SrCl_2$ (D) SO_2 (E) H_2S

15. Which species below is the sulphite ion?
(A) SO_2^{-2} (B) SO_3^{-2} (C) S^{2-} (D) SO_4^{-2} (E) HS^-

16. Which formula/name pair is **incorrect**?
(A) $Mn(NO_2)_2$ manganese(II) nitrite (B) $Mg(NO_3)_2$ magnesium nitrate
(C) $Mn(NO_3)_2$ manganese(IV) nitrate (D) Mg_3N_2 magnesium nitride
(E) $Mg(MnO_4)_2$ magnesium permanganate

17. When the following equation is balanced, the coefficients are _____.
$Al(NO_3)_3 + Na_2S \rightarrow Al_2S_3 + NaNO_3$
(A) 2, 3, 1, 6 (B) 2, 1, 3, 2 (C) 1, 1, 1, 1 (D) 4, 6, 3, 2 (E) 2, 3, 2, 3

18. There are _____ sulphur atoms in 25 molecules of $C_4H_4S_2$.
(A) 1.5×10^{25} (B) 4.8×10^{25} (C) 3.0×10^{25} (D) 50 (E) 6.02×10^{23}

19. 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

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

21. There are _____ atoms of oxygen are in 300 molecules of CH_3CO_2H.
(A) 300 (B) 600 (C) 3.01×10^{24} (D) 3.61×10^{26} (E) 1.80×10^{26}

22. How many moles of sodium carbonate contain 1.773×10^{17} carbon atoms?
(A) 5.890×10^{-7} (B) 2.945×10^{-7} (C) 1.473×10^{-7} (D) 8.836×10^{-7}
(E) 9.817×10^{-8}

23. Lithium and nitrogen react to produce lithium nitride:

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

How many moles of N_2 are needed to react with 0.500 mol of lithium?

(A) 3.00 (B) 0.500 (C) 0.167 (D) 1.50 (E) 0.0833

24. Which of the following are weak electrolytes?

HCl, $HC_2H_3O_2$, NH_3, KCl

(A) HCl, KCl (B) HCl, $HC_2H_3O_2$, NH_3, KCl (C) $HC_2H_3O_2$, KCl

(D) $HC_2H_3O_2$, NH_3 (E) HCl, $HC_2H_3O_2$, KCl

25. The balanced molecular equation for complete neutralization of H_2SO_4 by KOH in aqueous solution is _____.

(A) $2H^+(aq) + 2OH^-(aq) \rightarrow 2H_2O(l)$

(B) $2H^+(aq) + 2KOH(aq) \rightarrow 2H_2O(l) + 2K^+(aq)$

(C) $H_2SO_4(aq) + 2OH^-(aq) \rightarrow 2H_2O(l) + SO_4^{2-}(aq)$

(D) $H_2SO_4(aq) + 2KOH(aq) \rightarrow 2H_2O(l) + K_2SO_4(s)$

(E) $H_2SO_4(aq) + 2KOH(aq) \rightarrow 2H_2O(l) + K_2SO_4(aq)$

26. When aqueous solutions of _____ are mixed, a precipitate forms.

(A) $NiBr_2$ and $AgNO_3$ (B) NaI and KBr (C) K_2SO_4 and $CrCl_3$

(D) KOH and $Ba(NO_3)_2$ (E) Li_2CO_3 and CsI

27. The molarity of a solution prepared by diluting 43.72 mL of 5.005 M aqueous $K_2Cr_2O_7$ to 500. mL is _____M.

(A) 57.2 (B) 0.0044 (C) 0.438 (D) 0.0879 (E) 0.870

28. The wavelength of light emitted from a traffic light having a frequency of 5.75×10^{14} Hz is _____.

(A) 702 nm (B) 641 nm (C) 674 nm (D) 521 nm (E) 583 nm

29. The de Broglie wavelength of a 6.0 gram bullet traveling at the speed of sound is _____. The speed of sound is 331 m/sec.

(A) 2.7×10^{-34} m (B) 3.3×10^{-34} m (C) 3.35×10^{-33} m (D) 2.7×10^{-37} m

(E) 6.6×10^{-31} m

30. All of the orbitals in a given electron shell have the same value of the _____ quantum number.

(A) principal (B) azimuthal (C) magnetic (D) spin (E) psi

31. Which of the subshells below do <u>not</u> exist due to the constraints upon the azimuthal quantum number?

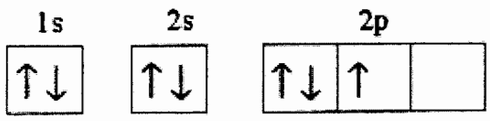
(A) 2 d (B) 2 s (C) 2 p (D) all of the above (E) none of the above

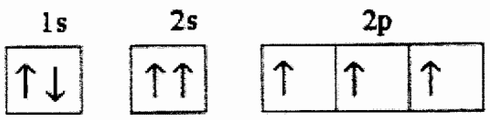
32. An electron cannot have the quantum numbers n = ____, l = _____, m_l = ____.
(A) 2, 0, 0 (B) 2, 1, -1 (C) 3, 1, -1 (D) 3, 2, 3 (E) 3, 2, 1

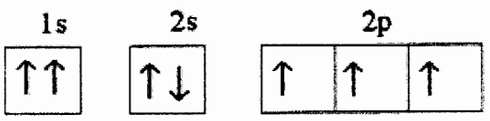
33. The _____ orbital is degenerate with $5p_y$ in a many-electron atom.
(A) 5s (B) $5p_x$ (C) $4p_y$ (D) $5d_{xy}$ (E) $5d^2$

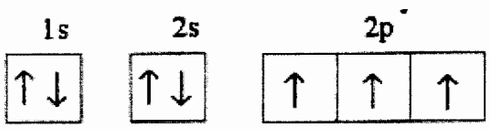
34. Which of the following is <u>not</u> a valid set of four quantum numbers? (n, l, m_l, m_s)
(A) 2, 0, 0, +1/2 (B) 2, 1, 0, -1/2 (C) 3, 1, -1, -1/2 (D) 1, 0, 0, +1/2
(E) 1, 1, 0, +1/2

35. Which one of the following is the correct electron configuration for a ground-state nitrogen atom?

(A) 

(B) 

(C) 

(D) 

(E) None of the above is correct.

36. The ground state electron configuration of Fe is _____.
(A) $1s^2 2s^2 3s^2 3p^6 3d^6$ (B) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$ (C) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
(D) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 4d^6$ (E) $1s^2 2s^2 3s^2 3p^{10}$

37. The ground state configuration of tungsten is _____.
(A) $[Ar]4s^2 3d^3$ (B) $[Xe]6s^2 4f^{14} 5d^4$ (C) $[Ne]3s^1$ (D) $[Xe]6s^2 4f^7$
(E) $[Kr]5s^2 4d^{10} 5p^5$

38. The element that has a valence configuration of $4s^1$ is _____.
(A) Li (B) Na (C) K (D) Rb (E) Cs

39. 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

40. 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

41. Which isoelectronic series is correctly arranged in order of increasing radius?
(A) $K^+ < Ca^{2+} < Ar < Cl^-$ (B) $Cl^- < Ar < K^+ < Ca^{2+}$ (C) $Ca^{2+} < Ar < K^+ < Cl^-$
(D) $Ca^{2+} < K^+ < Ar < Cl^-$ (E) $Ca^{2+} < K^+ < Cl^- < Ar$

42. 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

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

44. Which one of the following compounds would produce an acidic solution when dissolved in water?
(A) Na_2O (B) CaO (C) MgO (D) CO_2 (E) SrO

45. Based on the octet rule, magnesium most likely forms a _____ ion.
(A) Mg^{2+} (B) Mg^{2-} (C) Mg^{6-} (D) Mg^{6+} (E) Mg^-

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

47. What is the electron configuration for the Fe^{2+} ion?
(A) $[Ar]4s^03d^6$ (B) $[Ar]4s^23d^4$ (C) $[Ar]4s^03d^8$ (D) $[Ar]4s^23d^8$
(E) $[Ar]4s^63d^2$

48. The Lewis structure of AsH_3 shows _____ nonbonding electron pair(s) on As.
(A) 0 (B) 1 (C) 2 (D) 3 (E) This cannot be determined from the data given.

49. For a molecule with the formula AB_2 the molecular shape is _____.
(A) linear or bent (B) linear or trigonal planar (C) linear or T-shaped
(D) T-shaped (E) trigonal planar

50. Of the molecules below, only _____ is nonpolar.
(A) CO_2 (B) H_2O (C) NH_3 (D) HCl (E) $TeCl_2$

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) 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? [9]

(b) When magnesium metal is burned in air two products are formed. One is magnesium oxide, MgO, and the other magnesium nitride. Magnesium nitride reacts with water to form magnesium oxide and ammonia.

(i) Predict the formula of magnesium nitride.

(ii) Write a balanced equation for the reaction of magnesium nitride with water.

(iii) Magnesium nitride can also be formed by the reaction of magnesium with ammonia. Write a balance equation for this reaction.

(iv) If a 6.3 g Mg ribbon reacts with 2.57 g of $NH_3(g)$, which component is the limiting reactant?

(v) What mass of $H_2(g)$ is formed in the reaction in (iv)? [10]

(c) The watt is the derived SI unit of power, the measure of energy per unit time: 1 W = 1 J/s. A semiconductor in a CD player has an output wavelength of 780 nm and a power level of 0.10 mW. How many photons strike the CD surface during the playing of a CD 69 minutes in length? [6]

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? [8]

(b) The reaction of indium, In, with sulphur leads to three binary compounds, which we will assume to be purely ionic. The three compounds have the following properties:

compound	Mass % In	m.pt (°C)
A	87.7	653
B	78.2	692
C	70.5	1050

(i) Determine the empirical formulas of compounds A, B and C.

(ii) What is the oxidation number of In in each of these compounds?

(iii) Write the electron configuration of the indium ion in each of these compounds.
(iv) In which compound is the ionic radius of In expected to be smallest. Explain.
(v) The melting point of ionic compounds often correlates with the lattice energy. Explain the trends in melting points of the compounds A, B, and c in these terms. [17]

Question 3 (25 marks)

(a) Draw the Lewis structure for each of the following molecules or ions and predict their electron domain geometry and their molecular geometry.
(i) SF_4 (ii) XeF_2 (iii) IF_5 [12]

(b) The figure below shows the ball and stick drawings of an AF_3 molecule.

(i) (ii) (iii)

(i) For each shape, give the electron domain geometry on which the molecular geometry is based.
(ii) For each shape, how many nonbonding electron domains are there on atom A?
(iii) Which of the following molecules will lead to an AF_3 molecule with the shape in (ii): Li, B, N, Al, P, Cl?
(iv) Name an element A that is expected to lead to the structure in (iii). Explain your reasoning.
(v) Indicate which molecular geometry will give a polar and which give a non-polar molecule. [13]

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	ge	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	10 VIIIB	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.