UNIVERSITY OF SWAZILAND

FINAL EXAMINATION 2009/10

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
Detach the answer sheet from the question paper.

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 atomic number indicates _____.
   (A) the number of neutrons in a nucleus
   (B) the total number of neutrons and protons in a nucleus
   (C) the number of protons or electrons in a neutral atom
   (D) the number of atoms in 1 g of an element
   (E) the number of different isotopes of an element

2. Which pair of atoms constitutes a pair of isotopes of the same element?
   (A) ${}^{14}_{6}X$ ${}^{14}_{7}X$ (B) ${}^{14}_{6}X$ ${}^{12}_{6}X$ (C) ${}^{17}_{9}X$ ${}^{17}_{8}X$ (D) ${}^{19}_{10}X$ ${}^{19}_{9}X$ (E) ${}^{20}_{10}X$ ${}^{21}_{11}X$

3. The element _____ is the most similar to strontium in chemical and physical properties.
   (A) Li (B) At (C) Rb (D) Ba (E) Cs

4. What is the formula of the compound formed between strontium ions and nitrogen ions?
   (A) SrN (B) Sr_3N_2 (C) Sr_2N_3 (D) SrN_2 (E) SrN_3

5. The correct name for Al_2O_3 is _____.
   (A) aluminum oxide (B) dialuminum oxide (C) dialuminum trioxide
   (D) aluminum hydroxide (E) aluminum trioxide

6. The formula of phosphorus pentachloride is_____
   (A) PCl_4 (B) PCl_5 (C) P_2Cl_{10} (D) P_2Cl_5 (E) PCl_3

7. The correct name for $HClO_3$ is _____.
   (A) hydrochloric acid (B) perchloric acid (C) chloric acid
   (D) chlorous acid (E) hydrochlorous acid

8. The correct formula for molybdenum(IV) hypochlorite is _____.
   (A) $Mo(ClO_3)_4$ (B) $Mo(ClO)_4$ (C) $Mo(ClO_2)_4$
   (D) $Mo(ClO_4)_4$ (E) $MoCl_4$

9. Chromium and chlorine form an ionic compound whose formula is $CrCl_3$. The name of this compound is _____.
   (A) chromium chlorine (B) chromium(III) chloride
   (C) monochromium trichloride (D) chromium(III) trichloride
   (E) chromic trichloride

10. The name of the binary compound N_2O_4 is _____.

(A) nitrogen oxide (B) nitrous oxide (C) nitrogen(IV) oxide
(D) dinitrogen tetroxide (E) oxygen nitride

11. 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

12. The formula weight of calcium nitrate ($Ca(NO_3)_2$), rounded to one decimal place, is _____ u.

(A) 102.1 (B) 164.0 (C) 204.2 (D) 150.1 (E) 116.1

13. There are _____ molecules of methane in 0.123 mol of methane (CH_4).

(A) 5 (B) 2.46×10^{-2} (C) 2.04×10^{-25} D) 7.40×10^{22} (E) 0.615

14. What are the spectator ions in the reaction between KOH (aq) and HNO_3(aq)?

(A) $K^+$and H^+ (B) $H^+$and OH^- (C) $K^+$and NO_3^-
(D) $H^+$and NO_3^- (E) OH^-only

15. When aqueous solutions of $AgNO_3$ and KI are mixed, AgI precipitates. The balanced net ionic equation is _____.

(A) $Ag^+(aq) + I^-(aq) \rightarrow AgI\ (s)$)
(B) $Ag^+(aq) + NO_3^-(aq) \rightarrow AgNO_3(s)$
(C) $Ag^+(aq) + NO_3^-(aq) \rightarrow AgNO_3(aq)$
(D) $AgNO_3(aq) + KI\ (aq) \rightarrow AgI\ (s) + KNO_3(aq)$
(E) $AgNO_3(aq) + KI\ (aq) \rightarrow AgI\ (aq) + KNO_3(s)$

16. In which reaction does the oxidation number of oxygen increase?

(A) $Ba(NO_3)_2(aq) + K_2SO_4(aq) \rightarrow BaSO_4(s) + 2KNO_3(aq)$
(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) $2\ H_2O\ (l) \rightarrow 2\ H_2(g) + O_2\ (g)$

17. Which of the following is an oxidation-reduction reaction?

(A) $Cu\ (s) + 2AgNO_3(aq) \rightarrow 2Ag\ (s) + Cu(NO_3)_2(aq)$
(B) $HCl\ (aq) + NaOH\ (aq) \rightarrow H_2O\ (l) + NaCl\ (aq)$
(C) $AgNO_3(aq) + HCl\ (aq) \rightarrow AgCl\ (s) + HNO_3(aq)$
(D) $Ba(C_2H_3O_2)_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaC_2H_3O_2(aq)$
(E) $H_2CO_3(aq) + Ca(NO_3)_2(aq) \rightarrow 2HNO_3(aq) + CaCO_3(s)$

18. The wavelength of light that has a frequency of $1.20\times10^{13}s^{-1}$ is _____ m.
(A) 25.0 (B) 2.50×10^{-5} (C) 0.0400 (D) 12.0 (E) 2.5

19. 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}

20. At what speed (m/s) must a 10.0 mg object be moving to have a de Broglie wavelength of 3.3×10^{-41} m ?

(A) 4.1 (B) 1.9×10^{-11} (C) 2.0×10^{12} (D) 3.3×10^{-42} (E) 9.1×10^{31}

21. There are _____ orbitals in the third shell.
(A) 25 (B) 4 (C) 9 (D) 16 (E) 1

22. _____-orbitals are spherically symmetrical.
(A) s (B) p (C) d (D) f (E) g

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

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

24. There are _____ unpaired electrons in a ground state phosphorus atom.
(A) 0 (B) 1 (C) 2 (D) 3 (E) 4

25. All of the _____ have a valence shell electron configuration ns^1.

(A) noble gases (B) halogens (C) Lanthanides
(D) alkali metals (E) alkaline earth metals

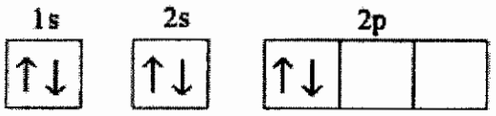
26. Elements in group _____ have a np^6 electron configuration in the outer shell.
(A) 14 (B) 16 (C) 17 (D) 18 (E) 15

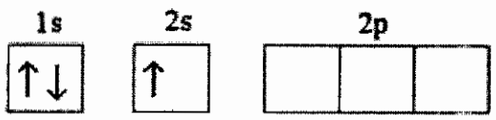
27. Which one of the following is an incorrect subshell notation?
(A) 4f (B) 2d (C) 3s (D) 2p (E) 3d

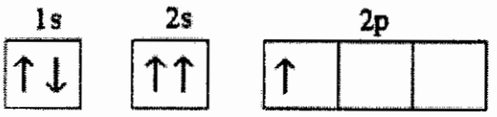
28. Which one of the following represents an acceptable set of quantum numbers for an electron in an atom? (arranged as n, l, m_l, and m_s)

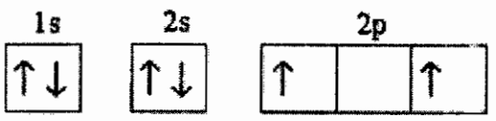
(A) 2, 2, -1, -1/2 (B) 1, 0, 0, 1/2 (C) 3, 3, 3, 1/2
(D) 5, 4,- 5, 1/2 (E) 3, 3, 3, -1/2

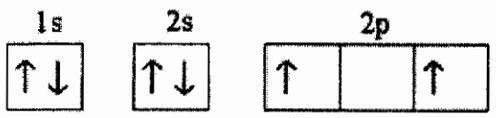
29. Which electron configuration represents a violation of the Pauli Exclusion Principle?

A) 

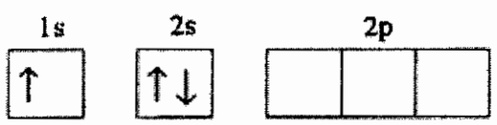
B) 

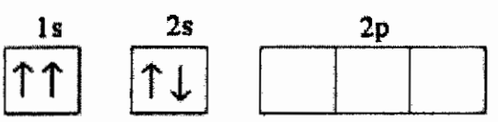
C) 

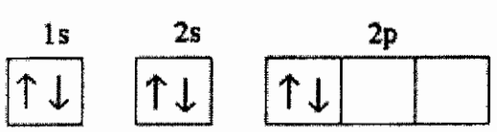
D) 

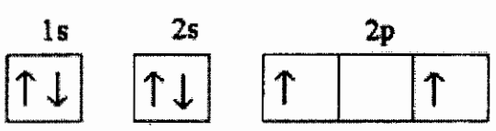
E) 

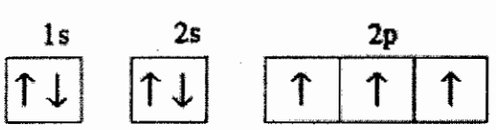
30. Which electron configuration represents a violation of Hund's rule for an atom in its ground state?

(A) 

B) 

(C) 

D) 

(E) 

31. The _____ have the most negative electron affinities.

(A) alkaline earth metals (B) alkali metals (C) halogens
(D) transition metals (E) chalcogens

32. In which set of elements would all members be expected to have very similar chemical properties?

(A) O, Si, Se (B) N, O, F (C) Na, K, Cs
(D) S, Se, Si (E) Ar, Na, Mg

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

(A) S (B) Fe (C) Ne (D) O (E) Cl

34. 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

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

36. _____ is isoelectronic with argon and _____ is isoelectronic with neon.
(A) Cl^-, F^- (B) Cl^-, Cl^+ (C) $F+, F^-$ (D) Ne^-, Kr^+ (E) Ne^-, Ar^+

37. 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

38. Which of the following has the largest second ionization energy?
(A) Ca (B) K (C) Ga (D) Ge (E) Se

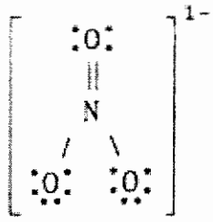
39. There are _____ paired and _____ unpaired electrons in the Lewis symbol for a phosphorus atom.
(A) 4, 2 (B) 2, 4 (C) 2, 3 (D) 4, 3 (E) 0, 3

40. 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^+

41. What is the electron configuration for the Co^{2+} ion?
(A) $[Ar]4S^1 3d^6$ (B) $[Ar]4S^0 3d^7$ (C) $[Ar]4S^0 3d^5$
(D) $[Ar]4S^2 3d^9$ (E) $[Ne]3S^2 3p^{10}$

42. A non-polar bond will form between two _____ atoms of _____ electronegativity.
(A) different, opposite (B) identical, different (C) different, different
(D) similar, different (E) identical, equal

43. The formal charge on nitrogen in NO_3^- is _____.



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

44. How many equivalent resonance forms can be drawn for CO_3^{2-} (C is the central atom)?
(A) 1 (B) 2 (C) 3 (D) 4 (E) 0

45. The molecular geometry of the SF_2 molecule is _____.
(A) linear (B) bent (C) trigonal planar (D) tetrahedral (E) octahedral

46. Of the following substances, only _____ has London dispersion forces as its only intermolecular force.
(A) CH_3OH (B) NH_3 (C) H_2S (D) CH_4 (E) HCl

47. Which one of the following should have the lowest boiling point?
(A) PH_3 (B) H_2S (C) HCl (D) SiH_4 (E) H_2O

48. _____ are particularly polarizable.
(A) Small nonpolar molecules (B) Small polar molecules
(C) Large nonpolar molecules (D) Large polar molecules
(E) Large molecules, regardless of their polarity,

49. When NaCl dissolves in water, aqueous Na^+ and Cl^- ions result. The force of attraction that exists between Na^+ and H_2O is called a(n) _____ interaction.
(A) dipole-dipole (B) ion-ion (C) hydrogen bonding
(D) ion-dipole (E) London dispersion force

50. What is the predominant intermolecular force in CBr_4?
(A) London-dispersion forces (B) ion-dipole attraction (C) ionic bonding
(D) dipole-dipole attraction (E) hydrogen-bonding

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.

Question 1 (25 marks)

(a) Calcium oxide reacts with water in a combination reaction to produce calcium hydroxide:

$$CaO\,(s) + H_2O\,(l) \rightarrow Ca(OH)_2\,(s)$$

A 4.50-g sample of CaO is reacted with 4.34 g of H_2O. How many grams of water remain after completion of reaction? [6]

(b) A chemist measured out 5.50 g of copper(II) bromide tetrahydrate, $CuBr_2 \cdot 4H_2O$.
(i) How many moles of $CuBr_2 \cdot 4H_2O$ were measured out?
(ii) How many moles of Br^- ions are present in the sample?
(iii) How many water molecules are present in the sample?
(iv) What fraction of the total mass of the sample was due to copper? [9]

(c) Nicotine has the mass composition 74.03% C, 8.70% H and 17.27% N and a molar mass 162.23 g/mol. Determine the molecular formula of nicotine. [6]

(d) How many protons, electrons and neutrons are present in the following species
(i) $^{9}Be^{2+}$ (ii) $^{32}S^{2-}$ [4]

Question 2 (25marks)

(a) Consider the following elements: potassium, oxygen, and fluorine.
(i) Write the ground state electron configuration of each element
(ii) Use an appropriate pair of the above elements and their Lewis symbols to illustrate covalent bond formation.
(iii) Use an appropriate pair of the above elements and their Lewis symbols to illustrate ionic bond formation. [7]

(b) Consider the following molecules: BF_3 and ClF_3
(i) Write the Lewis structure of each.
(ii) Predict the shape of the molecule using VSEPR model.
(iii) Predict, giving reasons, which molecule has the higher boiling point. [10]

(c) Explain why the lattice enthalpy of MgO (3850 kJ/mol) is greater than that of MgS (3406 kJ/mol) [4]

(d) Arrange the cations K^+, Mg^{2+}, Al^{3+}, Cs^+ in order of increasing polarizing power. Explain the reasons for your arrangement. [4]

Question 3 (25marks)

(a) A 10.0 mL sample of 3.0 M KOH(aq) is transferred into a 250.0 mL volumetric flask and diluted to the mark. It was found that 38.5 mL of this diluted solution was needed to reach the stoichiometric point in a titration of 10.0 mL of a phosphoric acid solution, according to the reaction

$$3\ KOH(aq) + H_3PO_4(aq) \rightarrow K_3PO_4(aq) + 3\ H_2O$$

(i) Calculate the molarity of the H_3PO_4 in the solution.
(ii) What mass of H_3PO_4 was in the initial sample? [9]

(b) A sample of quinine of mass 0.487 g was burned in excess oxygen and 1.321 g CO_2, 0.325 g H_2O and 0.0421 g N_2 were produced. The molar mass of quinine is 324 g/mol. Determine the empirical and molecular formulas of quinine, [10]

(c) Explain how you would prepare 500.0 mL of 0.010 M $KMnO_4(aq)$ staring with
(i) solid $KMnO_4$
(ii) 0.050 $MKMnO_4(aq)$ stock solution [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	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.