UNIVERSITY OF SWAZILAND

SUPPLEMENTARY 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. What is the chemical symbol of iron?
   (A) I (B) Fe (C) Ir (D) In (E) F

2. An isotope of the element uranium has a mass number of 235 and an atomic number of 92. The number of electrons, protons and neutrons, respectively in a neutral atom of this isotope is
   (A) 92, 92, and 235 (B) 92, 143, and 92 (C) 92, 92, and 143
   (D) 92, 93, 142 (E) 143, 143, and 235

3. Which of the following has 17 protons, 18 neutrons, and 18 electrons?
   (A) $^{32}S^{2-}$ (Z=16) (B) ^{40}Ar (Z=18) (C) ^{28}Si (Z=14)
   (D) $^{35}Cl^{-}$ (Z=17) (E) $^{41}P^{3-}$ (Z=15)

4. Which of the following is an alkaline earth metal?
   (A)V (B) Cs (C) Rb (D) Y (E) Ba

5. Which of the following elements is most likely to form an anion?
   (A) Ba (B) P (C) V (D) Rb (E) Zn

6. A homogeneous mixture can be described as
   (A) One prepared by shaking flour with water
   (B) A substance like a rock
   (C) One in which the composition is the same throughout the sample
   (D) One which is a patchwork of aggregates of different substances
   (E) A solution like milk

7. An example of a chemical property is
   (A) Chlorine melts at -101 °C.
   (B) Chlorine requires energy to boil
   (C) Chlorine burns in hydrogen to form hydrogen chloride
   (D) Chlorine liberates energy when it freezes
   (E) Chlorine is green-yellow in colour.

8. A solution of nickel(II) chloride contains the ions
   (A) Ni^{2+} and ClO^{-} (B) $2Ni^{+}$ and $2Cl^{-}$ (C) Ni^{2+} and Cl^{-}
   (D) NiO^{2+} and Cl^{-} (E) Ni^{4+} and Cl^{-}

9. The name of ClO^- is the
   (A) hypochlorite ion (B) chloric ion (C) perchlorate ion
   (D) chlorine oxide ion (E) chlorite ion

10. The name of the parent acid of the chlorite ion is
   (A) chlorous acid (B) hydrochloric acid (C) chloric acid
   (D) hypochlorous acid (E) hydrogen chloride

11. The name of the compound Co_2O_3 is
   (A) cobalt(III) oxide (B) cobalt(II) oxide (C) dicobalt trioxide
   (D) cobalt(III) trioxide (E) dicobalt oxide

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

13. Which of the following is longest?
   (A) 2.0 nm (B) 200 pm (C) 2.0×10^{-9} dm
   (D) 2.0×10^{-4}m (E) 2.0×10^{-10}cm

14. Gallium has two naturally occurring isotopes; Ga-69 and Ga-71, with a natural abundance of 60.20% and 39.80%, respectively. The molar mass of Ga-69 is 68.9256 g/mol and that of Ga-71 is 70.9247 g/mol. What is the average molar mass of gallium?
   (A) 69.93 g/mol B) 70.13 g/mol (C) 68.13 g/mol
   (D) 70.00 g/mol (E) 69.72 g/mol

15. If the molar mass of Ni is 58.71 g/mol, what mass contains 3.022 mol Ni?
   (A) 177.4 g (B) 88.70 g (C) 29.48 g (D) 51.47 g (E) 19.43 g

16. When aqueous solutions of barium nitrate and ammonium sulphate are mixed, what are the "spectator ions'?
   (A) NH_4^+ and NO_3^- (B) NH_4^+ and $SO4^{2-}$ (C) Ba^{2+} and NO_3^-
   (D) SO_4^{2-} and NO_3^- (E) Ba^{2+} and SO_4^{2-}

17. Which of the following is soluble in water?
   (A) lead(II) chloride (B) lead(II) sulphide (C) lead(II) acetate
   (D) lead(II) carbonate (E) lead(II) sulphate

18. What type of reagent is required to convert SO_3^{2-} to HSO_3^-?
   (A) acid (B) base (C) reducing agent (D) oxidizing agent
   (E) neutralization reagent

19. Which of the following oxides gives an acidic solution when dissolved in water?

(A)P_4O_{10} (B) CaO (C) Na_2O (D) SrO (E) K_2O

20. What is the oxidation number of chromium in Na_2CrO_4?
(A) +6 (B) +4 (C) +7 (D) +3 (E) 0

21. Calcium reacts with water to form calcium hydroxide and hydrogen. In the balanced equation for this reaction, what is the coefficient of hydrogen?
(A) 1 (B) 2 (C) 3 (D) 5 (E) ½

22. The following equation is unbalanced:
$CaH_2 + H_2O \rightarrow Ca(OH)_2 + H_2$
In the balanced equation, the coefficient of H_2 is
(A) 1 (B) 2 (C) 3 (D) 4 (E) 5

23. Which of the following pairs of solutions will give a precipitate when mixed?
(A) $AgNO_3(aq)$ and $NaCH_3COO(aq)$ (B) $Hg(NO_3)_2$ and NaCl(aq)
(C) $NH_4Cl(aq)$ and $Ca(CH_3COO)_2(aq)$ (D) $Na_2CO_3(aq)$ and $Ca(ClO_4)_2(aq)$
(E) $Na_2SO_4(aq)$ and $CuCl_2(aq)$

24. Consider the following reaction:
$2\,Fe^{3+}(aq) + 2\,Hg(l) + 2Cl^-(aq) \rightarrow 2\,Fe^{2+}(aq) + Hg_2Cl_2(s)$
In this reaction
(A) Hg(l) is reduced (B) $Fe^{3+}(aq)$ is oxidized (C)Hg(l) is oxidized
(D) $Fe^{3+}(aq)$ is the reducing agent (E) Hg(l) is the oxidizing agent

25. Calculate the wavelength of yellow light of frequency 5.20×10^{14} Hz.
(A) 520 nm (B) 1150 nm (C) 173 nm (D) 382 nm (E) 576 nm

26. Calculate the energy per photon of ultraviolet radiation of frequency 3.00×0^{15} Hz.
(A) 2.21×10^{-49} J (B) 1.99×10^{-18} J (C) 4.52×10^{48} J
(D) 5.97×10^{-10} J (E) 1200

27. An electron in a hydrogen atom has the quantum numbers n = 4, $l = 3$, $m_l = 0$. In what type of orbital is the electron located
(A) 4p (B) 4f (C) 4s (D) 4d (E) 3d

28. How many orbitals are there in a shell with $l = 2$?
(A) 5 (B) 4 (C) 7 (D) 2 (E) 1

29. For a 6p subshell, what is the most positive value of m_l?
(A) 0 (B) +1 (C)+6 (D) -1 (E) +5

30. What is the ground state electron configuration of a bromine atom?
(A) $[Ar]3d^{10}4s^24p^2$ (B) $[Ar]3d^{10}4s^24p^6$ (C) $[Ar]3d^{10}4s^24p^5$
(D) $[Ar]3d^{10}4s^24p^3$ (E) $[Ar]3d^{10}4s^24p^4$

31. What is the electron configuration of the Fe^{2+} ion?
(A) $[Ar]3d^54s^2$ (B) $[Ar]3d^5$ (C) $[Ar]3d^6$ (D) $[Ar]3d^54s^1$
(E) $[Ar]3d^44s^2$

32. What is the electron configuration of the Se^{2-} ion?
(A) $[Kr]5s^1$ (B) $[Ar]3d^{10}4s^24p^4$ (C) [Kr] [D] $[Kr]5s^2$ (E) $[Ar]3d^{10}4s^2$

33. Which of the following would have the smallest radius?
(A) Cl^{-1} (B) S^{2-} (C) K^+ (D) K (E) Ca^{2+}

34. Which of the following represents the second ionization energy of the element E?
(A) $E(s) \rightarrow E^+(g) + e^-(g)$ (B) $E(s) \rightarrow E^{2+}(g) + 2e^-(g)$
(C) $E^+(g) \rightarrow E^{2+}(g) + e^-(g)$ (D) $E(g) \rightarrow E^+(g) + e^-(g)$
(E) $E(g) \rightarrow E^{2+}(g) + 2e^-(g)$

35. The lattice enthalpy of lithium bromide is the energy change for the reaction
(A) $LiBr(s) \rightarrow Li(g) + \frac{1}{2}Br_2(g)$ (B) $LiBr(s) \rightarrow Li^+(g) + Br^-(g)$
(C) $Li(g) + Br(g) \rightarrow LiBr(s)$ (D) $Li(s) + \frac{1}{2}Br_2(l) \rightarrow LiBr(s)$
(E) $LiBr(s) \rightarrow Li(g) + Br(g)$

36. How many valenve electrons are there in the sulphite ion, SO_3^{2-}?
(A) 26 (B) 24 (C) 22 (D) 18 (E) 20

37. Which of the following has the highest boiling point?
(A) I_2 (B) Br_2 (C) F_2 (D) Cl_2 (E) Ar

38. Which of the following has the smallest standard molar enthalpy of vaporization?
(A) CH_4 (B) H_2O (C) NH_3 (D) HF (E) SnH_4

39. The boiling point of O_2 is higher than that of N_2 due to
(A) ion-dipole forces (B) Hydrogen bonding (C) London forces
(D) dipole-dipole forces (E) ion-ion forces.

40. Which of the following is likely to form hydrogen bonds in the pure stae?
(A) CH_3CH_2OH (B) CH_3OCH_3 (C) CH_4
(D) $CH_3C(O)CH_3$ (E) $(CH_3)_3N$

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) Separate samples of an unknown solution are treated with dilute solutions of HBr, H_2SO_4, and NaOH. A precipitate forms in all three cases. Which of the following cations could the solution contain: K^+, Pb^{2+}, Ba^{2+}? Support your answer with appropriate equations. [4]

(b) Which of the following solutions is most basic? 0.5 M NH_3; 0.1 M KOH; 0.1 M $Ca(OH)_2$? Explain [3]

(c) A 3.455 g sample of a mixture was analysed for barium ion by adding a small excess of sulphuric acid to an aqueous solution of the sample. The resultant reaction produced a precipitate of Barium sulphate, which was collected by filtration, washed, dried and weighed. If 0.2815 g of the barium sulphate was obtained, what was the mass percentage of barium in the sample? [4]

(d) The following redox reactions are important in the refining of certain elements.

$$\mathbf{SiCl_4(s)} + H_2(g) \rightarrow Si(s) + HCl(g)$$
$$\mathbf{SnO_2}(s) + C(s) \rightarrow Sn(s) + CO_2(g)$$
$$\mathbf{V_2O_5}(s) + Ca(l) \xrightarrow{\Delta} V(s) + CaO(s)$$

(i) Balance the above equations.
(ii) Name the source compound or ore of the element (in boldface).
(iii) What is the oxidation state of the element being extracted? [9]

Question 2 (20 marks)

(a) Phenol (C_6H_5OH), often used as a disinfectant in stables and drains is a common water pollutant. It can be converted to less harmful oxalic acid ($H_2C_2O_4$) by reaction with ozone:

$$C_6H_5OH + 11\ O_3 \rightarrow 3\ H_2C_2O_4 + 11\ O_2$$

(i) What mass of ozone would be required to react with 125.0 g of phenol?
(ii) What mass of oxalic acid would be produced? [6]

(b) Cadmium hydroxide, used in storage battery electrodes, is prepared by precipitation from a solution containing cadmium chloride and potassium hydroxide:

$$CdCl_2(aq) + 2\,KOH(aq) \rightarrow Cd(OH)_2(s) + 2\,KCl(aq)$$

What mass of cadmium hydroxide could be prepared from 125 mL of 0.250 M $CdCl_2$ mixed with 125 mL of 0.450 M KOH? [6]

(c) Oxygen difluoride can be prepared by bubbling gaseous fluorine into 0.5 M solution of NaOH:

$$2\,F_2(g) + 2\,NaOH(aq) \rightarrow OF_2(g) + 2NaF(aq) + H_2O(l)$$

Oxygen difluoride can be used to prepare compounds such as O_2AsF_6, containing the dioxygen cation, O_2^+, by the following reaction:

$$4\,OF_2 + 2\,AsF_5 \rightarrow 2\,O_2AsF_6 + 3F_2$$

If 14.0 g F_2 is bubbled through 650 mL of 0.500 M NaOH to prepare OF_2 with a 78.0% yield, how many grams of O_2AsF_6 can be prepared? [8]

Question 3 (20 marks)

(a) Consider the ammonia, NH_3 molecule

(i) The hydrogen and nitrogen atoms in ammonia are joined together by covalent bonds. What is meant by the term ***covalent bond***?

(ii) By referring to the formation of the ammonium ion from ammonia give the meaning of the term coordinate bond.

(iii) Give the VSEPR model shape of the ammonium ion

(iv) Name the major force of attraction which exists between molecules in liquid ammonia and explain how this type of force arises. [10]

(b) Write the Lewis structure of ICl_3 and calculate the formal charge of iodine. [4]

(c) (i) What is meant by the term polarizability?

(ii) Arrange the following atoms in order of increasing polarizability: O, S, Se, and Te.

(iii) Arrange the following molecules in order of increasing polarizability: CH_4, $GeCl_4$, $SiCl_4$, SiH_4, and $GeBr_4$. [6]

Question 4 (20 marks)

(a) a chemical reaction requires at least 0.683 mol of sulphur atoms to react with 0.683 mol of copper atoms.

(i) How many S atoms are required?

(ii) How many sulphur molecules, S_8, are necessary?

(iii) What mass of sulphur is needed for the reaction? [6]

(b) A chemist prepared an aqueous solution by mixing 2.50 g of ammonium phosphate trihydrate, $(NH_4)_3PO_4 \cdot 3H_2O$, and 1.5 g of potassium phosphate, K_3PO_4, with 500 g of water.

(i) Determine the number of moles of each compound that was measured?

(ii) How many moles of PO_4^{3-} ions are present in the solution?

(iii) Calculate the mass of phosphate ions present in the solution.

(iv) What is the total mass of water present I the solution? [8]

(c) Write the names of the following compounds

(i) $Cu(NO_3)_2 \cdot 6H_2O$

(ii) $NiF_2 \cdot 2H_2O$

(iii) $NaHCO_3$ [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
	$\hbar = h/2\pi$	$1.054\,57$ X-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.

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)		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)