Wanganui Park Secondary College
Victorian Certificate of Education
2012

CHEMISTRY – Unit One

Assessment Task: Written Examination

Tuesday June 12th, 2012

Name: SOLUTIONS

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Total marks*
A	20	20	20
B	8	8	53

Total 73

Directions to students

Materials
Question and answer book of 14 pages, with a detachable data sheet.
Answer sheet for multiple-choice questions. You should have at least one pencil and an eraser.
An approved calculator may be used.

The Task
This paper consists of two sections, Section A and Section B.
Answer **all** questions from Section A. Section A is worth 20 marks.
Section A questions should be answered on the answer sheet provided for multiple-choice questions.
Answer **all** questions from Section B. Section B is worth 53 marks.
Section B questions should be answered in the spaces provided in this book.
There are a total of 73 marks available.
Working space is provided throughout this book.
All written responses should be in English.

At the end of the task
Place the answer sheet for multiple-choice questions inside the front cover of this book and hand them in.

SECTION A

Specific instructions for Section A

Section A consists of 20 multiple-choice questions. Section A is worth approximately 27 per cent of the marks available. You should spend approximately 25 minutes on this section.
Choose the response that is **correct** or **best answers** the question, and indicate your choice on the multiple-choice answer sheet according to the instructions on that sheet.
A correct answer is worth 1 mark; an incorrect answer is worth no marks. No mark will be given if more than one answer is completed for any questions. Marks will **not** be deducted for incorrect answers. You should attempt every question.

Question 1

Atoms of carbon isotopes ^{14}C and ^{12}C have

A. a different number of electrons

B. the same number of neutrons

C. the same atomic number

D. **the same mass number**

Question 2

Which one of the following regarding first ionisation energy and electronegativity is correct?

A. **First ionisation energy and electronegativity increase from left to right in the Periodic Table.**

B. First ionisation energy decreases and electronegativity increases from left to right in the Periodic Table.

C. First ionisation energy increases and electronegativity decreases from left to right in the Periodic Table.

D. First ionisation energy and electronegativity decrease from left to right in the Periodic Table.

Question 3

The molar mass of calcium phosphate, $Ca_3(PO_4)_2$ is

A. 199

B. 279

C. **310**

D. 430

Question 4

In its ground state, the electrons of a calcium atom occupy

A. **4 subshells**

B. 5 subshells

C. 6 subshells

D. 7 subshells

Question 5

Which one of the following atoms has the greatest number of neutrons?

A. $^{58}_{26}Fe$

B. $^{57}_{27}Co$

C. $^{56}_{25}Mn$

D. $^{56}_{28}Ni$

Question 6

Silicon has been the element at the forefront of microchip technology. In the periodic table, silicon is located in

A.	Period 3	Group 4
B.	**Period 3**	**Group 14**
C.	Period 4	Group 4
D.	Period 4	Group 14

Question 7

The table below shows some properties of three solids: X, Y and Z.

Properties	X	Y	Z
Melting temperature (^{o}C)	800	80	1200
Soluble in water	Yes	No	No
Solid state conducts electricity	No	No	Yes
Molten state conducts electricity	Yes	No	Yes

Which of the following is the correct classification of the solids?

	Metallic	Ionic	Molecular covalent
A.	**Z**	**X**	**Y**
B.	X	Y	Z
C.	Y	Z	X
D.	Z	Y	X

Question 8

The percentage by mass of carbon in sucrose, $C_{12}H_{22}O_{11}$, is closest to

A. 12%

B. 27%

C. 33%

D. **42%**

Question 9

Which of the following would you expect to have the highest melting temperature?

A. water (H_2O)

B. chlorine (Cl_2)

C. **potassium chloride (KCl)**

D. potassium (K)

Question 10

What type of bond is broken when ice (water) melts?

A. ionic

B. intramolecular

C. non-polar covalent

D. **hydrogen**

Question 11

Which of the following is **not** a property of an ionic compound?

A. **malleability**
B. crystalline structure
C. high melting temperature
D. electrical conductivity when molten

Question 12

A list that contains empirical formulas **only** is

A. CO_2, H_2O_2, N_2O_4, KNO_3
B. **$NaCl$, NO_2, BH_3, SF_4**
C. MgO, C_6H_6, PH_3, $LiCl$
D. P_2O_5, Al_2O_3, C_2H_4, SiO_2

Question 13
Which one of the following represents a polar molecule?

A. **CH_2Cl_2**
B. CH_4
C. C_2H_6
D. Cl_2

Question 14

32 g of oxygen gas (O_2) contains

A. 6.0×10^{23} atoms of oxygen
B. **1.0 mol of O_2 molecules**
C. 2 atoms of oxygen
D. 2.0 mol of O_2 molecules

Question 15

The number of hydrogen atoms present in one molecule of butanoic acid, $CH_3CH_2CH_2COOH$, is

A. **8**
B. 9
C. 10
D. 11

Question 16

The fourth member of the **alkane** homologous series has the molecular formula

A. C_4H_8

B. **C_4H_{10}**

C. C_5H_{10}

D. C_5H_{12}

Question 17

Some students set out to determine the empirical formula of black copper oxide. They started with 2.65 g of black copper oxide which was then converted in a series of reactions to metallic copper. The mass of dry copper obtained was 2.12 g. The empirical formula of the oxide is

A. **CuO**

B. Cu_2O

C. Cu_3O_4

D. CuO_2

Question 18

All alkenes have

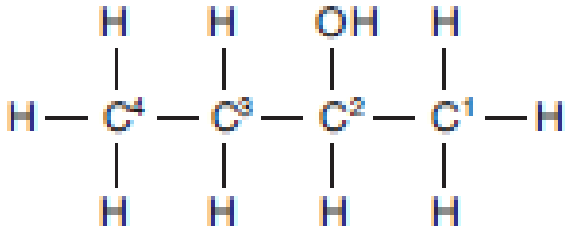
A. **only single carbon-to-carbon covalent bonds.**

B. at least one carbon-to-carbon double covalent bond.

C. similar size and shape molecules.

D. at least one carbon-to-carbon triple covalent bond.

Question 19



The name of the alkanol shown is

A. 1-butanol

B. **2-butanol**

C. 3-butanol

D. 4-butanol

Question 20

Which one of the following substances does **not** contain a carbon-to-carbon double bond, and so would **not** be able to undergo addition polymerisation.

A. **$CH_3(CH_2)_5CH_2Cl$**

B. $CHCl=CHCl$

C. $CH_2=CHCl$

D. $CH_3CH=CClCH_2Cl$

CHEMISTRY

Unit One: Unit Examination

DATA SHEET

Directions to students

Detach this data sheet during reading time.

This data sheet is provided for your reference.

The names and formulae of some common and positive and negative ions

Positive Ions (Cations)					
+1		+2		+3	
Lithium	Li^+	Magnesium	Mg^{2+}	Aluminium	Al^{3+}
Sodium	Na^+	Calcium	Ca^{2+}	Chromium	Cr^{3+}
Potassium	K^+	Barium	Ba^{2+}	Iron(III)	Fe^{3+}
Silver	Ag^+	Zinc	Zn^{2+}		
Copper(I)	Cu^+	Copper(II)	Cu^{2+}		
Ammonium	NH_4^+	Mercury(II)	Hg^{2+}		
		Iron(II)	Fe^{2+}		
		Nickel(II)	Ni^{2+}		
		Tin(II)	Sn^{2+}		
		Lead(II)	Pb^{2+}		

Negative Ions (Anions)					
-1		-2		-3	
Hydroxide	OH^-	Oxide	O^{2-}	Nitride	N^{3-}
Hydrogen carbonate	HCO_3^-	Sulfide	S^{2-}	Phosphate	PO_4^{3-}
Nitrate	NO_3^-	Sulfate	SO_4^{2-}		
Fluoride	F^-	Carbonate	CO_3^{2-}		
Chloride	Cl^-	Chromate	CrO_4^{2-}		
Bromide	Br^-	Dichromate	$Cr_2O_7^{2-}$		
Iodide	I^-				
acetate	CH_3COO^-				

Electronegativity values

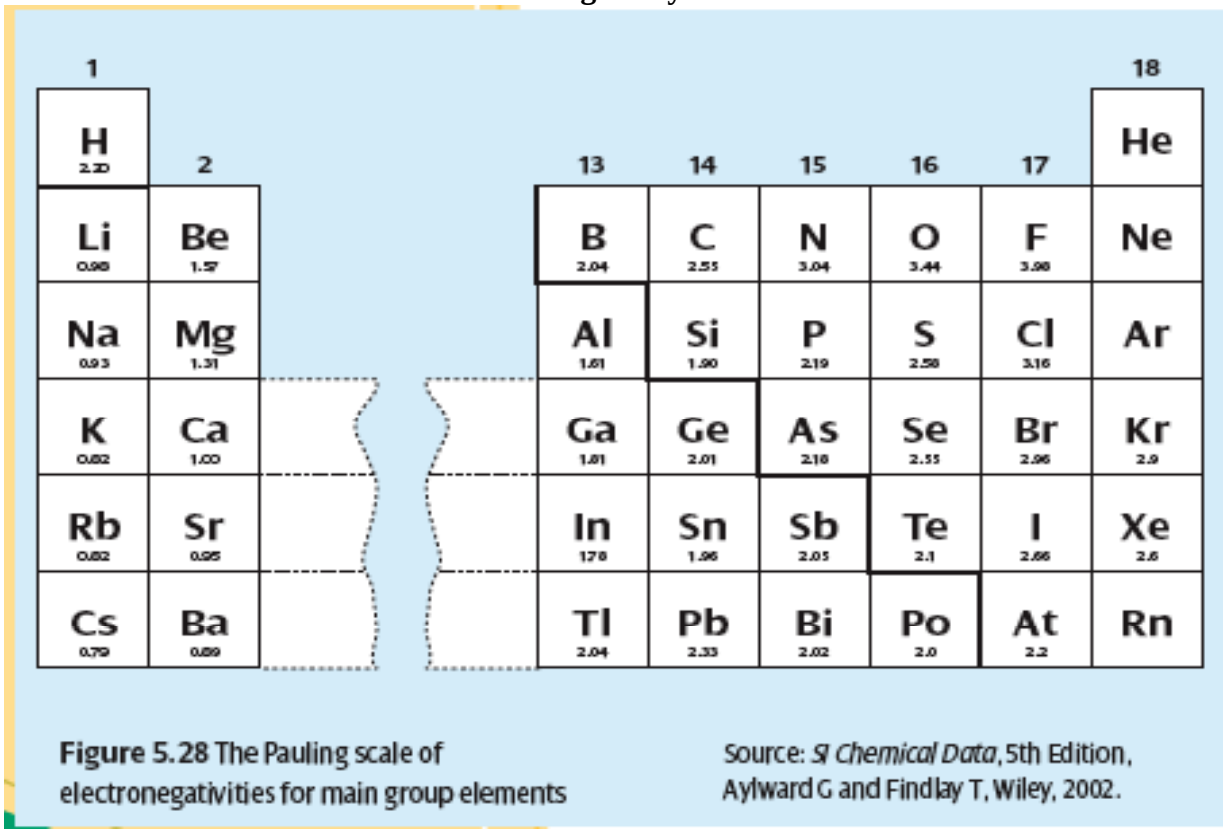


Figure 5.28 The Pauling scale of electronegativities for main group elements

Source: *SI Chemical Data*, 5th Edition, Aylward G and Findlay T, Wiley, 2002.

PERIODIC TABLE OF THE ELEMENTS

1 **H** 1.0																	2 **He** 4.0
3 **Li** 6.9	4 **Be** 9.0											5 **B** 10.8	6 **C** 12.0	7 **N** 14.0	8 **O** 16.0	9 **F** 19.0	10 **Ne** 20.2
11 **Na** 23.0	12 **Mg** 24.3											13 **Al** 27.0	14 **Si** 28.1	15 **P** 31.0	16 **S** 32.1	17 **Cl** 35.5	18 **Ar** 39.9
19 **K** 39.1	20 **Ca** 40.1	21 **Sc** 44.9	22 **Ti** 47.9	23 **V** 50.9	24 **Cr** 52.0	25 **Mn** 54.9	26 **Fe** 55.9	27 **Co** 58.9	28 **Ni** 58.7	29 **Cu** 63.6	30 **Zn** 65.4	31 **Ga** 69.7	32 **Ge** 72.6	33 **As** 74.9	34 **Se** 79.0	35 **Br** 79.9	36 **Kr** 83.8
37 **Rb** 85.5	38 **Sr** 87.6	39 **Y** 88.9	40 **Zr** 91.2	41 **Nb** 92.9	42 **Mo** 95.9	43 **Tc** 98.1	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
55 **Cs** 132.9	56 **Ba** 137.3	57 **La** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.8	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 197.0	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89 **Ac** (227)															

Lanthanides

58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.3	63 **Eu** 152.0	64 **Gd** 157.2	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0

Actinides

90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** 237.1	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (254)	100 **Fm** (257)	101 **Md** (258)	102 **No** (255)	103 **Lr** (256)

Data sheet formulae

The following information may be useful

$n = \frac{m}{M}$ where n = amount of substance in mol

m = mass of substance in grams

M = molar mass in g mol^{-1}

$n = \frac{N}{N_A}$ where N = number of particles

N_A= number of particles in 1 mol (6.02×10^{23})

$$\text{RAM (Atomic Mass)} = \frac{\sum(\text{RIM}_1 \text{ x relative abundance} + \text{RIM}_2 \text{ x relative abundance} + ...)}{100}$$

where RIM = relative isotopic mass

$$\%\text{ composition (element)} = \frac{\text{mass of element in compound x } 100}{\text{mass of compound}}$$

No of C atoms	**Alkanes (C_nH_{2n+2})**		**Alkenes (C_nH_{2n})**	
1	methane	CH_4		
2	Ethane	C_2H_6	Ethene	C_2H_4
3	Propane	C_3H_8	Propene	C_3H_6
4	Butane	C_4H_{10}	Butane	C_4H_8
5	Pentane	C_5H_{12}	Pentene	C_5H_{10}
6	Hexane	C_6H_{14}	Hexene	C_6H_{12}
7	Heptane	C_7H_{16}	Heptene	C_7H_{14}
8	Octane	C_8H_{18}	Octene	C_8H_{16}
9	Nonane	C_9H_{20}	Nonene	C_9H_{18}
10	Decane	$C_{10}H_{22}$	Decene	$C_{10}H_{20}$

Specific instructions for Section B

Section B consists of eight short-answer questions. You should answer all of these questions. This section is worth approximately 69 per cent of the total. You should spend approximately 63 minutes on this section.
The marks allotted are shown at the end of each question.
Questions should be answered in the spaces provided in this book.
To obtain full marks for your responses you should:

- Give simplified answers for all numerical questions; unsimplified answers will not be given full marks.
- Show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.
- Make sure all chemical equations are balanced and that the formulas for individual substances include an indication of state {for example, $H_2(g)$; Na(s)}

Question 1

A sample of iron has the following isotopic composition by mass.

Isotope	^{54}Fe	^{56}Fe	^{57}Fe
Relative abundance	5.95%	91.88%	2.17%

(a) Use the data above to calculate the relative atomic mass of iron. Show all working and give your answer to two decimal places.

RAM(Fe) = [(54 x 5.95) + (56 x 91.88) + (57 x 2.17)]/100
= 55.9027

(b) Iron has an atomic number of 26.

(i) State the period iron is in on the periodic table.

4

(ii) State the group iron is in on the periodic table.

8

(c) List the two types of particles found in a solid crystalline lattice of iron.

Iron cations and delocalised electrons

(d) Explain the electrical conductivity of solid iron.

Electrical conductivity requires free moving charged particles. The negatively charged delocalised electrons are able to move through the lattice, hence are able to transfer charge.

2 + (1 + 1) + 2 + 1 = 7 marks

Question 2

The diagram below represents a **section** of the periodic table.

Li	Be	B	C	N	O	F
Na	Mg	Al	Si	P	S	Cl

From the list of elements, give the **symbol** for the element in this section that represents:

(a) the most electronegative element

F

(b) the least electronegative element

Na

(c) an **atom** that has an electron configuration of $1s^2 2s^2 2p^4$

O

(d) a period 3 element that would be expected combine with oxygen to form a **metallic oxide**.

Any of Na, Mg or Al

(e) an element that would reaction combine form a **non-metallic oxide** that a **linear** shaped molecule.

C

(f) an element that is in Group 15 and period 2.

N

(1 + 1 + 1 + 1 + 1 + 1 = 6 marks)

Question 3

Ethanol, **C_2H_5OH**, is being used a biofuel. When combusted (burnt) in air, (O_2) it produces carbon dioxide and water vapour.

The balanced chemical equation for this reaction is:

$$C_2H_5OH_{(g)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(g)}$$

92 g of ethanol is burnt in excess air.

(a) Determine the molar mass of ethanol.

$M(C_2H_5OH)$ = (2 x 12) + (5 x 1) + 16 + 1
= 46 g mol^{-1}

(b) Calculate the amount, in mol, of 92 g of ethanol.

n = m/M
= 92/46
= 2 mol

(c) Determine the **number** of carbon **atoms** present in 92 g of ethanol.

N = n x N_A
= 2 x 6 x 10^{23}
= 1.2 x 10^{24}

(d) What is the percentage by mass of **oxygen** in ethanol?

%O = [m(O) x 100]/$M(C_2H_5OH)$
= (16 x 100)/46
= 34.8%

1 + 1 + 2 + 2 = 8 marks

Question 4

(a) Ethanoic acid is the acid found in vinegar, where is it used both as food flavouring and as a food preservative. It is composed of 40.0% carbon, 6.67% hydrogen and 53.33% oxygen by mass. Determine the empirical formula of ascorbic acid.

n(C) : n(H) : n(O)

40.0/12 : 6.67/1 : 53.33/16

3.33 : 6.67 : 3.33

3.33/3.33 : 6.67/3.33 : 3.33 : 3.33

1 : 2 : 1 Thus, empirical formula is CH_2O

(b) The molar mass of ascorbic acid is 60 g mol^{-1}. Use the empirical formula to determine the molecular formula of ascorbic acid.

M(Empirical Formula) = 12 + (2 x 1) + 16
= 30

M(Molecular Formula)/M(Empirical Formula) = 60/30
= 2

Thus, molecular formula = 2 x empirical formula
= 2 x CH_2O
= C_2H_4O

3 + 2 = 5 marks

Question 5

Complete the following table.

Name of compound	Formula
Sodium nitrate	**$NaNO_3$**
Hydrogen gas	**H_2**
Calcium phosphate	**$Ca_3(PO_4)_2$**
Iron (III) oxide	**Fe_2O_3**
Ammonium sulphate	**$(NH_4)_2SO_4$**

5 x 1 = 5 marks

Question 6

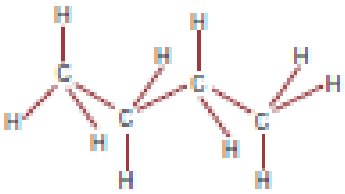
(a) Draw two possible structural formulas for compounds with the molecular formula $C_3H_6Cl_2$.

Draw any of the following structures

- **1,1-dichloropropane**
- **1,2-dichloropropane**
- **1,3-dichloropropane**
- **2,2-dichloropropane**

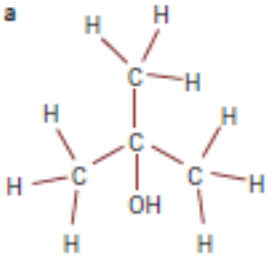
(b) Give the systematic names for the following compounds.

(i)



Name: **Butane**

(ii)



Name: **2-methyl propan-2-ol**

(c) The boiling points for three hydrocarbon compounds are shown in the table below.

Compound		Boiling temperature (^oC)
Methane	CH_4	- 162
Octane	C_8H_{18}	126
Dodecane	$C_{12}H_{26}$	216

(i) What is the main type of bonding interaction **between** the molecules of each of these three hydrocarbons?

Dispersion forces

(ii) State the reason for the difference in the boiling points of these three hydrocarbons.

Boiling temperature is related to the strength of attraction between the molecules. The strength of dispersion forces increases with increasing molecular size. Hence, boiling temperature of these non-polar hydrocarbons will increase with molecular size.

(2 + 1 + 1 + 1 + 1 = 6 marks)

Question 7

The arrangement of potassium ions and fluoride ions in solid potassium fluoride is represented in the diagram below. The arrangement extends in three dimensions to represent a crystal.

Diagram shows 3-dimensional arrangement of K^+ ions and F^- ions.
The lattice is cubed in its arrangement.

(a) What is the empirical formula of potassium fluoride? **KF**

(b) Would it be possible for magnesium fluoride (MgF_2) to have the same structure as potassium fluoride? Explain your answer.

No. The empirical formulas of the compounds are different; hence the arrangements of the positive cations and negative anions will be different

(c) In terms of the relative strengths of the bonding involved, explain why potassium fluoride has a much higher melting temperature (857 ^oC) than the non-polar molecule tetrafluormethane (-184 ^oC).

Melting temperature is related to the strength of attraction between the particles. Weak dispersion forces only operate between non-polar molecules, thus these molecules have a low melting temperature. Strong electrostatic forces operate between the cations and anions in an ionic lattice, hence these ionic compounds have a high melting temperature.

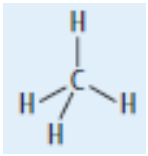
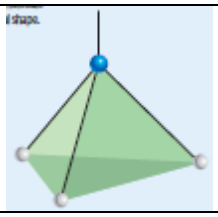
(d) The molten liquid form of potassium fluoride is a good conductor of electricity, whereas solid potassium fluoride does not conduct electricity at all. Explain this observation.

Free moving charged particles need to be present for a substance to conduct electricity. Solid potassium fluoride contains charged particles (the cations and anions), however, these ions are 'fixed' in the lattice (that is, they cannot move). Melting the solid means the ions can move, hence the molten liquid will conduct electricity.

1 + 2 + 2 + 2 = 7 marks

Question 8

Draw a formula showing the **structure** for each of the following molecules and state the shape of the molecule and indicate whether the molecules are polar or non-polar. You do not need to include non-bonding electrons. The first one has been done as an example.

Molecule	Structural diagram	Shape	Polar/Non-polar
H_2O		V-shape	Polar
H_2	**H – H**	**linear**	**Non-polar**
CH_4		**tetrahedral**	**Non-polar**
NH_3		**Pyramidal**	**Polar**
CO_2		**linear**	**Non-polar**

9 x 1 = 9 marks

END OF EXAMINATION

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