INSIGHT

Trial Exam Paper

2011

YEAR 11 CHEMISTRY

Written examination 1

Solutions book

This book contains:

- correct solutions with full working
- explanatory notes
- mark allocations
- tips and guidelines.

SECTION A – Multiple-choice questions

Question 1
Which of the following oxides of nitrogen contains the highest percentage by mass of nitrogen?
A. NO
B. NO_2
C. N_2O_4
D. N_2O_5

Answer is A.

Worked solution
- **A** is correct because the ratio of nitrogen to oxygen is 1 : 1. This is higher than any other alternative. The actual percentage could be calculated for each alternative but this uses up valuable time:

$$\%\text{N} = \frac{M(\text{N})}{M(\text{NO})} \times 100 = \frac{14}{30} \times 100 = 46.7\%$$

- **B** is incorrect because the %N is lower than in **A**. The ratio of N : O is 1 : 2
- **C** is incorrect as the %N is lower than in **A**. The ratio of N : O is 1 : 2, same as **B**.
- **D** is incorrect as the %N is lower than in **A**. The ratio of N : O is 2 : 5.

Question 2
Which of the following molecules will have the highest boiling point?
A. propane
B. propanol
C. butane
D. pentane

Answer is B.

Worked solution
- **B** is correct due to the presence of the hydroxyl functional group (it is an alkanol). The presence of the highly polar functional group will lead to a higher melting point than that of the alkane molecules. Although pentane is a longer molecule, its lack of a strong dipole will mean its boiling point is less than that of propanol.
- **A** is easy to pick as incorrect since propane will have a lower boiling point than butane and pentane, as it is a shorter molecule from the same homologous series.
- **C** will at least have a lower boiling point than pentane as it is a shorter molecule from the same homologous series.
- **D** will have a higher boiling point than propane and butane but it will be lower than that of propanol.

Question 3
Element Z forms a compound $Z_2(SO_4)_3$. When Z reacts with bromine to form a compound, the likely formula will be

A. ZBr
B. ZBr_2
C. ZBr_3
D. Z_2Br_3

Answer is C.

Worked solution

- **C** is correct because the charge on Z is +3 and the charge on bromide ion is –1. The charge on bromide is determined by observing that it is in Group 17 on the Periodic Table, with chlorine. The charge on Z is known because 2 Z atoms balance 3 SO_4^{2-} ions.
- **A** is incorrect because it would require Z and Br^- to have the same magnitude charge.
- **B** is incorrect because it would require the charge on Z to be double that of Br^-.
- **D** is incorrect as it would suggest Z has a charge of 1.5.

Question 4
In Rutherford's famous experiment, he bombarded a thin layer of gold foil with positive alpha particles. Most of the alpha particles passed through the foil easily, with only a small amount of deflection. The occasional particle rebounded drastically back in the direction it was fired from. Which of the following conclusions can be drawn from this experiment?

I Many atoms have isotopes.
II An atom is mostly space.
III An atom has a small positive nucleus.
IV The negative particles in an atom are clumped together.

A. I only
B. II only
C. II and III only
D. II, III and IV only

Answer is C.

Worked solution

- **C** is correct. Most particles went through the foil because the atom is mostly space. The occasional particle rebounding was due to the positive alpha particle colliding with a positive nucleus.
- **A** is incorrect as this experiment did not refer to isotopes.
- **B** is incorrect as it does not include option III.
- **D** is incorrect as the electrons are in different orbitals, not in a clump.

Question 5
Formic acid is the old name for an organic molecule present in the fluid of ants. The percentage composition of the atoms in it is

26.09% C, 4.35% H, 69.56% O

The IUPAC name for formic acid is
A. methanoic acid.
B. methanol.
C. ethanoic acid.
D. propanoic acid.

Answer is A.

Worked solution
- **A** is correct. The empirical formula must be calculated to realise this.
  $= \frac{26.09}{12} : \frac{4.35}{1} : \frac{69.56}{16} = 2.17 : 4.35 : 4.35 = 1 : 2 : 2 \ = CH_2O_2$
  This empirical formula matches the molecular formula of methanoic acid. The empirical formula has two oxygen atoms, matching a typical carboxylic acid; therefore the empirical formula should not be doubled or tripled.
- **B** is incorrect as it is not an acid, nor does the empirical formula match the above.
- **C** is incorrect as the empirical formula of ethanoic acid is CH_2O.
- **D** is incorrect as the empirical formula of propanoic acid is $C_3H_6O_2$.

Question 6
Which of the following contains the greatest mass of oxygen?
A. 1 mole of oxygen gas, O_2
B. 1.8 mole of oxygen atoms
C. 30 g of oxygen gas
D. 3.01×10^{24} atoms of oxygen

Answer is D.

Worked solution
- **D** is correct as it represents 5 moles of oxygen atoms. This is more than any other option.
  $n(\text{O}) = \frac{3.01 \times 10^{24}}{6.02 \times 10^{23}} = 5 \text{ mol}$
- **A** is incorrect as 1 mole of O_2 is the same as 2 moles of O atoms. This is less than **D**.
- **B** is incorrect as 1.8 moles is less than **D**.
- **C** is incorrect as 30 grams is less than 1 mole; hence it is less than **D**.

Question 7
Which of the following ground state configurations represents a transition series metal?
A. $1s^2 2s^2 2p^6 3s^2$
B. $1s^2 2s^2 2p^6 3s^2 3p^6$
C. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3$
D. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3 4s^2$

Answer is D.

Worked solution

- **D** is correct. The 3d orbitals are being filled when the first transition series is formed. **D** has 3 electrons in the 3d shell, so it is the third element in this series; i.e.vanadium.
- **A** is incorrect as it is not a transition metal. It has not filled up to the transition series at all.
- **B** is incorrect as it also has no electrons in d orbitals.
- **C** is incorrect as the electrons have not filled in the correct order. It might be a transition metal but, if so, it is not in its ground state. The question specifies that the element is in its ground state.

Tip

It is important to be able to remember the order in which orbitals fill. Your Data Book contains a Periodic Table; the order of orbitals filling can be determined from this. Use all resources at your disposal, of which the Data Book is an important one.

Question 8

Several elements are arranged from lowest to highest in regard to the trend in one of their properties.

Lowest						**Highest**
Na	Mg	Al	Si	P	S	Cl

This property is

A. melting point.
B. electronegativity.
C. metallic nature.
D. atomic radius.

Answer is B.

Worked solution

- **B** is correct. The elements listed all belong to the same period of the Periodic Table. As you move across the period, the number of electrons in the outer shell increases. As a consequence, the outer shell is getting closer to completion and the electronegativity is increasing.
- **A** is incorrect. Melting points do not follow a consistent trend. Furthermore, chlorine is in fact a gas, so cannot possibly have the highest value.
- **C** is incorrect. The metallic nature actually reduces as you move across the period.
- **D** is incorrect. The atomic radius also decreases as you move across the period, so this trend is in the wrong direction.

Question 9
It was not until 1895 that the first sample of helium was isolated by Scottish chemist William Ramsay. In fact, none of the noble gases were isolated before 1890. The noble gases were not identified earlier because
A. they are relatively scarce.
B. they are unreactive.
C. they are colourless.
D. all of the above.
Answer is D.

Worked solution
- **D** is correct because each factor listed in **A**, **B** and **C** is relevant. The noble gases are all very scarce, they are colourless and their lack of reactivity means there are very few compounds that could be analysed to alert scientists of their existence.
- **A** is a correct response but answer **D** incorporates **A**.
- **B** is a correct response but answer **D** incorporates **B**.
- **C** is a correct response but answer **D** incorporates **C**.

Questions 10 and 11 refer to the following list of chemicals.

Cu, $CuCl_2$, H_2O, Al, polyethene, Hg, CH_4

Question 10
The substances on this list that conduct electricity as solids are
A. Cu, Al.
B. Cu, Al, Hg.
C. Cu, $CuCl_2$, Al, Hg.
D. Cu, $CuCl_2$, H_2O, Al, polyethene, Hg, CH_4.

Answer is B.

Worked solution
- **B** is correct as it is a list of metals. Metals conduct as solids but most other substances do not. Mercury should be included in this list as it can turn to a solid at low temperatures and it conducts like other metals.
- **A** is incorrect as it does not include mercury.
- **C** is incorrect as it includes an ionic compound.
- **D** is incorrect as it includes polyethene and ionic compounds.

Question 11
The substances on this list that conduct electricity as liquids are
A. Cu, Al.
B. Cu, Al, Hg.
C. Cu, $CuCl_2$, Al, Hg.
D. Cu, $CuCl_2$, H_2O, Al, polyethene, Hg, CH_4.

Answer is C.

Worked solution

- **C** is correct as it contains all of the metals and ionic substances. Ionic substances conduct when molten due to the ions now being mobile.
- **A** is incorrect as it does not include mercury or the ionic compound.
- **B** is incorrect as it does not include the ionic compound.
- **D** is incorrect as it includes polyethene and molecular substances.

Question 12

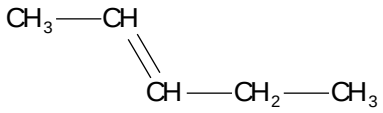
The number of hydrogen atoms in 2-pentene will be

A. 5
B. 9
C. 10
D. 12

Answer is C.

Worked solution

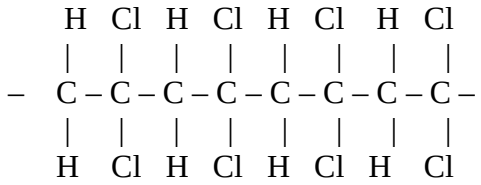
- **C** is correct. Draw the structure and count the hydrogen atoms; 10.



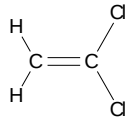
- **A** is incorrect because 10 is the answer.
- **B** is incorrect because 10 is the answer.
- **D** is incorrect because 10 is the answer. If it was an alkane, 12 would be correct.

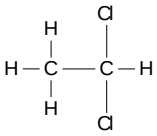
Question 13

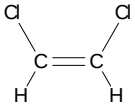
Vinylidene chloride is a specialist polymer used to make solar tinting for windows. A segment of its structure is drawn below.

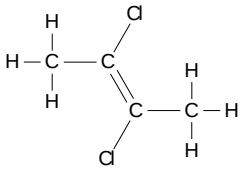


The monomer required to manufacture this polymer is

A. 

B. 

C. 

D. 

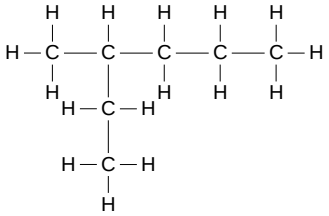
Answer is A.

Worked solution

- **A** is correct as the monomer needs to contain a double carbon bond for addition polymerisation and every second carbon needs two chlorine atoms attached to the same carbon atom.
- **B** is incorrect as it does not contain a double carbon bond.
- **C** is incorrect as both chlorine atoms must be attached to the same carbon atom.
- **D** is incorrect as it would lead to quite complex branches on the polymer.

Question 14

The correct IUPAC name for the molecule shown is



A. 3-methylhexane.
B. 2-ethylpentane.
C. 3-methylpentane.
D. 3-methylheptane.

Answer is A.

Worked solution

- **A** is correct as the longest carbon chain contains six carbon atoms. This is hexane. There is a methyl group on the third carbon from the end, hence 3-methylhexane. Do not call this an isomer of pentane – if you do, you are not identifying the longest carbon chain.
- **B** is incorrect as the longest carbon chain is hexane, not pentane.
- **C** is incorrect as the longest carbon chain is hexane, not pentane.
- **D** is incorrect as the longest carbon chain has six carbon atoms, making it hexane, not heptane. The methyl group is not included in the alkane name.

Tip

Learn to draw a line along the longest row of carbon to carbon bonds that you can find. In this case, it is six carbon to carbon bonds, not five. The methyl group is on the third carbon from the left end of the molecule – it would not be correct to write 4-methyl. The lowest possible number should be used.

Question 15

A quantity of 7 moles of copper sulfate, $CuSO_4$, contains

A. 7 moles of atoms.
B. 7 moles of oxygen atoms.
C. 28 moles of oxygen atoms.
D. $7 \times 6.02 \times 10^{23}$ atoms.

Answer is C.

Worked solution

- **C** is the correct answer. Each $CuSO_4$ molecule contains four oxygen atoms. Therefore the number of mole of oxygen atoms is $7 \times 4 = 28$.
- **A** is incorrect because it refers to 'atoms', not formula units of $CuSO_4$.
- **B** is incorrect as it does not take into account the O_4.
- **D** is incorrect as it does not take into account that the formula unit of $CuSO_4$ contains seven atoms.

Question 16

$$H_2O,\ AlCl_3,\ SO_2,\ NH_3,\ Cu,\ NaBr,\ Li_2O,\ Cl_2$$

From the list above, the substances that are covalent molecular substances are

A. $AlCl_3$, NaBr, Li_2O.
B. H_2O, SO_2, NH_3, $AlCl_3$.
C. H_2O, SO_2, NH_3, Cl_2.
D. H_2O, $AlCl_3$, SO_2, NH_3, Cu, NaBr, Li_2O, Cl_2.

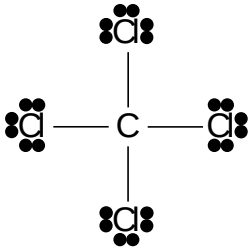
Answer is C.

Worked solution

- **C** is correct. It contains no metals and no ionic substances. Cl_2 should be included as it is a molecule even though it is an element.
- **A** is incorrect as it contains ionic substances.
- **B** is incorrect. Although it has covalent compounds, it does not include Cl_2. It is also wrong because it includes an ionic substance.
- **D** is incorrect as it contains metals and ionic substances.

Question 17

A diagram of the dry-cleaning fluid carbon tetrachloride, CCl_4, is shown below.



This molecule will

A. form a giant lattice.
B. conduct electricity due to the outer shell electrons.
C. be polar because of the high electronegativity of chlorine.
D. contain bond dipoles but will be non polar.

Answer is D.

Worked solution

- **D** is correct because although the molecule will contain bond dipoles between the chlorine and carbon, the bond dipoles are symmetrical and they will cancel each other out.
- **A** is incorrect because CCl_4 is a molecule, not a giant lattice.
- **B** is incorrect because molecules do not conduct electricity.
- **C** is incorrect because the molecule is non polar.

Question 18

The properties of a particular element are listed as

Melting point	961°C
Density	10.5 g mL^{-1}
Electrical conductivity	60 MS m^{-1}

The element is most likely to be

A. silver.
B. carbon.
C. chlorine.
D. aluminium.

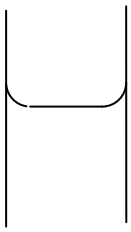
Answer is A.

Worked solution

- **A** is the correct answer. The electrical conductivity suggests a metal, as does the density. Silver has a high melting point. The other options do not fit the evidence.
- **B** is incorrect. Although carbon can conduct electricity as graphite, it is a low-density material. It has a much higher melting point as well.
- **C** is incorrect. Chlorine is a non-electrically conductive gas.
- **D** is incorrect. Although aluminium conducts electricity, it is a low-density material.

Question 19

A student measuring the volume in a glass measuring cylinder notices that the water surface is not completely horizontal, as shown in the diagram below. The reason for this effect is that



A. there are significant forces of attraction between the water molecules and the glass.
B. water particles attract each other more than they attract to glass.
C. water particles repel each other, pushing each other up the glass.
D. water contains nanoparticles that are affected by gravity.

Answer is A.

Worked solution

- **A** is correct. The water rises up the glass due to the attraction between the water molecules and the glass.
- **B** is incorrect as it suggests that the water should be *lower* at the edges, not *higher*.
- **C** is incorrect. Water particles attract each other due to the hydrogen bonds.
- **D** makes no sense at all.

Question 20

The width of a particular carbon nanotube is 23 nm. In metres, this corresponds to a width of

A. 2.3×10^{-9}
B. 2.3×10^{-8}
C. 2.3×10^{8}
D. 2.3×10^{10}

Answer is B.

Worked solution

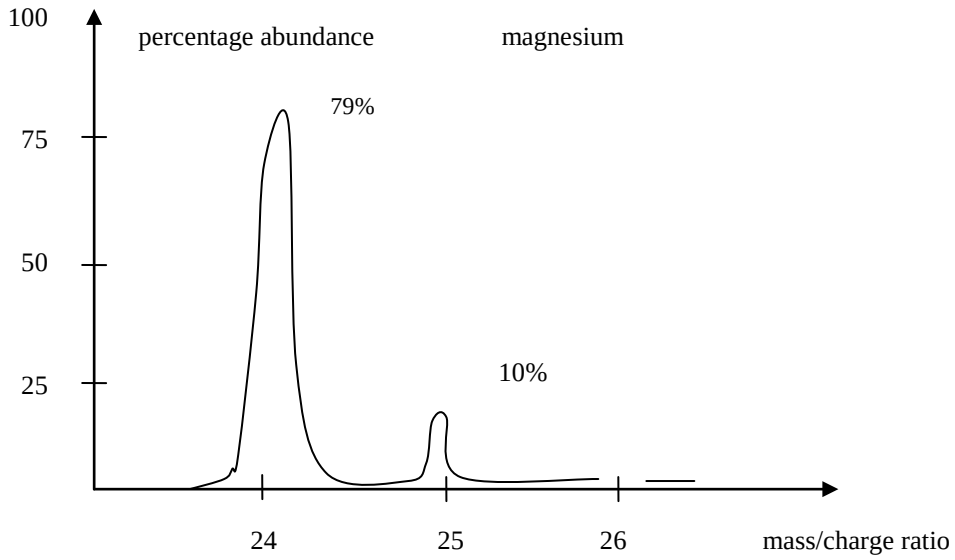
- **B** is correct. 1 nm = 10^{-9} m. Therefore 23 nm = $23 \times 10^{-9} = 2.3 \times 10^{-8}$.
- **A** is incorrect. The answer is too small by a factor of 10.
- **C** is incorrect as the power of 10 is positive.
- **D** is incorrect as the power of 10 is positive.

END OF SECTION A
TURN OVER

SECTION B – Short-answer questions

Question 1

Every element can be passed through a mass spectrometer. The number of isotopes of the element, and the exact mass of each isotope, is read from the spectrum obtained. A simplified mass spectrum for magnesium is drawn below. Note that a third peak has not been drawn in.



a. Draw in the third peak on the spectrum provided, indicating the height of the peak.

1 mark

b. Write the formula of each isotope in the form $^{A}_{Z}X$

3 marks

c. **i.** Write the ground state electron configuration of magnesium.

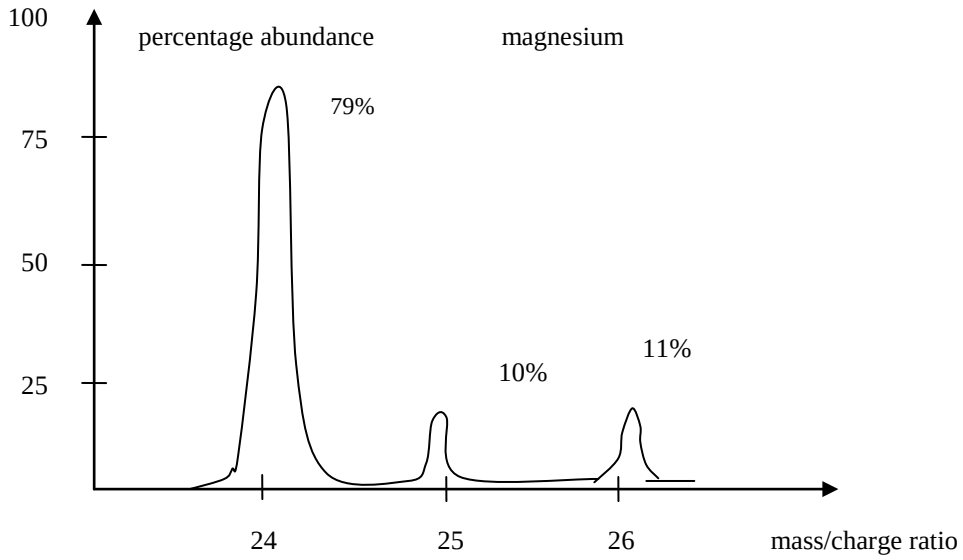
ii. What is the likely charge on a magnesium ion?

1 + 1 = 2 marks

Total 1 + 3 + 2 = 6 marks

Worked solution

a.



Mark allocation
1 mark for a peak at 26 that has a height of 11%.

Explanatory notes
The peaks should have a combined total of 100%.
Therefore the missing peak is 100 – 79 – 10 = 11.

b. $^{24}_{12}Mg$ $^{25}_{12}Mg$ $^{26}_{12}Mg$
Mark allocation
1 mark for each correct isotope.

Explanatory notes
Each isotope has one more neutron than the previous one. The atomic number, however, is 12 for each isotope.

c. **i.** $1s^2 2s^2 2p^6 3s^2$

ii. +2

Mark allocation
1 mark for exact configuration.
1 mark for +2 charge.
Explanatory note
Elements seek to obtain a complete outer shell of electrons. Magnesium will lose the two outer shell electrons, making its ion +2 in electrovalency.

Tip
It is important to learn the order of electrons filling. This can be obtained from the Periodic Table if you cannot remember the diagram with the arrows. You should also be able to predict the likely charge of each element when it forms an ion.

Question 2
An electron dot diagram of two imaginary elements, A and B, is drawn below.

a. A pure sample of element A exists as a solid with a high melting point.
i. What category of material is element A?

ii. Will element A conduct electricity as a solid? Explain your answer.

1 + 2 = 3 marks

b. A pure sample of element B exists as a diatomic gas.
i. List two properties that a sample of element B will exhibit.

ii. Use a diagram to show the bonding that will exist in a sample of the gaseous element B.

iii. Name the type of bonding present in this sample of element B.

1 + 1 + 1 = 3 marks

c. A compound forms between the two elements A and B.
i. Give a chemical formula for the compound formed.

ii. Describe what happens to the electrons when the compound forms.

iii. List three properties that the compound will exhibit.

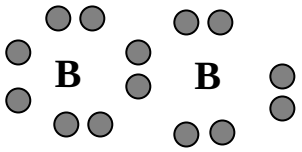
1 + 2 + 1 = 4 marks
Total 3 + 3 + 4 = 10 marks

Worked solution
a. **i.** metal
ii. Yes. The outer shell valence electrons in metals are delocalised. They can move through the metal structure, making the metal an electrical conductor.

Mark allocation
1 mark for the word metal.
1 mark for 'yes' to conductivity; 1 mark for a valid explanation.
Explanatory notes
Metals have one, two or three electrons in their outer shells. They give these electrons away readily.

b. **i.** Element B will be a covalent molecular substance. Therefore, its properties will include
- low boiling point/melting point.
- non-conductor of heat and electricity.
- non-malleable.
- low density.

ii. Element B will be diatomic with two atoms sharing one electron each. This gives both atoms complete outer shells.



iii. The bonding present is a covalent bond.

Mark allocation
1 mark for any two valid properties.
1 mark for a diagram showing shared electrons.
1 mark for the word *covalent*.

c. **i.** AB_2

ii. The two electrons from the metal A are transferred to non-metal B. Since each atom of B can accept only one electron, two atoms of B are required.

iii. Hard, high melting point, conducts electricity as a liquid, brittle.

Mark allocation
1 mark for giving the correct formula.
1 mark for mention of electron transfer; 1 mark for a reason why the formula requires more of B than A.
1 mark for any three valid properties of an ionic solid.
Explanatory notes
Metals reacting with non-metals produce ionic solids. Electrons are transferred from the metal to the non-metal. Element A has two electrons to donate but element B can accept only one; therefore two atoms of B are required for each atom of A, hence the formula is AB_2.

Question 3
The charges on some particular ions are shown in the table below.

Oxidation number	Elements or ions
+3	Al, Fe
+2	Mg, Ca, Ba
+1	Li, Na, K, NH_4
–1	F, Cl, NO_3
–2	S, SO_4
–3	PO_4

Use the charges provided to answer the following questions.

a. Write the names of the following compounds.

i. $NaNO_3$ _____

ii. $MgCl_2$ _____

2 marks

b. Write balanced chemical formulas for each of the following compounds.

i. calcium fluoride _____

ii. lithium phosphate _____

iii. aluminium sulfate _____

3 marks

c. Determine the electrovalency of the anion (i.e. the negative ion) in each of the following.

i. K_2CO_3 _____

ii. $Al(OH)_3$ _____

2 marks
Total 2 + 3 + 2 = 7 marks

Worked solution
a. **i.** $NaNO_3$ sodium nitrate
ii. $MgCl_2$ magnesium chloride

Mark allocation
1 mark for each correct name.

Explanatory note
It is expected that students can work out the names of ions like NO_3^-.

b. **i.** calcium fluoride CaF_2

ii. lithium phosphate Li_3PO_4

iii. aluminium sulfate $Al_2(SO_4)_3$

Mark allocation
1 mark for each correct formula.

c. **i.** K_2CO_3 –2 CO_3^{2-}

ii. $Al(OH)_3$ –1 OH^-

Mark allocation
1 mark for each correct oxidation number.

Explanatory notes
If K is +1, then the CO_3 must balance two positives; hence, it is –2.
Al is Al^{+3}; therefore the OH must be –1 since Al is balanced by three OH groups.

Question 4
Sodium carbonate is an ionic substance with a formula of Na_2CO_3. A student heats a sample of sodium carbonate to ensure that it contains no moisture and then weighs the sample. The mass is 40.26 g.

a. Determine the relative formula mass of Na_2CO_3.

1 mark

b. Determine the molar mass of Na_2CO_3.

1 mark

c. Determine, in the sample weighed by the student, the

i. number of mole of Na_2CO_3.

ii. number of mole of oxygen atoms.

iii. number of mole of atoms.

iv. number of atoms of oxygen.

1 + 1 + 1 + 1 = 4 marks

d. Calculate the mass of oxygen contained in the sample weighed.

2 marks
Total 1 + 1 + 4 + 2 = 8 marks

Worked solution
a. $M_r(Na_2CO_3) = 2 \times 23 + 12 + 48 = 106$

Mark allocation
1 mark for correct answer.

b. $M(Na_2CO_3) = 106 \text{ g mol}^{-1}$

Mark allocation
1 mark for correct answer.

Explanatory note
The numerical value of the relative atomic mass and molar mass will be the same but the molar mass will have units of g.

c. **i.** $n = \frac{m}{M} = \frac{40.26}{106} = 0.380$ mol

ii. $n(\text{O}) = 3 \times 0.380 = 1.14$ mol

iii. $n(\text{atoms}) = 6 \times 0.380 = 2.280$ mol (Na + Na + C + O + O + O = 6)

iv. Number of oxygen atoms = $n(\text{O}) \times 6.02 \times 10^{23} = 1.14 \times 6.02 \times 10^{23} = 6.86 \times 10^{23}$

Mark allocation
1 mark for each correct numerical answer.

Explanatory notes
For part **ii** each Na_2CO_3 contains three atoms of oxygen; hence, the number of mole of oxygen is 3 times the number of mole of Na_2CO_3.

For part **iii** each Na_2CO_3 contains six atoms, so the answer to part **i** is multiplied by 6.

Part **iv** asks for the 'number of atoms', not the 'number of mole'; hence, the answer needs to be multiplied by Avogadro's constant; i.e. 6.02×10^{23}.

Tips
Read very carefully exactly what the question is asking for. Notice that the question varies from 'number of mole of the substance' to 'number of mole of a particular atom' to the 'number of atoms'. The answer will change as the wording changes.

d. % mass oxygen = $\frac{3 \times 16}{106} \times 100 = 45.3\%$

Mass of oxygen = $\frac{45.3}{100} \times 40.26 = 18.2$ g

Alternative working: $m(\text{O}) = n \times M$
$= 1.14 \times 16$
$= 18.2$ g

Mark allocation
1 mark for calculating % oxygen or calculation using molar mass.
1 mark for finding the mass of oxygen. Units of g should be shown.

Question 5

The structure of organic molecules can be shown in several different formats. There are advantages and disadvantages of each style. This question uses the alkane molecule hexane, to test if you can use each formatting style competently.

a. Use the second column of the table provided to represent hexane in each of the requested formatting styles.

Formatting style	
molecular formula	
empirical formula	
semi-structural	
structural	

4 marks

b. **i.** Hexane has several isomers. Draw structural diagrams of two of these isomers.

ii. Name the isomers that you drew in part **b. i.**

_____ _____

2 + 2 = 4 marks

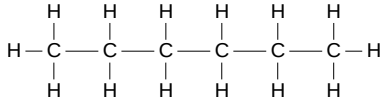
c. Hexane is a fuel. It burns in air to produce carbon dioxide and water.
Write a balanced equation for the combustion of hexane.

1 mark

Total 4 + 4 + 1 = 9 marks

Worked solution

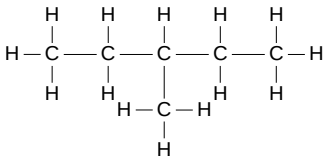
a.

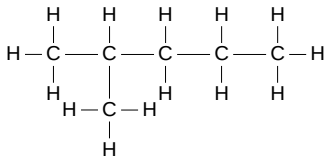
Formatting style	
molecular formula	C_6H_{14}
empirical formula	C_3H_7
semi-structural	$CH_3CH_2CH_2CH_2CH_2CH_3$
structural	

Mark allocation
1 mark for each correct formatting style.

Explanatory notes
Hexane has six carbon atoms; hence, its molecular formula is C_6H_{14}.
The empirical formula is the simplest ratio of the molecular formula – this is C_3H_7.
The semi-structural formula shows the arrangement around each particular carbon but it does not draw in each individual bond.
The structural diagram should show all bonds but it does not have to show the shape of the molecule.

b. i. There are several possibilities – two of which are drawn below.





ii. 3-methylpentane 2-methylpentane

Mark allocation
1 mark for each correct structure drawn.
1 mark for each correct name provided.

Tip
The second structure above must be named 2-methylpentane and not 4-methylpentane. This is because the numbering of the carbon atoms must start closest to the end of the molecule that contains the branch and must have the lowest possible number combination.

c. $2C_6H_{14}(g) + 19O_2(g) \rightarrow 12CO_2(g) + 14H_2O(g)$

Mark allocation
1 mark for correct coefficients. States should be included, but not essential for Unit 1.

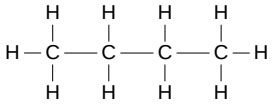
Tip
Put the products in first:
$C_6H_{14} + O_2 \rightarrow CO_2 + H_2O$

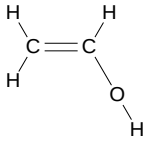
Then balance the carbon and hydrogen:
$C_6H_{14} + O_2 \rightarrow 6CO_2 + 7H_2O$

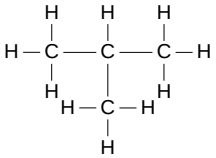
Balance the oxygen – you might have to use a value of a ½ to start with.
$C_6H_{14} + 9½O_2 \rightarrow 6CO_2 + 7H_2O$
$2C_6H_{14}(g) + 19O_2(g) \rightarrow 12CO_2(g) + 14H_2O(g)$

Question 6

Polymers are very long molecules formed from a repeating unit called a monomer. One of the molecules drawn below can act as a monomer in an addition polymerisation reaction.







a. Select the molecule that is the most suitable monomer to form an addition polymer and draw the structure of the polymer that is formed from it.

2 marks

b. The polymer formed is described as a *thermoplastic* material.

i. Explain the term *thermoplastic*.

ii. Explain how the thermoplastic nature of a polymer is related to its ability to be recycled.

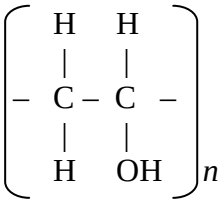
2 + 1 = 3 marks

c. Some polymers can be extruded (i.e. elongated/shaped) into pipes or tubing. Explain how the thermoplastic nature of a polymer is related to its ability to be extruded.

2 marks
Total 2 + 3 + 2 = 7 marks

Worked solution

a. The middle molecule is a monomer. The polymer formed has the following structure.



Mark allocation
1 mark for selecting middle molecule.
1 mark for drawing correct structure.

Explanatory note

Addition polymers usually have a monomer with a double bond. The middle molecule was the only one with a double bond.

b. **i.** Thermoplastic polymers have no significant cross-links between separate molecules. When heated, the molecules should be able to melt to form a liquid, where the forces holding the molecules together break before the bonds holding the molecules together.

ii. Thermoplastic polymers should be recyclable since they can melt and then be remoulded into a new object.

Mark allocation
1 mark for mentioning that there are no cross-links.
1 mark for explanation that molecule can melt.
1 mark for explaining molecule can be recycled since it can be remoulded.

c. During extrusion, the polymer is heated to form a molten liquid. It is then squeezed through a narrow opening in the shape desired; i.e. a hose or pipe. The liquid cools quickly to retain this shape.

Mark allocation
1 mark for mentioning that the polymer is molten and squeezed through a die/desired shape.
1 mark for explaining that the shape of the die is retained as the solid reforms.

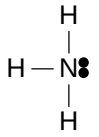
Question 7

a. The electronegativity values for hydrogen and nitrogen are 2.1 and 3.0 respectively.

i. Use the single bond shown below to draw in the bond dipole that will exist when nitrogen and hydrogen form a single covalent bond.

N – H

ii. Ammonia is a compound formed when nitrogen bonds to three hydrogen atoms. The electron dot diagram of ammonia is drawn below.
What will be the shape of the ammonia molecule?



iii. Will this molecule be polar or non polar? Explain your answer.

1 + 1 + 2 = 4 marks

b. Many covalent compounds have low melting points. Carbon, however, has a very high melting point whether it is present as diamond, graphite or nanotubes.

i. Explain why diamond has a high melting point but methane, which also has covalent bonds, has a low melting point.

ii. Compare the bonding of diamond with that of graphite and explain how they are very different even though they are both made from carbon.

2 + 2 = 4 marks

c. **i.** Draw the structure of 2-butene.

ii. Draw the structure of 2,2-dimethylpropane.

iii. Why is propene not written as 1-propene?

1 + 1 + 1 = 3 marks
Total 4 + 4 + 3 = 11 marks

Worked solution
a. **i.** $N^{\delta-} - H^{\delta+}$

ii. trigonal pyramid

iii. Ammonia will be polar. The dipoles are not symmetrical so do not cancel out.

Mark allocation
1 mark for showing the dipoles correctly.
1 mark for stating trigonal pyramid.
1 mark for explaining the shape; 1 mark for stating that the molecule is not symmetrical.

Explanatory notes
The element with the highest electronegativity will have the negative charge.
Some molecules can have bond dipoles and yet be non polar. Carbon dioxide is an example of this. Ammonia, however, is not an example.

Tips
The shapes of some molecules should be learnt off by heart as they are discussed and asked for frequently. Ammonia, water, methane and carbon dioxide are examples that should be learnt by rote.

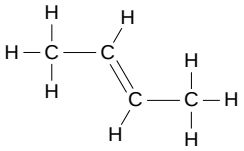
b. **i.** Diamond is a giant array/lattice. The whole structure is covalent bonding. Methane, however, is a molecule. Although the covalent bonding in the molecule is strong, the bonding between one molecule and another is weak, leading to a low melting point.

ii. Diamond and graphite are allotropes. As such, their structures are very different. Diamond is a 3-D giant array of carbon in a tetrahedral arrangement whereas graphite is a layered structure. The layers in graphite are not bonded strongly and they can slide past each other.

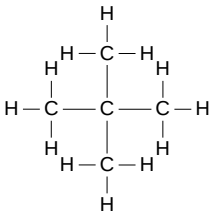
Mark allocation
1 mark for stating that diamond is a giant array compared to methane being a molecule.
1 mark for mentioning methane has weak bonds between molecules.
1 mark for mentioning allotropes.
1 mark for description of how the two giant arrays are quite different.

Explanatory notes
Students need to be clear that covalent bonding can be present in small molecules or it can be present in giant arrays/lattices. There are not many examples of giant arrays so the mention of diamond, graphite or silicon dioxide should alert the student to a giant array/lattice.

c. **i.**



ii.



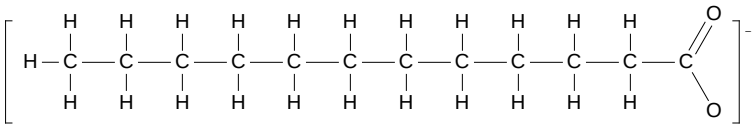
iii. There is no other spot where the double carbon bond can be placed, therefore the 1- is not necessary and should not be used.

Mark allocation
1 mark for each correct structure.
1 mark for explaining that the 1- in propene is superfluous.

Explanatory notes
The hydroxyl group in butanol can be on the first or second carbon. The 1- is used to declare onto which carbon it is attached. There is no other place the carboxyl group can go. It would cause too many bonds on a carbon if it was attached to the second carbon. The 1- should be used only when there is some other possible structure.

Question 8

a. A detergent molecule has a polar segment and a non-polar segment. An example is drawn below.



i. Explain how a detergent molecule can have a polar segment and a non-polar segment.

ii. Explain how the detergent molecule will orient itself when it meets a drop of oil on a greasy plate.

2 + 1 = 3 marks

b. Carbon nanotubes are an example of a new technology that is expected to be important in the future.

i. What does *nanotechnology* mean?

ii. List two potential uses for carbon nanotubes.

1 + 2 = 3 marks
Total 3 + 3 = 6 marks

Worked solution

a. **i.** The long alkane section of the chain is non polar; i.e. the section of CH_3CH_2 etc. The charged carboxyl end is polar because it contains an ionic group.

ii. The non-polar tail of the detergent will be attracted to the non-polar oil molecule; hence, the tail of the detergent will penetrate the oil surface. The charged part of the detergent is more attracted to the water so it will stay in the water.

Mark allocation
1 mark for correctly identifying the polar charged section; 1 mark for correctly identifying the non-polar alkane section.
1 mark for describing the action of detergent.

b. **i.** Nano means small. In particular, nano is of the order of 10^{-9} metres. By making such small things, scientists are finding unusual properties that should prove useful.

ii. Reinforcement for plastics, capturing of gases, electrical conductivity, light globe filaments.

Mark allocation
1 mark for explaining that nanotechnology is the investigation of the unusual properties of very small things.
1 mark for each correct use for nanotubes.

END OF SECTION B