VCE CHEMISTRY 2014

YEAR 11 TRIAL EXAM

Unit 1
Reading time: 15 minutes
Writing time: 1 hour 30 minutes

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	20	20	20
B	8	8	52
			Total 72

To download the Chemistry Data Book please visit the VCAA website:
http://www.vcaa.vic.edu.au/Documents/exams/chemistry/chemdata_2012-w.pdf

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STUDENT NUMBER

										Letter
Figures										
Words										

Student Name.....…….....

VCE Chemistry 2014 Year 11 Trial Exam Unit 1

Student Answer Sheet

Instructions for completing test. Use only a 2B pencil. If you make a mistake erase, it and enter the correct answer. Marks will not be deducted for incorrect answers.

Write your answers to the Short Answer Section in the space provided directly below the question. There are **20 Multiple Choice** questions to be answered by circling the correct letter in the table below.

Question 1	A	B	C	D	*Question 2*	A	B	C	D
Question 3	A	B	C	D	*Question 4*	A	B	C	D
Question 5	A	B	C	D	*Question 6*	A	B	C	D
Question 7	A	B	C	D	*Question 8*	A	B	C	D
Question 9	A	B	C	D	*Question 10*	A	B	C	D
Question 11	A	B	C	D	*Question 12*	A	B	C	D
Question 13	A	B	C	D	*Question 14*	A	B	C	D
Question 15	A	B	C	D	*Question 16*	A	B	C	D
Question 17	A	B	C	D	*Question 18*	A	B	C	D
Question 19	A	B	C	D	*Question 20*	A	B	C	D

VCE Chemistry 2014 Year 11 Trial Exam Unit 1

SECTION A – Multiple Choice Questions

(20 marks, 25 minutes)

This section contains 20 multiple choice questions.
For each question, choose the response that is correct or best answers the question.
Indicate your answer on the answer sheet provided.
(Choose only one answer for each question.)

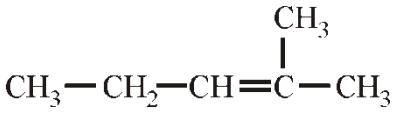
Question 1
Luminol, one of the key agents in producing chemiluminescence in light sticks, was analysed. The percentage by mass of carbon, hydrogen, nitrogen and oxygen were found to be 54.2 %, 3.95 %, 23.7 % and 18.1 % respectively. The empirical formula for luminol is
A. C_4H_3NO.
B. $C_5H_4N_2O$.
C. $C_9H_8N_3O_2$.
D. $C_8H_7N_3O_2$.

Question 2
In the fourth period of the Periodic Table, compared to gallium, selenium would display
A. more metallic characteristics and have a lower electronegativity.
B. more non-metallic characteristics and have a lower electronegativity.
C. more non-metallic characteristics and have a higher electronegativity.
D. more metallic characteristics and have a higher electronegativity.

Question 3
The structure of calcium oxide would involve
A. calcium and oxide ions arranged in a two dimensional lattice and held together by strong electrostatic forces within the lattice.
B. calcium oxide molecules with dipolar forces between the molecules.
C. calcium oxide molecules with weak dispersion forces between the molecules.
D. calcium and oxide ions arranged in a three dimensional lattice and held together by strong electrostatic forces.

Question 4
A sample of methane, CH_4, contains 4.82×10^{24} hydrogen atoms. The mass of the sample would be closest to
A. 26 g.
B. 32 g.
C. 128 g
D. 8 g.

Question 5
The systematic name for the hydrocarbon with the structure



is
A. 2-methylpent-2-ene.
B. 1,1-dimethylbut-1-ene.
C. 2-methylpent-3-ene.
D. 2-methylpentane.

Question 6
A neutral atom contains 60 electrons and 86 neutrons. The symbol for this isotope would be
A. $^{146}_{86}Rn$
B. $^{146}_{60}Nd$
C. $^{86}_{60}Nd$
D. $^{60}_{86}Rn$

Question 7
A molecule on the surface of a water drop will experience
A. an overall force of attraction towards the molecules beside it on the surface of the drop.
B. completely balanced forces of attraction.
C. an overall force of attraction towards the molecules inside the drop.
D. an overall force of attraction towards the gases that surround the drop.

Question 8
The electrical conductivity of metals is explained in the metallic bonding model by the free movement of
A. all of the electrons associated with the atoms in the lattice.
B. the ions in the metallic lattice.
C. electrons associated with defects in the positive ion lattice.
D. the delocalised electrons in the positive ions lattice.

Question 9
The physical properties of silicon carbide, SiC, are shown below.

Melting temperature	decomposes 2986 °C
Hardness (Moh's scale)	9.5
Density	3.23 g cm^{-3}
Electrical conductivity	insulator

The structure of silicon carbide would involve
A. a three dimensional network lattice with each silicon covalently bonded to four carbons and each carbon covalently bonded to four silicons.
B. covalently bonded silicon carbide molecules, with the molecules held together by dipolar forces.
C. a lattice of silicon and carbide ions.
D. a two dimensional network lattice with each silicon covalently bonded to three carbons and each carbon covalently bonded to three silicons.

Question 10
An element has two naturally occurring isotopes with mass numbers of 85 and 87. The abundance of the heavier isotope is about 30 %. The relative atomic mass for this element would be closest to
A. 86.0
B. 86.4
C. 85.3
D. 85.6

Question 11
The semistructural formulae for two compounds are

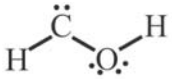
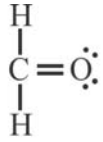
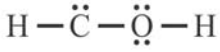
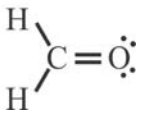
$$CH_3CH_2CHClCH{=}CHCH_2Cl \quad \text{and} \quad (CH_3)_2CHCH{=}CHCHCl_2$$

These two compounds are
A. sequential members in a homologous series of alkenes.
B. isomers because they have the same molecular formulae.
C. products of a reaction between chlorine and hexene.
D. isomers because they have the same empirical formulae.

Question 12
Metals will react with chlorine to form metal chloride compounds. In an experiment, a 1.369 g sample of a metal completely reacted with chlorine to form 4.173 g of the metal chloride. The percentage by mass of chlorine in this compound would be
A. 67.2 %.
B. 48.8 %.
C. 32.8 %.
D. 75.3 %.

Question 13
The monomers used to produce an addition polymer must
A. have functional groups at each end that will react and produce a small molecule.
B. have a carbon-oxygen double bond.
C. be alkanes.
D. have an unsaturated carbon-carbon bond.

Question 14
The forces present between the molecules in a sample of phosphine, PH_3, will be in order of decreasing strength
A. dipole-dipole interactions, hydrogen bonding and dispersion forces.
B. dipole-dipole interactions and dispersion forces.
C. dispersion forces, hydrogen bonding and dipole-dipole interactions
D. dispersion forces and dipole-dipole interactions.

Question 15
The structure for methanal, CH_2O, would be best represented by
A. 
B. 
C. 
D. 

Question 16
One of the limitations of the metallic bonding model is that it cannot simply explain
A. why metals can be drawn out into fine wires.
B. the ability of metals to be rolled into thin sheets.
C. why some metals are magnetic.
D. why a polished metal surface reflects light.

Question 17
The empirical formula for a compound was determined to be C_2H_2N. When 0.0010 mole of the molecules were decomposed they released 0.0020 mole of nitrogen gas. The molecular formula for this compound is
A. $C_4H_4N_2$.
B. C_2H_2N.
C. $C_{16}H_{16}N_8$.
D. $C_8H_8N_4$.

Question 18
The contribution that Ernest Rutherford made to the development of atomic theory was to
A. propose that most of the mass of an atom was due to the protons and neutrons.
B. discover the existence of the neutron.
C. propose that most of the mass of an atom was in its central core.
D. explain how atoms undergo radioactive decay.

Question 19
The sizes of nanoparticles are in the range
A. 1.0×10^{-9} m to 1.0×10^{-7} m.
B. 1.0×10^{-11} m to 1.0×10^{-9} m.
C. 1.0×10^{-7} m to 1.0×10^{-5} m.
D. 1.0×10^{-15} m to 1.0×10^{-13} m.

Question 20
Many addition polymers can be readily shaped or reshaped using gentle heating because
A. they melt at low temperatures.
B. the polymer chains can easily slide over one another.
C. the polymer chains can move within the solid lattice.
D. the heat breaks some of the bonds within the polymer chains which then reform when cooled.

End of Section A

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SECTION B – Short Answer Questions

(52 marks, 65 minutes)

This section contains eight questions, numbered 1 to 8.
All questions should be answered in the spaces provided.
The mark allocation and approximate time that should be spent on each question are given.

Question 1 (5 marks, 6 minutes)

Surface interactions play a significant role in many industrial and everyday processes.

a. Give an explanation why chemists have found that catalysts consisting of nanoparticles are more active than when a bulk sample of the same material is used. **1 mark**

b. Explain why the electrical conductivity of metal nanoparticles is less than that for a bulk sample of the same metal. **1 mark**

c. The leaves of some plants have a waxy coating. A plant scientist wished to use a water soluble leaf treatment for the plants, and dissolved the substance in water.

i. Why would this aqueous solution not be as effective as expected? **1 mark**

ii. What could the plant scientist do to achieve a better level of effectiveness with this water soluble treatment? **1 mark**

d. Explain why the surface energies for metals are considerably higher than those for polymeric materials such as polyethene. **1 mark**

Question 2 (7 marks, 9 minutes)

a. For the following molecules, draw diagrams to describe their geometries that show all bonding and non-bonding electrons, and state if the molecules will have permanent dipoles.

i. Hydrogen cyanide, HCN. **1 mark**

ii. Hydrogen sulfide, H_2S. **1 mark**

b. Alloying is a method used to alter the properties of metals. Explain the difference between the structures of interstitial and substitutional alloys. **2 marks**

c. Explain why solid sodium chloride does not conduct an electric current whereas it does conduct an electric current when molten. **2 marks**

d. Methane, CH_4, and ammonia, NH_3, are molecules with comparable molecular masses. However the boiling temperature for methane (-182.5 °C) is significantly lower than that for ammonia (-78 °). Give an explanation why this difference between the boiling temperatures of these two compounds occurs. **1 mark**

Question 3 (7 marks, 9 minutes)

a. John Dalton proposed an atomic theory in 1805. For each of the proposals of this theory listed below, state how the proposal compares with the current atomic theory.

i. All matter consists of indivisible atoms. **1 mark**

ii. Atoms of a particular element are identical in weight and have identical properties. **1 mark**

iii. The most stable compounds of two elements contain atoms in a one to one ratio. **1 mark**

b. Write the ground state electronic configurations for the following atoms or ions in terms of sub-shells.

i. A fluoride ion. **1 mark**

ii. A cobalt atom. **1 mark**

c. When the nucleus of an uranium-235 atom undergoes radioactive decay, it releases a helium-4 nucleus. Write the symbol for the other atomic particle that would be produced as a result of this decay. **1 mark**

d. What experimental evidence led Niels Bohr to first propose the electron shell model for atoms? **1 mark**

Question 4 (7 marks, 9 minutes)

a. Chlorine and sodium are two elements in the third period of the Periodic Table.

i. Explain, stating the reason, how the atomic radius of a chlorine atom compares with that of a sodium atom. **2 marks**

ii. Both of these elements will react with oxygen to form compounds with the chemical formulae of Cl_2O and Na_2O. Explain the differences in the bonding that would characterise these two compounds. **2 marks**

b. Magnesium and strontium are both members of Group 2 in the Periodic Table. Explain how the chemical reactivity of strontium would compare with that of magnesium. **2 marks**

c. Explain why neon is unreactive even under extreme conditions. **1 mark**

Question 5 (6 marks, 7 minutes)

a. **i.** Draw the structure for 2,2-dimethylbutane. **1 mark**

ii. Give the systematic name for another structural isomer of this hydrocarbon. **1 mark**

b. Write appropriate chemical equations for the following reactions of hydrocarbon compounds.

i. The complete combustion of butane, that is a component of LPG. **1 mark**

ii. The reaction between bromine and propene. **1 mark**

iii. The reaction of steam with ethene catalysed by the presence of phosphoric acid, H_3PO_4. **1 mark**

c. Write the molecular formulae for the next two hydrocarbon compounds following hexane in the alkane homologous series. **1 mark**

Question 6 (7 marks, 9 minutes)

a. What instrument is used to determine the isotopic composition of an element? **1 mark**

b. Determine the molar mass for propanoic acid, CH_3CH_2COOH. **1 mark**

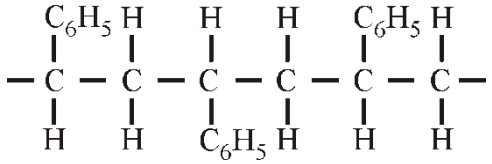
c. When hydrogen gas is passed over a heated sample of vanadium oxide, a chemical reaction occurs and vanadium and water vapour are produced.
When this reaction was carried out using a 2.370 g sample of vanadium oxide, 1.173 g of water was produced.

i. Determine the mass of oxygen present in this sample of vanadium oxide. **2 marks**

ii. Determine the empirical formula for this sample of vanadium oxide. **3 marks**

Question 7 (6 marks, 7 minutes)

a. Polystyrene is a widely used polymer and the diagram below shows the structure of a section of the polymer chain.



i. Draw the structure of the monomer used to produce polystyrene. **1 mark**

ii. Polystyrene foam is widely used as a packaging and insulation material. How would this material be produced from a bulk sample of polystyrene? **1 mark**

b. High-density polyethene, HDPE, and low-density polyethene, LDPE, are both produced from the same monomer, ethene.

i. What is the main difference in the structures of the polymer chains for these two materials? **1 mark**

ii. How does this difference in structure affect the physical properties of the polymers? **1 mark**

c. Polymer chemists often mention the term cross-linking.

i. Explain what this term refers to in polymer chemistry. **1 mark**

ii. What is the main effect that cross-linking has on the physical properties of a polymer? **1 mark**

Question 8 (7 marks, 9 minutes)

a. Heat treatments can be used to modify the hardness and ductility of metals. Annealing a metal involves heating the material to moderate temperatures then allowing it to cool slowly.

i. What effect would this have on the size of the crystals with a sample of metal? **1 mark**

ii. What effects would annealing have on the physical properties of the metal? **1 mark**

b. Use the ground state electronic configurations to show how the electrons are rearranged when sodium oxide, Na_2O, is formed from its elements. **2 marks**

c. Calcium chloride forms hydrated crystals with the chemical formula, $CaCl_2 \cdot 6H_2O$.

i. Determine the percentage by mass of water in these crystals. **2 marks**

ii. Determine the mass of solid remaining in a crucible when 5.613 g of the hydrated solid were completely dehydrated. **1 mark**

End of Section B

End of Trial Exam

Suggested Answers

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SECTION A – Multiple Choice Answers

(1 mark per question)

Q1 **D** Determine the mole ratio by assuming 100 g of compound.

$$n(C) : n(H) : n(N) : n(O) = \frac{54.2}{12.0} : \frac{3.95}{1.0} : \frac{23.7}{14.0} : \frac{18.1}{16.0}$$

$$4.52 : 3.95 : 1.69 : 1.13$$

Divide all values by the smallest number, 1.13.

$$3.99 : 3.49 : 1.50 : 1$$

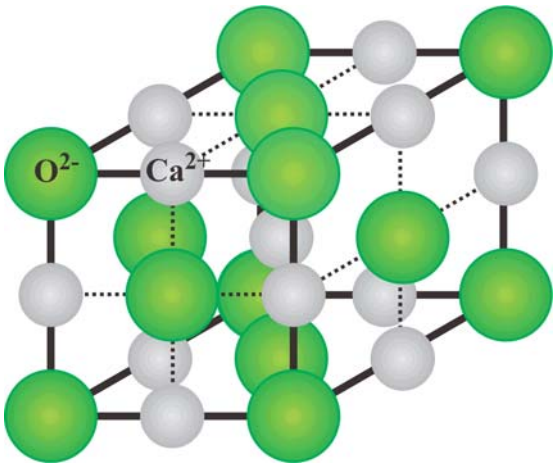
Since the ratio for H and N are close to half values then multiply all values by two.

$$8 : 7 : 3 : 2$$

$C_8H_7N_3O_2$.

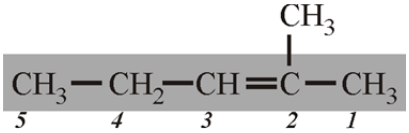
Q2 **C** Moving across a period in the periodic table, the non-metallic characteristics of the elements increase. Since selenium is in Group 16, compared to gallium in Group 13, selenium will exhibit more non-metallic characteristics.
The core and effective nuclear charge of the atoms increases moving across a period in the Periodic Table. Since the electronegativity is a measure of an atom's ability to attract an electron into its outer shell, then the electronegativity will increase moving across a period. (Electronegativities: Ga = 1.81, Se = 2.55)

Q3 **D** Calcium oxide, CaO, is an ionic compound because it involves metallic and non-metallic elements. Ionic compounds have the ions arranged alternating in a three dimensional lattice. There are strong electrostatic forces between the positive and negative ions throughout the lattice. This strong bonding between the ions results in ionic compounds having high melting temperatures and being hard brittle crystalline solids.



Q4 **B** The molar mass of methane would be:
$M(CH_4) = 12.0 + 4\times1.0 = 16.0$ g mol^{-1}
$N(H) = 4.82\times10^{24}$ atoms
$n(H) = N(H)/N_A = 4.82\times10^{24} / 6.02\times10^{23} = 8.0$ mol
$n(CH_4) = n(H)/4 = 8.0/4 = 2.0$ mol
$m(CH_4) = n\times M = 2.0 \times 16.0 =$ **32 g**

Q5 **A** The hydrocarbon contains a carbon-carbon double bond therefore is an alkene. Locate the longest carbon-carbon atom chain containing the carbon-carbon double bond and number the carbon atoms from the end that gives the first carbon atom in the double bond the smaller number.



There are five carbon atoms in the longest chain, with the carbon-carbon double bond between carbon atoms 2 and 3 ⇒ **pent-2-ene**
A methyl group is attached to carbon atom number 2 ⇒
2-methylpent-2-ene

Q6 **B** The neutral atom contains 60 electrons, therefore the nucleus will contain 60 protons. The atomic number will be 60. Referring to the Periodic Table (Table 1: VCE Chemistry Data Book) this element would be neodymium, Nd.
The mass number is the number of protons plus neutrons in the nucleus.
A = 60 + 86 = 146
$^{146}_{60}$Nd

Q7 **C** The molecules on the surface of the drop experience forces of attraction towards the molecules that surround them. Because there are no water molecules above the surface, this will result in an overall force of attraction towards the inside of the drop.

Q8 **D** The metallic bonding model considers metals as a three dimensional lattice of positive ions surrounded by delocalised electrons. The electrical conductivity of metals can be explained by the free movement of these delocalised electrons within the positive ions lattice.

Q9 **A** Silicon and carbon are both non-metals, therefore the bonding expected to be present in silicon carbide would be covalent. The physical properties of silicon carbide indicate that it is a three dimensional network lattice. Both carbon and silicon are in the same group in the Periodic Table and have four valence electrons, therefore would be expected to form four carbon-silicon covalent bonds. The structure of silicon carbide is similar to that for diamond, with alternating carbon and silicon atoms.

Q10 **D** The relative atomic mass is the weighted average of the isotopic masses. The isotopic masses are close to the mass numbers for the element. Therefore the relative atomic mass for this element would be:
A_r = (85 × 70/100) + (87 × 30/100) = **85.6**

Q11 **B** Both compounds have the same molecular formula, $C_6H_{10}Cl_2$, but the atoms are arranged in a different manner therefore they are **isomers**.
Isomers are different structural arrangements of the atoms in compounds with the same **molecular formulae**.
While both compounds have the same empirical formula, the empirical formula is the lowest whole number ratio of the atoms present and not what atoms are actually present in the compound.

Q12 **A** m(compound) = 4.173 g
m(chlorine) = m(compound) – m(compound) = 4.173 – 1.369 = 2.804 g
%(chlorine) = m(chlorine)/m(compound) × 100/1
%(chlorine) = (2.804 / 4.173) × 100/1 = **67.2 %**

Q13 **D** The monomers used to produce addition polymers must be unsaturated molecules. In the reaction a pair of electrons from the carbon-carbon double bond are rearranged and new bonds are formed linking the monomer units. The monomer used to produce polyethene is ethene, $CH_2=CH_2$.

Q14 **B** The electronegativity of phosphorous is slightly greater than that of hydrogen, therefore each phosphorous-hydrogen bond will be polar. Since the molecule will be similar to that of ammonia, due to the lone pair of electrons on the phosphorous, then phosphine will be a dipolar molecule.
Dispersion forces, due to the instantaneous development of dipoles within particles, are present between all atoms and molecules.
Dipole-dipole interactions are stronger than dispersion forces.

Q15 **D** Carbon has four valence electrons therefore will form four covalent bonds. Oxygen has six valence electrons, therefore will form two covalent bonds and will have two lone pairs of electrons. Hydrogen forms a single covalent bond. The only possible arrangement to achieve the necessary bonding is to have the two hydrogens and the oxygen bonded to the carbon. The carbon-oxygen bond will be a double bond, thereby creating three regions of electron density around the central carbon. These will repel each other and the least energetic will be when the molecule is planar with a H-C-O angle of about 120 °. (*The experimentally measured H-C-O angle is 121 °)*

Q16 **C** The magnetic nature of metals such as iron, cobalt and nickel cannot be simply explained by the metallic bonding model.
The malleability (being rolled into thin sheets) and ductility (drawn into fine wires) of metals can be explained because the layers of positive ions in the lattice can be moved over one another.

Q17 **D** Nitrogen gas is N_2. Therefore the ratio between molecules and nitrogen is 1:4. $(C_2H_2N)\times4 = \mathbf{C_8H_8N_4}$.

Q18 **C** Rutherford's classic experiment of firing α-particles, helium nuclei, at a thin piece of gold foil showed that most of the particles passed through while some were deflected. From this he proposed that most of the mass of an atom was located in its central core (nucleus). At the time Rutherford made his proposal (1911), the neutron had not been discovered. *While the masses of the protons and neutrons in the nucleus make the major contribution to an atom's mass, (Response A) Rutherford did not specifically make this proposal in his model.*

Q19 **A** The size range for nanoparticle is 1.0×10^{-9} m to 1.0×10^{-7} m.
Referring to Table 4: VCE Chemistry Data Book the size of 1 nm would be
1 nm = 1.0×10^{-9} m

Q20 **B** The forces of attraction between the polymer chains, in addition polymers, involve weak bonding interaction. The application of heat allows these to be overcome so that the polymer chains can slide over each other.

SECTION B - Short Answer (Answers)

Question 1 (5 marks, 6 minutes)

a. Nanoparticles have **large surface areas** thereby providing **more active sites** for catalysis to occur at **(1 mark)**.

b. Because nanoparticles are very small clusters of atoms, the numbers of delocalised electrons available within the particles is reduced, thereby lowering the number of mobile charge carriers available to carry the current **(1 mark)**.

c. **i.** The leaf surface will be hydrophobic and the aqueous solution will form droplets and run off the leaf, taking the treatment with it. The solution would not wet the surface. The water would form droplets because the force of attraction between water molecules is greater than that between the leaf and the water **(1 mark)**.

ii. Better wetting of the surface could be achieved by the adding of a surfactant or detergent to the solution **(1 mark)**.

d. The surface energy is a measure of the energy required to form a new surface. Metals have a lattice of positive ions surrounded by delocalised electrons, therefore there are strong electrostatic interactions bonding the metal together. In polymeric materials, the polymer chains are attracted to each other by weaker forces (such as dipole-dipole interactions or dispersion forces). Therefore the energy required to form a new metal surface would be larger because more energy would be needed to disrupt the forces between the particles **(1 mark)**.

Question 2 (7 marks, 9 minutes)

a. **i.** The number of valence electron on hydrogen, carbon and nitrogen are one, four and five respectively. Therefore hydrogen will form a single bond, carbon will form four and nitrogen three together with a pair of non-bonding electrons. There will be a **carbon-nitrogen triple bond** between the carbon and nitrogen. The molecule will have a **linear structure**. **Nitrogen is more electronegative** than either carbon or hydrogen, therefore the molecule will have a **permanent dipole (1 mark)**.

ii. Hydrogen and sulfur have one and six valence electrons respectively. Sulfur will form two bonds and have two pairs of non-bonding electrons, therefore there will be **four zones of electronic density around the sulfur**. This will result in a **bent structure** similar to that of water. Sulfur has a slightly higher electronegativity and because of the structure the molecule will have (like water) a **permanent dipole (1 mark)**.

b. In an **interstitial alloy** the atoms of the material added to the metal **occupy spaces between the atoms in the metal lattice (1 mark)**. These materials are generally smaller in size compared to the metal atoms.
The added material in **substitutional alloys replaces the metal atoms in the lattice (1 mark)**. The materials used in these alloys generally have sizes comparable with those of the metal atoms.

c. In **solid** sodium chloride the **ions are fixed within the lattice** and **cannot freely move**. This results in the solid not being a conductor of an electric current **(1 mark)**. When **molten the ions are free to move** around in the liquid, therefore since they are charged they can conduct an electric current **(1 mark)**.

d. The **boiling temperature of a molecular substance reflects the extent of the intermolecular forces**. In methane this is less than ammonia as evidenced by the lower boiling temperature. The **forces between the methane molecules only involve weak dispersion forces**, whereas in **ammonia there are additional dipole-dipole and hydrogen bonding interactions (1 mark)**.

Question 3 (7 marks, 9 minutes)

a. **i.** The concept of the indivisible atom has been replaced in modern atomic theory to atoms being made up of sub-atomic particles; electrons, protons and neutrons **(1 mark)**.

ii. The discovery of isotopes has shown that not all atoms of a particular element have the same weight (mass). While many of the physical properties of different isotopes are similar, there are some notable differences in the properties resulting from the nuclear constitution (knowledge about which was not known during Dalton's era) **(1 mark)**.

iii. This is probably the main proposal from Dalton's theory that attracts discussion, as water is clearly the most stable compound formed between hydrogen and oxygen and it has the formula of H_2O **(1 mark)**.

b. The order of sub-shell filling for ground state electronic configurations is
1s > 2s > 2p > 3s > 3p > 4s* > 3d > 4s ……..
The maximum number of electrons in s, p and d sub-shells are 2, 6 and 10 respectively.
* A half or full 3d sub-shell will occur before a 4s sub-shell is filled due to lower electronic energies for these configurations, therefore for Cr …$3d^5 4s^1$ and Cu ….$3d^{10} 4s^1$

i. Fluorine (Z = 9)
The fluoride ion is F^-, therefore: **$1s^2 2s^2 2p^6$ (1 mark)**.

ii. Cobalt (Z = 27)
The 4s sub-shell fills before the 3d sub-shell
$1s^2 2s^2 2p^6 3s^2 3p^6 3d^7 4s^2$ (1 mark).
Note: The two electrons in the 4s sub-shell constitute the outer shell and it is these that are lost when cobalt forms the cobalt(II) ion.

c. Uranium-235 and helium-4 are represented by $^{235}_{92}U$ and $^{4}_{2}He$
When the decay occurs, the atomic number will decrease by 2 to 90, therefore the element will be thorium, Th.
The mass number will decrease by four to 231.
The symbol will therefore be: $^{231}_{90}Th$ **(1 mark)**.

d. The experimental evidence that led Bohr to propose the electronic shell model was the emission spectra of the elements, particularly hydrogen **(1 mark)**.

Question 4 (7 marks, 9 minutes)

a. **i.** The atomic radius for a chlorine atom is **less** than that for a sodium atom because atomic radii decrease moving across a period in the Periodic Table **(1 mark)**. (Na 186 pm compared to Cl 99 pm.) Even though there are additional electrons in the outer shell of a chlorine atom, the atomic radius is smaller because of the **higher effective nuclear charge**, which attracts the electrons closer to the nucleus **(1 mark)**. The effective nuclear charge for a sodium atom is +1 compared to the +7 charge for the chlorine atom.

ii. **Cl_2O will be a covalent molecular compound** because it has been formed from two non-metal elements **(1 mark)**. In this molecule the chlorine will be joined to the oxygen by a single chlorine-oxygen covalent bond. Overall the molecule will have a bent shape, similar to that of water, with a Cl-O-Cl bond angle of about 111 °.

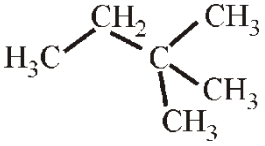
Na_2O will be an ionic compound because it is formed from metal and non-metal elements, therefore the structure will contain a lattice of sodium, Na^+, and oxide, O^{2-}, ions **(1 mark)**.

b. Strontium will be more reactive than magnesium because the reactivity of the metallic elements increases moving down a group in the Periodic Table **(1 mark)**. The reason for this difference in reactivity is because when metallic elements react, they act as reductants transferring electrons to the substance they are reacting with. Moving down the group these electrons are coming from a valence shell further from the nucleus, therefore these electrons are more easily transferred as the force attracting them to the nucleus decreases **(1 mark)**.

c. Neon is a Group 18 element in the Periodic Table and has the ground state electronic configuration of $1s^2 2s^2 2p^6$. Therefore the number of electrons in the outer shell is at its maximum, making it a very stable electronic configuration **(1 mark)**.
Note: Krypton, another Group 18 element, will react under extreme conditions with fluorine, however the compound formed is unstable.

Question 5 (6 marks, 7 minutes)

a. **i.** 2,2-dimethyl**butane** – The longest carbon atom chain in the compound contains four carbon atoms, joined by single carbon-carbon bonds.
2,2-dimethylbutane – There are two methyl groups, CH_3, attached to the second carbon atom from one end of the carbon atom chain.



(1 mark)

ii. Since this hydrocarbon is an alkane and contains six carbon atoms, all possible isomers will have the molecular formula C_6H_{14}. Possible isomers are listed below. **[1 mark if any one of these is selected]**

hexane	$CH_3CH_2CH_2CH_2CH_2CH_3$
2-methylpentane	$CH_3CH(CH_3)CH_2CH_2CH_3$
3-methylpentane	$CH_3CH_2CH(CH_3)CH_2CH_3$
2,3-dimethylbutane	$CH_3CH(CH_3)CH(CH_3)CH_3$

b. **i.** When a hydrocarbon is completely burnt it produces carbon dioxide and water.
Butane, C_4H_{10}.
Write down reactants and products.
$C_4H_{10}(g) + O_2(g) \rightarrow CO_2(g) + H_2O(l)$
Balance number of carbon atoms.
$C_4H_{10}(g) + O_2(g) \rightarrow 4CO_2(g) + H_2O(l)$
Balance number of hydrogen atoms.
$C_4H_{10}(g) + O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$
Balance number of oxygen atoms
$C_4H_{10}(g) + \frac{13}{2}O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$ **(1 mark)**
Combustion reaction chemical equations can be left at this stage or multiplied by two to remove fractional amounts of oxygen gas.
$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l)$
Ensure appropriate states are added.

ii. The reaction between bromine and an alkene results in the addition of bromine across the carbon-carbon double bond.
$CH_3CH = CH_2(g) + Br_2(l) \rightarrow CH_3CHBrCH_2Br(l)$ **(1 mark)**
States not critical in this reaction.

iii. The reaction of alkenes with steam results in the addition of H to one carbon atom and OH to the other carbon atom of the carbon-carbon double bond.
$CH_2 = CH_2(g) + H_2O(g) \xrightarrow{H_3PO_4(l)} CH_3CH_2OH(g)$ **(1 mark)**

c. The molecular formulae of successive members of a homologous series differ by CH_2. Therefore the since hexane has the molecular formula of C_6H_{14}, then heptane, **C_7H_{16}**, and octane, **C_8H_{18} (1 mark)**.

Question 6 (7 marks, 9 minutes)

a. A **mass spectrometer** is used to determine the isotopic composition of an element. **(1 mark)** The spectrometer is used to determine the relative isotopic masses of the isotopes and their abundances.

b. Propanoic acid, $CH_3CH_2COOH = C_3H_6O_2$
$M(C_3H_6O_2) = 3\times12.0 + 6\times1.0 + 2\times16.0 =$ **74.0 g mol^{-1} (1 mark)**
Units must be stated in order to receive the allocated mark.

c. **i.** $M(H_2O) = 2\times1.0 + 16.0 = 18.0$ g mol^{-1}
$n(H_2O) = m/M = 1.173 / 18.0 = 6.517\times10^{-2}$ mol **(1 mark)**
$n(O) = n(H_2O) = 6.517\times10^{-2}$ mol
$m(O) = n\times M = 6.517\times10^{-2} \times 16.0 =$ **1.043 g (1 mark)**
Alternative calculations:
$m(O) = (M(O)/M(H_2O)) \times m(H_2O) = (16.0/18.0)\times 1.173 = 1.043$ g

ii. m(V) = 2.370 – 1.043 = 1.327 g **(1 mark)**

Determine molar ratio of the two elements

$$n(V) : n(O) = \frac{1.327}{50.9} : \frac{1.043}{16}$$

$$= 2.608\times10^{-2} : 6.52\times10^{-2}$$ **(1 mark)**

Divide both by the smaller value

$$= 1 : 2.5$$

Multiply both by 2

$$= 2 : 5$$

V_2O_5 (1 mark)

Alternative calculations:

%O = (1.043/2.370) × (100/1) = 44.0 %

%V = 100 – 44.0 = 56.0 %

Determine molar ratio of the two elements, assuming 100 g

$$n(V) : n(O) = \frac{56.0}{50.9} : \frac{44.0}{16}$$

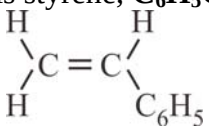
$$= 1.10 : 2.75$$

$$= 1: 2.5$$

$$= 2: 5$$ ***V_2O_5***

Question 7 (6 marks, 7 minutes)

a. i. The monomer required is styrene, **$C_6H_5CH=CH_2$ (1 mark)**.



ii. Polystyrene foam is produced by blowing a gas, such as carbon dioxide through a molten sample of polystyrene **(1 mark)**. This causes the polymer mixture to expand in volume and makes a lightweight material. *Prior to their banning, CFC's were used as the gas to expand the polymer.*

b. i. The main difference in the structures of HDPE and LDPE is the **amount of branching on the polymer chains**. HDPE has less branching so more polymer chains can be packed in a volume, therefore it will have a higher density **(1 mark)**.

ii. The larger amount of branching on the LDPE polymer chains makes the material softer and more flexible compared to HDPE **(1 mark)**.

c. i. Cross-linking refers to the formation of covalent bonds between polymer chains **(1 mark)**.

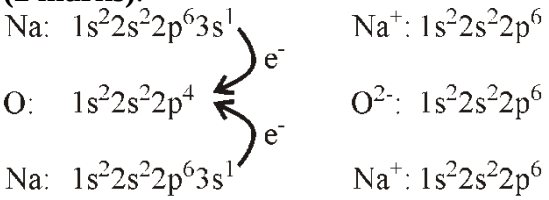
ii. Because there are strong covalent bonds between the polymer chains in cross-linked polymers, they become more rigid materials **(1 mark)**.

Question 8 (7 marks, 9 minutes)

a. **i.** The slow cooling of the metal would allow the formation of **larger crystals (1 mark)**.

ii. Annealing makes the metal softer and more ductile **(1 mark)**. Because there are less crystals in the sample there are fewer grain boundaries (where the crystals meet), therefore less energy will be required to rearrange the crystals.

b. The diagram must show the correct electronic configurations for sodium, oxygen and their ions with the electrons being transferred from the sodium to the oxygen **(2 marks)**.



c. **i.** $M(H_2O) = 2\times1.0 + 16.0 = 18.0$ g mol^{-1}

$M(CaCl_2\cdot6H_2O) = 40.1 + 2\times35.5 + 6\times18.0 = 219.1$ g mol^{-1} **(1 mark)**

$\%(H_2O) = ((6\times18.0)/219.1) \times (100/1) =$ **49.3 % (1 mark)**

A useful alternative method uses a table.

Ca	1	40.1	40.1	
Cl	2	35.5	71.0	
H_2O	6	18.0	108.0	(108.0/219.1)×(100/1) = **49.3%**
		M	219.1	

ii. Since the percentage by mass of water is 49.3 % then the percentage by mass that would remain after the solid were completely dehydrated would be

%(remaining) = 100 – 49.3 = 50.7 %

m(remaining) = 5.613 × (50.7/100) = **2.846 g (1 mark)**

Alternative solution.

$n(CaCl_2\cdot6H_2O) = m/M = 5.613/219.1 = 2.56\times10^{-2}$ mol

$n(CaCl_2) = n(CaCl_2\cdot6H_2O) = 2.56\times10^{-2}$ mol

$M(CaCl_2) = 40.1 + 2\times35.5 = 111.1$ g mol^{-1}

$m(CaCl_2, \text{remaining}) = 2.56\times10^{-2} \times 111.1 = 2.846$ g

End of Suggested Answers