VCE CHEMISTRY 2010

YEAR 11 TRIAL EXAM UNIT 1

Time allowed: 90 Minutes
Total marks: 77

Section A
Contains 24 Multiple Choice Questions
24 marks, 29 minutes

Section B
Contains 6 Short Answer Questions
53 marks, 61 minutes

To download the Chemistry Data Book please visit the VCAA website:
http://www.vcaa.vic.edu.au/vce/studies/chemistry/chem1_sample_2008.pdf *Page 20*

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Student Name....………………………...

VCE Chemistry 2010 Year 11 Trial Exam Unit 1

Student Answer Sheet

Instructions for completing test. Use only a 2B pencil. If you make a mistake erase 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 24 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
Question 21	A	B	C	D	*Question 22*	A	B	C	D
Question 23	A	B	C	D	*Question 24*	A	B	C	D

VCE Chemistry 2010 Year 11 Trial Exam Unit 1

Multiple Choice Questions - Section A

(24 marks, 29 minutes)

This section contains 24 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
8.00 g of ammonium nitrate, NH_4NO_3, would contain
A. 6.02×10^{23} hydrogen atoms.
B. 1.20×10^{23} nitrogen atoms.
C. 1.81×10^{24} oxygen atoms.
D. 6.02×10^{22} nitrogen atoms.

Question 2
Which one of the following pairs of molecules would be members of the same homologous series of hydrocarbons?
A. C_5H_{10} and C_5H_{12}.
B. C_4H_{10} and C_5H_{10}.
C. C_5H_{12} and C_8H_{18}.
D. C_4H_8 and C_6H_{14}.

Question 3
Compared to a polyethene sample with no branching on the polymer chain, a polyethene sample with a significant degree of chain branching would have
A. a slightly higher density and be softer.
B. a slightly lower density and be less flexible.
C. a slightly lower density and be softer.
D. a slightly higher density and be less flexible.

Question 4
The ionic bonding model has difficulty in explaining why
A. sodium chloride is soluble and silver chloride is insoluble.
B. concentrated aqueous solutions of sodium chloride will be moderate conductors of an electric current.
C. the melting temperature for magnesium oxide is higher than that for sodium chloride.
D. solid calcium oxide will not conduct an electric current.

Question 5
The elemental analysis of a solid found that it contained carbon, hydrogen and oxygen in the percentages by mass of 40.7 %, 5.12 % and 54.2 % respectively. The empirical formula for this compound is
A. $C_3H_5O_3$.
B. CHO.
C. $C_4H_3O_4$.
D. $C_2H_3O_2$.

Question 6
0.0130 mol of an alkane had a mass of 2.21 g. The molecular formula for this alkane is
A. $C_{14}H_{28}$.
B. $C_{12}H_{26}$.
C. $C_{12}H_{28}$.
D. $C_{10}H_{22}$.

Question 7
In the anaesthetic halothane, which contains the molecule bromochlorotrifluoroethane, $C_2HBrClF_3$, the least polar bond, after the carbon-carbon bond, would be
A. the carbon-hydrogen bond.
B. the carbon-bromine bond.
C. the carbon-chlorine bond.
D. the carbon-fluorine bond.

Question 8
Ethanol, C_2H_6O, will dissolve completely, is miscible, in water. The strongest intermolecular forces between the ethanol and water molecules in an aqueous ethanol solution will be
A. dipole-dipole interactions.
B. covalent bonding.
C. hydrogen bonding.
D. dispersion forces.

Question 9
Which one of the following compounds would have the highest percentage by mass of chlorine?
A. KCl.
B. $GaCl_3$.
C. $SrCl_2$.
D. NaCl.

Question 10
The ground-state electronic configuration for a sulfide ion is
A. $1s^2 2s^2 2p^4 3s^2 3p^4 4s^2$.
B. $1s^2 2s^2 2p^6 3s^2 3p^6$.
C. $1s^2 2s^2 2p^6 3s^2 3p^4$.
D. $1s^2 2s^2 2p^4 3s^2 3p^4 3d^2 4s^2$.

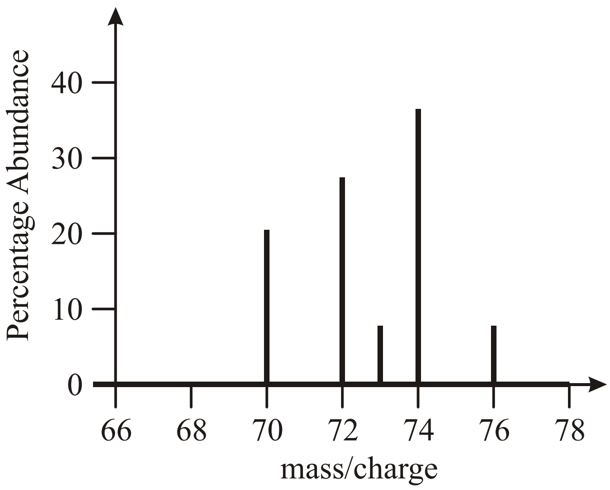
Question 11
The structure for graphite is
A. a layer lattice with covalent bonding between the carbon atoms in the layer, and weak interactions between the layers.
B. a network lattice where there is covalent bonding between all adjacent carbon atoms in the lattice.
C. a network lattice where there is covalent bonding between the carbon atoms in two directions, and weak interactions in the third direction.
D. a layer lattice with covalent bonding between layers of atoms, and weak interactions between the carbon atoms within the layers.

Question 12
A sample of sodium carbonate, Na_2CO_3, contains 1.72×10^{22} atoms. The number of mole of sodium carbonate in this sample is
A. 2.86×10^{-2} mol.
B. 9.52×10^{-3} mol.
C. 4.76×10^{-3} mol.
D. 5.71×10^{-3} mol.

Question 13
Isomers are
A. molecules with the same empirical formula but different arrangements of the atoms in the molecule.
B. molecules with the same molecular formula but different arrangements of the atoms in the molecule.
C. molecules with the same empirical formula but different molecular formulae.
D. molecules that contain atoms that have the same atomic number but different mass numbers.

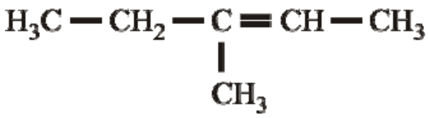
Question 14
When a water droplet is placed on the surface of a clean glass slide it spreads out. This wetting of the surface is due to
A. the ion-dipole interactions formed between the water and the glass surface being stronger than the hydrogen bonds between the water molecules.
B. the hydrogen bonds formed between the water and the glass surface being stronger than the hydrogen bonds between the water molecules.
C. the ion-dipole interactions formed between the water and the glass surface being weaker than the hydrogen bonds between the water molecules.
D. the hydrogen bonds formed between the water and the glass surface being weaker than the hydrogen bonds between the water molecules.

Question 15
The mass spectrum for a naturally occurring sample of germanium is shown.



In this sample of germanium
A. the most abundant of the five isotopes corresponds to ^{72}Ge.
B. the ^{76}Ge isotope is more abundant than the ^{70}Ge isotope.
C. the ^{74}Ge isotope will be deflected more by the magnetic field than the ^{76}Ge isotope.
D. the ^{72}Ge isotope is the second most abundant of the five isotopes.

Question 16
The systematic name for the hydrocarbon whose structure is shown below is



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

Question 17
J. J. Thompson's 1897 model of the atom was based on the latest experimental evidence that indicated that
A. atoms contained positively charged particles concentrated in the core or nucleus of the atom.
B. atoms contained negatively charged particles orbiting the nucleus of the atom.
C. atoms contained positively charged particles and negatively charged particles.
D. most of the mass of the atom is located in the nucleus.

Question 18
The melting temperature of sodium chloride is 801 ºC whereas the melting temperature for hydrogen chloride is -114 ºC. The best explanation for this observation is that
A. sodium chloride has a higher molar mass than hydrogen chloride.
B. the electrostatic forces between the sodium and chloride ions are significantly stronger than the intermolecular forces in hydrogen chloride.
C. the electrostatic forces between the sodium and chloride ions are significantly stronger than those between the hydrogen and chloride ions.
D. the bonding between the elements in hydrogen chloride is significantly weaker compared to the bonding in sodium chloride.

Question 19
The earlier work of Jöns Berzelius was of great importance to Mendeleev in the development of the Periodic Table because it provided
A. accurate data about the reactivity of all of the then known elements.
B. the electronic configurations for the known elements based on their emission spectra.
C. data about the relative atomic masses of the elements.
D. a listing of the known elements according to their atomic number.

Question 20
The explanation for the ductility of metals using the metallic bonding model is that
A. layers of metal atoms can slide over each other because the delocalised electrons are free to move throughout the metal lattice.
B. the layers of positive metal ions can slip over each other while still being held together by the delocalised electrons.
C. the layers of metal atoms are free to move over each other because there are only weak forces between the metal atoms in adjacent layers.
D. the delocalised electrons reduce the forces of attraction between the metal atoms, allowing them to freely slip over each other.

Question 21
Which one of the following statements about the elements in Group 2 of the Periodic Table is **incorrect**?
A. All of the elements would be expected to form a +2 ion when they react with a non-metal element.
B. Removing a valence electron from a barium atom would require less energy than that required for a calcium atom.
C. Barium would be expected to be more reactive, compared to magnesium.
D. A strontium atom would be larger than a barium atom.

Question 22
The shape of a molecular species is determined mainly by
A. all of the electrons in the atoms present in the molecule.
B. the non-bonding electrons in the atoms present in the molecule.
C. both the bonding and non-bonding electrons in the atoms present in the molecule.
D. the bonding electrons in the atoms present in the molecule.

Question 23
When a sodium atom reacts with an oxygen atom,
A. each sodium atom will gain one electron from each of the two oxygen atoms it reacts with.
B. each oxygen atom will gain two electrons from each sodium atom it reacts with.
C. each sodium atom will gain two electrons from each oxygen atom it reacts with.
D. each oxygen atom will gain one electron from each of the two sodium atoms it reacts with.

Question 24
Naturally occurring boron consists of two isotopes, ^{10}B and ^{11}B. The relative atomic mass for boron is 10.8, therefore the abundance of the lighter of the two isotopes is approximately
A. 80 %.
B. 50 %.
C. 20 %.
D. 10 %.

End of Section A

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Short Answer Questions - Section B

(53 marks, 61 minutes)

This section contains six questions, numbered 1 to 6.
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 (9 marks, 10 minutes)

a. When metal oxides are treated with hydrogen, they can be converted to the metal and water. 5.622 g of water was formed when a 17.85 g sample of a manganese oxide was treated with hydrogen.

i. What mass of oxygen is present in the water formed?

(2 marks)

ii. Determine the empirical formula for the manganese oxide.

(3 marks)

b. Ammonium iron(II) sulfate is a crystalline solid with the formula $(NH_4)_2Fe(SO_4)_2{\cdot}6H_2O$.

i. Determine the percentage by mass of water in this compound.

(2 marks)

ii. A group of VCE chemistry students heated a 4.674 g sample of this compound to constant mass, in a crucible. Their results showed that the mass of solid remaining at the end of this process was 1.812 g. Did the heating process completely dehydrate the sample, or did other decomposition reactions occur?

(2 marks)

Question 2 (11 marks, 13 minutes)

a. Magnesium and chlorine are both located in the third period of the Periodic Table.

i. Write the ground-state electronic configurations for both of these elements.

Magnesium:

Chlorine:

(2 marks)

ii. How would the atomic radius for chlorine compare with that for magnesium?

(1 mark)

iii. The electronegativity for chlorine is 3.2. How would the electronegativity for magnesium compare with this value?

(1 mark)

iv. What would be the empirical formula for the compound that forms when chlorine and magnesium react?

(1 mark)

v. What type of bonding would be present in the compound that forms when magnesium reacts with chlorine?

(1 mark)

b. When Mendeleev drew up his Periodic Table, gallium had not yet been discovered, however he was able to predict the chemical and physical properties for this element. Use your knowledge about the trends in the Periodic Table to complete the following table for element 120, Ubn.

Element	**Element-120 Ubn**
Group	
Period	
Ground-state valence shell electronic configuration	
Formula for oxide	
Reactivity with water compared to earlier elements in the Group.	

(5 marks)

Question 3 (9 marks, 10 minutes)

a. What is the key structural difference that distinguishes alkenes from alkanes?

(1 mark)

b. Draw the two **different structures** and give the systematic names for alkenes that contain four carbon atoms.

(2 marks)

c. An ice cream container has a recycling symbol that identifies that it is made from polypropene.

i. Write the **semi-structural** formula for the monomer that would be used to produce this polymer.

(1 mark)

ii. What type of chemical reaction occurs during the production of polypropene from its monomer?

(1 mark)

iii. Draw the part of the structure for a polypropene molecule.

(1 mark)

d. Polymeric materials can be grouped into one of two classes, thermoplastics or thermosetting plastics.

i. What is the important structural difference between these two types of polymeric materials?

(1 mark)

ii. What is the difference in the behaviour of these two classes of polymeric materials when they are heated?

(1 mark)

e. Propane is the major constituent of LPG. Write an appropriate chemical equation for the complete combustion of propane.

(1 mark)

Question 4 (8 marks, 9 minutes)

a. The surface energies for copper and diamond are 1370 mJ m^{-2} and 9800 mJ m^{-2} respectively.

i. What is surface energy the measure of?

(1 mark)

ii. Explain why the surface energy for diamond is significantly higher than that for copper.

(1 mark)

b. Teflon®, $(CF_2CF_2)_n$, and polyvinylchloride, $(CH_2CHCl)_n$, are two commonly used polymers.

i. Which one of these two polymers would have the higher surface energy?

(1 mark)

ii. Give one reason for the selection made in i. above.

(1 mark)

c. Explain why the surface energy for liquids such as water decreases with increasing temperature.

(1 mark)

d. Recently the media has contained a number of reports raising concern over the potential for nanoparticles to do damage to human cells. What is the main property of nanoparticles that would allow them to potentially act in this manner?

(1 mark)

e. The properties of nanoparticles are significantly different to those observed for bulk samples of the same material.

i. Why would metal nanoparticles display properties that were less metallic in character?

(1 mark)

ii. Why would nanoparticles be expected to be more reactive than bulk samples of the same material?

(1 mark)

Question 5 (6 marks, 7 minutes)

a. Calculate the relative atomic mass for an element using the mass spectral data given in the table.

Relative Isotopic Mass	Relative Abundance (%)
49.95	4.31
51.94	83.76
52.94	9.55
53.94	2.38

(2 marks)

b. Nuclear fusion occurs when the nuclei of two atoms join together to form a heavier atomic nucleus. In a nuclear reaction a $^{9}_{4}Be$ and a $^{4}_{2}He$ fuse.

i. What sub-atomic particles are present in the $^{9}_{4}Be$ nucleus?

(1 mark)

ii. What sub-atomic particles are present in the $^{4}_{2}He$ nucleus?

(1 mark)

iii. What sub-atomic particles would be in the nucleus of the particle formed when these two nuclei fuse?

(1 mark)

iv. What is the symbolic representation of the isotope formed in this nuclear fusion reaction?

(1 mark)

Question 6 (10 marks, 12 minutes)

a. For each of the following molecules:

Draw their structures showing **all** bonding and non-bonding electron pairs.
Use $\delta+$ and $\delta-$ to show the polarity of the bonds.
State the strongest form of intermolecular forces between the molecules.

i. Carbon dioxide, CO_2.

(2 marks)

ii. Ammonia, NH_3.

(2 marks)

iii. Chloromethane, CH_3Cl.

(2 marks)

b. Draw an electron transfer diagram to show what occurs when aluminium oxide is formed from its elements.

(2 marks)

c. Most of the metals that are used extensively in society are alloys. What is the main requirement of the material added to a metal to form an interstitial alloy?

(1 mark)

d. How does quenching change the physical properties of a metal?

(1 mark)

End of Section B

End of Trial Exam

Suggested Answers

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Multiple Choice Questions - Section A

(1 mark per question)

Q1 **B** $M(NH_4NO_3) = 2\times14.0 + 4\times1.0 + 3\times16.0 = 80.0$ g mol^{-1}
$n(NH_4NO_3) = m / M = 8.00 / 80.0 = 1.00\times10^{-1}$ mol
$n(N)= 2\times n(NH_4NO_3) = 2.00\times10^{-1}$ mol
$n(H)= 4\times n(NH_4NO_3) = 4.00\times10^{-1}$ mol
$n(O)= 3\times n(NH_4NO_3) = 3.00\times10^{-1}$ mol
N(N) $= n(N) \times N_A = 2.00\times10^{-1} \times 6.02\times10^{23} =$ **1.20×10^{23} atoms**
$N(H) = n(H) \times N_A = 4.00\times10^{-1} \times 6.02\times10^{23} = 2.41\times10^{23}$ atoms
$N(O) = n(O) \times N_A = 3.00\times10^{-1} \times 6.02\times10^{23} = 1.81\times10^{23}$ atoms
Only response B is correct.

Q2 **C** The **molecular formulae** for **successive members** in an homologous series **differ by CH_2**.
Response A: These two molecular formulae have the same number of carbon atoms but different numbers of hydrogen atoms. These formulae are for pentene and pentane members of different homologous series.
Response B: These two molecular formulae have a difference of one in the number of carbon atoms but have the same numbers of hydrogen atoms. These formulae are for butane and pentene, members of two different homologous series.
Response C: These two molecular formulae have a **difference of three carbon atoms and six hydrogen atoms [$(CH_2)_3$]**, therefore fulfil the criteria for being members of an homologous series. These formulae are for pentane and octane, both members of the alkane homologous series.
Response D: These two molecular formulae have a difference of two carbon atoms and six hydrogen atoms, therefore do not fulfil the criteria. These two formulae are for butene and hexane, members of two different homologous series.

Q3 **C** The greater the degree of branching on a polymer chain results in the polymer strands not being able to pack so closely together. Therefore a polymer with significantly branched chains would have a **lower density** compared to a polymer derived from the same monomer with little chain branching. Also this polymer would be softer and more flexible.
Low density polyethene, LDPE, is a polymer with significant chain branching and is soft and flexible, making it suitable for use in cling films and squeeze bottles. High density polyethene, HDPE, is stronger and less flexible, making it suitable for use in making buckets, containers and pipes.

Q4 **A** One of the main limits to the ionic bonding model is that it cannot predict the solubilities of the various compounds. Since both sodium chloride and silver chloride contain singly charged positive and negative ions, one should expect both to have similar solubilities, because the interactions of these ions with each other and the water molecules of the solvent should be the same.

Q5 **D** The empirical formula for a compound is the lowest whole number mole ratio of the atoms of the elements present in the compound. Assuming 100 g then the mass of each element is numerically equivalent to the percentage.

n(X) = m(X)/M(X)

$$n(C) : n(H) : n(O) = \frac{m(C)}{M(C)} : \frac{m(H)}{M(H)} : \frac{m(O)}{M(O)} = \frac{40.7}{12.0} : \frac{5.12}{1.0} : \frac{54.2}{16.0}$$

= 3.39 : 5.12 : 3.39 divide all values by smaller value.

= 1.0 : 1.5 : 1.0 multiply by 2 to remove 1.5 value

= 2 : 3 : 2 **$C_2H_3O_2$**

Q6 **B** Alkanes have the general formulae C_nH_{2n+2}.

$$M(C_nH_{2n+2}) = \frac{m}{n} = \frac{2.21}{0.0130} = 170 \text{ g mol}^{-1}$$

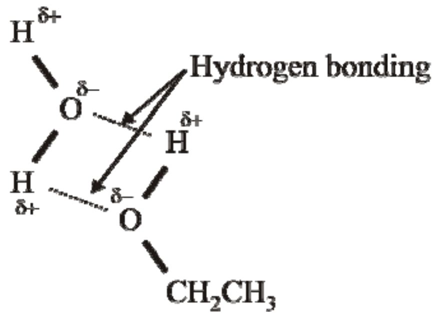
$M(C_nH_{2n+2}) = n \times 12.0 + (2n + 2) \times 1.0 = 14n + 2$

$14n + 2 = 170 \Rightarrow 14n = 168 \Rightarrow n = 12$

$C_{12}H_{26}$ $[M(C_{12}H_{26}) = 12 \times 12.0 + 26 \times 1.0 = 170.0 \text{ g mol}^{-1}]$

Q7 **A** The polarity of a bond in a compound is determined by the difference in electronegativities of the two elements that form the bond. Bromine, chlorine and fluorine are members of Group 17 in the periodic table and are highly electronegative, 2.8, 3.0 and 4.0 respectively. Therefore the carbon-hydrogen bond would be the least polar because hydrogen has the lowest electronegativity, 2.1, of the four elements.

Q8 **C** Both ethanol and water are polar compounds because of the polarity of the oxygen-hydrogen bonds in particular. Therefore, when these two molecules interact, they will, in addition to dispersion forces, form dipole-dipole interactions. Because these **interactions involve hydrogen and oxygen atoms, hydrogen bonding will occur and be the strongest intermolecular forces between the two molecules**.



Q9 **D** The percentage by mass of chlorine in each of the compounds:

$$KCl: \ \%Cl = \frac{35.5}{39.1 + 35.5} \times \frac{100}{1} = 47.6 \ \%$$

$$GaCl_3: \ \%Cl = \frac{3 \times 35.5}{69.7 + 3 \times 35.5} \times \frac{100}{1} = 60.4 \ \%$$

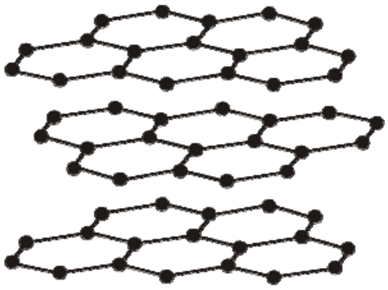
$$SrCl_2: \ \%Cl = \frac{2 \times 35.5}{87.6 + 2 \times 35.5} \times \frac{100}{1} = 44.8 \ \%$$

$$NaCl: \ \%Cl = \frac{35.5}{23.0 + 35.5} \times \frac{100}{1} = 60.7 \ \%$$

Therefore NaCl has the highest chlorine percentage by mass.

Q10 **B** The sulfide ion is an S^{2-} ion, therefore contains 18 electrons.
The s, p and d sub-shells can each hold a maximum of 2, 6 and 10 electrons respectively and the filling order for the sub-shells is;
1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, ...
Therefore for **18 electrons** the ground-state electronic configuration is;
$\mathbf{1s^2 2s^2 2p^6 3s^2 3p^6}$.

Q11 **A** The structure for graphite is a layer lattice where each carbon atom in the layers is covalently bonded to three other carbon atoms and the fourth valence electron on each carbon atom is delocalised throughout the entire layer. Between the layers there are weak interactions, which allow the layers to readily slip over each other.



Q12 **C** Avogadro's constant is the number of particles present in one mole of substance.
$N_A = 6.02\times10^{23}$ mol^{-1}

$$n(\text{atoms}) = \frac{N(\text{atoms})}{N_A} = \frac{1.72\times10^{22}}{6.02\times10^{23}} = 2.86\times10^{-2}\ \text{mol}$$

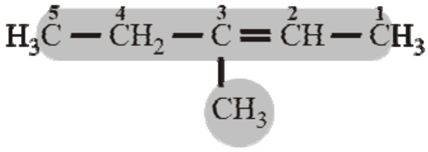
Each Na_2CO_3 contains 6 atoms in total
$n(Na_2CO_3)$ = n(atoms)/6 = 2.86×10^{-2} / 6 = 4.76×10^{-3} mol

Q13 **B** Isomers are molecules with the **same molecular formulae** but **different structures**.
Two possible semi-structural formulae for C_2H_6O are CH_3CH_2OH and CH_3OCH_3.

Q14 **A** Glass has ionic sites on its surface and the polar water molecules can form ion-dipole interactions with these sites. Because the water spreads out over the surface of the clean glass and wets it, then the forces of attraction between the glass and the water are greater than the forces of attraction between the water molecules.

Q15 **D** The mass spectrum shows that germanium has five isotopes, the most abundant being ^{74}Ge and the least abundant either ^{73}Ge or ^{76}Ge. The ^{72}Ge isotope is the second most abundant. In a mass spectrometer, the ion with the highest mass to charge ratio will be deflected the most by the magnetic field.

Q16 **A** To determine the systematic name for an organic compound, the following rules are followed:
Find the longest carbon-carbon atom backbone in the molecule that contains any carbon-carbon double bond.
In this compound, a double bond is present and the longest carbon-carbon backbone with this contains 5 carbon atoms, **pentene**.
Number the carbon atoms for this backbone so that the first carbon atom in the double bond has the lowest number, **pent-2-ene**.
Locate any substituent groups and determine which carbon atom they are attached to. In this case a methyl, CH_3, group attached to carbon atom 3,
3-methylpent-2-ene.



Q17 **C** The Thompson model, commonly referred to as the 'plum pudding' model, had the atom consisting of positive and negative particles.
Later work by Rutherford showed that the nucleus had a positive charge and that most of the mass of the atom was located in this nucleus.

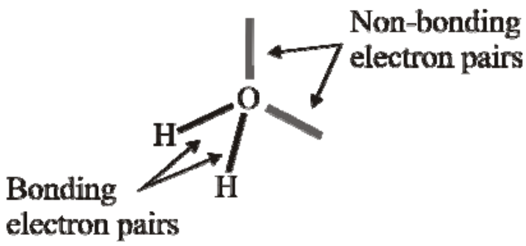
Q18 **B** Sodium chloride is an ionic compound, therefore its melting temperature reflects the energy required to break the ions free of their lattice. Hydrogen chloride is a covalent compound, and here the melting temperature reflects the energy required to overcome intermolecular forces between the molecules. In the case of hydrogen chloride, these weak bonding interactions are dispersion forces and dipole-dipole interactions.

Q19 **C** Jöns Berzelius was an analytical chemist who determined the relative atomic masses (weights as they were referred to at the time) of the elements. When Mendeleev was arranging the elements for his Periodic table, he sorted them in order of increasing relative atomic mass.

Q20 **B** The ductility of a metal is its ability to be drawn out into wires, therefore the particles in the metal lattice need to be able to slip over each other while the lattice is still held together. In the metal bonding model, the valance electrons of the metal are delocalised throughout the lattice and the resultant positive metal ions are arranged in a regular lattice.

Q21 **D** Group 2 of the Periodic Table contains the elements Be, Mg, Ca, Sr, Ba and Ra, all of which are metals and have two electrons in their outer (valence) shell, therefore when they react they would be expected to form a +2 ion.
Moving down a group in the Periodic Table, the valence shell becomes further from the nucleus, therefore it becomes easier to remove these electrons and the elements become more reactive. Similarly, since there are more electrons occupying more space, **the size of the atoms increases, moving down a group**.

Q22 **C** The shape of a molecule is determined by both the bonding and non-bonding electron pairs, as these zones of negative charge each repel each other. The water molecule has a bent shape due to the two bonding and two non-bonding electron pairs around the oxygen atom.



Q23 **D** Sodium is a Group 1 element therefore it has one valence electron, which it will lose when it reacts to form a sodium ion, Na^+. Oxygen is a Group 16 element and has six valence electrons, therefore it will gain two electrons when it reacts to form an oxide ion, O^{2-}. In the reaction between sodium and oxygen, the oxygen will gain one electron from each of the two sodium atoms it reacts with.
At an atomic level, the reaction can be represented by: $2Na + O \rightarrow Na_2O$

Q24 **C** The relative atomic mass is the weighted average of the isotopic masses since this takes into account the abundance of each isotope. Since the relative atomic mass is closer to the higher isotopic mass, then the abundance of the lighter isotope has to be less than 50 %.
If x is the percentage abundance of the lighter isotope then;

$$\text{RAM} = \frac{x}{100}\times 10 + \frac{(100-x)}{100}\times 11 = 10.8$$

Solve by multiplying both sides by 100 and expanding brackets and like terms.
$10x + 1100 - 11x = 1080$
$x = 1100 - 1080 = 20 \Rightarrow 20\%$

Short Answer (Answers) - Section B

Question 1 (9 marks, 10 minutes)

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

$$n(H_2O) = m/M = \frac{5.622}{18.0} = 3.12\times10^{-1} \text{ mole}$$

$n(O) = n(H_2O) = 3.12\times10^{-1}$ mole **(1 mark).**
$m(O) = n\times M = 3.12\times10^{-1} \times 16.0 =$ **4.99 g (1 mark).**

ii. Let the oxide have the formula Mn_xO_y.
$m(Mn_xO_y) = 17.85$ g
$m(Mn) = m(Mn_xO_y) - m(O) = 17.85 - 4.99 = 12.9$ g **(1 mark).**
The empirical formula for a compound is the lowest whole number mole ratio of the atoms of the elements present in the compound.

$$n(Mn) : n(O) = \frac{m(Mn)}{M(Mn)} : \frac{m(O)}{M(O)} = \frac{12.9}{54.9} : \frac{4.99}{16}$$ **(1 mark).**

= 0.235 : 0.312 divide both by the smaller value
= 1.00 : 1.33 multiply both by 3 to remove 1.33
= 3 : 4 **Mn_3O_4 (1 mark).**

b. i. The percentage by mass of water in $(NH_4)_2Fe(SO_4)_2{\cdot}6H_2O$.
In this calculation it is better to treat water separately from the other hydrogen and oxygen atoms in the formula.
$M(H_2O) = 2\times1.0 + 16.0 = 18.0$ g mol^{-1}.

N:	2×14.0	28.0
H:	8×1.0	8.0
Fe:	1×55.9	55.9
S:	2×32.1	64.2
O:	8×16.0	128.0
H_2O:	6×18.0	108.0
M		**392.1 g mol^{-1} (1 mark).**

$$\%(H_2O) = \frac{108.0}{392.1} \times \frac{100}{1}$$
$= \mathbf{27.5\ \%}$ **(1 mark).**

ii. Dehydration would only remove the water of crystallization from the solid. If this was the only process that occurred, then the percentage mass change would be equivalent to the percentage by mass of water in the compound. The percentage mass loss for this sample is determined as follows:
mass(loss) = mass(original sample) – mass(after heating)
mass(loss) = 4.674 – 1.812 = 2.862 g
$$\%(\text{loss}) = \frac{2.862}{4.674} \times \frac{100}{1} = \mathbf{61.2\ \%}$$ **(1 mark).**
Since the percentage mass loss is significantly greater than the percentage by mass of water, then **processes other than just dehydration occurred (1 mark).**

Question 2 (11 marks, 13 minutes)

a. i. The ground-state filling order for the sub-shells is;
1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, ...
Magnesium (Z=12) $\mathbf{1s^2 2s^2 2p^6 3s^2}$ **(1 mark).**
Chlorine (Z=17) $\mathbf{1s^2 2s^2 2p^6 3s^2 3p^5}$ **(1 mark).**

ii. The atomic radius for chlorine would be **smaller** than that for magnesium **(1 mark).** The trend within a period is that the atomic radii for the elements decrease moving across the period. The effective nuclear charge for an element is the number of protons in the nucleus minus the number of electrons occupying the inner shells. The effective nuclear charges for magnesium and chlorine are +2 and +7 respectively. This trend in properties occurs because while the valence shell being populated is the same, the effective nuclear charge that these electrons are experiencing is increasing, thereby exerting a stronger force on the electrons and bringing them closer to the nucleus.

iii. The electronegativity for magnesium would be **less than** that for chlorine **(1 mark).** The trend within a period of the Periodic Table is for the electronegativity to increase moving left to right across the period. The electronegativity of an element is a measure of the element's ability to attract electrons into its valence shell. The observed trend occurs because the electrons are being attracted into the same valence shell, but the effective nuclear charge increases moving across the period.

iv. Magnesium has two valence electrons and chlorine has seven valence electrons. Since magnesium is a Group 2 metal and chlorine is a Group 17 non-metal, then each chlorine can accept one electron to get eight electrons in its valence shell, while each magnesium can lose two electrons to achieve eight electrons in its outer shell. The formula for the compound, magnesium chloride, will be **$MgCl_2$. (1 mark).**

v. The reaction between a metal and a non-metal will produce a compound with **ionic bonding (1 mark).**

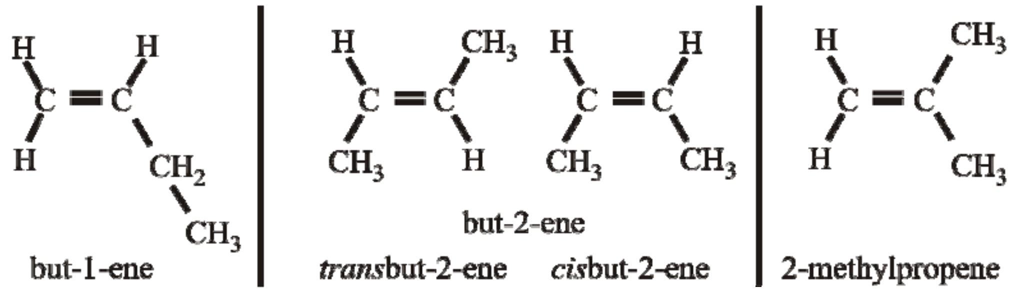
b. Using the Periodic Table, element 120 will be in the next period, Period 8, and in the same group as magnesium, Group 2. All elements in Group 2 have two electrons in their outer shells therefore an s^2 ground state electronic configuration. For Ubn the outer shell will be the eighth shell therefore $8s^2$. This group is to the left-hand side of the Periodic Table, therefore Ubn will be a metal and will lose its two outer shell electrons to form the Ubn^{2+} ion when it reacts with oxygen to form its oxide. Since each oxygen atom can accept two electrons to form the O^{2-} ion, the formula for the oxide will be UbnO. Since the reaction involves the atoms losing electrons, the reactivity of the elements increases, moving down a group as the electrons involved are further from the nucleus.

Element	**Element-120 Ubn**
Group	**2 (1 mark).**
Period	**8 (1 mark).**
Ground-state valence shell electronic configuration	**$8s^2$ (1 mark).**
Formula for oxide	**UbnO (1 mark).**
Reactivity with water compared to earlier elements in the Group.	**It will be more reactive than earlier members of the same Group (1 mark).**

Question 3 (9 marks, 10 minutes)

a. Alkenes and alkanes are **both hydrocarbons**. The key structural difference between the two groups of compounds is that **alkenes contain at least one carbon-carbon double bond** in their structure, whereas **alkanes only have single carbon-carbon bonds (1 mark).**

b. There are three possible structures for an alkene that has four carbon atoms
(1 mark for correct structure and systematic name
Total marks allocated: 2 marks).

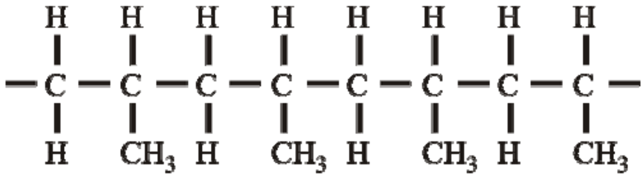


The structures for the two geometric isomers of but-2-ene are shown, however this form of isomerism is not required for VCE chemistry.

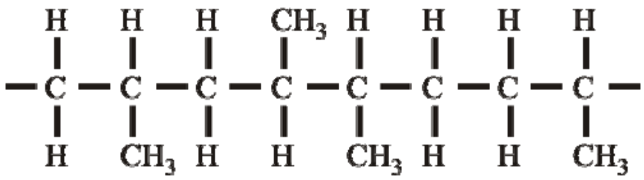
c. i. The monomer required to produce polypropene is **propene**, **$CH_3CH{=}CH_2$** **(1 mark).**

ii. When propene reacts to form polypropene, **an addition reaction occurs (1 mark).** During this process, the electrons from one of the pairs of electrons that form the carbon-carbon double bond are rearranged to form bonds between the monomer units.

iii. The structure for part of a polypropene molecule is shown below **(1 mark).**



isotactic polypropene



atactic polypropene

The key points in the structure are single carbon-carbon bonds and methyl groups attached to one of the carbon atoms in every two. The structure shows both the isotactic form, where all of the methyl groups, the side groups, are on the same side of the carbon-carbon backbone. This form of polymer allows for closer packing of the polymer strands, and as a result there are increased forces of attraction between the polymer chains, making the polymer stronger. The atactic structure has the methyl groups randomly attached to the backbone. This will result in a much softer polymer and in the case of polypropene, a material that is only useful as a lubricant.

d. i. The important structural difference between thermoplastics and thermosetting plastics is that in a **thermosetting plastic there are covalent bonds between the polymer chains (1 mark).** These bonds increase the rigidity of the structure.

ii. When heated, a **thermoplastic will soften** whereas a **thermosetting plastic will remain rigid (1 mark).** This is due to the covalent bonds between the polymer chains not being readily broken. Thermosetting plastics will not soften and will decompose if sufficient heat is applied.

e. The complete combustion of a hydrocarbon produces carbon dioxide and water. Propane is an alkane that contains three carbon atoms and has the molecular formula C_3H_8. The chemical equation is best developed using a stepwise procedure.

Write down the reactants and products for the reaction.

$$C_3H_8(g) + O_2(g) \rightarrow CO_2(g) + H_2O(l)$$

Balance the carbon atoms with carbon dioxide.

$$C_3H_8(g) + O_2(g) \rightarrow 3CO_2(g) + H_2O(l)$$

Balance the hydrogen atoms with water.

$$C_3H_8(g) + O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$$

Balance the oxygen atoms.

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$$ **(1 mark).**

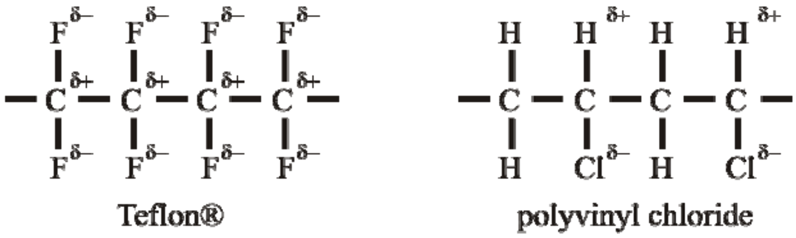
Question 4 (8 marks, 9 minutes)

a. i. Surface energy is a measure of the **energy required to increase the surface area** of the material by a specified amount **(1 mark).** It therefore is a measure of the bonding interactions between the particles in a sample of the material.

ii. Diamond has a covalent network lattice structure, therefore to increase the surface area for **diamond, strong carbon-carbon covalent bonds have to be broken,** therefore a large amount of energy is required to achieve this. In the **copper metallic lattice, the positive metal ions can slip easily over each other while the delocalised electrons hold the lattice together**, therefore a lower amount of energy is required **(1 mark).**

b. i. **Polyvinyl chloride** has the higher surface energy of 41 mJ m^{-2} compared to Teflon 20 mJ m^{-2} **(1 mark).**

ii. In **polyvinyl chloride,** there are polar bonds due to the electronegativity differences between the carbon, hydrogen and chlorine atoms, which result in the hydrogen atoms carrying a small positive charge and the chlorine a slight negative charge. Therefore there would be some degree of **dipole-dipole interactions between the polymer molecules**. In **Teflon®,** while the carbon-fluorine bond is polar, all the fluorine atoms would carry a negative charge, therefore there would be **no dipole-dipole interactions** between the molecules **(1 mark).**



c. In liquids, the particles are free to move about, therefore they are continually making and breaking weak bonds between the particles. When the temperature is increased, this process also increases, therefore it would be easier to increase the surface area of the liquid because the particles are freer to move about **(1 mark).**

d. The **size** of the nanoparticles is what gives them the potential to either enter cells or act on the surfaces of cells and change how a cell may function **(1 mark).** The size of nanoparticles is typically in the ranges of 1 to 100 nm, compared to human cells which are around 30000 nm.

e. i. The properties of a metal are due to a significant extent on the delocalisation of the valence electrons throughout the lattice. In nanoparticles, the lattice is extremely small, therefore the **valence electrons are more closely associated with their atom,** altering the properties of the material **(1 mark).**

ii. The increased reactivity of nanoparticles is due to their **large surface area to volume ratio,** thereby providing more sites for a reaction to occur at **(1 mark).**

Question 5 (6 marks, 7 minutes)

a. The relative atomic mass is the weighted average of the relative isotopic masses for the isotopes present in the sample. This is calculated by multiplying the relative isotopic masses by their corresponding abundances and then adding these together.
RAM = [(49.95×4.31) + (51.94×83.76) + (52.94×9.55) + (53.94×2.38)]/100
RAM = 52.0 **(2 marks).**

b. i. $^{9}_{4}Be$: The atomic number is 4, therefore there are **4 protons**.
The mass number is 9, therefore 9 – 4 = **5 neutrons (1 mark).**

ii. $^{4}_{2}He$: The atomic number is 2, therefore there are **2 protons**.
The mass number is 4, therefore 4 – 2 = **2 neutrons (1 mark).**

iii. The particle formed by fusing these two nuclei would contain:
Protons: 4 + 2 = **6 protons**
Neutrons: 5 + 2 = **7 neutrons (1 mark).**

iv. Atomic Number = number of protons = 6
Therefore the element is **carbon**.
Mass Number = number of protons + neutrons = 6 + 7 = 13
Isotope formed is $^{13}_{6}C$ **(1 mark).**

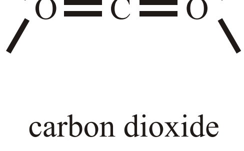
Question 6 (10 marks, 12 minutes)

a. The structures for the three molecules are shown below.

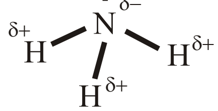
i. Carbon dioxide has a linear molecular structure with two carbon-oxygen double bonds. Due to the electronegativity difference between the carbon and oxygen, the carbon-oxygen bonds are polarised, so that the oxygen atom has a small negative charge and the carbon atom a small positive charge **(1 mark).**
Because the whole molecule is non-polar, then the strongest interaction between carbon dioxide molecules will be **dispersion forces (1 mark).**

ii. The structure of the ammonia molecule has a **triangular pyramidal shape** due to the non-bonding electron pair on the nitrogen atom. Each nitrogen-hydrogen single bond is polarised, with the hydrogen atoms having a slight positive charge and the nitrogen atom a slight negative charge **(1 mark).**
The molecule has a permanent dipole and because the intermolecular interaction involves hydrogen and nitrogen atoms, then the strongest intermolecular force will be **hydrogen bonding (1 mark).**

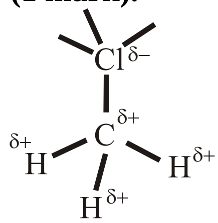
iii. Chloromethane has a tetrahedral structure involving four single bonds. The electronegativity differences between the carbon, hydrogen and chlorine atoms will result in the chlorine having a slight negative charge and the carbon atom and hydrogen atoms a slight positive charge **(1 mark).**
The molecule has a permanent dipole, therefore the strongest intermolecular interaction will involve **dipole-dipole interactions (1 mark).**



carbon dioxide

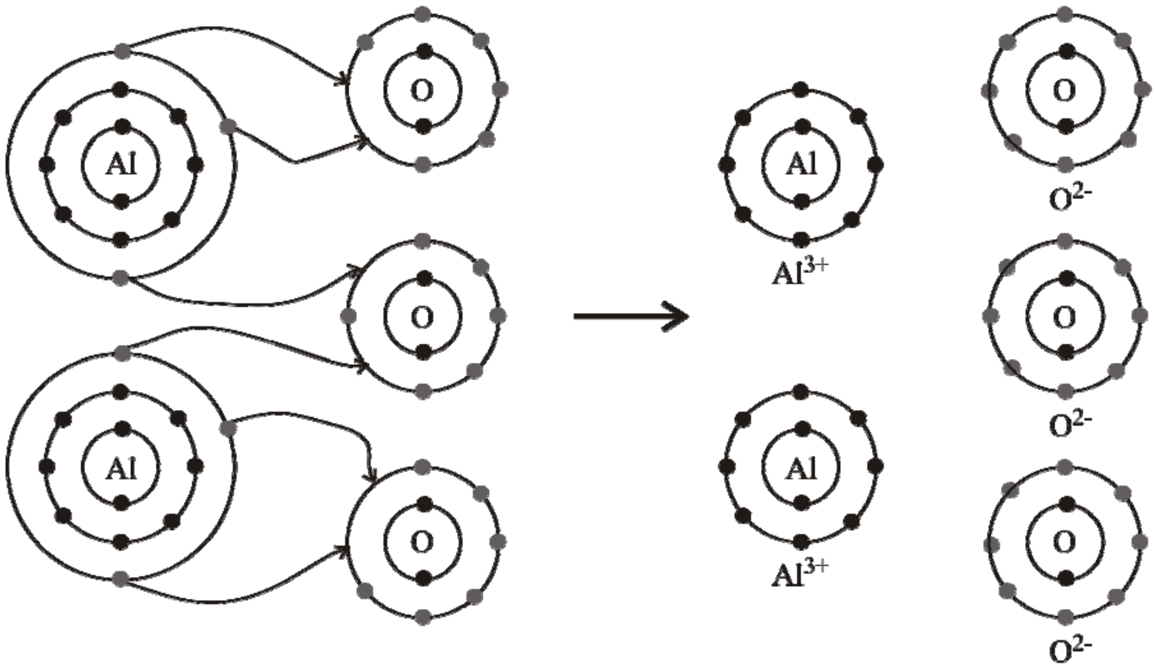


ammonia

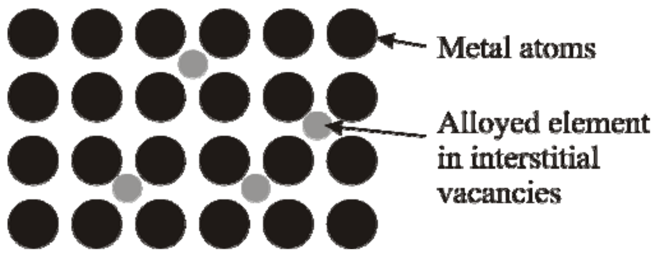


chloromethane

b. The electron transfer diagram for the reaction between aluminium and oxygen is shown below **(2 marks).** The ground-state electronic configurations for aluminium and oxygen are $1s^22s^22p^6\mathbf{3s^23p^1}$ and $1s^22s^2\mathbf{2p^4}$ respectively. When aluminium reacts, each atom will lose its three valence electrons and each oxygen atom can gain two electrons to achieve a full second shell. Therefore in this reaction a total of six electrons will need to be transferred to form the two Al^{3+} and three O^{2-} ions.



c. For an added element to form an interstitial alloy with a metal, its **atomic radius must be smaller than that of the metal,** so that it can occupy the spaces between the metal atoms in the metallic lattice **(1 mark).**



d. Quenching involves heating the metal to moderate temperatures then cooling it rapidly. This results in the **formation of very small crystals** in the solid, thereby increasing the surface area of the crystals and resulting in an **increase in the hardness** of the metal **(1 mark).** However this process also makes the **metal more brittle**.

End of Suggested Answers