VCE CHEMISTRY 2012

YEAR 11 TRIAL EXAM UNIT 1

Time allowed: 90 Minutes
Total marks: 74

Section A
Contains 24 Multiple Choice Questions
24 marks, 30 minutes

Section B
Contains 6 Short Answer Questions
50 marks, 60 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 2012 Year 11 Trial Exam Unit 1

Student Answer Sheet

There are 24 Multiple Choice questions to be answered by circling the correct letter in the table below. Use only a 2B pencil. If you make a mistake, erase and enter the correct answer. Marks will not be deducted for incorrect answers

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 2012 Year 11 Trial Exam Unit 1

SECTION A – Multiple Choice Questions

(24 marks, 30 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
The particle with the same number of neutrons present in its nucleus as there are in a $^{54}Fe^{2+}$ ion is
A. ^{54}Cr.
B. ^{51}V.
C. ^{58}Ni.
D. ^{48}Ti.

Question 2
The percentage by mass of water in manganese(II) sulfate pentahydrate, $MnSO_4 \cdot 5H_2O$, is
A. 37.3 %
B. 42.8 %
C. 40.7 %
D. 10.7 %

Question 3
The electronegativity for silicon is 1.90, therefore the electronegativity for magnesium will be
A. about 0.
B. greater than 1.90.
C. about 1.90.
D. less than 1.90.

Question 4
The mass of 1 mol of nitrogen atoms will be approximately the same as that of
A. 7 mol of hydrogen molecules.
B. 1 mol of carbon atoms.
C. 0.64 mol of carbon dioxide molecules.
D. 1 mol of silicon atoms.

Question 5
In a mass spectrometer, immediately after the particles have been ionised they are
A. accelerated by a magnetic field.
B. separated as they pass through an electric field.
C. separated as they pass through a magnetic field.
D. accelerated by an electric field.

Question 6
The ground state electronic configuration for phosphorus is
A. $1s^2 2s^2 2p^4 3s^2 3p^4 4s^1$.
B. $1s^2 2s^2 2p^6 3s^2 3p^2 4s^1$.
C. $1s^2 1p^4 2s^2 2p^4 3s^2 3p^1$.
D. $1s^2 2s^2 2p^6 3s^2 3p^3$.

Question 7
The person credited with showing that the nucleus of an atom contains most of its mass and is positively charged is
A. John Dalton.
B. Marie Curie.
C. Ernest Rutherford.
D. John Thomson.

Question 8
A 5.884 g sample of potassium dichromate, $K_2Cr_2O_7$, contains
A. 1.20×10^{22} potassium ions.
B. 6.02×10^{21} dichromate ions.
C. 1.20×10^{22} atoms.
D. 2.40×10^{22} chromium atoms.

Question 9
An ion with a double positive charge contains 46 electrons and 63 neutrons. This ion can be represented by the symbol
A. ${}^{111}_{48}Cd^{2+}$
B. ${}^{109}_{46}Pd^{2+}$
C. ${}^{107}_{44}Ru^{2+}$
D. ${}^{111}_{44}Ru^{2+}$

Question 10
A reaction between lead and oxygen resulted in the formation of a lead oxide with the formula Pb_2O_3. The mass of oxygen required to react with 3.243 g of lead to form this oxide is
A. 0.251 g.
B. 0.752 g.
C. 0.376 g.
D. 0.167 g.

Question 11
The early work on the Periodic Table focused on grouping together the known elements based on their
A. chemical properties.
B. electronic configurations.
C. atomic mass (weight).
D. physical properties.

Question 12

The standard used to determine the relative atomic masses of the elements is that the

A. relative atomic mass of carbon is 12 exactly.

B. relative isotopic mass of carbon-12 is 12 exactly.

C. relative isotopic mass of oxygen-16 is 16 exactly.

D. relative atomic mass of hydrogen is 1 exactly.

Question 13

Both decane and hexane are liquid hydrocarbons at room temperature. Compared to decane, hexane will have

A. a lower boiling temperature and a higher viscosity.

B. a higher boiling temperature and a lower viscosity.

C. a lower boiling temperature and a lower viscosity.

D. a higher boiling temperature and a higher viscosity.

Question 14

In molecular compounds, which one of the following will be the **least** polar bond?

A. Carbon-chlorine.

B. Carbon-oxygen.

C. Carbon-fluorine.

D. Carbon-bromine.

Question 15

Which one of the following is correct when comparing the molar mass, boiling temperature and chemical properties of two alkanes that are isomers?

	Molar Mass	**Boiling Temperature**	**Chemical Properties**
A.	Same	Same	Different
B.	Different	Different	Similar
C.	Same	Different	Similar
D.	Different	Same	Similar

Question 16

The surface energy for water is greater than that of ethanol, because

A. the boiling temperature of water is higher than that of ethanol.

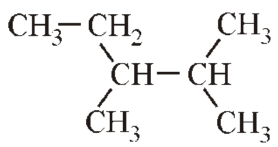
B. in water there is hydrogen bonding between the water molecules, whereas in ethanol there are dipole-dipole interactions.

C. covalent bonds have to be broken in water.

D. the forces between the water molecules are stronger than those between the ethanol molecules.

Question 17

The systematic name for the hydrocarbon shown below is



A. 2-ethyl-3-methylbutane.

B. heptane.

C. 2,3-dimethylpentane.

D. 2,2-dimethylpentane.

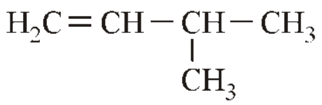
Question 18
The main structural requirement for monomers that can be used to produce addition polymers is that they contain
A. two hydroxy functional groups.
B. an hydroxy and a carboxy functional group.
C. an unsaturated carbon-carbon bond.
D. an amino and a carboxy functional group.

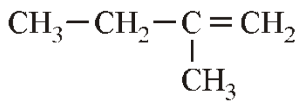
Question 19
A typical compound that has ionic bonding will have
A. a low melting temperature and will not be an electrical conductor in either the solid or liquid (molten) states.
B. a moderately high melting temperature, will not be an electrical conductor in the solid state but will conduct electricity in the liquid (molten) state.
C. a moderately high melting temperature and will be an electrical conductor in the solid and liquid (molten) states.
D. a low melting temperature, will not be an electrical conductor in the solid state but will conduct electricity in the liquid (molten) state.

Question 20
Comparing addition polymers with a significant degree of branching along the polymer chain with those that have few branches along the polymer chain, the polymers with the lesser degree of branching will
A. have a lower density.
B. be less flexible.
C. be softer.
D. will soften at a lower temperature.

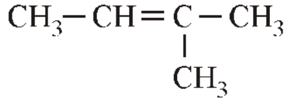
Question 21
A rod is found to be a good conductor of heat. The bonding between the particles that make up the rod will involve
A. ionic bonding.
B. covalent bonding.
C. covalent network lattice bonding.
D. metallic bonding.

Question 22
The structure for 2-methylbut-1-ene can be represented by

A.


B.


C.


D.


Question 23
Cross-linking involves the formation of
A. hydrogen bonds between the polymer chains.
B. ion-dipole interactions between the polymer chains.
C. covalent bonds between the polymer chains.
D. dipole-dipole interactions between the polymer chains.

Question 24
Compared with a sample of the bulk metal, metal nanoparticles tend to
A. have a higher electrical conductivity.
B. behave as thermal and electrical insulators.
C. be less reactive.
D. display electrical properties between those of metal and non-metals.

End of Section A

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SECTION B – Short Answer Questions

(50 marks, 60 minutes)

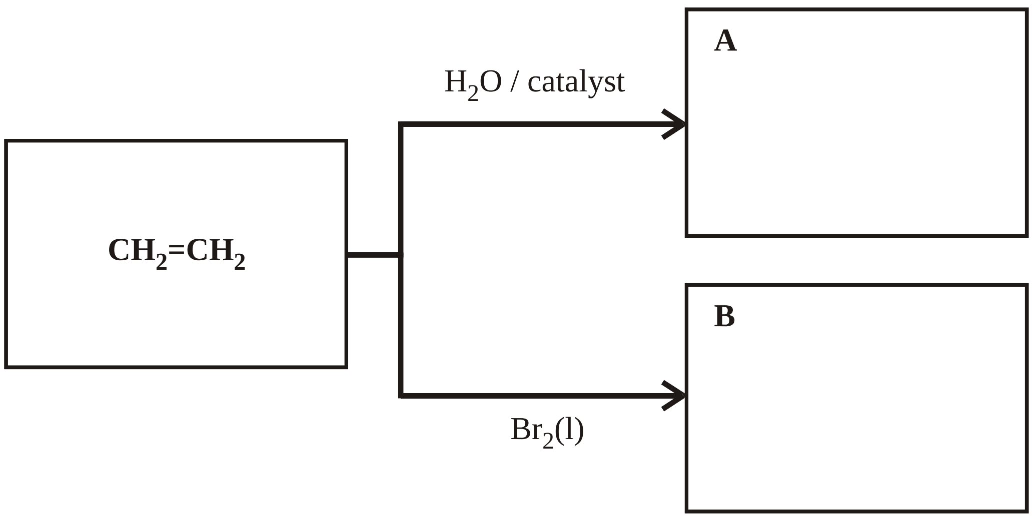
This section contains six questions, numbered 1 to 6.
All questions should be answered in the spaces provided.
The mark allocation and approximate time that should be spent on each question are given.

Question 1 (10 marks, 12 minutes)

a. Draw the structures for the two isomers of butane and label them with their systematic names.

(2 marks)

b. i. On the reaction scheme below, show the products, labelled A and B, that would be produced when ethene reacts with the reagents shown.



(2 marks)

ii. What are the systematic names for the compounds labelled A and B in the above scheme?

Compound A:

Compound B:

(2 marks)

c. Write an appropriate chemical equation to represent the complete combustion of butane.

(1 mark)

d. i. Draw the structure for a section of the polymer that could be produced from styrene, C_6H_5-CH=CH_2.

(2 marks)

ii. How would a copolymer differ from a polymer such as polyethene?

(1 mark)

Question 2 (8 marks, 10 minutes)

a. Diamond and graphite are two allotropes of carbon.

i. What is one similarity in the bonding present in these two allotropes?

(1 mark)

ii. What is one difference in the bonding present in these two allotropes?

(1 mark)

iii. What are two physical properties of these two allotropes that are significantly different?

(2 marks)

iv. Select one of the properties given in iii. above and explain why the property differs between the two allotropes.

Property:

(1 mark)

b. What is the requirement for the element added to a metal so that it forms an interstitial alloy?

(1 mark)

c. Hydrogen sulfide, H_2S, has a boiling temperature of -60 °C.

i. Draw the structure for hydrogen sulfide, showing all bonding and non-bonding electron pairs.

(1 mark)

ii. What are the strongest interaction forces that exist between the hydrogen sulfide molecules?

(1 mark)

Question 3 (7 marks, 8 minutes)

a. The diagram below shows how a droplet of mercury would behave when placed on a clean glass plate.

Explain why the mercury does not wet the glass plate.

(2 marks)

b. Explain why the surface energy of solid sulfur, S_8, would be expected to be less than that for solid sodium chloride.

(2 marks)

c. Silver ions have antimicrobial properties. Over recent years a number of consumer products, such as clothing and food containers, have been released on the market that are made from materials impregnated with silver nanoparticles.

i. Why would the silver nanoparticles show much greater antimicrobial activity than other forms of silver?

(1 mark)

ii. What could be two concerns that could be raised about the use of these types of materials that are impregnated with silver nanoparticles?

(2 marks)

Question 4 (10 marks, 12 minutes)

a. Analysis showed that a compound contained the elements carbon, hydrogen and oxygen. When this compound was completely burnt, all of the carbon was converted to carbon dioxide.
A 3.218 g sample of the compound produced 7.452 g. carbon dioxide.
The compound was also found to contain 8.77 % hydrogen by mass.
The molar mass of the compound was determined to be 228 g mol^{-1}.

i. Calculate the percentage by mass of carbon in this sample of the compound.

(3 marks)

ii. Determine the percentage by mass of oxygen in the compound.

(1 mark)

iii. Determine the empirical formula for the compound.

(2 marks)

iv. Determine the molecular formula for the compound.

(1 mark)

b. The total number of atoms present in a sample of phosphorus(III) chloride, PCl_3, is 3.20×10^{21} atoms.

i. Determine the amount in mole of phosphorus(III) chloride in the sample.

(2 marks)

ii. Determine the mass of the sample.

(1 mark)

Question 5 (8 marks, 10 minutes)

a. Copper has two naturally occurring isotopes. The isotopic abundances of the lighter isotope is 69.1 %. The relative isotopic mass of the heavier isotope is 64.93.

i. Determine the relative isotopic mass for the lighter isotope.

(3 marks)

ii. How many of each sub-atomic particle are present in a copper(II) ion, Cu^{2+}, of the lighter isotope?

(2 marks)

b. i. The atomic radii for beryllium and oxygen are 105 pm and 60 pm respectively. Explain why the atomic radius for oxygen is less than that for beryllium, even though it has a higher atomic number.

(1 mark)

ii. Sodium metal will react vigorously when it is added to water, however rubidium metal will explode when it comes in contact with water. Give an explanation for this difference in the chemical reactivity of these two elements, even though they are in the same group.

(1 mark)

iii. Give an explanation why selenium would be expected to display non-metallic characteristics.

(1 mark)

Question 6 (7 marks, 8 minutes)

a. Write the ground state electronic configurations, in terms of subshells, for the following:

i. Nickel(II) ion, Ni^{2+}.

ii. Sulfide ion, S^{2-}.

(2 marks)

b. i. Explain what happens to some of the electrons when an atom absorbs energy.

(1 mark)

ii. What happens when an atom that has absorbed energy returns to its ground state?

(1 mark)

c. Following his work on the atomic spectra of hydrogen, Niels Bohr introduced an atomic model which placed the electrons in shells orbiting the nucleus of the atom.

i. In this model what is the maximum number of electrons that can occupy the third shell?

(1 mark)

ii. What is one of the assumptions made by this model?

(1 mark)

iii. What modification had to be made to this model to explain the electronic configuration for some heavier atoms, such as potassium?

(1 mark)

End of Section B

End of Trial Exam

Suggested Answers

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SECTION A – Multiple Choice Questions

(1 mark per question)

Q1 **B** The atomic number (Z) is the number of protons present in the nucleus of a particle. The mass number (A) is the number of protons plus neutrons present in the nucleus of a particle, therefore

The number of neutrons = Mass number – Atomic number = A – Z

$^{54}Fe^{2+}$ (Z=26): N(n) = 54 – 26 = 28

A: ^{54}Cr (Z=24): N(n) = 54 – 24 = 30

B: ^{51}V (Z=23): N(n) = 51 – 23 = 28

C: ^{58}Ni (Z=28): N(n) = 58 – 28 = 30

D: ^{48}Ti (Z=22): N(n) = 48 – 22 = 26

Q2 **A** $M(H_2O) = 2\times1.0 + 16.0 = 18.0$ g mol^{-1}

$M(MnSO_4 \cdot 5H_2O) = 54.9 + 32.1 + 4\times16.0 + 5\times18.0 = 241.0$ g mol^{-1}

The mass of 1 mol of $MnSO_4 \cdot 5H_2O$ is 241.0 g.

In 1 mol of the solid there are 5 mol of water.

$m(H_2O) = 5 \times 18.0 = 90.0$ g

$\%(H_2O) = (90.0/241.0) \times (100/1) =$ **37.3 %**

Q3 **D** Both **silicon and magnesium are in the same period** of the Periodic Table (third period). **Moving across a period** in the Periodic Table, the **electronegativity increases,** since the outer shell or valence electrons are influenced by a higher effective nuclear charge. Since **magnesium is before silicon in the third period** of the Periodic Table then its **electronegativity will be less than that for silicon**. The electronegativity for magnesium is 1.31.

Q4 **A** M(N) = 14.0 g mol^{-1}

The mass of 1 mol of nitrogen atoms is 14.0 g

A: $M(H_2) = 2 \times 1.0 = 2.0$ g mol^{-1} : $m(H_2) = n\times M = 7\times2.0 = 14.0$ g

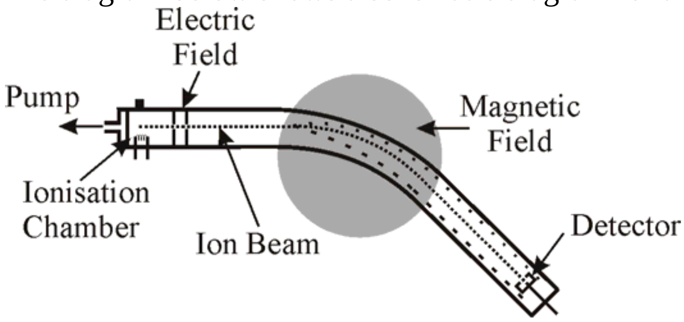
B: M(C) = 12.0 g mol^{-1} : m(C) = 1 × 12.0 = 12.0 g

C: $M(CO_2) = 12.0 + 2\times16.0 = 44.0$ g mol^{-1}

$m(CO_2) = 0.64\times44 = 28.2$ g

D: M(Si) = 28.1 : m(Si) = 1×28.1 = 28.1 g

Q5 **D** In a mass spectrometer, once the gas particles have been ionised, they are **accelerated by an electric field**. The charged particles are then separated according to their mass/charge ratio as they pass through a magnetic field before they are collected.
The diagram below shows a schematic diagram for a mass spectrometer.



Q6 **D** Phosphorus (Z = 15) atoms contain 15 electrons.
The ground state electronic configuration is the arrangement of electrons in their subshells having the lowest electronic energy. Because of their energies, subshells fill in the following order:
1s 2s 2p 3s 3p 4s ………..
The maximum numbers of electrons in any s and p subshell are 2 and 6 respectively.
Therefore the ground state electronic configuration for phosphorus is
$\mathbf{1s^2 2s^2 2p^6 3s^2 3p^3}$.

Q7 **C** In 1911 **Ernest Rutherford** reported the results of an experiment where he fired a beam of alpha particles, helium nuclei He^{2+}, at a thin sheet of gold foil. The results showed that the majority of the particles passed through the foil. However, a small number of the particles were deflected by large angles and some bounced back. At this stage the atomic model was the Thomson model, and Rutherford showed that the experimental results were not consistent with this model. From his results, Rutherford proposed that atoms consisted of a nucleus which contained most of the mass and was positively charged.

Q8 **D** $M(K_2Cr_2O_7) = 2\times39.1 + 2\times52.0 + 7\times16.0 = 294.2 \text{ g mol}^{-1}$.
$n(K_2Cr_2O_7) = m / M = 5.884 / 294.2 = 2.000\times10^{-2}$ mol
$N(K_2Cr_2O_7) = n \times N_A = 2.000\times10^{-2} \times 6.02\times10^{23} = 1.20\times10^{22}$
For each response:
A: $N(K^+) = 2 \times N(K_2Cr_2O_7) = 2 \times 1.20\times10^{22} = 2.40\times10^{22}$ ions
B: $N(Cr_2O_7^{2-}) = N(K_2Cr_2O_7) = 1.20\times10^{22}$ ions
C: $N(\text{atoms}) = 11 \times N(K_2Cr_2O_7) = 11 \times 1.20\times10^{22} = 1.32\times10^{23}$ atoms
D: $\mathbf{N(Cr) = 2 \times N(K_2Cr_2O_7) = 2 \times 1.20\times10^{22} = 2.40\times10^{22}}$ **atoms**

Q9 **A** The doubly charged ion contains 46 electrons and 63 neutrons.
Determining the atomic and mass numbers:
A double positive ion means that there are two protons more than the number of electrons, therefore the atomic number (number of protons) equals 46 + 2 = **48.**
Referring to the Period Table this is **Cd**.
Mass number = 48 + 63 = **111**.

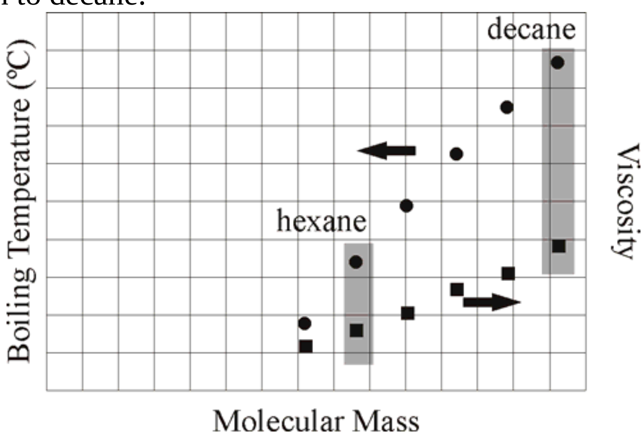
Therefore the symbol is ${}^{111}_{48}Cd^{2+}$

Q10 C The formula for the oxide is Pb_2O_3
n(Pb) = m / M = 3.243 / 207.2 = 1.565×10^{-2} mol
In the compound since the atom ratio of Pb : O is 2 : 3
n(O) = $^3/_2$ × n(Pb) = $^3/_2$ × 1.565×10^{-2} = 2.348×10^{-2} mol
m(O) = n × M(O) = 2.348×10^{-2} × 16.0 = **0.376 g**
Alternative solution:
The chemical equation for the reaction would be:
$$4Pb(s) + 3O_2(g) \rightarrow 2Pb_2O_3(s)$$
n(Pb) = m / M = 3.243 / 207.2 = 1.565×10^{-2} mol
From the equation the molar ratio of Pb : O_2 is 4 : 3
$n(O_2)$ = $^3/_4$ × n(Pb) = $^3/_4$ × 1.565×10^{-2} = 1.17×10^{-2} mol
$m(O_2)$ = n × $M(O_2)$ = 1.17×10^{-2} × 32.0 = ***0.376 g***

Q11 A When trying to group the known elements, chemists such as Johann Dobereiner (1780-1849), John Newlands (1837-1898), Dmitri Mendeleev (1839-1907) and Julius Meyer (1830-1895) used the **chemical properties of the elements** as their main criteria for grouping elements together.

Q12 B In 1961 the International Union of Pure and Applied Chemistry (IUPAC) agreed on the **relative isotopic of carbon-12 being exactly 12** as the standard for determining the relative isotopic and atomic masses for other atoms and the elements. Prior to this, a number of different standards were used such as Dalton's, where the masses were relative to hydrogen being given the value of 1.

Q13 C The intermolecular forces between the alkane molecules in both compounds will involve dispersion forces. Since less energy will be required to change the state of a lower molecular mass hydrocarbon, then hexane will have a **lower boiling temperature**. Low viscosity liquids flow more freely. As the molecular mass increases then the viscosity of the liquid will also increase, therefore **hexane will be less viscous** than decane. The diagram below shows how the boiling temperature and viscosity for the hydrocarbons pentane through to decane.



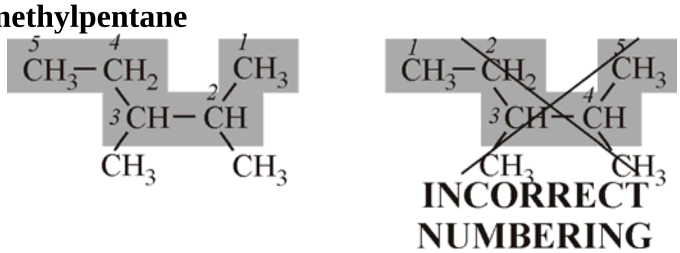
Q14 D The **polarity of a molecular bond depends on the difference in the electronegativities between the two elements**. Fluorine and oxygen have high electronegativities, therefore these two elements will produce highly polarised bonds with carbon. Bromine is the least electronegative element (electronegativity decreases moving down a group in the Periodic Table), therefore the **carbon-bromine bond will be the least polar**.

Q15 C Isomers are compounds with the **same molecular formulae** but different structural formulae, therefore their **molar masses will be identical**. Since the compounds are alkanes, then their chemical properties will be similar because the reactivity is mainly determined by the carbon-carbon and carbon-hydrogen bonds. The **differences in the structures will affect how the molecules interact with one another** and as a result, the **boiling temperatures will differ**. Considering the two hydrocarbons with the molecular formula C_4H_{10}, the boiling temperatures for butane, $CH_3CH_2CH_2CH_3$, and 2-methylpropane, $(CH_3)_2CHCH_3$, are -0.5 ºC and -11.7 ºC respectively.

Q16 D The surface energy of a substance reflects the strength of the interactions between the particles that make it up. The strength of the interactions between the water molecules is larger than that between the ethanol molecules. Both interactions involve hydrogen bonding, however these interactions are stronger in water.
Response A is true in that water has a boiling temperature greater than that of ethanol, 100 °C compared with 78.3 ºC respectively. This property is the result of the stronger interactions between the water molecules and does not fully answer the question.
Response B is partially correct, however it is not the best answer. There are hydrogen bonding interactions between the ethanol molecules in addition to dipole-dipole bonding. However the strength of these interactions between the ethanol molecules are less than those between the water molecules.

Q17 C The systematic name for a hydrocarbon can be determined by following the following rules.

1. Locate the longest carbon-carbon atom chain or backbone in the structure that contains any unsaturated carbon-carbon bonds.
   In this case the longest chain contains five carbon atoms which are joined by only single carbon-carbon bonds ⇒ **pentane**
2. Locate any groups attached to this chain and number the carbon atoms in the chain so that the substituent numbers are the lower of the two possibilities.
   In this hydrocarbon there are two methyl, $-CH_3$, groups and these are attached to carbon atoms 2 and 3 in the chain ⇒ **2,3-dimethyl-**.
   2,3-dimethylpentane



The diagram above also shows the incorrect numbering of the carbon atoms in the chain, which would give the name as 3,4-dimethylpentane.

Q18 **C** Addition polymers are formed by the polymerisation of monomers that contain unsaturated carbon-carbon bonds. This most commonly involves a carbon-carbon double bond as in the formation of polyethene from ethene.

$$nCH_2 = CH_2 \rightarrow -(CH_2 - CH_2)_n -$$

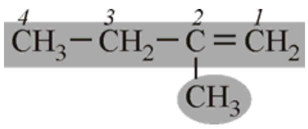
The functional groups stated in the other responses can give rise to condensation polymers.

Q19 **B** **Ionic** compounds consist of **positive and negative ions held together by electrostatic forces**. A typical ionic compound has a **moderately high melting temperature** because of the strong electrostatic forces between the positive and negative ions (e.g.: NaCl m.t. 801 ºC).
In the **solid state, the charged ions are in a lattice and not free to move** about in the solid, therefore solid ionic compounds are **not electrical conductors**. In the **liquid state**, and in aqueous solutions, **the ions are free to move about**, therefore the ions **will carry an electric current**.

Q20 **B** The chains of polymers with a low degree of branching will be able to pack together more readily and the chains can twist around each other. This will result in a material that has a higher density, is harder and less flexible and softens at a higher temperature.
High-density polyethene, HDPE, is an example of a polymer where there is little branching along the polymer chain making it stronger and more rigid than low-density polyethene, LDPE, that has a significant degree of branching along the chain.

Q21 **D** To be a good conductor of heat, the thermal energy must be able to pass along the length of the rod. For this to occur, particles must be able to move within the structure. In **metallic bonding,** the electrons are free to move within the lattice, therefore can transfer the thermal energy along the rod as they move about.

Q22 **B** 2-methyl**but**-1-ene: The longest carbon-carbon atom contains four carbon atoms.
2-methylbut-**1-ene**: There is a single carbon-carbon double bond between carbon atoms 1 and 2 in the chain.
2-methylbut-1-ene: There is a methyl group attached to carbon atom 2.



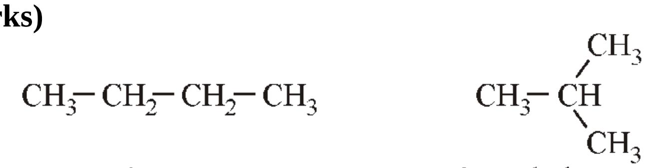
Q23 **C** Cross-linking involves the formation of ‘strong’ **covalent bonds** between the polymer chains. This reduces the ability of the chains to move freely over each other, thereby increasing the rigidity of the material.
The other responses all involve weak interactions between the polymer chains.

Q24 **D** The electrical conductivity of a metal is dependent on the free movement of the delocalised outer shell or valence electrons within the solid. In a metal nanoparticle, since there are less positively charged ions in the lattice, the outer shell or valence electrons are more closely associated with their atoms and not as widely delocalised. As a result, the nanoparticles display electrical properties between those of metals and non-metals, such as a lower electrical conductivity.

SECTION B – Short Answer (Answers)

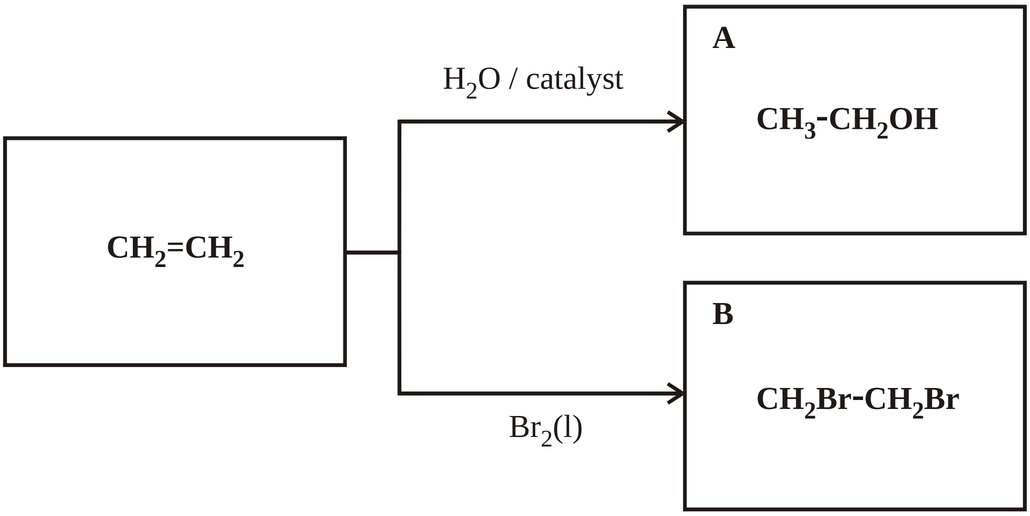
Question 1 (10 marks, 12 minutes)

a. Butane has the molecular formula C_4H_{10}. This is an alkane and only contains carbon-carbon single bonds. There are two structural isomers for butane, **butane** and **2-methylpropane**. The structures for the isomers are shown below.
(Mark allocation: 1 mark for both correct structure and name. Total marks 2 marks)



butane 2-methylpropane

b. i. Both these reactions are **addition reactions across the carbon-carbon double bond**.
For compound A, the water is added across the carbon-carbon double bond so that a hydrogen attaches to one of the carbon atoms involved in the carbon-carbon double bond and an hydroxy group, -OH, attaches to the other carbon atom.
For compound B, a bromine atom attaches to each of the carbon atoms involved in the carbon-carbon double bond.



(2 marks)

ii. Compound A: This has an hydroxy, -OH, functional group and a single carbon-carbon bond, therefore is the alkanol **ethanol**. **(1 mark)**
Compound B: This has two bromine atoms attached on different carbon atoms and a single carbon-carbon bond, therefore is **1,2-dibromoethane**. **(1 mark)**

c. The products of the complete combustion of a hydrocarbon are carbon dioxide and water. The chemical equation can be developed using the following steps.

1. Write down the reactants and products.
$C_4H_{10}(g) + O_2(g) \rightarrow CO_2(g) + H_2O(l)$
2. Balance the carbon atoms in the chemical equation.
$C_4H_{10}(g) + O_2(g) \rightarrow 4CO_2(g) + H_2O(l)$
3. Balance the hydrogen atoms in the chemical equation.
$C_4H_{10}(g) + O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$

4. Balance the oxygen atoms in the chemical equation.

$$C_4H_{10}(g) + \frac{13}{2}O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$$

5. If the coefficient of the oxygen gas is not a whole number then multiply the equation by 2.

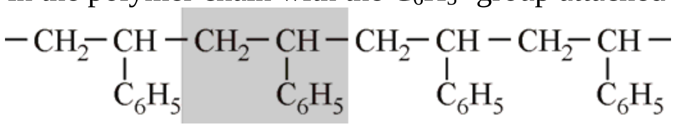
$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l)$$ **(1 mark)**

Ensure that states have been included in the final chemical equation.

A combustion chemical equation may be stated as at the end of step 4.

d. i. The polymer polystyrene should show at least three repetitions of the monomer unit. **(2 marks)**

The section of the structure should show a backbone of single carbon-carbon bonds in the polymer chain with the C_6H_5- group attached to this backbone.

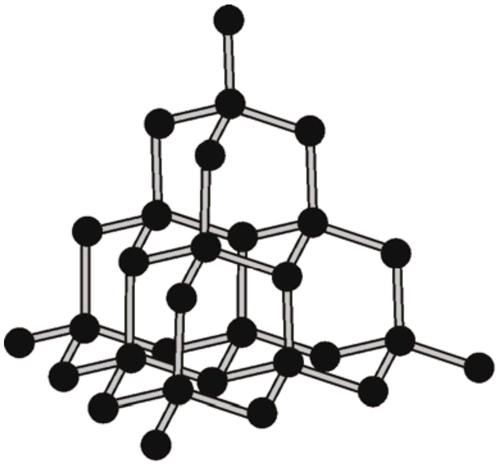


ii. **Polyethene** is a polymer **made from a single monomer,** whereas a **copolymer is made from at least two monomers**. **(1 mark)** An example of a copolymers is one that is made from styrene and butadiene. This copolymer would have different properties to those of either of the polymers made from the single monomers.

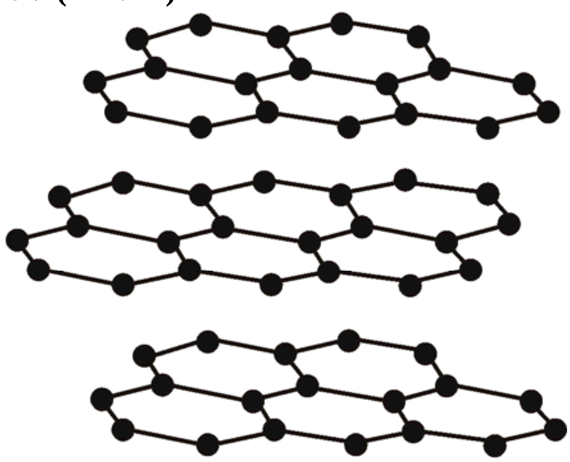
Question 2 (8 marks, 10 minutes)

a. i. In the structures of both diamond and graphite, carbon atoms are joined by **covalent bonds in a network lattice**. **(1 mark)**

ii. In **diamond** the network lattice is **three dimensional** with **each carbon atom covalently bonded to four other carbon atoms**. In **graphite** the lattice is **two dimensional** with each **carbon atom covalently bonded to three other carbon atoms,** forming a layer and the **remaining electron on each carbon atom is delocalised** within the layer. **(1 mark)**



Diamond



Graphite

iii. Possible answers include:

(Mark Allocation: 1 mark for correct response. Total 2 Marks)

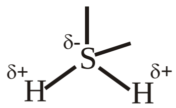
Hardness

Electrical conductivity

iv. **(Mark Allocation: 1 mark)**
Hardness – Overall, **graphite** is **soft** because the **layers of carbon atoms can slide over each** other as there are **only weak forces between the layers**, whereas **diamond is hard** due to the **strong covalent bonding** extending in the **three directions**. *(On the Moh's scale of hardness, graphite is between 1 and 2 whereas diamond is 10.)*
Electrical conductivity – Because of the **delocalised electrons in the layers of graphite, it is a weak conductor of electricity**. Since there are **no mobile charge carriers** in the structure of **diamond** it is a **non-conductor**. The electrical conductivity of graphite is about 2.5×10^{3} S m^{-1} compared to 1×10^{-13} S m^{-1} for diamond. (Gold: 4.5×10^{7} S m^{-1})

b. Interstitial alloys have the added element atoms located in the spaces between the metal atoms in the metallic lattice. For the added element to be able to do this then the **size of the atoms must be small enough to fit in the space available**. **(1 mark)** In general this requires that the size of the added element be smaller than that of the metal.

c. i. Sulfur (Z = 16) has six valence electrons, two of which will form covalent bonds with the hydrogen atoms, thereby resulting in two lone pairs of electrons. **(1 mark)**



The bond polarities are not required for the mark allocated.

ii. Sulfur is more electronegative than hydrogen, therefore the hydrogen-sulfur bond will be polarised. Since the central sulfur atom has two polar bonds and two pairs of lone electrons overall the molecule will be dipolar. The **strongest interaction between the hydrogen sulfide molecules will be dipole-dipole interactions**. **(1 mark)** Weaker dispersion forces will also be present between the molecules.

Question 3 (7 marks, 8 minutes)

a. For a liquid to **wet** a solid, the **force of attraction between the particles in the liquid must be less than the force of attraction between the particles on the surface of the solid and the particles in the liquid**. **(1 mark)** **Mercury is a metal** therefore the particles in the drop of mercury will undergo **metallic bonding**, therefore the **force of attraction between the mercury atoms will be strong**. This will be stronger than the force of attraction between mercury and ionic glass surface, and as a result the mercury will not wet the glass surface. **(1 mark)**

b. The **surface energy is the energy required to increase the surface area** of a substance. Increasing the surface area of a material requires **breaking the bonds between the particles that make up the material**, therefore the **surface energy reflects the forces of attraction between the particles** in the material. Sulfur is a non-metal, therefore there will be covalent bonding between the sulfur atoms in the sulfur, S_8, molecules. However since the sulfur molecules will not be polar, there will be **only weak dispersion forces between the sulfur molecules**. **Sodium chloride is an ionic solid** and there will be **strong electrostatic forces of attraction between the ions, Na^{+} and Cl^{-}, in the lattice**. Since the **forces of attraction between the particles in sulfur are less than those between the ions in sodium chloride, the surface energy of sulfur would be expected to be less than that for sodium chloride**. **(2 marks)**

c. i. The active antimicrobial agent is silver ions. Silver **nanoparticles have a large surface area to volume ratio** compared with other forms of silver, therefore they can react readily with various substances, such as moisture, to release silver ions that will kill the microbes. **(1 mark)**

ii. Possible answers:
(1 mark each. Total marks allocated = 2 marks)
The silver nanoparticles could react, thereby releasing silver ions that could be ingested or absorbed into the body and this could have adverse effects, such as poisoning.
The silver nanoparticles could be absorbed directly into the body and could enter cells and inadvertently kill body cells.
The silver nanoparticles or silver ions could be released from the objects during washing and enter the environment and cause problems. Silver compounds have been shown to be highly toxic to marine organisms.
Silver nanoparticles are very small and if released from the material have the potential to enter cells where they could cause different processes to occur within the cell.

Question 4 (10 marks, 12 minutes)

a. i. $M(CO_2) = 12.0 + 2\times16.0 = 44.0$ g mol^{-1}
$n(CO_2) = m / M = 7.452 / 44.0 = 1.694\times10^{-1}$ mol **(1 mark)**
$m(C) = n \times M = 1.694\times10^{-1} \times 12.0 = 2.032$ g **(1 mark)**
$\%(C) = (2.032/3.218) \times (100/1) =$ **63.16 % (1 mark)**
Alternative solution:
$m(C) = (12.0/44.0) \times 7.452 = 2.032$ g
*$\%(C) = (2.032/3.218) \times (100/1) =$ **63.16 %***

ii. $\%(O) = 100 – (\%(C) + \%(H))$
$\%(O) = 100.00 – (63.16 + 8.77) =$ **28.07 % (1 mark)**

iii. Assuming 100 g of material and determine the molar ratio of the elements.
$$n(C) : n(H) : n(O) = \frac{63.16}{12.0} : \frac{8.77}{1.0} : \frac{28.07}{16.0}$$
$= 5.26 : 8.77 : 1.75$ **(1 mark)**
Divide all three values by the smallest value to get the lowest ratio
$$= \frac{5.26}{1.75} : \frac{8.77}{1.75} : \frac{1.75}{1.75}$$
$= 3.01 : 5.01 : 1.00$
Therefore the empirical formula is $\mathbf{C_3H_5O}$. **(1 mark)**

iv. The molecular formula is a whole number multiple of the empirical formula, $(C_3H_5O)_x$.
$M(C_3H_5O) = 3\times12.0 + 5\times1.0 + 16.0 = 57.0$ g mol^{-1}
$M((C_3H_5O)_x) = 57.0 \times x = 228$ g mol^{-1}
Evaluate for x
$x = 228 / 57.0 = 4$
Molecular formula is $(C_3H_5O)_4 \Rightarrow$ $\mathbf{C_{12}H_{20}O_4}$. **(1 mark)**

b. i. $N_A = 6.02\times10^{23}$ mol^{-1}
$n(atoms) = N / N_A = (3.20\times10^{21})/(6.02\times10^{23}) = 5.32\times10^{-3}$ mol **(1 mark)**
Each molecule of phosphorus (III) trichloride has four atoms (one phosphorous plus three chlorine).
$n(PCl_3) = ¼ \times n(atoms) = ¼ \times 5.32\times10^{-3} =$ $\mathbf{1.33\times10^{-3}}$ **mol (1 mark)**

ii. $M(PCl_3) = 31.0 + 3\times35.5 = 137.5$ g mol^{-1}
$m(PCl_3) = n \times M = 1.33\times10^{-3} \times 137.5 =$ $\mathbf{1.83\times10^{-1}}$ **g (1 mark)**

Question 5 (8 marks, 10 minutes)

a. i. From the VCE Chemistry Data Book Periodic Table;

$A_r(Cu) = 63.6$

The abundance of the heavier isotope = 100 – 69.1 = 30.9 % **(1 mark)**

The relative atomic mass, A_r, is the weighted average of the relative isotopic masses.

Let the relative isotopic mass of the lighter isotope equal x.

$A_r(Cu) = (69.1 \times x + 30.9 \times 64.93)/100 = 63.6$ **(1 mark)**

Multiply both sides of equation by 100 and evaluate terms in bracket.

$69.1x + 2006.3 = 6360$

$69.1x = 6360 - 2006.3 = 4353.7$

x = 4353.7 / 69.1 = **63.0** **(1 mark)**

ii. The mass number, A, for a particle is a whole number, therefore the mass number for the lighter isotope will be 63, ^{63}Cu.

Therefore the sub-atomic particles present in a $^{63}Cu^{2+}$ ion will be:

The number of protons in the nucleus of an atom is equal to the atomic number, Z. Therefore using the Periodic Table, this ion will contain **29 protons**.

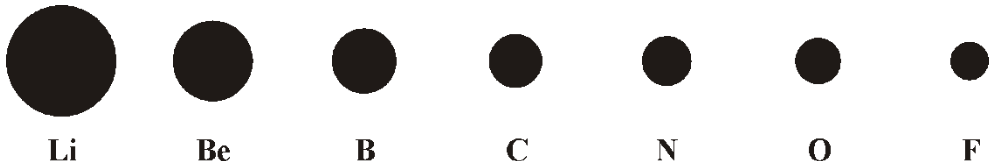
The number of electrons in a neutral particle is equal to the number of protons. Since the particle is a 2+ ion, there will be two less electrons.

Number(electrons) = 29 – 2 = **27 electrons** **(1 mark)**

The mass number is the number of protons plus neutrons in the nucleus of the particle.

Number(neutrons) = 63 – 29 = **34 neutrons** **(1 mark)**

b. i. Beryllium and oxygen are both in period 2 of the Periodic Table. The atomic radius for oxygen is less than that for beryllium **because the outer shell or valence electrons for oxygen are more strongly attracted to the higher effective charged nucleus**. **(1 mark)** The effective nuclear charges for beryllium and oxygen are 2+ and 6+ respectively. Therefore based on Coulomb's electrostatic attraction, an electron will be more strongly attracted to the oxygen nucleus, and as a result be closer to the nucleus. The trend **within a period** of the Periodic Table is that **moving across a period, the atomic radius of the elements decreases**. The diagram below is a representation of the atomic radii of the elements in period 2 of the Periodic Table.



ii. The chemical reactivity of an element involves the outer shell or valence electrons. Both sodium and rubidium are in Group 1 of the Periodic Table and are metals. When metals react, they lose electrons, are oxidised. The outer shell or valence electron in rubidium is in the fifth shell (….$5s^1$) compared to sodium where the outer shell or valence electron is in the third shell (….$3s^1$), therefore it will be **further from the nucleus and experience a weaker attractive force towards the nucleus and be more easily removed**. **(1 mark)**

iii. Selenium is in group 16 and period 4 of the Periodic Table. The **metallic character of an element decreases moving across a period** making the element's properties more non-metallic. **(1 mark)**

Question 6 (7 marks, 8 minutes)

a. The ground state electronic configuration for a particle is when the electrons are in their lowest energy state. The order of energies for the subshells is
$1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p < 5s$ ……………….
The maximum number of electrons that can occupy s, p, and d subshells are 2, 6 and 10 respectively.

i. Nickel(II) ion, Ni^{2+}. A neutral nickel atom will contain 28 electrons, therefore the ground state electronic configuration for nickel will be;
$1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$.
When an ion is formed, electrons are either lost or added to the **outer or valence shell**. The **outer shell** in nickel is the **fourth** shell, therefore when the nickel(II) ion forms, the two electrons in the 4s subshell will be lost.
$1s^2 2s^2 2p^6 3s^2 3p^6 3d^8$. (1 mark)

ii. A sulfide ion contains two more electrons than a sulfur atom (Z=16), therefore 18 electrons.
$1s^2 2s^2 2p^6 3s^2 3p^6$. (1 mark)

b. i. When an atom absorbs energy, an excited electron will **move to a higher energy level**. **(1 mark)**

ii. When electrons relax from an excited state back to their ground state, they **emit light equal in energy to the energy difference of the two states**.
(1 mark) Therefore the emission (and absorption) spectra are distinctive for a given element.

c. i. The maximum number of electrons that can occupy a shell is given by the formula $2n^2$ where n is the shell number.
Therefore for the third shell n = 3
Maximum number of electrons = $2 (3)^2$ = **18 electrons (1 mark)**

ii. Possible answers: **(1 mark)**
The electrons circle or orbit the nucleus of the atoms without losing any energy.
Electrons within the same shell are about the same distance from the nucleus of the atom.
The electrons can only move in orbits with a particular energy.
Within a particular shell, the energies of the electrons are about the same.

iii. To explain the electronic configuration of heavier atoms one needs to apply the modification that the **outer shell is limited to eight electrons** even when it's maximum is higher **(1 mark)**. For example, if this modification were not applied potassium would have a shell electronic configuration of 2, 8, 9 when in fact it is 2, 8, 8, 1.

End of Suggested Answers