VCE CHEMISTRY 2016

YEAR 11 **TRIAL** EXAM

Units 1/2
Reading time: 15 minutes
Writing time: 2 hours 30 minutes

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	30	30	30
B	14	14	90
			Total 120

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STUDENT NUMBER Letter

Figures										
Words										

Student Name...………………………...

VCE Chemistry 2016 Year 11 Trial Exam Units 1/2

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 **30 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
Question 25	A	B	C	D	*Question 26*	A	B	C	D
Question 27	A	B	C	D	*Question 28*	A	B	C	D
Question 29	A	B	C	D	*Question 30*	A	B	C	D

VCE Chemistry 2016 Year 11 Trial Exam Unit 1/2

SECTION A – Multiple Choice Questions

(30 marks)

This section contains 30 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
Moving across (left to right) a period in the Periodic Table, the atomic radii of the elements
A. increases as there are more electrons in the outer shell.
B. decreases as the outer shell electrons are more strongly attracted to the nucleus.
C. are similar because the electrons are occupying the same outer shell.
D. decreases because the size of the sub-shells decreases with atomic number.

Question 2
The good electrical conductivity of metals in the solid state, can be explained using the metallic bonding model by
A. the particles in the lattice being able to move.
B. the positive ions in the lattice being able to move when an electric field is applied.
C. the particles that make up the lattice being close together.
D. the valence electrons being able to move through the lattice of positive ions.

Question 3
The chemical formula for a compound formed between magnesium and nitrogen would be
A. Mg_3N_2
B. MgN
C. Mg_2N
D. Mg_2N_3

Question 4
The percentage by mass of sulfur in sodium sulfite, Na_2SO_3, would be
A. 22.90 %
B. 25.46 %
C. 25.81 %
D. 31.13 %

Question 5
In a 19.06 g sample of magnesium chloride, $MgCl_2$, there will be
A. 6.02×10^{22} chloride ions.
B. 1.204×10^{23} ions.
C. 2.408×10^{23} magnesium ions.
D. 3.612×10^{23} ions.

Question 6

Which one of the following statements best describes a significant difference between the properties of main group (p-block) metal elements and transition group (d-block) metal elements?

A. Most main group metal elements tend to be better electrical conductors.
B. Most transition group metal elements tend to have lower densities.
C. Metals that are magnetic are only found among the transition group metal elements.
D. Main group metal elements are harder and less ductile.

Question 7

Compared to a bulk sample of silver, silver nanoparticles will

A. be more chemically reactive because there are more sites where a reaction can occur.
B. have similar chemical properties because the reactions involve the rearrangement of the valence electrons.
C. be more chemically reactive because there will be more valence electrons available to be rearranged in a chemical reaction.
D. be less chemically reactive because they are smaller and there is a lower probability for the reactant particles coming into contact with the nanoparticles.

Question 8

An ion of an element with a -2 charge contains 18 electrons and 18 neutrons. The isotopic symbol for the neutral atom that this ion was formed from would be

A. $^{36}_{18}Ar$
B. $^{36}_{16}S$
C. $^{34}_{16}S$
D. $^{34}_{18}Ar$

Question 9

The polar characteristics of the compounds, chloromethane, CH_3Cl, dichloromethane, CH_2Cl_2, trichloromethane, $CHCl_3$, and tetrachloromethane, CCl_4, are best described by

	CH_3Cl	CH_2Cl_2	$CHCl_3$	CCl_4
A.	polar	non-polar	polar	non-polar
B.	non-polar	non-polar	non-polar	polar
C.	non-polar	polar	non-polar	polar
D.	polar	polar	polar	non-polar

Question 10

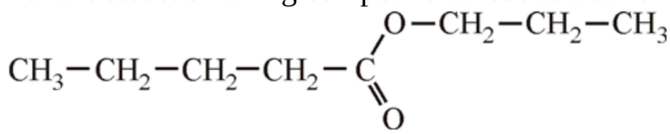
In the structure of fullerenes with the formula C_{60}, each carbon atom is covalently bonded to

A. three adjacent carbon atoms and the material has a low melting point.
B. four adjacent carbon atoms and the material has a high melting point.
C. four adjacent carbon atoms and the material has a low melting point.
D. three adjacent carbon atoms and the material has a high melting point.

Question 11
The structural characteristic that distinguishes but-2-yne from other hydrocarbons containing four carbon atoms is
A. a carbon-carbon double bond at the end of a four carbon atom chain.
B. a carbon-carbon triple bond in the middle of a four carbon atom chain.
C. a carbon-carbon triple bond at the end of a four carbon atom chain.
D. a carbon-carbon double bond in the middle of a four carbon atom chain.

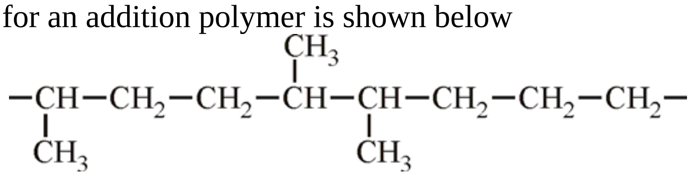
Question 12
A material made from a thermosetting polymer will tend to be rigid as a result of
A. covalent bonding between the polymer strands.
B. twisting of the polymer strands into bundles.
C. polar interactions between the polymer strands.
D. the branched polymer strands not being able to move over each other.

Question 13
The systematic name for the sweet smelling compound whose structure is shown below is



A. butyl butanoate.
B. propyl butanoate.
C. propyl pentanoate.
D. pentyl propanoate.

Question 14
Part of the structure for an addition polymer is shown below



This polymer could be synthesised from
A. but-2-ene.
B. but-2-ene and propene.
C. propene.
D. ethene and propene.

Question 15
A pure substance in the solid state was found to be brittle, hard, a poor electrical and thermal conductor with a melting point of 770 °C. The type of bonding present in the substance would be
A. metallic bonding.
B. ionic bonding.
C. covalent molecular bonding.
D. covalent network lattice bonding.

Question 16
The amount of energy, in kJ, required to raise the temperature of 5.00 L of water from 25.0 °C to 95.0 °C would be

A. 1.46 kJ
B. 1.99 kJ
C. 1460 kJ
D. 1990 kJ

Question 17
The boiling point for hydrogen sulfide, H_2S, is -60 °C. The reason why this Group 16 hydride has a boiling point significantly different to water is that

A. the hydrogen-sulfur bonds in H_2S are more polar than the hydrogen-oxygen bonds in water.
B. the bonding interactions between the water molecules are stronger than those between the hydrogen sulfide molecules.
C. hydrogen sulfide molecules have a heavier mass, therefore require more energy to change into a gas.
D. the bonding interactions within the water molecules are stronger than those within the hydrogen sulfide molecules.

Question 18
A precipitate will be formed when aqueous solutions of

A. sodium chloride and zinc nitrate are mixed.
B. copper(II) nitrate and manganese(II) chloride are mixed.
C. cobalt(II) chloride and silver nitrate are mixed.
D. potassium chloride and barium nitrate are mixed.

Question 19
The pH of a 100.0 mL sample of aqueous 0.0100 M sodium hydroxide would be

A. 2
B. 3
C. 11
D. 12

Question 20
The reaction that occurs when aqueous 0.5 M sulfuric acid solution is added to some solid copper(II) oxide can best be described by the ionic equation

A. $CuO(s) + H^+(aq) \rightarrow CuOH^+(aq)$

B. $CuO(s) + H_2SO_4(aq) \rightarrow CuSO_4(s) + H_2O(l)$

C. $CuO(s) + 2H^+(aq) \rightarrow Cu^{2+}(aq) + H_2O(l)$

D. $O^{2-}(s) + 2H^+(aq) \rightarrow H_2O(l)$

Question 21
In a reduction-oxidation, redox, reaction, the oxidant

A. donates electrons and is reduced.
B. accepts electrons and is reduced.
C. accepts electrons and is oxidised.
D. donates electrons and is oxidised.

Question 22
The conjugate base for the hydrogen carbonate ion, $HCO_3^-(aq)$, is

A. $OH^-(aq)$
B. $H_2CO_3(aq)$
C. $CO_3^{2-}(aq)$
D. $H_2CO_4^{2-}(aq)$

Question 23
In which one of the following lists will **all** of the compounds be soluble in water?

A. NaCl, CH_3OH, CH_3COOH, C_6H_6
B. C_2H_5OH, KCl, HCOOH, HCl
C. CH_4, C_8H_{18}, CH_3OH, CCl_4
D. HCl, $CaCl_2$, C_6H_{14}, NH_3

Question 24
The reaction between dilute hydrochloric acid and magnesium metal can be described by the ionic equation

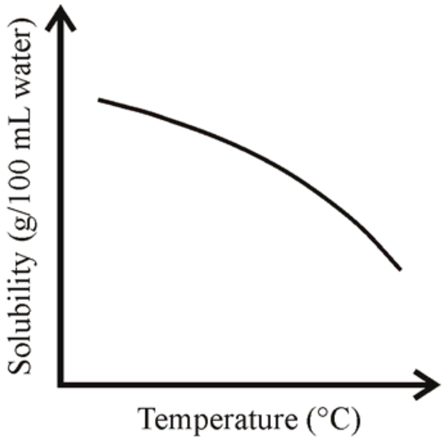
$$Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$$

In this reaction, the H^+ ions are acting as

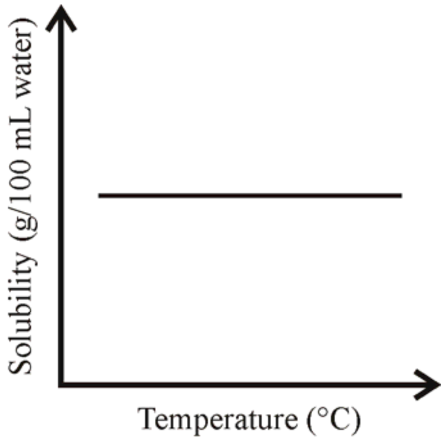
A. an oxidant.
B. an acid.
C. a reductant.
D. a base.

Question 25
A group of VCE students were investigating the solubility of sugar between 10 °C and 90 °C. When they plotted their data, which of the following graphs would their solubility curve most likely resemble?

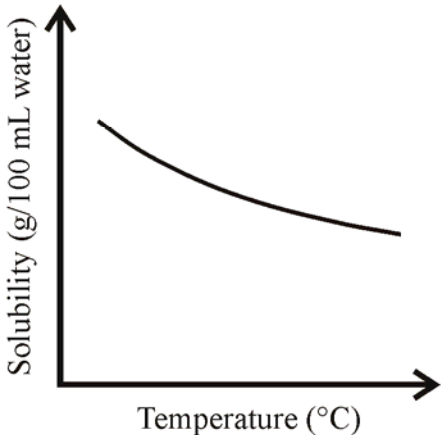
A.



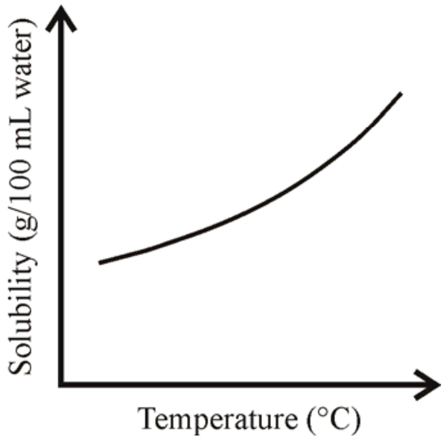
B.



C.



D.



Question 26
Historical records revealed that mercury based materials were used to extract gold and may have entered the waterway of an old gold mining area. The most suitable method that an environmental chemist could use to determine the levels of mercury in the local creek water would be a technique that used

A. high performance liquid chromatography.
B. volumetric analysis.
C. atomic absorption spectrophotometry.
D. gravimetric analysis.

Question 27
A student placed 10.0 mL of an aqueous 0.10 M sodium sulfate solution in a flask and diluted this to 250.0 mL with deionised water. When mixed, the sulfate ion concentration of the solution would be

A. 0.0040 M
B. 0.0080 M
C. 0.040 M
D. 0.080 M

Question 28
The label on a domestic cleaning product stated that it contained 17 % NH_4OH (m/v). What would be the numerical value for the concentration of NH_4OH in mol L^{-1}?

A. 0.0049
B. 0.049
C. 0.49
D. 4.9

Question 29
The data that a student collected in an experiment to determine the amount of dissolved salts in a sample of sea water are shown below.

Mass of empty evaporating basin	35.094 g
Mass of evaporating basin plus sea water	137.594 g
Mass of evaporating basin plus solid – first weighing	39.039 g
Mass of evaporating basin plus solid – second weighing	38.274 g
Mass of evaporating basin plus solid – third weighing	38.274 g

What was the percentage by mass (% m/m) of the dissolved salts in this sample of sea water?

A. 9.06 %
B. 3.85 %
C. 3.10 %
D. 2.31 %

Question 30
The reaction between dilute aqueous solutions of sulfuric acid and sodium hydrogen carbonate can be represented by the chemical equation

$$H_2SO_4(aq) + 2NaHCO_3(aq) \rightarrow Na_2SO_4(aq) + 2CO_2(g) + 2H_2O(l)$$

What would be the volume of 0.1200 M aqueous sulfuric acid required to neutralise 20.00 mL of 0.1350 M aqueous sodium hydrogen carbonate solution?

A. 8.89 mL
B. 11.25 mL
C. 17.78 mL
D. 22.25 mL

End of Section A

VCE Chemistry 2016 Year 11 Trial Exam Unit 1/2

SECTION B – Short Answer Questions

(90 marks)

This section contains 14 questions, numbered 1 to 14.
All questions should be answered in the spaces provided.
The mark allocation for each question is given.

Question 1 (8 marks)

a. Beryllium and fluorine are elements in the second period of the Periodic Table.

i. Explain, with reasoning, how the electronegativity of beryllium would compare with that of fluorine. **2 marks**

ii. The first ionisation energies for beryllium and fluorine are 906 kJ mol^{-1} and 1687 kJ mol^{-1} respectively. Explain what the first ionisation energy of an element is a measure of, and why there is a significant difference between the first ionisation energies for beryllium and fluorine. **2 marks**

b. In a class experiment, students placed cleaned and similar sized samples of calcium and magnesium into separate test tubes. 5 mL of deionised water was then added to each test tube. The students noted that the calcium readily reacted, liberating a gas. The magnesium also reacted, but at a very much slower rate.

i. Explain why there is a difference in the reactivity of these two metals with water. **1 mark**

ii. Describe what the students would have seen if they had also placed a piece of barium in another test tube and added the deionised water. **1 mark**

c. Write the ground state electronic configurations, in terms of sub-shells, for the following particles:

i. an arsenic atom **1 mark**

ii. an aluminium ion, Al^{3+} **1 mark**

Question 2 (6 marks)

a. One of the minerals present in iron ore is haematite, Fe_2O_3. The production of iron involves heating the ore together with coke, C, and limestone, $CaCO_3$, in a blast furnace.

i. In the furnace the coke reacts with oxygen to produce carbon monoxide, which then reacts with the solid iron oxide to form molten iron. Write an appropriate balanced chemical equation for this reaction including the states of the materials. **1 mark**

ii. What would be one significant environmental impact of the production of iron in this way? **1 mark**

iii. The iron produced in the blast furnace is not pure iron metal but an alloy of iron and carbon. The atomic radii of carbon and iron are 71 pm and 124 pm (1 pm = 1×10^{-12} m) respectively. Explain the type of alloy that this material would be. **1 mark**

b. The hardness and ductility of a metal can be altered by various heat treatments.

i. Quenching is a process where the metal object is heated to red hot then rapidly cooled. Explain what effect this process would have on the crystal structure (or microstructure) of the metal and how it would affect these properties of the metal. **2 marks**

ii. An alternative process, annealing, cools the metal slowly from red hot. Explain how the physical properties of an annealed metal sample would compare with those of one that had been quenched. **1 mark**

Question 3 (7 marks)

a. Explain why molten sodium chloride and aqueous solutions of sodium chloride will conduct an electric current, whereas sodium chloride is a non-conductor in the solid state. **2 marks**

b. Draw an appropriate electron shell diagram **and** write a simple equation to represent the bonding that would occur when calcium and fluorine react. **2 marks**

c. Explain, giving an example, what a polyatomic ion is. **1 mark**

d. **i.** Write the complete chemical formula for copper(II) sulfate pentahydrate. **1 mark**

ii. Explain what would occur when a sample of this solid is heated in a crucible. **1 mark**

Question 4 (6 marks)

a. An element has two isotopes with relative isotopic masses of 68.93 and 70.93 respectively. The relative abundance of the heavier isotope was determined by mass spectrometry to be 39.9 %.
Determine the relative atomic mass for this element. **2 marks**

b. Determine the molar mass for sodium carbonate decahydrate, $Na_2CO_3 \cdot 10H_2O$. **1 mark**

c. An experiment determined that a 9.572 g sample of a chromium oxide contained 6.549 g of chromium.
Determine the empirical formula for this compound. **3 marks**

Question 5 (7 marks)

a. Draw the chemical structures and give the systematic names for two alkenes that contain four carbon atoms. **4 marks**

b. The elemental analysis of an organic compound showed that it contained carbon, hydrogen and oxygen.
The percentage by mass of the three elements were: 54.5 %, 9.1 % and 36.4 % respectively.
The molar mass of the compound was found to be 88.0 g mol^{-1}.

i. Determine the empirical formula for the compound. **2 marks**

ii. Determine the molecular formula for the compound. **1 mark**

Question 6 (6 marks)

a. Diamond and graphite are two different structures for carbon.
Explain with reference to the structures why:

i. graphite is a significantly better electrical conductor than diamond. **1 mark**

ii. diamond is significantly harder than graphite. **1 mark**

b. Methanol, CH_3OH, is a liquid at room temperature.

i. Draw an appropriate diagram to represent the arrangement of the atoms in a methanol molecule, showing all bonding and non-bonding electrons. **1 mark**

ii. Explain all of the different types of bonding that would occur between methanol molecules. **2 marks**

iii. Use the structural and bonding data to predict the solubility of methanol in water. **1 mark**

Question 7 (5 marks)

a. Draw a structure showing four repeating units present in the polymer that would be formed from propene. **2 marks**

b. The physical properties of a sample of a polymer can be altered by a number of different factors.

i. Explain the effect that increasing the length of the polymer molecule chain would have on the physical properties of the material. **1 mark**

ii. Explain why a sample of a polymeric material that is highly crystalline would be harder than one that is less crystalline. **1 mark**

iii. What are plasticisers and how does their presence affect the physical properties of a polymeric material? **1 mark**

Question 8 (4 marks)

a. Write appropriate chemical equations to describe the reactions that would occur when the following pairs of aqueous solutions are mixed.

i. Iron(III) sulfate and sodium hydroxide. **1 mark**

ii. Nickel(II) sulfate and barium nitrate. **1 mark**

b. The latent heat of vaporisation is the amount of energy required to change a specific amount of the material from its liquid state to the gaseous state at the boiling point of the material. Methane and water are compounds with similar molecular masses. The latent heat of vaporisation of methane and water are 8.6 kJ mol^{-1} and 40.7 kJ mol^{-1} respectively.

i. Explain why there is such a significant difference between these two values considering that both molecules have similar molecular masses. **1 mark**

ii. What implication does this have with regards to the storage of these two materials at temperatures near their boiling points? **1 mark**

Question 9 (8 marks)

a. The hydrogen sulfite ion, HSO_3^-, is amphiprotic.

i. Using the Brønsted-Lowry theory of acids and bases, explain the meaning of the term amphiprotic. **1 mark**

ii. Write appropriate chemical equations that would demonstrate this property for this ion. **2 marks**

b. Explain the difference between a strong acid and a concentrated acid. **2 marks**

c. Calculate the concentrations of the $H_3O^+(aq)$ and $OH^-(aq)$ ions in an aquarium that has a pH of 7.5 at 25 ºC. **2 marks**

d. Write an appropriate chemical equation to describe the reaction that would occur when a dilute aqueous solution of nitric acid, $HNO_3(aq)$, is added to some solid marble chips, $CaCO_3$. **1 mark**

Question 10 (9 marks)

a. Students were investigating the redox properties of three metals, X, Y and Z. They placed small pieces of the metal in aqueous solutions of the metal ions, $X^{2+}(aq)$, $Y^{+}(aq)$ and $Z^{2+}(aq)$. They tabulated their observations, using a tick to show if a reaction occurred, as shown below.

		Metal ion solutions		
		$X^{2+}(aq)$	$Y^{+}(aq)$	$Z^{2+}(aq)$
Metal	X	-	✓	✓
	Y	×	-	×
	Z	×	✓	-

i. Use the students' tabulated data to determine the strongest oxidant and strongest reductant. **2 marks**

ii. Write the appropriate chemical half-equation for the oxidation and reduction half-reactions that occur when metal Z is added to an aqueous solution of $Y^{+}(aq)$. **2 marks**

iii. Write the overall chemical equation for the reaction that occurs when metal Z is added to an aqueous solution of $Y^{+}(aq)$. **1 mark**

b. Corrosion of metals, especially iron based materials, is a significant burden on society.

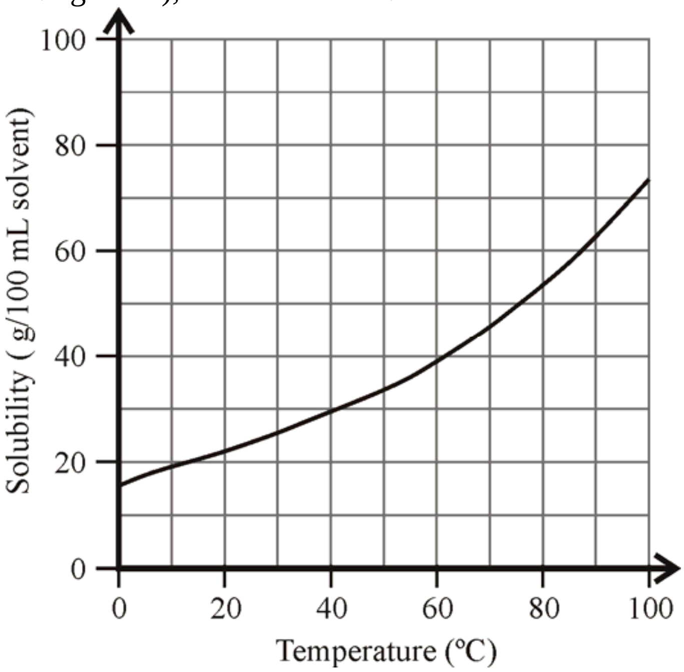
i. Steel cans used for foods are plated with a thin coating of tin. Explain how this method protects the steel. **1 mark**

ii. What will happen to the steel if the tin surface is scratched away in a small area on the can? **1 mark**

iii. Roofing steel sheets are coated with a thin coating of zinc. Explain how this protects the steel. **1 mark**

iv. What would be the main reason that zinc is not used as a coating on food cans? **1 mark**

Question 11 (5 marks)
The experimental determined solubility curve for copper(II) sulfate pentahydrate, $CuSO_4{\cdot}5H_2O$ (M = 249.6 g mol^{-1}), is shown below.



a. A group of students placed 10.0 g of solid copper(II) sulfate pentahydrate in a test tube and added 20.0 mL of deionised water. Determine the temperature that they would have to heat the mixture to in order to form a saturated solution. **1 mark**

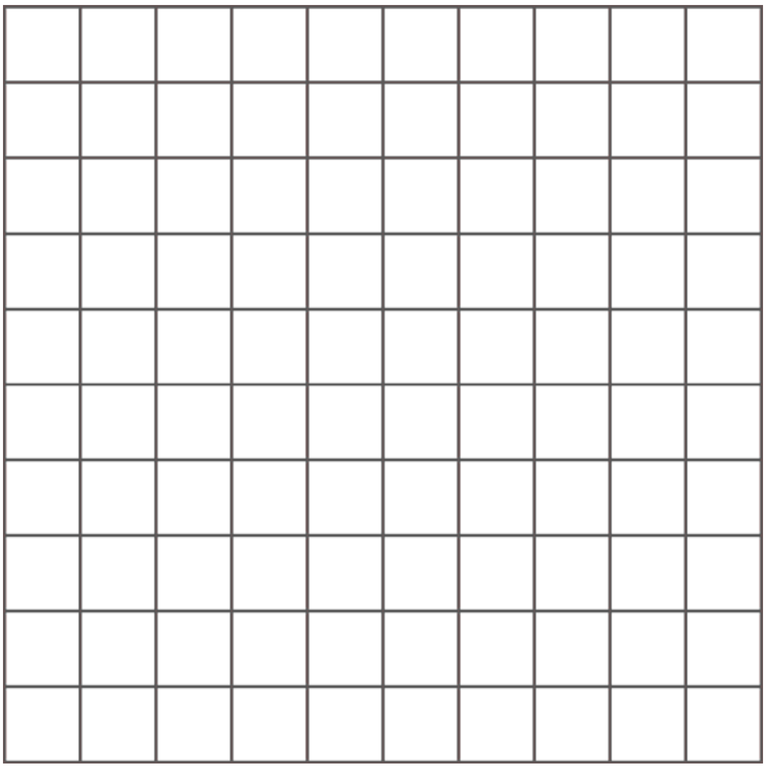
b. What mass of solid should crystallise when 250.0 mL of a saturated solution at 90 ºC is cooled to 20 ºC? **2 marks**

c. A chemist calculated that they required a 3.0 M aqueous solution for an experiment that they were planning to conduct. Explain, using the solubility data, if this solution could be prepared or not. **2 marks**

Question 12 (6 marks)
In an experimental investigation designed to measure the amount of dissolved salts present in samples of creek water, students followed the following method to measure the electrical conductivity of water samples.
All glassware used in the experiment was thoroughly rinsed with deionised water.
A stock solution of sodium chloride was prepared and this was diluted to prepare a set of calibration solutions.
The electrical conductivity of these solutions and a sample of creek water were measured using the same conditions and meter. The data collected are shown below.

NaCl Concentration ($g\ L^{-1}$)	**Electrical Conductivity (units)**
Deionised water	20
1.0	1712
2.0	3295
3.0	5002
4.0	6583
5.0	8217
Water sample	3676

a. On the grid below, draw a calibration curve for the electrical conductivity of the aqueous sodium chloride solutions. **3 marks**



b. Use the data to determine the equivalent amount of sodium chloride that would correspond to the amount of dissolved salts in the water sample. **1 mark**

c. Explain why all of the glassware used in the experiment was thoroughly rinsed with deionised water prior to commencing the experiment. **1 mark**

d. What could be one possible cause for this level of dissolved salts in the creek water analysed by the students? **1 mark**

Question 13 (6 marks)

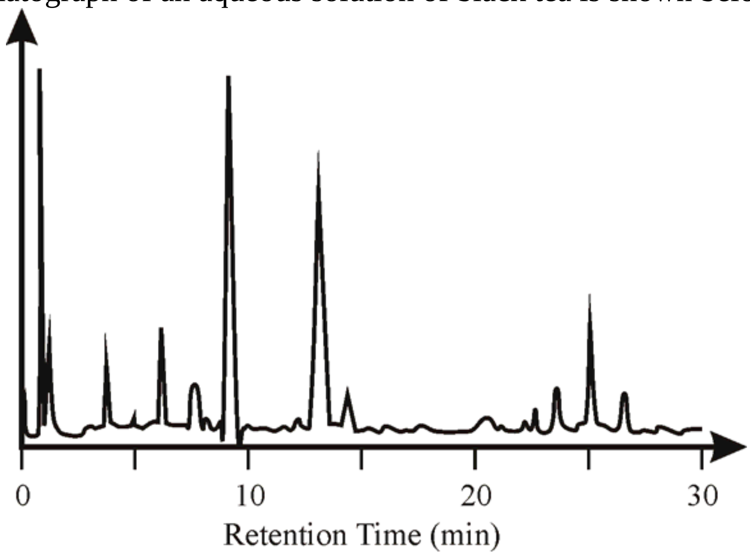
a. Organic contaminants of water supplies can pose a significant environmental problem.

i. What could be two materials that could be the sources of organic contaminants in water supplies? **2 marks**

ii. Explain the potential environmental impact of one of the materials that led to the organic contaminants given in i. above. **1 mark**

b. A technique for determining organic material (either contaminant or naturally occurring) in water samples or aqueous solutions, is high performance liquid chromatography, hplc.

The chromatograph of an aqueous solution of black tea is shown below.



i. How would it be possible to identify which of the peaks in the chromatogram is due to caffeine? **1 mark**

ii. Explain how a chemist could use the chromatogram to determine the amount of caffeine in the sample once the peak due to caffeine had been identified. **2 marks**

Question 14 (7 marks)

As part of a VCE Chemistry investigation, a group of students aimed to determine the amount of ethanoic acid in vinegar.

The reaction between aqueous solutions of ethanoic acid and sodium carbonate can be described by the chemical equation

$$2CH_3COOH(aq) + Na_2CO_3(aq) \rightarrow 2NaCH_3COO(aq) + CO_2(g) + H_2O(l)$$

The students diluted a 20.00 mL sample of vinegar with deionised water so that the total volume of the solution was 250.0 mL. 10.00 mL aliquots of aqueous 0.100 M sodium carbonate solution were titrated with the diluted vinegar solution. The average titre required was 11.50 mL.

a. Determine the amount of sodium carbonate in the aliquot. **1 mark**

b. Determine the amount of ethanoic acid that reacted with the sodium carbonate. **1 mark**

c. Determine the concentration of ethanoic acid in the diluted vinegar solution. **1 mark**

d. Determine the concentration of ethanoic acid in the original vinegar. **1 mark**

e. Express this concentration as a percentage mass per volume, % (m/v), and compare it with the manufacturer's claim that the vinegar contains 12.5 % (m/v) of ethanoic acid. **3 marks**

End of Section B

End of Trial Exam

Suggested Answers

VCE Chemistry 2016 Year 11 Trial Exam Unit 1/2

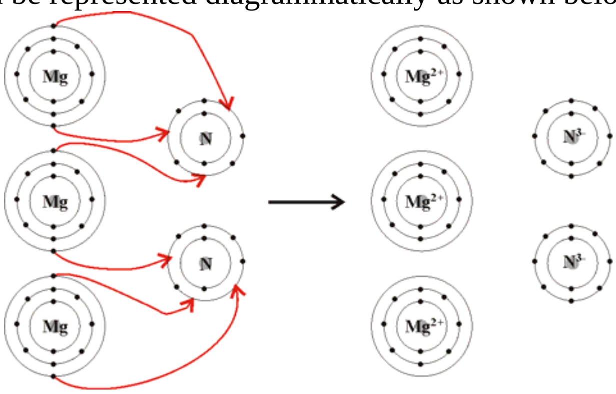
SECTION A – Multiple Choice Answers

(1 mark per question)

Q1. **B** Moving across a period in the Periodic Table, the nuclear charge increases. Therefore, the forces of attraction between the nucleus and the outer shell electrons increases and this results in a decrease in the atomic radii.

Q2. **D** The metallic bonding model describes the solid in terms of a lattice of positive ions where the valence electrons are delocalised (free to move about). Therefore, electrons can freely flow through a metal lattice when an electric field is applied.

Q3. **A** Referring to the *VCE Chemistry Data Book: Table 1 – The Periodic Table*, the atomic numbers for magnesium and nitrogen are 12 and 7 respectively. Therefore, the ground state electronic configurations of magnesium and nitrogen are $1s^2 2s^2 2p^6 3s^2$ and $1s^2 2s^2 2p^3$ (or in shell configurations as 2,6,2 and 2,5) respectively.
When these two elements form a compound, each magnesium can donate two electrons and in doing so form a magnesium ion, Mg^{2+}, while each nitrogen can accept three electrons to form a nitride ion, N^{3-}.
This can be represented diagrammatically as shown below.



The formula for the compound formed, magnesium nitride, will therefore be Mg_3N_2.

Q4. **B** Molar mass: $M(Na_2SO_3) = 2\times23.0 + 1\times32.1 + 3\times16.0 = 126.1$ g mol^{-1}
In one mole m(S) = 32.1 g
%(S) = m(S)/$M(Na_2SO_3)$ × (100/1)
%(S) = (32.1/126.1)×(100/1) = 25.46 %
An alternative calculation layout that shows the calculation of the percentage by mass of each element in the compound.

	Number	M_A	*Mass in 1 mol*		*%*
Na	*2*	*23.0*	*46.0*	*(46.0/126.1)×(100/1)*	*36.48*
S	*1*	*32.1*	*32.1*	*(32.1/126.1)×(100/1)*	*25.46*
O	*3*	*16.0*	*48.0*	*(48.0/126.1)×(100/1)*	*38.07*
Molar Mass			*126.1*		

Q5. **D** Molar Mass: $M(MgCl_2) = 24.3 + 2\times35.5 = 95.3$ g mol^{-1}
$n(MgCl_2)$ = m/M = 19.06 / 95.3 = 0.200 mol
$N(MgCl_2) = n(MgCl_2)\times N_A = 0.200 \times 6.02\times10^{23} = 1.204\times10^{23}$ particles
Since each $MgCl_2$ contains one Mg^{2+} and two Cl^- ions
$N(Mg^{2+}) = 1.204\times10^{23}$ Mg^{2+} ions
$N(Cl^-) = 2 \times 1.204\times10^{23} = 2.408\times10^{23}$ Cl^- ions
$N(\text{ions}) = 1.204\times10^{23} + 2.408\times10^{23} = 3.612\times10^{23}$ ions

Q6. **C** The metallic elements that are magnetic are; iron, cobalt and nickel. These three elements are members of the first transition metal series in the Periodic Table.
While all metals will conduct electricity, the transition group metal elements in general tend to be better conductors.
Most transition group metal elements tend to have higher densities than those in the main group.
Main group metal elements tend to have a low to medium hardness and are generally ductile.

Q7. **A** Nanoparticles are more chemically reactive than bulk materials because they have a significantly larger surface area for a given amount of material where reactions may occur.

Q8. **C** The ion has a -2 charge therefore the ion contains two more electrons than there are protons in the nucleus.
Number of protons = 18 – 2 = 16 protons
Atomic number (Z) = 16, therefore sulfur, S.
Mass number (A) = number of protons + number of neutrons
A = 16 + 18 = 34
$^{34}_{16}S$

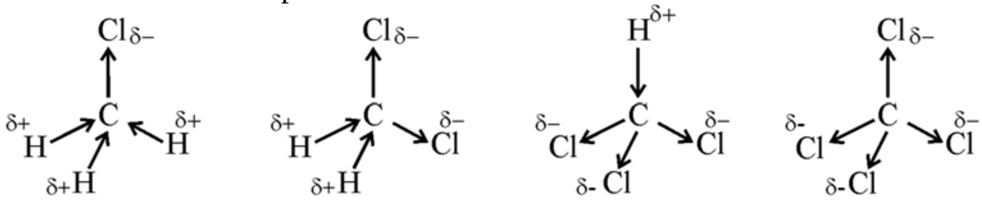
Q9. **D** In each of the molecules the C-Cl bond will be polarised due to the difference in the electronegativity between the carbon and chlorine (2.5 and 3.0 respectively). This results in an uneven electron distribution in the bond between the two atoms and results in the chlorine having a small negative (δ-) charge.

The difference in the electronegativity between carbon and hydrogen will also induce a polarising of the C-H with the hydrogen developing a small positive (δ+) charge.

The overall polar nature of the molecule is the combination of the individual bonds and the structure of the molecule.

In chloromethane, dichloromethane and trichloromethane, the structure will yield an overall dipolar molecule.

In tetrachloromethane, while the individual bonds are polar, the overall structure will be non-polar.



Q10. **A** The C_{60} structure has each carbon atom covalently bonded to three adjacent carbon atoms in alternating hexagonal and pentagonal rings joined to give an overall ball-type structure.

Because the material is made up from discrete C_{60} molecules, its melting point is low. *In the case of diamond and graphite, because the bonding extends throughout a very large lattice, the melting points are high.*

Q11. **B** From the systematic name of the compound, but-2-yne, the structure can be established.

but-2-yne: Four carbon atom chain.

but-2-**yne**: Contains a carbon-carbon triple bond (alkyne).

but-**2**-yne: Carbon-carbon triple bond is between second and third carbon atoms in the chain. In this case in the middle.

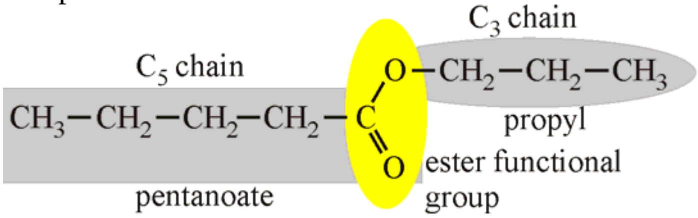
$CH_3 - C \equiv C - CH_3$

Q12. **A** In a thermosetting polymer there is cross-linking between the polymer strands that results in a rigid structure. The cross-linking involves covalent bonds between the polymer chains.

Thermosetting polymers will as a result not melt when heated.

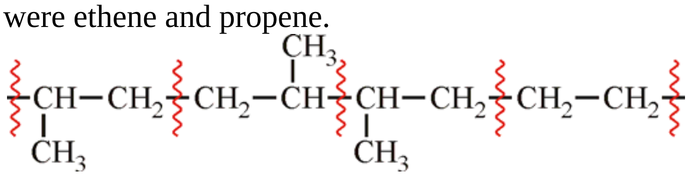
When there is no cross-inking between the polymer strands, the material is a thermoplastic and it will melt when heated. Varying the degree of branching on the polymer strand, the arrangement of attached groups and/or the types of weak interactions between the polymer strands will alter the properties of the material.

Q13. **C** The compound contains an ester functional group, -COO-.
The carbon chain attached to the oxygen contains three carbons joined by single carbon-carbon bonds. This is a propyl group.
There are five carbons in the remaining chain joined by single carbon-carbon bonds, pentan-. This chain contains the carbon of the ester functional group, therefore pentanoate.



This ester would be synthesised by the reaction of propanol and pentanoic acid in the presence of a catalyst.

Q14. **D** Addition polymers are synthesised from alkenes, where the addition reaction occurs at the carbons in the carbon-carbon double bonds.
Dividing the structure into two carbon unit segments identifies the monomers that the polymer was formed from.
In this case, there are two different types of segment in the structure, one containing two carbons and the other three carbons. Therefore, the monomers were ethene and propene.



Q15. **B** The properties of the substance reflect the bonding characteristics present.
The only type of bonding that matches all of the properties described is ionic bonding.
Metallic bonding would result in the substance being a good electrical and thermal conductor.
Covalent molecular bonding would result in the substance having a low melting point and being soft.
Covalent molecular lattice bonding would result in the substance having a very high melting point.

Q16. **C** Referring to the *VCE Chemistry Data Book: Table 3*
Specific heat capacity for water: c = 4.18 J g^{-1} $°C^{-1}$
Density of water = 1.00 g mL^{-1}
5.00 L = 5.00 × 1000 = 5000 mL = 5000 g
$\Delta T = 95.0 - 25.0 = 70.0$ °C
$Q = m \times c \times \Delta T = 5000 \times 4.18 \times 70.0 = 1.46 \times 10^6$ J
$Q = 1.46 \times 10^6 / 1000 = 1460$ kJ

Q17. B Like hydrogen sulfide, water is a Group 16 hydride.
The boiling point of hydrogen sulfide is significantly lower than that for water (-60 °C compared to 100 °C).
Since the boiling temperature reflects the bonding interactions **between** the molecules, the forces attracting the water molecules to each other are greater.
Both water and hydrogen sulfide are polar molecules because of the difference in the electronegativities of hydrogen, oxygen and sulfur. Therefore there will be dipole-dipole interactions between both H_2O and H_2S molecules.
However, in water there are stronger hydrogen bonding interactions between the molecules and this accounts for the increased temperature of the boiling point.

Q18. C All common nitrate compounds are soluble in water.
Chlorides other than those of silver and lead(II) are soluble.
Therefore, when aqueous solutions of cobalt(II) chloride and silver nitrate are mixed, a precipitate of silver chloride will form.
Full equation:

$$CoCl_2(aq) + 2AgNO_3(aq) \rightarrow Co(NO_3)_2(aq) + 2AgCl(s)$$

Ionic equation:

$$Cl^-(aq) + Ag^+(aq) \rightarrow AgCl(s)$$

Q19. D The definition of pH
$pH = -\log_{10}[H_3O^+]$
0.0100 M aqueous sodium hydroxide, NaOH.
$[OH^-] = 0.0100$ M
The ionic product for water $K_w = [H_3O^+][OH^-] = 1.0\times10^{-14}$ M^2
$[H_3O^+](0.0100) = 1.0\times10^{-14}$
$[H_3O^+] = (1.0\times10^{-14})/(0.0100) = 1.0\times10^{-12}$ M
$pH = -\log_{10}(1.0\times10^{-12}) = 12$

Q20. C The reaction between a metal oxide and an acid will produce water plus a solution of the salt of the metal.
The sulfuric acid will provide H^+ ions that will react with the metal oxide.
In this case the salt will be copper(II) sulfate.
In an ionic equation **only the reacting materials are shown**.

$$CuO(s) + 2H^+(aq) \rightarrow Cu^{2+}(aq) + H_2O(l)$$

The question specifically asked for the ionic equation. Response B provides the full equation.

Q21. B The oxidant in a redox reaction is the material that causes oxidation to occur, therefore the oxidant will accept electrons and in the process is itself reduced.
For example, the oxidant in the reaction that occurs when a piece of zinc metal is placed in an aqueous solution of copper(II) sulfate is the copper(II) ion, $Cu^{2+}(aq)$.
The half-equation for the reduction of the oxidant is

$$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$$

The half-equation for the oxidation of the reductant is

$$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$$

The overall equation is

$$Cu^{2+}(aq) + Zn(s) \rightarrow Cu(s) + Zn^{2+}(aq)$$

Q22. C The conjugate base will be formed when the species acts as an acid.
An acid is a proton, H^+, donor.
Therefore, the formula for conjugate base has had a proton, H^+, removed.

$$HCO_3^-(aq) + H_2O(l) \rightarrow CO_3^{2-}(aq) + H_3O^+(aq)$$

For the hydrogen carbonate ion, the conjugate base is the carbonate ion, $CO_3^{2-}(aq)$.
The hydrogen carbonate ion is an amphiprotic ion. The conjugate acid for this ion is carbonic acid, $H_2CO_3(aq)$.

Q23. B For a compound to be soluble in water, the water molecules need to form bonds with the materials in the compound. Since water is a polar molecule, then the compound needs to be either a polar molecule or an ionic substance.
Water forms ion-dipole bonds with the ions in an ionic compound.
Water forms hydrogen bonds and dipole-dipole interactions with polar compounds.
Response A: The list contains the non-polar C_6H_6, benzene, which is not soluble in water. NaCl is an ionic compound. CH_3OH and CH_3COOH are polar molecules.
Response B: All four compounds are soluble because they are either polar molecules or ionic compounds.
Response C: CH_4, C_8H_{18} and CCl_4 are all non-polar.
Response D: C_6H_{14} is non-polar.
Remember: Like dissolves like.

Q24. A In this reaction the H^+ ions are accepting an electron from the magnesium to form hydrogen gas, H_2. Therefore, the H^+ ions are acting as the oxidant and will be reduced.

$$2H^+(aq) + 2e^- \rightarrow H_2(g)$$

Q25. D The solubility for solids generally increases with temperature. More sugar will dissolve in hot water than in cold water. Only Response D fulfils this criterion.

Q26. C Mercury is a metal and in this case the concentration of mercury compounds in the water should be low. The most suitable technique would involve atomic absorption spectrophotometry.
High performance liquid chromatography is more appropriate for organic contaminants of the water.
Volumetric analysis is better suited to materials that are present in higher concentrations and can be involved in either acid-base or redox reactions.
Gravimetric analysis involves weighing precipitates or solids from evaporated solutions, therefore is better suited to higher concentrations of materials.

Q27. A The solution is diluted by the factor of 10/250.
For the solution:
$c(Na_2SO_4) = 0.10 \times (10/250) = 0.0040$ M
Since each Na_2SO_4 contains one sulfate ion, SO_4^{2-}, then
$c(SO_4^{2-}) = 0.0040$ M

Q28. D The concentration is given as a %(m/v) therefore in 100 mL there will be 17 g of the compound, NH_4OH.
In 1.0 L there will be 170 g
$M(NH_4OH) = 14.0 + 5\times1.0 + 16.0 = 35.0$ g mol^{-1}
$n(NH_4OH) = m/M = 170 / 35.0 = 4.9$ mol
$c(NH_4OH) = n/V = 4.9 / 1.0 = 4.9$ mol L^{-1} (or 4.9 M)
Alternative solution
17 % NH_4OH = 17 g in 100 mL
$n(NH_4OH) = 17 / 35.0 = 0.49$ mol
$c(NH_4OH) = n/V = 0.49 / (100/1000) = 4.9$ mol L^{-1}

Q29. C The required percentage by mass is % m/m
Since the first weighing of the solid is higher than the consecutive weighing's this must still have contained water. This result is therefore not used.
m(sea water) = 137.594 – 35.094 = 102.50 g
m(salts) = 38.274 – 35.094 = 3.180 g
% (m/m) = (3.180 / 102.50) × (100/1) = 3.10 % (m/m)

Q30. B The chemical equation for the reaction provides the mole ratio of the reactants
$n(NaHCO_3) = c\times V = 0.1350 \times (20.00/1000) = 2.700\times10^{-3}$ mol
$n(H_2SO_4) = ½\times n(NaHCO_3) = ½ \times 2.700\times10^{-3} = 1.350\times10^{-3}$ mol
$V(H_2SO_4) = n/c = 1.350\times10^{-3} / 0.1200 = 1.125\times10^{-2}$ L
$V(H_2SO_4) = 1.125\times10^{-2} \times 1000 = 11.25$ mL

SECTION B – Short Answer (Answers)

Question 1 (8 marks)

a. **i.** The electronegativity of **beryllium would be less** than that for fluorine because the electronegativities of the elements increase moving across a period in the Periodic Table **(1 mark)**.
The electronegativity values for Be and F are 1.57 and 3.98 respectively. Fluorine is the element with the highest electronegativity in the Periodic Table.
The electronegativity is a measure of the electron attracting power of an element. Since both elements are in the second period of the Periodic Table, the second shell is the outer or valence shell. The effective nuclear charge is the nuclear charge minus the number of electrons in any inner shell/s. Beryllium has an effective nuclear charge of +2 compared with +7 for fluorine. Therefore, fluorine will be a more powerful electron attractor **(1 mark)**.

ii. The first ionisation energy is the energy required to remove an electron from the outer shell of an atom **(1 mark)**.
Since both elements are in the same period, the second shell is the outer or valence shell for both. The electrons in the outer shell of fluorine are attracted by a +7 effective nuclear charge, whereas those in beryllium are attracted by a +2 effective nuclear charge. Consequentially more energy is required to remove an electron from the outer shell of a fluorine atom compared to that for a beryllium atom **(1 mark)**.

b. Magnesium and calcium are both in Group 2 of the Periodic Table.
When elements react it involves the rearrangement of the outer or valence shell electrons.

i. The chemical reactivity of Group 2 elements increases moving down the group because the reactions involve the loss of the outer or valence shell electrons. Magnesium is in the second period and calcium is in the third period of the Periodic Table. Therefore, calcium will more readily release the outer or valence shell electrons compared to magnesium, making it more reactive **(1 mark)**.

ii. Barium is in the sixth period of the Periodic Table, therefore it will be significantly more reactive than either calcium or magnesium. The students would most probably see a violent reaction between barium and water **(1 mark)**.

c. The order in which the sub-shells fill is: 1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, ...
The maximum number of electrons in s, p and d sub-shells are 2, 6 and 10 respectively

i. As: Z = 33 $\Rightarrow$ 33 electrons
$\mathbf{1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^3}$ **(1 mark)**.

ii. Al: Z = 13: Al^{3+} ion $\Rightarrow$ 10 electrons
$\mathbf{1s^2 2s^2 2p^6}$ **(1 mark)**.

Question 2 (6 marks)

a. **i.** The carbon monoxide, CO, would react with the iron oxide to form carbon dioxide, CO_2. Both these compounds are gases at room temperature.
The chemical equation can be developed stepwise once the reactants and products are identified.

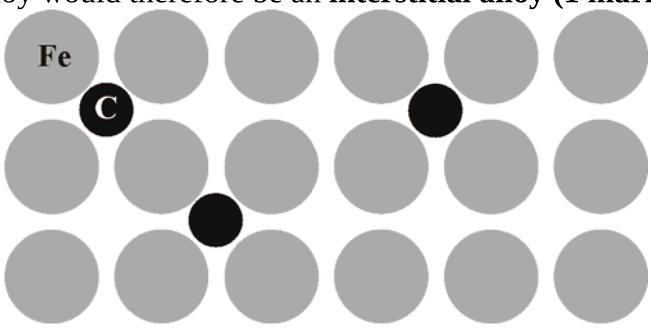
$$Fe_2O_3(s) + CO(g) \rightarrow Fe(l) + CO_2(g)$$

Each CO 'accepts' an O from the iron oxide

$$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(l) + 3CO_2(g)$$ **(1 mark)**.

ii. The readily identifiable environmental impact would be the production of carbon dioxide.
Since the process produces carbon dioxide that would be released into the atmosphere, this would contribute to the enhanced greenhouse effect and global warming **(1 mark)**.
Other environmental impacts that could be considered include:
Production of the slag by-product.
Noise and dust pollution from the furnace.

iii. Since the atomic radius of the carbon atoms is smaller than that for iron, the carbon atoms would occupy the spaces between the iron atoms in the lattice. The alloy would therefore be an **interstitial alloy (1 mark)**.



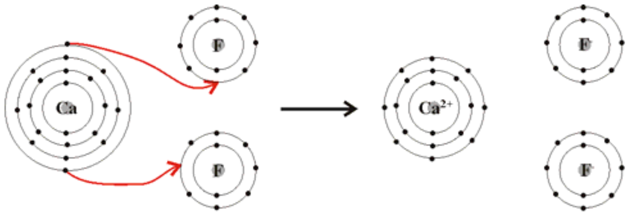
b. **i.** Quenching will result in the formation of **small crystals** in the solid **(1 mark)**.
Because the solid contains many small crystals then there will be a large surface area where the crystals will be in contact with one another. This will make the **metal hard but brittle (1 mark)**.

ii. Annealing allows the formation of larger crystals and as a result, the metal will be **softer and more ductile** than a quenched sample **(1 mark)**.

Question 3 (7 marks)

a. In **molten sodium chloride**, the sodium, $Na^+(l)$, and chloride, $Cl^-(l)$, **ions are free to move about in the liquid**, whereas in the solid, the ions are in fixed positions within the lattice. The **free moving ions** can therefore **carry an electric current (1 mark)**.
In an aqueous solution, **the hydrated ions**, ions surrounded by water molecules (attracted to the ions by ion-dipolar interactions), **are free to move in the solution**. Again it is these free moving ions that can carry an electric current **(1 mark)**.

b. Diagram should show formation of ions with electrons being transferred from the calcium to the fluorine.



(1 mark)

$$\underset{2,8,8}{Ca^{2+}} + \underset{2,8}{2F^-} \rightarrow CaF_2$$ **(1 mark)**

c. A polyatomic ion is an ion that **consists of two or more tightly bound atoms** that form an ion with an overall charge on the group of atoms. Polyatomic ions can have either a positive or negative charge.
Examples include (but are not limited to): ammonium, NH_4^+; hydroxide, OH^-; carbonate, CO_3^{2-}; sulfate, SO_4^{2-}; nitrate, NO_3^-; phosphate, PO_4^{3-};
[Mark allocation: Must have example of an appropriate ion together with the explanation: (1 mark)]

d. **i.** Copper(II) Sulfate pentahydrate
Copper(II) = Cu^{2+}
Sulfate = SO_4^{2-}
Pentahydrate = $5H_2O$
$CuSO_4 \cdot 5H_2O$ (1 mark).

ii. In hydrates, the water of crystallisation is weakly bonded to the ions through ion-dipole interactions. When a sample of the hydrate is heated, the solid will decompose and the water of crystallisation will be released into the atmosphere **(1 mark)**. *The colour of the solid will change from blue to white when this dehydration occurs.*

$$CuSO_4 \cdot 5H_2O(s) \rightarrow CuSO_4(s) + 5H_2O(g)$$

Question 4 (6 marks)

a. The relative atomic mass is the weighted average of the isotopic masses.
The relative abundance for the lighter isotope will be 100 – 39.9 = 60.1 % **(1 mark)**.
A_r = 68.93 × (60.1/100) + 70.93 × (39.9/100) = **69.7 (1 mark)**.

b. Referring to the *VCE Chemistry Data Book: Table 1*.
$M(Na_2CO_3{\cdot}10H_2O)$ = 2×23.0 + 12.0 + 13×16 + 20×1.0
$M(Na_2CO_3{\cdot}10H_2O)$ = **286 g mol^{-1} (1 mark)**.

c. m(compound) = 9.572 g
m(Cr) = 6.549 g
m(O) = 9.572 – 6.549 = 3.023 g
Determine the molar ratio
n(Cr) : n(O) = m(Cr)/M(Cr) : m(O)/M(O)
= 6.549/52.0 : 3.023/16.0
= 0.126 : 0.189 **(1 mark)** (divide the larger value by the smaller)\
= 0.126/0.126 : 0.189/0.126
= 1 : 1.5 **(1 mark)** (convert to whole number ratio)
= 2 : 3

Cr_2O_3 (1 mark)

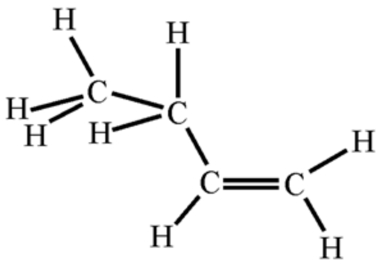
Question 5 (7 marks)

a. An alkene contains a carbon-carbon double bond.
The molecular formula for the alkene will be C_4H_8.
There are three possible structural isomers for a C_4 alkene.

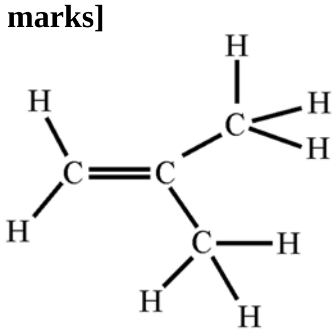
but-1-ene
but-2-ene
2-methylpropene

The diagram below shows two stereoisomers for but-2-ene. Stereoisomers are not part of the Unit 1 VCE course.

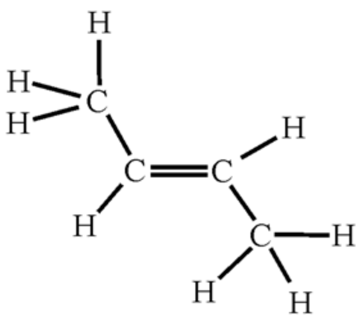
[1 mark for a correct structure. 1 mark for the correct systematic name for the structure drawn. Total mark allocation = 4 marks]

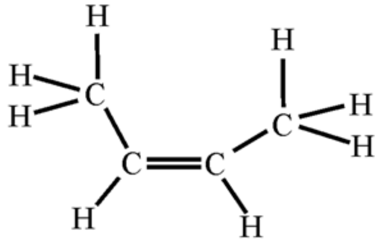


but-1-ene



2-methylpropene





trans (E) stereoisomer **but-2-ene** *cis (Z) stereoisomer*

b. **i.** Determine the mole ratio of the elements.

n(C) : n(O) : n(H) = 54.5/12.0 : 9.1/1.0 : 36.4/16.0

= 4.54 : 9.1 : 2.275 **(1 mark)**

(divide all values by the smallest value)

= 2 : 4 : 1

C_2H_4O (1 mark)

ii. The molecular formula is a whole number multiple of the empirical formula.

$M(C_2H_4O) = 2\times12.0 + 4\times1.0 + 16.0 = 44.0$ g mol^{-1}

$M((C_2H_4O)_x) = 44.0\times x = 88.0$

$x = 88.0/44.0 = 2$

$(C_2H_4O)_2$ = **$C_4H_8O_2$ (1 mark)**

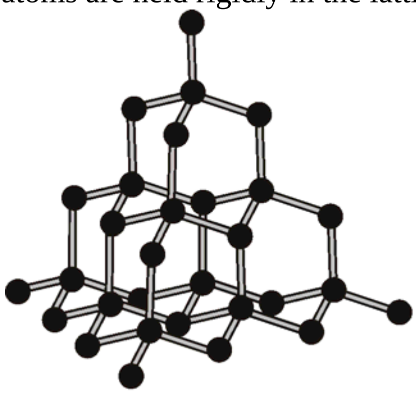
Question 6 (6 marks)

a. **i.** In the structure of diamond, each carbon atom is covalently bonded to four adjacent carbon atoms in a three-dimensional lattice. In this case, all four valence electrons are involved in the bonding. There are no free or mobile electrons, therefore diamond is a non-conductor of electricity.

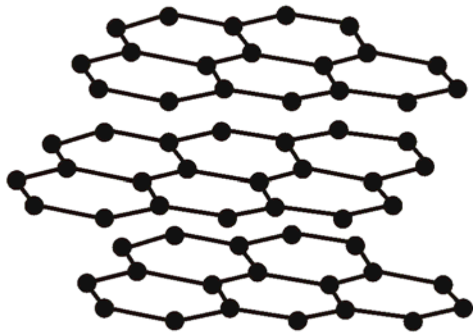
The structure of graphite has each carbon atom covalently bonded to three other adjacent carbon atoms in a two-dimensional sheet-type structure. The fourth valance electron from each carbon atom is delocalised, and therefore mobile, within the layer.

The delocalisation of the electrons allows an electron current to flow through a layer of graphite **(1 mark)**.

ii. Because of the layer structure for graphite, the various layers can slide over each other making it soft. The covalent bonding throughout the three-dimensional lattice in graphite results in the material being hard as the atoms are held rigidly in the lattice by covalent bonds **(1 mark)**.



Diamond

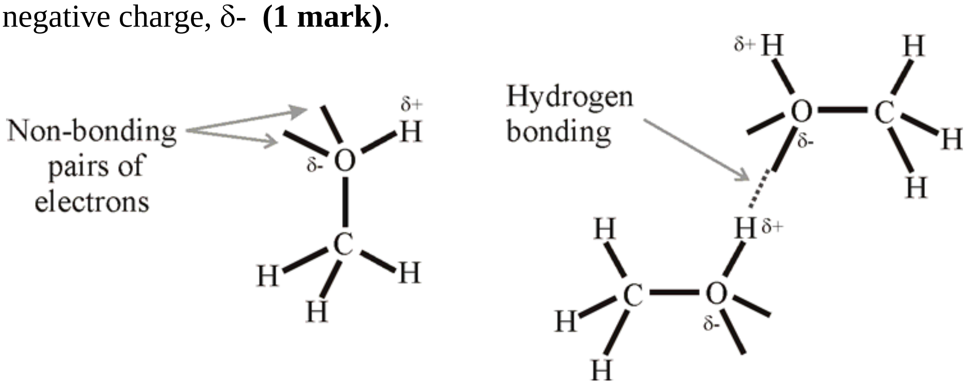


Graphite

b. **i.** The central carbon will have three single carbon-hydrogen covalent bonds and a single carbon-oxygen covalent bond. In addition to being covalently bonded to the carbon, the oxygen will form a single oxygen-hydrogen bond. Oxygen will also have two non-bonding electron pairs.

There will be four regions of electron density around the carbon and oxygen, as a result of the electron repulsion these will both have tetrahedral arrangements.

Because of the differences in the electronegativities of carbon, hydrogen and oxygen, all of the bonds will be polarised with the oxygen developing a small negative charge, δ- **(1 mark)**.



ii. As with any species there will be weak **dispersion forces** between the methanol molecules. In the case of methanol, these will be the weakest intermolecular forces.

Because the methanol molecules are polar then there will be **dipole-dipole interactions** between the molecules.

Since hydrogen and oxygen are involved in the dipole then the strongest intermolecular interaction will be **hydrogen bonding**.

[Mark Allocation: All three correct: 2 marks. Two correct: 1 mark]

iii. Because methanol is polar and has a small hydrocarbon chain attached to the polar O-H bond then methanol would be expected to be soluble in water **(1 mark)**.

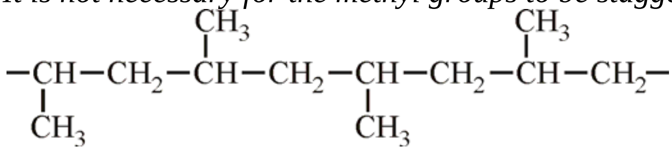
The methanol molecules will form hydrogen bonds with the water molecules similar to those that they form with each other.

Methanol is completely miscible (mixes completely) with water, so aqueous solutions over the entire concentration can be prepared.

Question 7 (5 marks)

a. The diagram must show the correct repeating units and bonds at both ends to signify extension of the molecule **(2 marks)**.

It is not necessary for the methyl groups to be staggered or on one side only.



b. **i.** Possible answers include: **(1 mark)**

Increasing the length of the polymer molecule chain will increase the strength of the material as the longer chains tend to tangle more easily and therefore more energy will be required to get the chains to slide over each other.

Increasing the chain length will increase the melting point of the material because of the higher molecular mass.

ii. In polymeric materials that are highly crystalline, the polymer chains are arranged in regular order, requiring larger forces to deform the material **(1 mark)**.

iii. Plasticisers are **small molecular compounds** that are added to polymeric materials. These materials are located between the polymer chains **making it easier for them to slide over one another**. This results in a **softer material (1 mark)**.

Question 8 (4 marks)

a. Full or ionic equations are acceptable.

The equations **must** show states to be awarded marks.

i. All common Group 1 element compounds are soluble in water. The precipitate formed will be iron(III) hydroxide **(1 mark)**.

$$Fe_2(SO_4)_3(aq) + 6NaOH(aq) \rightarrow 2Fe(OH)_3(s) + 3Na_2SO_4(aq)$$

$$Fe^{3+}(aq) + 3OH^{-}(aq) \rightarrow Fe(OH)_3(s)$$

ii. All common nitrate compounds are soluble. The precipitate will be barium sulfate **(1 mark)**.

$$NiSO_4(aq) + Ba(NO_3)_2(aq) \rightarrow Ni(NO_3)_2(aq) + BaSO_4(s)$$

$$SO_4^{2-}(aq) + Ba^{2+}(aq) \rightarrow BaSo_4(s)$$

b. **i.** The higher latent heat of vaporisation for water is due to the stronger interactions between the water molecules **(1 mark)**.

Because methane is a non-polar molecule, only dispersion forces will occur between the methane molecules.

Water is a polar molecule and the stronger dipole-dipole interactions and hydrogen bonding will occur, in addition to dispersion forces, between the molecules.

As the forces of attraction between the water molecules are stronger, a larger amount of energy will be required to overcome these as water changes from a liquid into a gas.

ii. The higher value for the latent heat of vaporisation for water, means that liquid water can be stored in open containers, whereas liquid methane would need to be stored in sealed containers to prevent evaporation **(1 mark)**.

Question 9 (8 marks)

a. **i.** The Brønsted-Lowry theory of acids and bases defines an acid as a proton donor and a base as a proton acceptor. An amphiprotic substance is one that can act as both an acid and a base **(1 mark)**.

ii. The hydrogen sulfite ion acting as an acid **(1 mark)**.

$$HSO_3^-(aq) + H_2O(l) \rightarrow SO_3^{2-}(aq) + H_3O^+(aq)$$

$$HSO_3^-(aq) + OH^-(aq) \rightarrow SO_3^{2-}(aq) + H_2O(l)$$

The hydrogen sulfite ion acting as a base **(1 mark)**.

$$HSO_3^-(aq) + H_2O(l) \rightarrow H_2SO_3(aq) + OH^-(aq)$$

$$HSO_3^-(aq) + H_3O^+(aq) \rightarrow H_2SO_3(aq) + H_2O(l)$$

$$HSO_3^-(aq) + H^+(aq) \rightarrow H_2SO_3(aq)$$

b. A strong acid is one that **completely ionises in solution,** liberating protons **(1 mark)**.
A concentrated acid refers to a **larger amount of the acidic material in solution**.
(1 mark).
Hydrochloric acid is a strong acid whereas ethanoic acid is a weak acid.
Pure ethanoic acid, which is a liquid, is a concentrated acid (approximately 17 M), but ethanoic acid is a weak acid.
The pH of 0.10 M aqueous solutions of hydrochloric and ethanoic acids are 1.0 and 2.9 respectively. Aqueous solutions of weak acids have a higher pH than aqueous solutions of strong acids with the same concentration.

c. Referring to the *VCE Chemistry Data Book: Table 3*
Ionic product for water: $[H_3O^+][OH^-] = 1.00\times10^{-14}$ M^2
pH = 7.5
$[H_3O^+] = 10^{-pH} = 10^{-7.5} =$ **3.2×10^{-8} M (1 mark)**.
$[OH^-] = 1.00\times10^{-14} / [H_3O^+] = 1.00\times10^{-14} / 3.2\times10^{-8} =$ **3.2×10^{-7} M (1 mark)**.

d. When acids react with carbonates, carbon dioxide, water and an aqueous solution of the metal ion salt are formed **(1 mark)**.
Appropriate states must be shown to be awarded mark.
Full or ionic equations would be acceptable.

Full equation: $CaCO_3(s) + 2HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + CO_2(g) + H_2O(l)$

Ionic equation: $CaCO_3(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + CO_2(g) + H_2O(l)$

$CaCO_3(s) + 2H_3O^+(aq) \rightarrow Ca^{2+}(aq) + CO_2(g) + 3H_2O(l)$

Question 10 (9 marks)

a. **i.** Oxidation is the loss of electrons and reduction is the gain of electrons. The oxidant causes the oxidation reaction to occur, therefore the oxidant will accept electrons and be reduced. Similarly the reductant causes the reduction reaction to occur, therefore the reductant will lose electrons and be oxidised.
The oxidants in this experiment are the metal ions, therefore the strongest oxidant will be the metal ion that reacts with all of the other metals. In this case it will be **Y^+(aq) (1 mark)**.
The reductants will be the metals, the strongest reductant will react with all of the other metal ion solutions. In this case **X (1 mark)**.

ii. Oxidation involves the loss of electrons.

Oxidation half-equation: $Z(s) \rightarrow Z^{2+}(aq) + 2e^-$ **(1 mark)**.

Reduction half-equation: $Y^+(aq) + e^- \rightarrow Y(s)$ **(1 mark)**.

iii. The overall equation is obtained by adding the two half-equations adjusting each so that the number of electrons produced and consumed is the same. Since two electrons are released in the oxidation half-reaction and one electron is consumed in the reduction half-reaction, when adding the two half-equations, the reduction half-equation must be multiplied by 2

$(Y^+(aq) + e^- \rightarrow Y(s))\times 2$

$2Y^+(aq) + 2e^- \rightarrow 2Y(s)$

$Z(s) \rightarrow Z^{2+}(aq) + 2e^-$

$2Y^+(aq) + Z(s) \rightarrow 2Y(s) + Z^{2+}(aq)$ **(1 mark)**.

b. **i.** Tin is a weaker reductant than iron, therefore will be less reactive. The tin forms a protective coating on the surface of the steel preventing its oxidation **(1 mark)**.

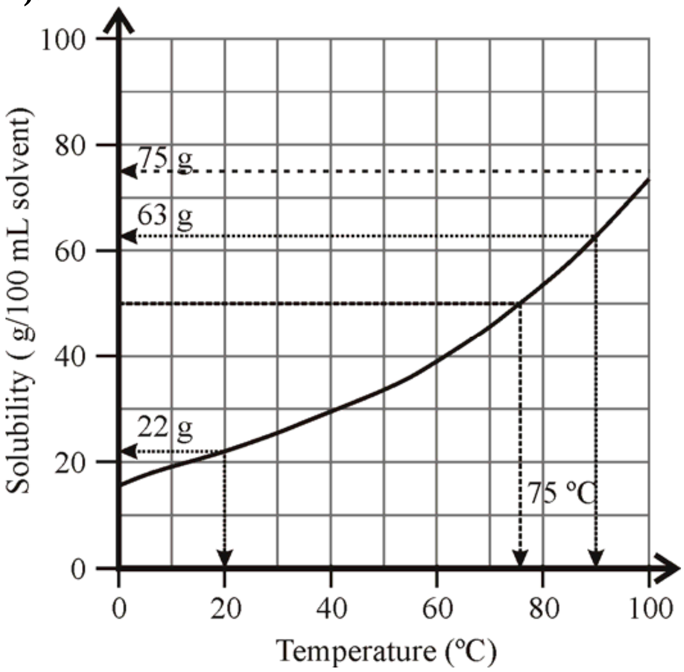
ii. Once the surface coating is broken, the iron in the steel, will be oxidised in preference to the tin and the can will rust **(1 mark)**.

iii. Zinc is more reactive than iron therefore will corrode in preference to the steel. This is known as sacrificial protection **(1 mark)**. When the zinc is oxidised, it becomes coated with a thin layer of material which protects the surface from further oxidation. If this surface layer of oxidised material is damaged, a new layer will form until all of the zinc coating has been consumed.

iv. Zinc is not used as a coating on food cans because zinc compounds are toxic **(1 mark)**.

Question 11 (5 marks)

a. Solubility is expressed in terms of mass of solute dissolved in 100 mL of solvent.
The mass of solute in 100 mL of solvent would be
m = 10.0 × (100/20.0) = 50.0 g
Using the solubility curve as shown below, this would require the mixture be heated to **75 ºC (1 mark)**.



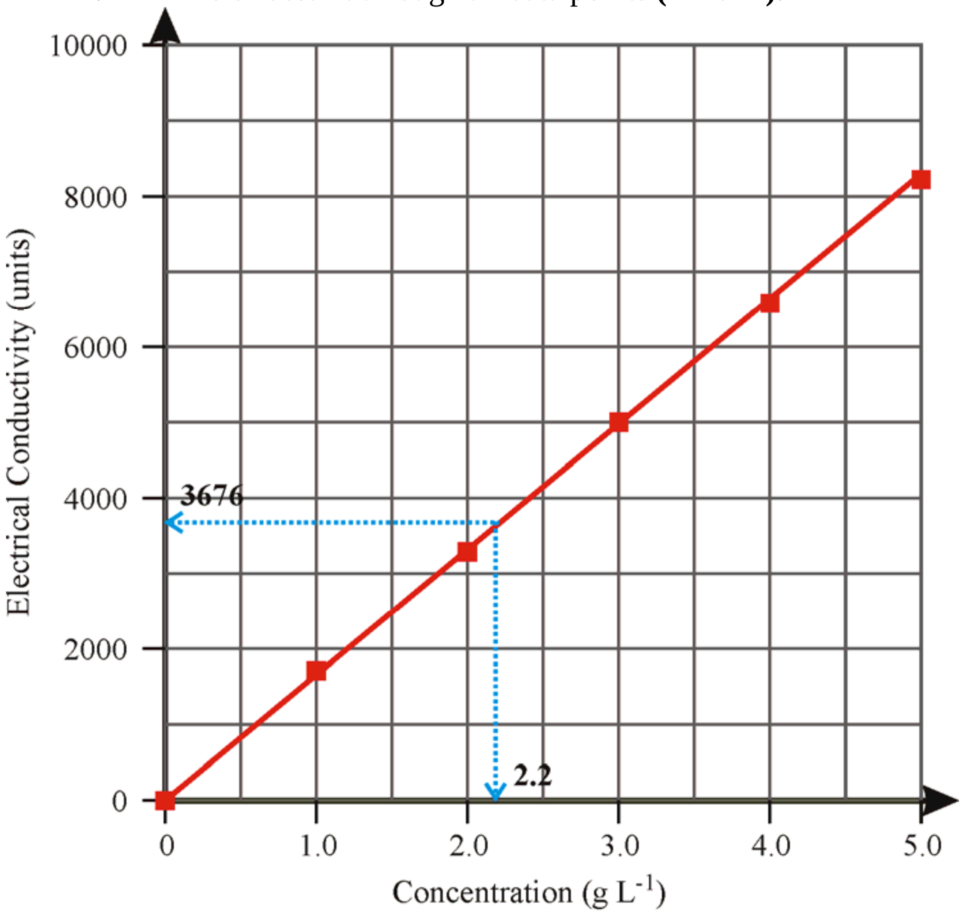
b. From the solubility curve data, the solubilities at 20 ºC and 90 ºC are 22 g/100 mL and 63 g/100 mL respectively.
Therefore, the mass of solid that should crystallise when 100 mL of a saturated solution is cooled over the temperature range will be
m = 63 – 22 = 41 g **(1 mark)**.
For 250 mL of solution
m = 41 × (250/100) = 103 g **(1 mark)**.

c. $M(CuSO_4{\cdot}5H_2O) = 249.6\ g\ mol^{-1}$
$c = 3.0\ M = 3.0\ mol\ L^{-1}$
Therefore, in 100 mL
$n(CuSO_4{\cdot}5H_2O) = c \times V = 3 \times (100/1000) = 0.3\ mol$
$m(CuSO_4{\cdot}5H_2O) = n \times M = 0.3 \times 249.6 = 75\ g$ **(1 mark)**.
From the solubility curve it can be seen that this mass is greater than the solubility at 100 ºC. Therefore, a 3.0 M solution could not be prepared **(1 mark)**.

Question 12 (6 marks)

a. Calibration curve graph should have:

- **i.** Correctly labelled axes **(1 mark)**.
- **ii.** Correctly plotted data **(1 mark)**.
- **iii.** Line of best fit through all data points **(1 mark)**.



b. From the calibration curve, an electrical conductivity of 3676 units corresponds to a sodium chloride concentration of **2.2 g L^{-1} (1 mark)**.

c. All the glassware was thoroughly rinsed with deionised water prior to commencing to ensure that any soluble materials were removed, thereby preventing these from contributing to the measurements and providing higher electrical conductivity results **(1 mark)**.

d. Answers could include: **[(1 mark) for an appropriate answer]**

Solids dissolved in the run-off from either agricultural or urban land.

If the creek was near the coast, salt water coming from the sea as a result of back flow into the creek from the sea, due to either low flow rates of fresh water down the creek or storm surges pushing salty sea water up the creek.

Dissolution of solids from the soil in the creek bed.

Waste materials containing ionic compounds entering the stream either accidentally or deliberately.

In northern hemisphere countries, the dissolved salts in creek water could be due to run off following snow, as salt is used in road de-icing processes.

Note: The answer, 'pollution' would not be considered to be an acceptable answer.

Question 13 (6 marks)

a. **i.** Suitable answers could include, but are not limited to:
[Mark allocation: 1 mark for a suitable answer. Total 2 marks]
Insecticide residues that have been washed from the land or sprayed over water sources.
Pesticides that have been used to kill weeds being washed into waterways.
Oil spills, either during transport or at filling facilities (including petrol stations).
Materials that have been used domestically that have not broken down, this could include hand sanitiser materials or compounds used in shampoos.
Leakage of organic materials from industrial storage areas.
Non-biodegradable detergents.
Antibiotics from either human or animal waste.
Dioxins.

ii. The answer must link the selected organic material to a plausible environmental impact **(1 mark)**.
Example: Pesticides – The residues being concentrated in an animal higher up the food chain eating consumers and having an effect on that animal.

b. **i.** The peak due to caffeine could be identified by running a chromatograph using an aqueous solution of caffeine under the same conditions. Then using the retention time for the caffeine to identify a peak with the same retention time in the tea solution **(1 mark)**.

ii. It would first be necessary to construct a calibration curve using solutions with known concentrations. The calibration curve is constructed by plotting the concentration versus the area under the peak, or less accurately the peak height **(1 mark)**.
The area under the peak, or peak height, is then used to determine the concentration from the calibration curve **(1 mark)**.

Question 14 (7 marks)

a. The aliquots are 10.00 mL of 0.100 M aqueous sodium carbonate.
$n(Na_2CO_3) = c \times V = 0.100 \times (10.00/1000) =$ **1.00×10^{-3} mol (1 mark)**.

b. The stoichiometry of the reaction is given by the chemical equation

$$2CH_3COOH(aq) + Na_2CO_3(aq) \rightarrow 2NaCH_3COO(aq) + CO_2(g) + H_2O(l)$$

$n(CH_3COOH) = 2\times n(Na_2CO_3) = 2 \times 1.00\times10^{-3} =$ **2.00×10^{-3} mol (1 mark)**.

c. $c(CH_3COOH) = n/V = (2.00\times10^{-3}) / (11.50/1000) =$ **1.74×10^{-1} M** (0.174 M) **(1 mark)**.

d. The diluted vinegar solution was prepared by diluting a 20.00 mL sample with deionised water to 250.0 mL. In the original sample
$c(CH_3COOH) = (1.74\times10^{-1}) \times (250.0/20.0) =$ **2.17 M (1 mark)**.

e. The amount of ethanoic acid in 1.00 L (1000 mL) of solution can be determined
$M(CH_3COOH) = 2\times12.0 + 4\times1.0 + 2\times16.0 = 60.0$ g mol^{-1}
$m(CH_3COOH) = n\times M = 2.17 \times 60.0 = 130$ g **(1 mark)**.
$\%(CH_3COOH) = (130/1000) \times (100/1) = 13.0$ % (m/v) **(1 mark)**.
This value is slightly higher than the manufacturer's claim of 12.5 % (m/v). The higher concentration may have been the result of evaporation of water from the vinegar **(1 mark)**.
The boiling point of ethanoic acid is 118 ºC which is higher than water. The water would therefore evaporate faster than the ethanoic acid and the concentration would increase.

End of Suggested Answers