CATHOLIC SECONDARY SCHOOLS ASSOCIATION

2003 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

CHEMISTRY– MARKING GUIDELINES

Section I
Total marks – 75
Part A (15 marks)
Questions 1–15 (1 mark each)

Question	Correct Response	Outcomes Assessed	Target Performance Bands
1	D	H9	2 – 3
2	D	H6	3 – 4
3	C	H4, H6	3 – 4
4	B	H6	4 – 5
5	B	H10, H12	4 – 5
6	A	H12	2 – 3
7	D	H6	2 – 3
8	A	H7, H9, H14	3 – 4
9	C	H10, H12, H14	5 – 6
10	D	H14	5 – 6
11	C	H11	2 – 3
12	A	H9, H13	3 – 4
13	B	H7, H14	3 – 4
14	D	H3, H5	3 – 4
15	B	H6	4 – 5

Section I
Part B (60 marks)

Question 16 (4 marks)
(a) (1 mark)
Outcomes Assessed: H6
Targeted Performance Bands: 2-3

Criteria	Mark
• Identifies X as a neutron	1

(b) (3 marks)
Outcomes Assessed: H5, H6
Targeted Performance Bands: 3-6

Criteria	Marks
• Outlines the steps used to synthesise the named element and accounts for the inability to isolate large samples of the element	3
• Outlines the steps used to synthesise the named element including appropriate materials (ie neutron or small nucleus and an appropriate larger target nuclei)	2
• Identifies an element (by name or symbol) discovered after 1940	1

Sample answer
Element 110 (ununnilium) was first isolated by bombarding a nuclei of lead with a smaller nuclei of nickel. The nickel nuclei are accelerated by an ion accelerator and fuse with the target lead nuclei. Only a few atoms of ununnilium were produced and because they have a very short half-life none have been preserved. The experiment has yet to be replicated and so further samples have not been isolated.

Question 17 (5 marks)
Outcomes Assessed: H2, H9, H13, H14
Targeted Performance Bands: 2-6

Criteria	Marks
• Compares the type of reaction that occurs to produce each polymer including appropriate equations for each reaction	4-5
• Describes the type of reaction that occurs to produce either polymer, including an appropriate equation OR • Describes the type of reaction that occurs to produce both polymers without the use of chemical equations	2-3
• Identifies that both substances are polymers OR • Classifies polyethylene as an addition polymer OR cellulose as a condensation polymer	1

Sample answer
Polyethylene and cellulose are both examples of polymers, which are long-chained molecules made by the joining of a number of small molecules called monomers. However they differ in the type of polymerisation reaction that produces them. Polyethylene is a synthetic addition polymer, formed when ethene monomers join as their double bonds 'open out' allowing them to bond to each other:

$$n\ (CH_2{=}CH_2) \rightarrow -(CH_2\text{-}CH_2)_n-$$

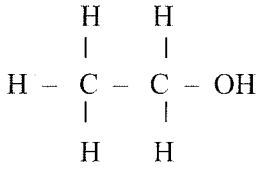
Cellulose is a biopolymer formed from the condensation polymerisation of glucose monomers. In such a process, functional groups on adjacent monomers react and a small molecule is eliminated.

$$n\ (HO\text{-}C_6H_{10}O_4\text{-}OH) \rightarrow -(O\text{-}C_6H_{10}O_4)_n- + n\text{-}1\ H_2O$$

Question 18 (4 marks)
(a) (1 mark)
Outcomes Assessed: H9, H13
Targeted Performance Bands: 2-3

Criteria	Mark
• Draws a correct structural formula for ethanol	1

Sample answer



(b) (3 marks)
Outcomes Assessed: H3, H4, H6, H9, H13
Targeted Performance Bands: 2-4

Criteria	Marks
• Identifies and explains TWO or more implications of the presence of ethanol in petrol	3
• Identifies TWO or more implications of ethanol in petrol OR • Identifies and explains ONE implication of ethanol in petrol	2
• Identifies ONE implication of ethanol in petrol	1

Sample answer
Ethanol produced from fermentation contains water which can cause corrosion of the engine. Ethanol at greater than 20% requires engine modifications and this is expensive. Ethanol from sugarcane is using a by-product that makes sugarcane production more sustainable.

Question 19 (7 marks)
(a) (1 mark)
Outcomes Assessed: H11
Targeted Performance Bands: 2-3

Criteria	Mark
• Identifies an appropriate device to accurately measure mass change	1

(b) (3 marks)
Outcomes Assessed: H2, H12, H13
Targeted Performance Bands: 2-4

Criteria	Marks
• Diagram includes fermentation vessel, delivery tube and limewater trap; diagram is fully and correctly labelled	3
• Diagram includes fermentation vessel, delivery tube and limewater trap; diagram may include partial labels or some labels are incorrect	2
• Diagram includes a suitable reaction vessel and some method of collecting the gas	1

Sample answer
Any suitable diagram of the apparatus required is appropriate. Diagram must show reaction flask, delivery tube and limewater trap. Diagram must be labelled.

(c) (3 marks)
Outcomes Assessed: H10, H12, H14
Targeted Performance Bands: 3-5

Criteria	Marks
• Calculates the correct volume of carbon dioxide produced and describes a valid assumption	3
• Calculates the volume of carbon dioxide gas produced (using incorrect molar volume) and includes valid assumption OR • Calculates correct volume of carbon dioxide produced but does not include a valid assumption	2
• Calculates the number of moles of carbon dioxide gas produced OR • Calculates volume of carbon dioxide gas produced from an incorrect mole calculation OR • Describes a valid assumption made in carrying out calculation	1

Sample answer
Assumption: Mass decrease is only due to loss of CO_2.
mass of CO_2 released = 15g

$n(CO_2) = n/MM = 15/44$
$= 0.34g$

$V = n \times V_m$
$= 0.34 \times 24.79$
$= 8.45$ L

Question 20 (5 marks)
(a) (1 mark)
Outcomes Assessed: H8
Targeted Performance Bands: 2-3

Criteria	Mark
• Identifies an acid-base indicator, e.g. phenolphthalein	1

(b) (1 mark)
Outcomes Assessed: H11
Targeted Performance Bands: 3-4

Criteria	Mark
• Identifies a limitation of using the indicator named in (a)	1

Sample answer
Phenolphthalein changes in the basic region therefore it cannot distinguish between neutral and acidic solutions.

(c) (1 mark)
Outcomes Assessed: H11
Targeted Performance Bands: 3-4

Criteria	Mark
• Identifies ONE advantage of using a pH meter instead of an indicator	1

Sample answer
The pH meter is more accurate than the indicator.

(d) (2 marks)
Outcomes Assessed: H12, H13, H14
Targeted Performance Bands: 3-4

Criteria	Marks
Explanation includes TWO of the following: • Identifies that a pH meter must be calibrated in solutions of differing pH to give accurate readings • Identifies that a pH meter must be thoroughly rinsed before each use to give accurate readings • Identifies that a pH meter that has not been stored correctly will not give accurate readings	2
• Identifies that a pH meter must be calibrated in solutions of differing pH to give accurate readings OR • Identifies that a pH meter must be thoroughly rinsed before each use to give accurate readings OR • Identifies that a pH meter that has not been stored correctly will not give accurate readings	1

Sample answer
A pH meter will only give accurate readings if it has been stored correctly, and it is calibrated before use. Additionally the probe must be thoroughly rinsed before each reading to prevent contamination of the sample being measured.

Question 21 (5 marks)
Outcomes Assessed: H8, H9, H11, H12, H13
Targeted Performance Bands: 2-5

Criteria	Marks
• Uses an example to outline the procedure for making an ester AND • Explains the use of refluxing AND • Explains the use of concentrated sulfuric acid	4-5
• Uses an example to outline the procedure for making an ester AND explains the use of refluxing OR concentrated sulfuric acid OR • Outlines the procedure for making an ester, without an example AND explains the use of refluxing OR concentrated sulfuric acid	2-3
• Identifies that an ester is produced from an alkanol and an alkanoic acid OR • Identifies refluxing as an appropriate method OR • Identifies concentrated sulfuric acid as a catalyst for this reaction	1

Sample answer
An alkanol, e.g. methanol, is added to an alkanoic acid, e.g. salicylic acid in the presence of concentrated sulfuric acid and refluxed at high temperature to form an ester (methylsalicylate). The concentrated sulfuric acid acts as a catalyst to speed up the reaction while refluxing allows the volatile chemicals to react without a dangerous build-up of pressure or loss of the volatile chemicals.

Question 22 (6 marks)

(a) (1 mark)

Outcomes Assessed: H1, H6

Targeted Performance Bands: 2-3

Criteria	Mark
• Outlines Davy's idea about acids	1

Sample answer

Davy in 1815 defined acids as substances that contained hydrogen, which could be replaced by metals.

(b) (2 marks)

Outcomes Assessed: H1, H6

Targeted Performance Bands: 3-6

Criteria	Marks
• Explains how the Bronsted-Lowry theory of acids and bases was an improvement on earlier ideas	2
• Briefly outlines the Bronsted-Lowry theory of acids and bases	1

Sample answer

One of the improvements of the Bronsted-Lowry definition was that it showed that the acidity of a substance depends not only on the structure of the substance itself, but also on its properties relative to the other reactants present.

(c) (3 marks)

Outcomes Assessed: H6, H10, H13

Targeted Performance Bands: 3-5

Criteria	Marks
• Defines an amphiprotic substance AND • Uses equations to describe the behaviour of an amphiprotic substance in acidic AND basic solutions	3
• Defines an amphiprotic substance AND uses an equation to describe the behaviour of an amphiprotic substance in an acidic OR basic solution OR • Uses equations to describe the behaviour of an amphiprotic substance in acidic AND basic solutions	2
• Defines an amphiprotic substance OR • Uses an equation to describe the behaviour of an amphiprotic substance in an acidic OR basic solution	1

Sample answer

An amphiprotic substance can act as both a proton donor and a proton acceptor – depending on its properties relative to the other reactant. HPO_4^{2-} is an amphiprotic substance:

HPO_4^{2-} as a base $\quad HPO_4^{2-} + H_3O^+ \rightleftharpoons H_2PO_4^- + H_2O$

HPO_4^{2-} as an acid $\quad HPO_4^{2-} + OH^- \rightleftharpoons PO_4^{3-} + H_2O$

Question 23 (4 marks)
Outcomes Assessed: H3, H8, H10, H12, H14
Targeted Performance Bands: 3-6

Criteria	Marks
• Clearly demonstrates a quantitative understanding of pH as it relates to $[H_3O^+]$ AND • Explains the effect of a decrease in $[H_3O^+]$ with reference to the second equation	3-4
• Demonstrates a understanding of pH as it relates to $[H_3O^+]$ AND • Explains the effect of a decrease in $[H_3O^+]$ with reference to the second equation	2
• Identifies the pH change as becoming more basic or less acidic OR • Identifies that a pH change of 1 represents a tenfold change in concentration OR • Identifies a decrease of SO_2 with a shift to the left of the second equation	1

Sample answer
The addition of metabisulphite ($S_2O_5^{2-}$) increases the concentration of HSO_3^- (first equation). In the second equation, the system adjusts to overcome this increase in concentration of HSO_3^- by favouring the forward reaction. This causes the concentration of H_3O^+ to decrease and the pH to increase.

Question 24 (4 marks)
(a) (1 mark)
Outcomes Assessed: H3
Targeted Performance Bands: 2-3

Criteria	Mark
• Identifies a branch of chemistry, e.g. analytical chemistry	1

(b) (3 marks)
Outcomes Assessed: H3, H13
Targeted Performance Bands: 3-5

Criteria	Marks
• Identifies and explains a chemical principle used in the branch named in Question 24 (a)	3
• Identifies and describes a chemical principle used in the branch named in Question 24 (a)	2
• Identifies a chemical principle used in the branch in Question 24 (a)	1

Sample answer
In gas chromatography, the principle of solubility is used. Here the components of a vaporised sample dissolve into the liquid stationary phase to differing degrees. The more soluble the component, the slower it moves through the liquid column. The different components therefore take different times to travel through the column. By checking against the time taken for different substances to travel through the column, the various components of the mixture can be identified.

Question 25 (5 marks)
(a) (1 mark)
Outcomes Assessed: H8
Targeted Performance Bands: 2-3

Criteria	Mark
• Correctly identifies the precipitate as barium sulfate	1

(b) (4 marks)
Outcomes Assessed: H11, H12, H14
Targeted Performance Bands: 3-6

Criteria	Marks
• Discusses THREE or more means of improving the reliability of the method	3-4
• Discusses TWO or more means of improving the reliability of the method	2
• Discusses ONE means of improving the reliability of the method	1

Sample answer
Minimise loss of precipitate by studying temperature vs solubility curves of all components of the fertiliser and compare with the solubility of the precipitate to determine the optimum practical temperature of the solvent during filtering. Use the minimum amount of solvent for rinsing the precipitate. Use small and frequent rinsing out of containers to make rinsing more efficient. Test filtrate for the presence of sulfate ion using barium chloride and if still present add more barium chloride and refilter. Dry precipitate slowly and weigh to constant mass.

Question 26 (4 marks)
Outcomes Assessed: H3, H8, H9, H14
Targeted Performance Bands: 2-5

Criteria	Marks
• Identifies TWO relevant indicators and justifies their choice	3-4
• Identifies ONE relevant indicator and justifies their choice OR • Identifies TWO relevant indicators	2
• Identifies ONE indicator of water quality	1

Sample answer
Biological Oxygen Demand would indicate the amount of fruit waste in the waste water as the breakdown of this waste uses oxygen. Turbidity would also be a good indicator of the amount of fruit waste in the water as it would not dissolve.

Question 27 (7 marks)
Outcomes Assessed: H4, H6, H9, H13, H14
Targeted Performance Bands: 2-6

Criteria	Marks
• Describes uses of CFCs and their impact on the atmosphere • Includes chemical equations to show the release of chlorine radicals; the reaction of this radical on ozone and the re-formation of the chlorine radical to continue the process • Identifies and makes judgments about the effectiveness of measures to reduce the use of CFCs	6-7
• Describes uses of CFCs and their impact on the atmosphere • Includes some chemical equations to show the release of chlorine radicals; the reaction of this radical on ozone and the re-formation of the chlorine radical to continue the process • Describes measures taken to reduce the use of CFCs	4-5
• Identifies uses of CFCs OR their impact on the atmosphere • Describes measures taken to reduce the use of CFCs	2-3
• Identifies uses of CFCs OR their impact on the atmosphere OR • Describes measures taken to reduce the use of CFCs	1

Sample answer
Since CFCs are non–toxic, easily compressed to liquids and unreactive, they became the gas of choice for use in refrigeration and air conditioners; as propellants for spray cans of such chemicals as deodorants and insecticides; as solvents, particularly in dry cleaning; as blowing agents for plastic foams; as fire extinguishers. By the 1980s thousands of tonnes of CFCs were being used every year and because of their volatility, released into the atmosphere.

The problems caused by CFCs relate to ozone depletion and the subsequent thinning of the ozone layer. In 1985 satellite mapping found that the ozone layer in the stratosphere over the South Pole had developed a thinned area, or "hole".

Ozone is important to life on Earth as it absorbs high energy ultra violet (UV) radiation that is damaging to living things.

When the chemically inert CFCs build up in the stratosphere, they are dissociated (broken down) by the UV radiation to produce reactive chorine radicals . These radicals then break down the ozone molecules and this leads to the ozone hole.

$CH_3Cl \xrightarrow{\text{UV radiation}} CH_3 + Cl$; $Cl + O_3 \xrightarrow{\text{UV radiation}} ClO + O_2$;
$ClO + O \rightarrow Cl + O_2$

In 1987 worries about environmental damage lead some countries to sign the Montreal Protocol, one article of which was an agreement to reduce emissions of gases that damage the ozone layer. The CFCs can be replaced by less reactive chemicals such as HFCs or hydrofluorocarbons, and other solvents such as water can be used in aerosols. However, third world countries are reluctant to stop using the cheap and readily available CFCs, and the major cheap alternative for a refrigerant is ammonia, a poisonous and corrosive gas.

Option – Industrial Chemistry

Question 28 (25 marks)
(a) (i) (1 mark)
Outcomes Assessed: H6
Targeted Performance Bands: 2-3

Criteria	Mark
• Correctly identifies ONE property of sulfur that allows it to be extracted from underground mineral deposits	1

Sample answer
Sulfur has a relatively low melting point (113° C)

(a) (ii) (2 marks)
Outcomes Assessed: H8, H13
Targeted Performance Bands: 3-4

Criteria	Marks
• Describes all processes in the extraction of sulfur from underground mineral deposits	2
• Describes ONE process in the extraction of sulfur from underground mineral deposits	1

Sample answer
There are three pipes into the sulfur deposit. Superheated water is forced down one pipe, this melts the sulfur and forms a sulfur-water emulsion. Compressed air is forced down another pipe and this in turn forces the sulfur-water emulsion up the third pipe. After cooling, the sulfur is sufficiently insoluble in the water to separate from it.

(b) (i) (2 marks)
Outcomes Assessed: H10, H13
Targeted Performance Bands: 3-4

Criteria	Marks
• Writes a full formula equation for the production of sodium hydroxide from sodium chloride • Equation is balanced and all states included	2
• Writes a full formula equation for the production of sodium hydroxide from sodium chloride	1

Sample answer
$2NaCl\ (aq) + 2H_2O\ (l) \rightarrow 2NaOH\ (aq) + Cl_2\ (g) + H_2\ (g)$

(b) (ii) (4 marks)
Outcomes Assessed: H3, H4, H13, H14
Targeted Performance Bands: 2-6

Criteria	Marks
• Describes completely the diaphragm process including reactions at the anode and cathode • Explains thoroughly why this process is being phased out of industry	4
• Describes the diaphragm process including reactions at the anode and cathode • Explains why this process is being phased out of industry	3
• Describes completely the diaphragm process including reactions at the anode and cathode OR • Explains thoroughly why this process is being phased out of industry OR • Describes the reaction at the anode or cathode AND describes why this process is being phased out of industry	2
• Identifies the product at the anode or cathode OR • Describes why this process is being phased out of industry	1

Sample answer
Anode: $2Cl^- \rightarrow Cl_2 + 2e^-$ This has a titanium metal anode to withstand the chlorine that is formed.
Cathode: $2H_2O + 2e^- \rightarrow H_2 + OH^-$ This has an iron mesh cathode to withstand the formation of OH–
The diaphragm separating the anode from the cathode is made of asbestos. Its purpose is to allow Na^+ to migrate from the anode to the cathode and minimising the migration of Cl^-. This process is being phased out in industry due to health and environmental concerns regarding the use of asbestos. Another reason is the slight contamination of the OH^- with Cl^-.

(c) (i) (2 marks)
Outcomes Assessed: H12
Targeted Performance Bands: 2-4

Criteria	Marks
• Identifies an emulsion that can be made in the school laboratory • Outlines the procedure used to make this emulsion	2
• Identifies an emulsion that can be made in the school laboratory OR • Defines an emulsion	1

Sample answer
French dressing is an emulsion. It is made by adding a very small amount of mustard powder to a small amount of red wine vinegar. Small amounts of olive oil are added to it 'bit by bit' until all of it has been added. The mixture is shaken vigorously then allowed to stand.

(c) (ii) (3 marks)
Outcomes Assessed: H3, H6, H13
Targeted Performance Bands: 3-5

Criteria	Marks
• Describes at least TWO properties of the emulsion and relates them to its use	3
• Describes ONE property of the emulsion and relates it to its use	2
• Identifies at least ONE property of the emulsion	1

Sample answer
French dressing is a water–in–oil emulsion that is used on salads, therefore taste, texture and presentation are important. The production of the emulsion means that there is not a layer of oil "floating" in the dressing, therefore it looks more appetising. The even distribution of oil and red wine vinegar particles means that there is a consistent texture and taste to the dressing – not the individual components of the dressing.

(d) (i) (2 marks)
Outcomes Assessed: H10, H12
Targeted Performance Bands: 2-4

Criteria	Marks
• Write a correct expression for the equilibrium constant for the formation of ammonia	2
• Writes a generalised expression in terms of products and reactants	1

Sample answer

$$K = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

(d) (ii) (3 marks)
Outcomes Assessed: H12, H14
Targeted Performance Bands: 3-6

Criteria	Marks
• Calculates value for K correctly, showing all working	3
• Calculates equilibrium values for nitrogen and hydrogen using correctly balanced equation OR • Uses values to substitute into the equation to calculate K	2
• Correct value for K, without showing working OR • Writes a balanced equation for Haber process	1

Sample answer

	N_2	+	$3H_2$	$\rightleftharpoons$	$2NH_3$
Before equilibrium:	0.20		0.60		0
At equilibrium:	$0.20 - (1/2 \times 0.10)$		$0.60 - (3/2 \times 0.10)$		0.10
	0.15		0.45		0.10

$$K = \frac{[NH_3]^2}{[N_2][H_2]^3} = \frac{[0.10]^2}{[0.15][0.45]^3} = 0.73$$

(e) (6 marks)

Outcomes Assessed: H4, H7, H8, H14

Targeted Performance Bands: 2-6

Criteria	Marks
• Discusses at least TWO environmental problems associated with the Solvay process AND • Explains how each environmental problem is being addressed	5-6
• Discusses at least TWO environmental problems associated with the Solvay process OR • Discusses TWO environmental problem associated with the Solvay process AND explains how it is being addressed	3-4
• Identifies TWO environmental problems associated with the Solvay process OR • Describes ONE environmental problem associated with the Solvay process	2
• Identifies ONE environmental problem associated with the Solvay process	1

Sample answer

The Solvay process is very exothermic thus large amounts of heat are produced. Cooling water from local waterways is used to absorb this heat. This heated water must then be disposed but this would increase the temperature of the waterways affecting aquatic life. Thus the water must be stored in cooling ponds or put through heat diffusers before it can be discharged back into the local waterways.

Another problem is the disposal of large quantities of calcium chloride. Some countries use some of it to de-ice roads but this only uses a small proportion of the calcium chloride produced. If the plant is located near the ocean, the calcium chloride is discharged into it, however this is not possible with smaller local waterways since it would increase the Cl^- too much. Some calcium chloride is evaporated and buried but this is very expensive.

Production of calcium hydroxide is another problem. It is neutralised with hydrochloric acid prior to being released into the environment.

Due to these issues alternative processes for the production of Na_2CO_3 are being developed.

Option – Shipwrecks, Corrosion and Conservation

Question 29 (25 marks)
(a) (i) (1 mark)
Outcomes Assessed: H1
Targeted Performance Bands: 2-3

Criteria	Mark
• Correctly identifies – Michael Faraday	1

(a) (ii) (2 marks)
Outcomes Assessed: H1, H8
Targeted Performance Bands: 3-4

Criteria	Marks
• Thorough description of Davy's contribution to our understanding of electron transfer reactions	2
• Identifies ONE of Davy's contribution to our understanding of electron transfer reactions	1

Sample answer
Davy developed the largest battery then built and was the first to use Volta's pile to decompose molten salts by electrolysis to isolate metals such as sodium and potassium.

(b) (i) (2 marks)
Outcomes Assessed: H3
Targeted Performance Bands: 2-3

Criteria	Mark
• Correctly identifies – iron	1

(b) (ii) (1 marks)
Outcomes Assessed: H8, H13
Targeted Performance Bands: 2-4

Criteria	Marks
• Distinguishes between active and passivating metals by comparison of the formation (or not) of an impervious layer	2
• Defines a passivating metal OR an active metal	1

Sample answer
Passivating metals, although reactive, form an impervious layer of the metal oxide which strongly binds to the metal preventing any further reaction between the metal and the oxidising agent. An active metal, on the other hand, does not form an impervious layer and so the oxidising agent continues to react with the metal.

(b) (iii) (3 marks)
Outcomes Assessed: H3, H6, H8, H14
Targeted Performance Bands: 2-6

Criteria	Marks
• Identifies ONE type of steel • Explains how the composition of the steel affects its properties and uses	3
• Identifies ONE type of steel AND • Explains how the composition of the steel affects its properties OR describes the properties and uses of the steel	2
• Identifies ONE type of steel	1

Sample answer
Stainless steel contains 10–20% chromium and about 10% nickel, the rest of it is iron. Nickel is relatively inert and improves the corrosion resistance of the steel. It also promotes toughness at low temperatures. Chromium also improves the corrosion resistance of steel and improves the strength of the steel at high temperatures. Its corrosion resistance, makes stainless steel ideal for cutlery and surgical instruments.

(c) (i) (2 marks)
Outcomes Assessed: H7, H8, H12
Targeted Performance Bands: 2-4

Criteria	Marks
• Identifies a factor AND • Outlines the method used to determine how it affects an electrolysis reaction	2
• Identifies a factor that can affect an electrolysis reaction	1

Sample answer
Factor – Nature of the electrolyte.
Inert carbon electrodes were placed into a U–tube filled with copper sulfate. The electrodes were connected to a power pack set at 2 V. A drop of universal indicator is added to both the anode and the cathode. The experiment was repeated with the U–tube filled with sodium sulfate instead of copper sulfate.

(c) (ii) (3 marks)
Outcomes Assessed: H11, H14
Targeted Performance Bands: 3-5

Criteria	Marks
• Justifies why the method outlined in part (c) (i) was used	3
• Explains why at least part of the method was used	2
• Identifies ONE variable that must be controlled	1

Sample answer
To determine the effect of the change in electrolyte on the electrolysis reaction, all other variables must be kept the same. Thus, the concentration and volume of the electrolyte must be kept constant, so too must the types of electrodes, applied voltage and a consistent volume of indicator added to each electrode. The type of electrolyte is the only variable that is changed. The drops of universal indicator are added to each electrode to determine what gases are being evolved at the electrode – if oxygen is being evolved, then so too are H^+, so the universal turns red. If however, hydrogen is being evolved, so too are OH^- so the universal will turn purple.

(d) (i) (2 marks)
Outcomes Assessed: H8
Targeted Performance Bands: 2-4

Criteria	Marks
• Correctly identifies at least THREE factors	2
• Correctly identifies ONE factor	1

Sample answer
Temperature, pressure, solubility of O_2, solubility of NaCl, increasing abundance of anaerobic bacteria.

(d) (ii) (3 marks)
Outcomes Assessed: H8, H13
Targeted Performance Bands: 2-6

Criteria	Marks
• Identifies a factor • Explains how this factor changes with depth • Explains how this factor affects the corrosion of metal wrecks	3
• Identifies a factor AND explains how this factor changes with depth OR • Identifies a factor AND explains how this factor affects the corrosion of metal wrecks	2
• Describes how a factor identified in (d) (i) changes with depth	1

Sample answer
Although the solubility of O_2 increases with depth since it increases as the temperature decreases, the concentration of O_2 actually decreases with depth. The concentration of O_2 is greatest at the surface since the water is well aerated by the wave action. It is also aided by the presence of many organisms, such as phytoplankton that produce O_2. There are organisms that respire as well but more O_2 is produced than is used up. As depth increases, however, the sun does not penetrate through the water as well so there are no organisms that can photosynthesise but there are many organisms that respire and so the O_2 concentration decreases. Since it decreases with depth and it is necessary for corrosion, the corrosion rate of metal wrecks should decrease with depth.

(e) (6 marks)

Outcomes Assessed: H3, H7, H8, H12, H13, H14

Targeted Performance Bands: 2-6

Criteria	Marks
• Identifies AND evaluates at least THREE ways in which ocean-going vessels may be protected from corrosion	5-6
• Identifies and evaluates TWO ways in which ocean-going vessels may be protected from corrosion OR • Identifies and explains THREE ways in which ocean-going vessels may be protected from corrosion	3-4
• Identifies and describes TWO ways of protecting an ocean-going vessels may be protected from corrosion	2
• Identifies ONE method of protecting an ocean-going vessel from corrosion	1

Sample answer

Several methods are used to protect ocean-going vessels from corrosion. The superstructure is painted so there is a physical barrier between the metal and the oxygen and water to prevent corrosion – this is not very successful, however, since if the paint is scratched then corrosion can continue even under the rest of the painted metal. Another method is to use stainless steel since the chromium and nickel in it prevent corrosion, but this is too expensive so is not used. A more economical and thus acceptable method is to spray the surface of the steel with a thin layer of chromium and nickel, thus creating a stainless steel-like surface at a fraction of the cost. Polymer based paints also form an impervious layer to oxygen and water. The hull of ocean-going vessels are protected by the use of sacrificial anodes such as magnesium or zinc. These are more reactive than iron and so will set up a galvanic cell and react preferentially to the iron. This works very well in sea water where there is a good conducting medium . The zinc and magnesium react slowly enough to be economically viable yet also give good protection to the ship's hull.

Option – The Biochemistry of Movement

Question 30 (25 marks)
(a) (i) (1 mark)
Outcomes Assessed: H6, H7
Targeted Performance Bands: 2-3

Criteria	Mark
• Adenosine triphosphate OR ATP	1

(a) (ii) (2 marks)
Outcomes Assessed: H6, H7
Targeted Performance Bands: 3-4

Criteria	Marks
• Describes ATP as producing energy for all cell reactions AND • Identifies the bonds between phosphate bonds as the source of energy	2
• Describes ATP as producing energy for the cell OR • Identifies the bonds between phosphate bonds as the source of energy	1

Sample answer
Adenosine triphosphate is an extremely important high energy compound which has it's available energy locked in the bonds between it's three phosphate groups. The energy is provided by breaking these bonds. ATP is necessary for all work done in the cell, such as muscle contraction, the movement of ions, the breakdown of larger molecules. ATP must be continually produced in the cell by the process of respiration as it cannot be stored.

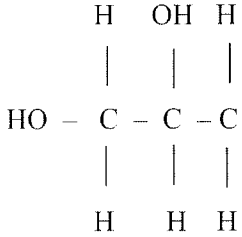
(b) (i) (1 mark)
Outcomes Assessed: H6
Targeted Performance Bands: 2-3

Criteria	Mark
• Describes glycogen as being stored as granules in the muscles and liver	1

(b) (ii) (2 marks)
Outcomes Assessed: H6, H13
Targeted Performance Bands: 3-4

Criteria	Marks
• Correct graphic formula AND • Correct IUPAC name	2
• Correct graphic formula OR • Correct IUPAC name	1

Sample answer



1,2,3–propanetriol

(b) (iii) (3 marks)
Outcomes Assessed: H4, H13, H14
Targeted Performance Bands: 4-5

Criteria	Marks
• States that glucose is stored as the polymer glycogen in liver and muscles • Compares the higher energy of fats (lipids) with energy from glucose • Describes how both lipids and glucose are broken into Acetyl CoA and produce ATP for muscle action	3
• Describes how glucose is stored as the polymer glycogen in the liver and muscles AND EITHER • Compares the energy density of lipids and glycogen OR • Describes how glycogen and fatty acids can be respired to produce ATP but glycogen storage is limited	2
• States that glucose is stored as glycogen OR • States that glycogen is stored in muscles OR in liver OR • States that glucose or glycogen do not produce as much energy as lipids	1

Sample answer
During exercise, when blood glucose levels drop the glucose polymer glycogen stored in muscles and liver breaks down to produce more glucose. However, there is a limit to how much can be stored. Glucose therefore does not produce as much energy per gram as do fats (lipids). If more energy is needed the stored lipids are broken into fatty acids and undergo reactions to produce acetyl CoA and proceed through the respiratory cycle. Eating a lot of carbohydrate may allow the body to store its maximum amount of glycogen, but the length and intensity of the event will determine how long before the energy from fats begins to be metabolized.

(c) (i) (2 marks)
Outcomes Assessed: H8, H12
Targeted Performance Bands: 2-4

Criteria	Marks
• Names a suitable enzyme and identify the substrate • Describes the experiment including a range of temperatures/pH values	2
• Names a suitable enzyme OR • Outlines a series of relevant steps	1

Sample answer
The enzyme used was catalase and liver was used a source. The factor investigated was temperature. The substrate this enzyme acts on is hydrogen peroxide.
Step 1. Cut fresh liver into small pieces. Add equal amounts to each of 5 of 10 test tubes.
Step 2. Add about 2 ml of water to each test tube and place pairs of test tubes in 5 separate water baths (beakers)
Step 3. Place a thermometer in each beaker and use ice of hot water to adjust the water temperatures to respectively 10, 20, 30 , 40 50 °C.
Step 4. When temperatures have stabilized, add one drop to detergent to each test tube, and add 2 mL of hydrogen peroxide to each pair of test tubes. The tube without the liver is the control.
Step 5. **After 5 minutes**, (or 10 or 30) measure the height of bubbles on the test tubes.

(c)(ii) (3 marks)
Outcomes Assessed: H6, H14
Targeted Performance Bands: 3-5

Criteria	Marks
• Describes suitable results • Explains the structure of an enzyme • Relates changing the shape of the active site to the loss of activity of the enzyme	3
• Any TWO of the indicators above	2
• Any ONE of the indicators above	1

Sample answer
The bubbles are oxygen that is produced by the breakdown of hydrogen peroxide by the catalase. As the temperature rose the amount of oxygen increased to a maximum at 40°C and then dropped to zero. These results show that catalase has an optimum operating temperature of about 40°C. Above 40°C activity dropped to zero because enzyme had been denatured.

(d)(i) (1 mark)
Outcomes assessed: H9
Targeted Performance Bands: 2-3

Criteria	Mark
• Correctly identifies actin AND myosin	1

(d)(ii) (4 marks)
Outcomes Assessed: H6, H7, H13
Targeted Performance Bands: 2-5

Criteria	Marks
• Describes clearly and completely all processes involved in muscle contraction • Identifies all substances involved in muscle contraction	3-4
• Describes some processes involved in muscle contraction	2
• States that ATP is needed OR relates shape change of fibres to contraction OR • Makes some attempt at diagram	1

Sample answer
The contraction is initiated by a nerve impulse that stimulates the outer layer of the muscle fibre bundle to produce calcium ions.
Actin and myosin protein filaments in the muscle fibre are usually attached to each other.
The presence of ATP causes the myosin to separate from the myosin fibre.
The ATP then breaks down into ADP and PO_4, and this allows the myosin fibre to re-attach to the actin fibre, but at a different position. Because of the breakdown of ATP, this bond is a high energy bond and so is unstable.
The instability causes the myosin fibre to slide along the actin fibre to the low energy position, dragging the actin fibre along, causing contraction.

(e) (6 marks)
Outcomes Assessed: H4, H7, H8, H9, H13, H14
Targeted Performance Bands: 2-6

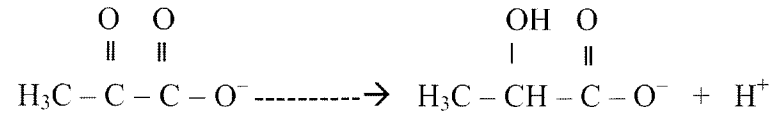
Criteria	Marks
• Identifies several problems and explains the implications of each for the sprinter • Uses relevant equations to support their answer	6
• Identifies a couple of problems and explains the implications of each for the sprinter • Uses at least ONE relevant equation to support their answer OR • Identifies several problems and explains the implications of at least one for the sprinter • Uses at least ONE relevant equation to support their answer	4-5
• Identifies a couple of problems and explains the implications of at least ONE for the sprinter	2-3
• Identifies ONE problem, related to the respiratory chain, for the sprinter	1

Sample answer
During a sprint the muscles must contract both powerfully and rapidly. Type II muscle cells are needed for this rapid and powerful contraction. These cells do not contain many mitochondria. Mitochondria contain the two parts of the respiratory chain that produce the most ATP, the TCA cycle and the oxidative chain. These pathways supply 36 molecules of ATP for each molecule of glucose, but they require oxygen to do this. However, the first problem for a sprinter is that blood cannot supply oxygen and glucose fast enough to supply energy for these rapidly contracting cells.

The sprinter must produce sufficient ATP for muscle contraction without the TCA cycle and the oxidative chain. Therefore the only way to supply energy to the muscles of a sprinter is the anaerobic glycolysis pathway, where glucose, stored in muscles as glycogen, is broken into pyruvate producing only two molecules of ATP for each molecule of glucose, without the need for oxygen.

This cycle must turn very fast to produce enough ATP to the muscle fibres to contract, but after four to six seconds (for a very fit athlete) the supply of glucose is depleted. The length of time a sprinter can run is limited because the amount of stored glycogen is limited, and the brain depends on glucose alone for energy and so the body cannot allow glucose levels to drop below a certain level.

Another problem confronting the sprinter is that because of the anaerobic nature of the glycolysis, the pyruvate cannot be converted into carbon dioxide. Instead it is converted into lactate. Because of the high rate of pyruvate production, the lactate builds up in working muscle cells. The lactate is a weak acid and dissociates giving a proton,



lowering the pH of the muscle cell. The effect on pH changes on protein mean that muscle fatigue occurs, which also limits the time a sprinter can keep moving rapidly.

Option – The Chemistry of Art

Question 31 (25 marks)
(a) (i) (1 mark)
Outcomes Assessed: H6
Targeted Performance Bands: 2-3

Criteria	Mark
• Identifies correctly – H_2O	1

(a) (ii) (2 marks)
Outcomes Assessed: H6, H13
Targeted Performance Bands: 3-4

Criteria	Marks
• Explains why NH_3 can act as a ligand but BH_3 cannot	2
• Identifies that a ligand forms a coordinate covalent bond with a transition metal	1

Sample answer
Ligands form coordinate covalent bonds with transition metals, thus, they must have an unbonded pair of electrons in their valence shell.
All of boron's valence electrons are already bonded so it cannot form a coordinate covalent bond with a transition metal whereas nitrogen has one unbonded pair that can form a coordinate covalent bond with the transition metal.

(b) (i) (1 mark)
Outcomes Assessed: H1
Targeted Performance Bands: 2-3

Criteria	Mark
• Correctly identifies – Neils Bohr	1

(b) (ii) (2 marks)
Outcomes Assessed: H6
Targeted Performance Bands: 3-4

Criteria	Marks
• Distinguishes between emission spectra and absorption spectra	2
• Defines emission spectra OR absorption spectra	1

Sample answer
Emission spectra are produced when a sample of a metal ion absorbs energy and goes to a higher energy level, as it returns to a lower level, it releases energy which correspond to particular wavelengths. These are seen as coloured lines against a dark background.
Absorption spectra however, are formed when white light passes through the vapourised cation and absorbs wavelengths. Hence wavelengths are "missing" from the spectrum. This is seen as black lines against a coloured background.

(b) (iii) (3 marks)
Outcomes Assessed: H1, H6
Targeted Performance Bands: 3-6

Criteria	Marks
• Explains how careful observation of the spectra of elements both supported AND hindered the complete acceptance of Bohr's atomic model	3
• Explains how careful observation of the spectra of elements supported OR hindered the complete acceptance of Bohr's atomic model	2
• Identifies that spectral lines are caused by the movement of electrons from one energy level to another	1

Sample answer
Line emission spectra supported Bohr's model because it was evidence for electrons moving between discrete energy levels and emitting or absorbing energy as they did so. However, further analysis of spectra using more accurate instrumentation found that single emission lines could be resolved into several lines – this could not be explained by Bohr's model. The observed line spectra did not agree with Bohr's model when more than one electron was present, i.e. all elements except hydrogen.

(c) (i) (2 marks)
Outcomes Assessed: H6, H13
Targeted Performance Bands: 2-4

Criteria	Marks
• Outlines details of a first-hand investigation undertaken about colour changes as a result of changes in the oxidation state of a transition metal	2
• Identifies the materials used to conduct a first-hand investigation regarding colour changes as a result of changes in the oxidation state of a transition metal	1

Sample answer
The yellow VO_2^+ [Vanadium(V)] reacts with zinc in dilute hydrochloric acid to undergo a series of reductions which are observed by the colour changes.

(c) (ii) (3 marks)
Outcomes Assessed: H6, H10, H13, H14
Targeted Performance Bands: 3-6

Criteria	Marks
• Describes the results of the investigation • Accounts for the observed colour changes • Includes relevant chemical equations	3
• Describes the results of the investigation AND accounts for the observed colour changes OR • Describes ONE observed colour change AND includes a relevant equation	2
• Describes observed colour changes	1

Sample answer
The yellow VO_2^+ [Vanadium(V)] reacts with zinc in dilute hydrochloric acid to undergo a series of reductions to blue VO^{2+} [Vanadium(IV)] to green V^{3+} [Vanadium(III)] and finally violet V^{2+} [Vanadium(II)]. The relevant equations representing the reduction of vanadium are:

$VO_2^+(aq) + e^- + 2H^+(aq) \rightarrow VO^{2+}(aq) + H_2O(l)$ product – blue VO^{2+} [Vanadium(IV)]
$VO^{2+}(aq) + e^- + 2H^+(aq) \rightarrow V^{3+}(aq) + H_2O(l)$ product – green V^{3+} [Vanadium(III)]
$V^{3+}(aq) + e^- \rightarrow V^{2+}(aq)$ product – violet V^{2+} [Vanadium(II)]

Source: Irwin, D et al (2001). *Chemistry Contexts 2 CD-ROM*, Pearson Education Australia

(d) (i) (1 mark)
Outcomes Assessed: H6, H12, H13
Targeted Performance Bands: 2-3

Criteria	Mark
• States electron configuration, in terms of shells and subshells, for the element magnesium	1

Sample answer
$1s^2\ 2s^2\ 2p^6\ 3s^2$

(d) (ii) (2 marks)
Outcomes Assessed: H6, H12, H14
Targeted Performance Bands: 3-6

Criteria	Marks
• Identifies correctly the letter for the element that is magnesium • Justifies the selection	2
• Identifies correctly the letter for the element that is magnesium	1

Sample answer
E since it is a Group II element. C has the highest first ionisation energy so it must be a Group VIII element since it is chemically stable (large energy is needed to remove an electron). Since the elements are consecutive, the group II element is the second one after C, i.e. E. It also has a slightly higher ionisation energy than F since it has a full 3s subshell.

(d) (iii) (2 marks)
Outcomes Assessed: H6, H12, H14
Targeted Performance Bands: 3-6

Criteria	Marks
• Identifies the element with the highest electronegativity (by letter) • Explains why it has the highest electronegativity	2
• Identifies the element with the highest electronegativity (by letter) OR • Defines – electronegativity	1

Sample answer
B (Group VII) – electronegativity increases as you go from left to right across the period since the nuclear charge increases across the period (excluding Group VIII since it rarely forms molecules with other atoms). As this increases, the force of attraction between the nucleus and the valence electrons also increases, as does its ability to attract other electrons to itself.

(e) (6 marks)
Outcomes Assessed: H1, H4,H6 H13, H14
Targeted Performance Bands: 2-6

Criteria	Marks
• Discusses the impact of minerals containing transition metals in the decoration of the environment and people for Aborigines AND ONE other early civilisation, naming appropriate minerals	5-6
• Describes the impact of minerals containing transition metals in the decoration of the environment and people for Aborigines AND ONE other early civilisation, naming appropriate minerals OR • Discusses the impact of minerals containing transition metals in the decoration of the environment and people for EITHER Aborigines OR ONE other early civilisation, naming appropriate minerals	3-4
• Describes the impact of minerals containing a transition metal in the decoration of the environment and people for EITHER Aborigines OR ONE other early civilisation	1-2

Sample answer
The Aboriginal people were the earliest users of minerals as a means of creating colour. Since they were the pioneers of this, the techniques were fairly crude in terms of mixing and grinding of the minerals. They also had a limited range of very basic colours, hence their artwork also had limited colours. They used minerals containing iron extensively for drawing on cave walls and also as paints, when ground and mixed with a liquid. Red ochre contains anhydrous iron(III) oxide, Fe_2O_3, while yellow ochre was made from hydrated iron oxides, e.g. $Fe_2O_3.H_2O$. This use of colours allowed the Aboriginal people to pass on stories of their dreamtime from one generation to another.

The ancient Egyptians, being a more recent 'civilisation' were able to employ better techniques and thus could produce pigments that were more finely ground and, through sieving, of higher purity. They also used a greater variety of minerals to create their colours, e.g. bright green pigment made from malachite ($CuCO_3.Cu(OH)_2$) and azurite ($2CuCO_3.Cu(OH)_2$) produced a bright blue colour. Not only did the Egyptians use the pigments to produce a greater range of paints but also as cosmetics and body paints. They also developed techniques for developing textile dyes which allowed them to create colourful clothes.

Option – Forensic Chemistry

Question 32 (25 marks)
(a) (i) (1 mark)
Outcomes Assessed: H9
Targeted Performance Bands: 2-3

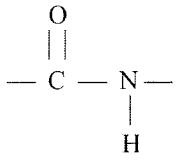
Criteria	Mark
• Identifies both functional groups of amino acids	1

Sample answer
The functional groups of amino acids are the amine group ($-NH_2$) and the carboxylic acid group (-COOH).

(a) (ii) (2 marks)
Outcomes Assessed: H9, H13
Targeted Performance Bands: 3-4

Criteria	Marks
• Explains that proteins are chains of amino acids AND • Describes the nature of the peptide bond	2
• Explains that proteins are chains of amino acids OR • Describes the nature of the peptide bond	1

Sample answer
Proteins are large polymers which are formed by amino acids coming together in condensation reactions. The amino acids in proteins are held together by peptide bonds, which have the following structure:



(b) (i) (2 marks)
Outcomes Assessed: H4, H9
Targeted Performance Bands: 3-5

Criteria	Marks
• Identifies that similarities in the DNA of individuals who are related are caused by the inheritance of DNA (half from each parent) AND • Identifies that the areas of non-coding DNA (introns or 'junk DNA') are used to look for similarities between people's DNA	2
• Identifies that similaries in the DNA of individuals who are related are caused by the inheritance of DNA (half from each parent) OR • Identifies that unrelated individuals will not show similaries in their DNA OR • Identifies that each person's DNA is unique	1

Sample answer
The non-coding bits of DNA that separate genes vary significantly from person to person, making each person unique. These introns, also known as 'junk DNA', show some similarities in people who are related. Since each person inherits half of their DNA from each parent, parents and their children have about 50% of their DNA introns in common, while the introns of people who are not related will have very little in common.

(b) (ii) (4 marks)
Outcomes Assessed: H4, H9, H13
Targeted Performance Bands: 2-6

Criteria	Marks
• Describes at least THREE of the following: DNA extraction, replication by PCR, cutting by restriction enzymes, separation by electrophoresis, comparison of DNA 'fingerprints' OR • Communicates a detailed understanding of at least one of the following: DNA extraction, replication by PCR, cutting by restriction enzymes, separation by electrophoresis, comparison of DNA 'fingerprints' AND • Identifies other processes involved in DNA analysis	3-4
• Identifies several of the following: DNA extraction, replication by PCR, cutting by restriction enzymes, separation by electrophoresis, comparison of DNA 'fingerprints' OR • Clearly describes at least one of the following: DNA extraction, replication by PCR, cutting by restriction enzymes, separation by electrophoresis, comparison of DNA 'fingerprints'	1-2

Sample answer
The first step in DNA analysis is the extraction of DNA from a sample. During amplification by PCR (polymerase chain reaction) fragments from particular positions along DNA molecules are duplicated so that multiple copies of the DNA segments are produced. PCR involves the use of primers which stick to the desired part of DNA and enzymes which copy the DNA segments. Changing the temperature of the reaction solution enables the DNA strands to separate, and the primers to attach tot he open DNA strands. Electrophoresis is then used to separate DNA fragments of different sizes. Fluorescent or radioactive labels allow the 'fingerprint' generated for an individual to be visualised and compared to that generated from a sample collected at a crime scene.

(c) (i) (2 marks)
Outcomes Assessed: H9, H11
Targeted Performance Bands: 2-4

Criteria	Marks
• Identifies a reagent used to test for reducing sugars AND • Identifies the need to warm the test solution AND • Identifies the colour of a positive test	2
• Identifies a reagent used to test for reducing sugars	1

Sample answer
Reducing sugars can be identified by testing with Benedict's solution. The solution of the sugar and a few drops of Benedict's solution should be heated gently. The solution starts out blue and forms a red-brown precipitate in the presence of reducing sugars.

(c) (ii) (3 marks)
Outcomes Assessed: H9, H11, H13
Targeted Performance Bands: 3-5

Criteria	Marks
• Defines reducing sugars AND • Explains the chemical basis of the test for a reducing sugar using equations of the reaction	3
• Defines reducing sugars AND • Describes the chemical basis of the test for a reducing sugar, naming chemical species involved in the reaction	2
• Defines reducing sugars OR • Identifies chemical species involved in the test for a reducing sugar	1

Sample answer
Reducing sugars contain a reactive carbonyl group (-C=O) which is not involved in the glycosidic link. In the open-chain form, they contain either –CHO or –CO-CH_2OH groups which are easily oxidized.
Benedict's solution is a weak oxidizing agent. It's Cu^{2+} ions react with the carbonyl groups of reducing sugars when gently heated to produce a red precipitate of copper(I)oxide. The aldehyde group in the reducing sugar will be oxidized to a carboxylic acid group.

$$R\text{-}CHO + 2\,Cu^{2+} + 5OH^- \rightarrow Cu_2O\,(s) + R\text{-}COO^- + 3H_2O$$
$$R\text{-}CO\text{-}CH_2OH + 2\,Cu^{2+} + 5OH^- \rightarrow Cu_2O\,(s) + R\text{-}CHOH\text{-}COO^- + 3H_2O$$

(d) (i) (2 marks)
Outcomes Assessed: H9
Targeted Performance Bands: 3-5

Criteria	Marks
• Identifies that the basis of the separation in paper chromatography is solubility in the solvent used AND • Describes the movement of substances in paper chromatography in terms of the mobile phase and stationary phase	2
• Identifies that the basis of the separation in paper chromatography is solubility in the solvent used OR • Describes the movement of substances in paper chromatography in terms of the mobile phase and stationary phase	1

Sample answer
The parts of the mixture have been separated because of differences in their solubility in the solvent used. During paper chromatography substances which are highly soluble in the mobile phase (the liquid which moves up the paper) move up the paper quickly. Those substances which are highly soluble in the stationary phase (the water trapped in the cellulose fibres of the paper) travel only a short distance.

(d) (ii) (3 marks)
Outcomes Assessed: H9, H13, H14
Targeted Performance Bands: 2-5

Criteria	Marks
• Explains that not all components of the mixture have been separated by step (b) because they have similar solubilities in the solvent used AND • Explains the need to use a second solvent in which the components of the mixture have different solubilities from each other	3
• Identifies that not all components of the mixture have been separated by step (b) AND/OR • Identifies that some components of the mixture had similar solubilities in the solvent used AND/OR • Identifies the need to use a second solvent in which the components of the mixture have different solubilities from each other	2
• Identifies that not all components of the mixture have been separated by step (b) OR • Identifies that some components of the mixture had similar solubilities in the solvent used OR • Identifies the need to use a second solvent in which the components of the mixture have different solubilities from each other	1

Sample answer
In diagram (b) two of the spots are overlapping. Paper chromatography with the first solvent was not able to separate all of the components of the mixture because some of them had similar solubilities in the solvent used. Substances that have similar solubilities in one solvent may have different solubilities in another. Therefore, by using a different solvent in step (c) chemists were able to clearly identify all components of the mixture, and this would allow accurate comparison of samples.

(e) (6 marks)
Outcomes Assessed: H4, H9, H13, H14
Targeted Performance Bands: 2-6

Criteria	Marks
• Effectively communicates a thorough understanding of a sensitive analytical technique used in forensic investigations AND • Discusses at least TWO impacts of this technique on forensic investigations	5-6
• Describes a sensitive analytical technique used in forensic investigations AND • Discusses at least ONE impact of this technique on forensic investigations OR • Describes at least TWO impacts of this technique on forensic investigations	3-4
• Identifies a sensitive analytical technique used in forensic investigations AND/OR • Describes at least ONE impact of this technique on forensic investigations	1-2

Sample answer
Mass spectrometers are sensitive analytical tools which forensic scientists use to analyse both inorganic and organic samples. Mass spectroscopy identifies substances on the basis of the masses of the positive ions which are formed by those substances when they are bombarded by high energy particles in a vaccum. The positive ions which are formed during mass spectroscopy are separated by magnetic fields which send ions of different sizes on different paths towards a collector slit.

Mass spectra show complex patterns of peaks, which allow the accurate determination of the many components of a mixture. Not only are the relative amounts of different elements present in a sample shown, but the proportions of different isotopes of the elements are also shown. As the spectra of different compounds obtained by mass spectroscopy are unique, they can be used as 'fingerprints'. Comparison of a particular sample's spectra with a database of known fingerprints allows forensic chemists to confidently identify samples.

Mass spectrometers are useful to forensic chemists because of their high resolution, high speed scans, and high sensitivity. High resolution is important because ions of almost identical mass can be separated, allowing the accurate and reliable comparison of samples. The impact of this on forensic investigations has been to increase the degree of confidence in results obtained. The high speed of scanning in mass spectroscopy is also important because analyses that would have previously required highly skilled chemists to undergo a complex series of tests are now performed in a few seconds. The high sensitivity of mass spectrometers means that samples of only a few nanograms can be analysed. This has had a huge impact on forensic investigations because in the past there were many cases where samples were too small to allow traditional chemical analysis. Today a small portion of a sample may be analysed by mass spectroscopy, and the remaining sample can be subject to other analytical techniques.