2018 HSC Chemistry Marking Guidelines

Section I, Part A

Multiple-choice Answer Key

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

Section I, Part B

Question 21 (a)

Criteria	Marks
• Provides a correct name for the process	1

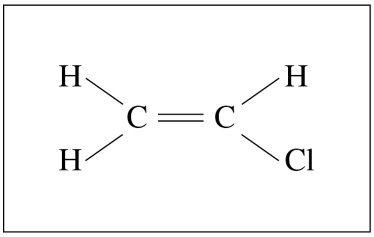
Sample answer:

Cracking.

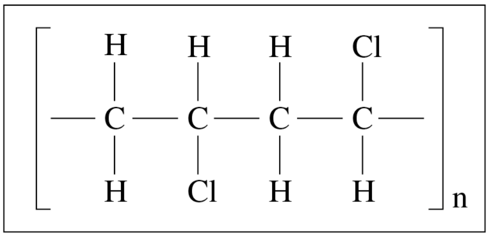
Question 21 (b)

Criteria	Marks
• Provides TWO substantially correct structural formulae	2
• Provides some relevant information	1

Sample answer:



Vinyl chloride

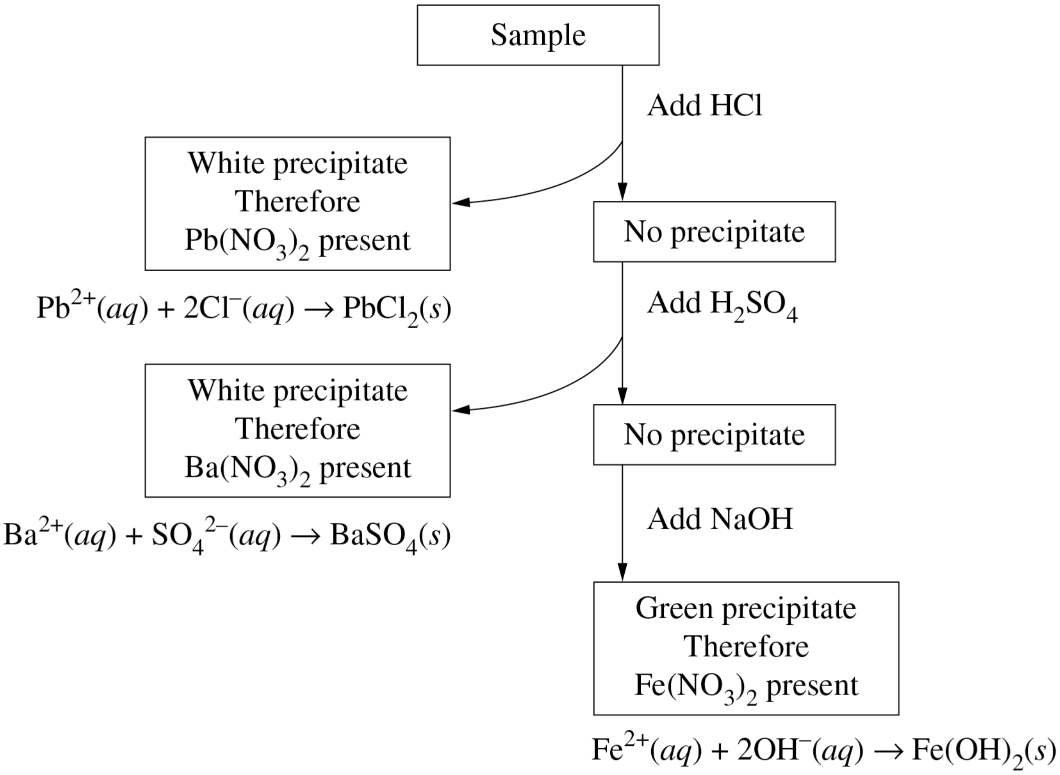


Polyvinyl chloride

Question 22

Criteria	Marks
• Provides clear logical sequence of steps to identify the solution • Provides observations and conclusions • Provides correct ionic equations	4
• Provides a sequence of steps that could identify the solution • Provides some observations • Provides ONE ionic equation	3
• Provides a step to identify the solution • Includes ONE observation or equation	2
• Provides some relevant information	1

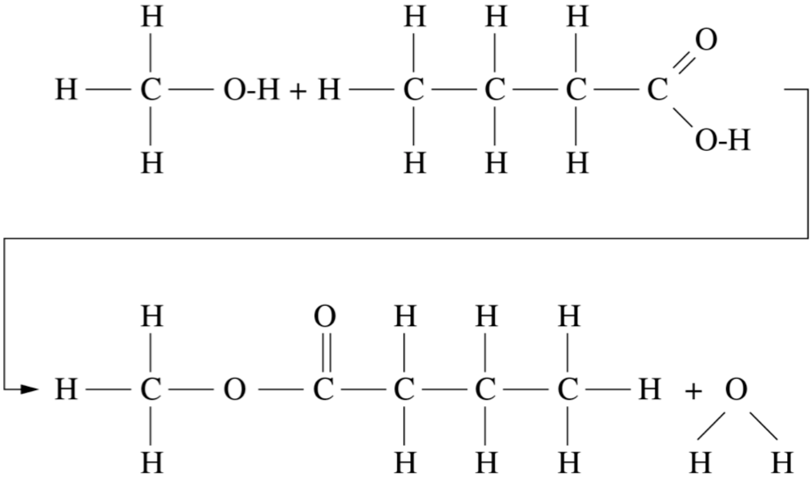
Sample answer:



Question 23 (a)

Criteria	Marks
• Provides correct equation using structural formulae	2
• Provides some relevant information	1

Sample answer:



Question 23 (b)

Criteria	Marks
• Explains conditions under which esterification can be carried out safely and efficiently in a school laboratory	4
• Outlines some conditions necessary for esterification to be carried out safely and/or efficiently and explains at least ONE condition	3
• Identifies some conditions necessary for esterification to be carried out safely and/or efficiently OR • Outlines a relevant condition	2
• Provides some relevant information	1

Sample answer:

Concentrated sulfuric acid is added to the reaction mixture of alkanol and alkanoic acid.

The concentrated acid acts as a catalyst increasing the rate at which the ester is produced. It also acts as a dehydrating agent, shifting position of equilibrium to the right and thereby increasing the yield of ester.

The mixture is heated with a heating mantle or water bath. This allows for safe heating of flammable chemicals as there are no naked flames.

Answers could include:

The mixture is heated under reflux.

This allows the vessel to be heated for an extended period without the loss of volatile reactants and products and without danger of gas pressure build up which could cause an explosion.

Question 24 (a)

Criteria	Marks
• Provides correct equation including states	1

Sample answer:

$C_6H_{12}O_6(aq) \rightarrow 2C_2H_5OH(l) + 2CO_2(g)$

Question 24 (b)

Criteria	Marks
• Provides correct steps in the calculation of the mass of glucose	3
• Provides some relevant calculation steps	2
• Provides some relevant information	1

Sample answer:

$$n = \frac{v}{V_{molar}}$$

$$\frac{0.0055\ \text{L}}{24.79} = 2.2186 \times 10^{-4}\ \text{mol CO}_2 \div 2 = 1.1093 \times 10^{-4}\ \text{mol glucose (as molar ratio 2:1)}$$

$$m = nM$$

$$\text{M glucose} = 180.156$$

$$m = 1.093 \times 10^{-4} \times 180.156$$

$$m = 0.019985\ \text{g glucose}$$

$$= 0.020\ \text{g}$$

Question 25

Criteria	Marks
• Explains why changing the temperature and adding a catalyst can change reaction rate • Makes relevant reference to the graph • Relates kinetic energy of particles to reaction rate • Relates explanation to NH_3 production	4
• With reference to the graph, explains the effect of changing the temperature and/or adding a catalyst on the rate of production of ammonia, showing a good understanding of activation energy	3
• Explains the effect of changing the temperature and/or adding a catalyst on ammonia production	2
• Provides some relevant information	1

Sample answer:

Gas particles need to attain a level of kinetic energy sufficient to collide and react with each other known as the activation energy (E_A).

On the graph it can be seen that some particles have a kinetic energy above E_A at any one time. Therefore the number of N_2 and H_2 particles with enough energy to react and produce ammonia is greater per time at a higher temperature.

A catalyst lowers the activation energy. On the graph if the E_A is moved to the left, there will be a greater number of particles that can react in a given time and therefore the rate of ammonia production will increase.

Question 26 (a)

Criteria	Marks
• Outlines ONE appropriate method	2
• Provides some relevant information	1

Sample answer:

Radiographers could wear radiation badges containing photographic film that turns cloudy when exposed to radiation.

Question 26 (b)

Criteria	Marks
• Analyses impact on society of the use of a named radioisotope • Relates properties of the isotope to its use and the impact on society	5
• Shows an understanding of the impact on society of the use of a named radioisotope • Relates one or more properties of the isotope to its use and/or impact on society	4
• Outlines advantage(s) AND/OR disadvantage(s) of the use of ONE named radioisotope in society AND/OR its properties	2–3
• Provides relevant information	1

Sample answer:

Technetium-99m is a radioisotope commonly used in medical diagnostic procedures such as scanning of internal organs for blood clots. This has impacts on society by increasing life expectancy and by improving quality of life through early and precise diagnosis. As a gamma-emitter Tc-99m is easily detected by a camera during a scan. However, the gamma-radiation does pose a health risk especially if healthcare workers are exposed to long-term high doses. This risk is minimal if well managed compared to the significant health benefits of the diagnostic procedures.

It has a short half-life of 6 hours which allows it to be injected into a patient but removed from the body in a short time, minimising gamma ray exposure for the patient and workers. Therefore, it must be made locally, possibly close to urban areas with the risk of radiation exposure to the public. This is because its effectiveness is reduced during transit. The risks are accepted in society and monitored to allow for equitable access to important medical procedures.

Question 27 (a)

Criteria	Marks
• Provides correct name of the compound	1

Sample answer:

2-chloro-1,1-difluoroethane

Question 27 (b)

Criteria	Marks
• Relates the properties of HCFCs and CFCs to their impact on the atmosphere • Makes an assessment of the suitability of HCFCs as a replacement for CFCs	4
• Describes the properties of HCFCs and CFCs and their impact on the atmosphere	3
• Identifies some properties and/or impacts of HCFCs and/or CFCs OR • Outlines a property/impact of HCFCs and/or CFCs	2
• Provides some relevant information	1

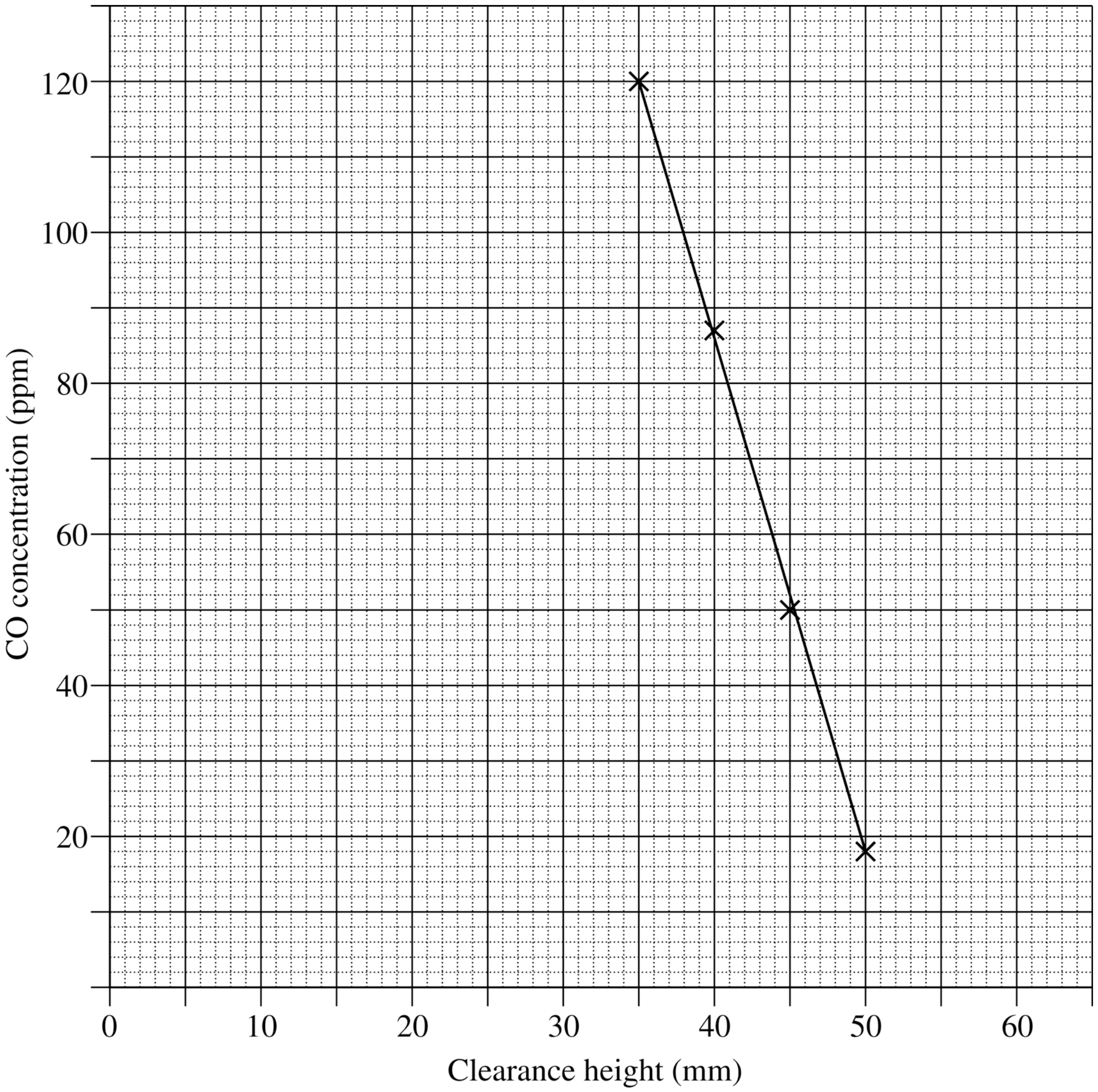
Sample answer:

Hydrochlorofluorocarbons (HCFCs) are very similar in structure and properties to CFCs, but they contain one or more H atoms. They are suitable as a propellant in aerosols, but are more reactive than a CFC because of the C–H bond, and would probably be decomposed in the troposphere. However, any gas that reaches the stratosphere would still destroy ozone because of the presence of a C–Cl bond in the molecule. This chlorine atom would behave in exactly the same way as chlorine atoms from CFCs. Overall the compound is not suitable as a CFC replacement for aerosols because it would still destroy ozone.

Question 28 (a)

Criteria	Marks
• Labels axes correctly including units • Uses appropriate scale • Plots points correctly • Rules line of best fit	3
• Provides a substantially correct graph	2
• Includes ONE correct feature	1

Sample answer:



Question 28 (b)

Criteria	Marks
• Identifies the minimum clearance height	1

Sample answer:

From the graph, the minimum height above the flame is 48 mm.

Question 28 (c)

Criteria	Marks
• Provides correct steps in the calculation of the maximum water temperature using relevant fuel efficiency and CO concentration data	4
• Provides some steps towards calculation of maximum water temperature that can be safely achieved	2–3
• Provides some relevant information	1

Sample answer:

- To be safe CO concentration, clearance height must be 47–48 mm
- Fuel efficiency at this height is 40%
- $\therefore \Delta H = 40\% \times 2877 = 1151 \text{ kJ mol}^{-1}$
- $\text{Mol butane available} = \dfrac{m}{M} = \dfrac{15.0}{58.12}$
  $= 0.258 \text{ mol}$
- Energy from 0.258 mol butane (at 48 mm)
  $= 0.258 \times 1151$
  $= 297 \text{ kJ}$
- $q = mC\Delta T$
  $297000 \text{ J} = 1.0 \times 4.18 \times 10^3 \times \Delta T$
  $\therefore \Delta T = 71.1°\text{C}$
- Since starting temperature = 20°C the water could reach 91.1°C.

Question 29 (a)

Criteria	Marks
• Explains why Na_2CO_3 can form a standard solution	2
• Provides some relevant information	1

Sample answer:

Because Na_2CO_3 is a stable compound that does not readily absorb water from the atmosphere, an accurate weight of Na_2CO_3 can be obtained (weighed out).

Question 29 (b)

Criteria	Marks
• Applies correct process to calculate HCl concentration to four significant figures	3
• Provides some relevant steps for the calculation of HCl concentration	2
• Provides a relevant step in the calculation	1

Sample answer:

$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$
Average titre = 21.65 mL
No. moles $Na_2CO_3 = 0.1050 \times 0.02500 = 0.002625$ mol
Molar ratio = 2:1
No. moles HCl = 2×0.002625
= 0.005250 mol HCl
$C = n/V = 0.005250 \div 0.02165 = 0.2425$ mol L^{-1}

Question 29 (c)

Criteria	Marks
• States the effect on HCl concentration of using phenolphthalein • Explains why HCl concentration would be higher	2
• Identifies an effect of using phenolphthalein on the results	1

Sample answer:

Calculated concentration of HCl would be higher because the colour change of phenolphthalein would occur with a lower volume of acid added.

Question 30

Criteria	Marks
• Analyses factors that affect CO_2 equilibrium, with reference to scientists' observations • Relates burning of fossil fuels to changing conditions and draws out implications • Includes relevant equations	7
• Explains factors that affect CO_2 equilibrium with reference to scientists' observations • Relates burning of fossil fuels to changing conditions • Includes relevant equation(s)	6
• Describes factors that affect CO_2 equilibrium with reference to scientists' observations	4–5
• Identifies factors that affect CO_2 equilibrium AND • Outlines at least one of the factors OR • Describes a factor that affects CO_2 equilibrium	3
• Identifies factors that affect CO_2 equilibrium OR • Outlines a factor that affects CO_2 equilibrium	2
• Provides some relevant information	1

Sample answer:

1. Combustion of fossil fuels releases CO_2 and heat energy, both of which are released into the atmosphere. Increased burning of fossil fuels will contribute to further rises in atmospheric CO_2.

eg Burning octane $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$ ΔH –ve

2. Carbon dioxide combines with water according to the following equilibrium. The reaction is exothermic.

$$CO_2(g) + H_2O(l) \leftrightarrow H_2CO_3(aq) \leftrightarrow H^+(aq) + HCO_3^-(aq) \qquad \Delta H \text{ –ve}$$

- This is an equilibrium and by Le Chatelier's Principle (LCP) when the system is altered the reaction will oppose this change. Factors that affect equilibrium are temperature, pressure and concentration of reactants and products.

- As the concentration of CO_2 in the air rises, so will the pressure due to CO_2 and the system will oppose this by absorbing more CO_2 into the oceans removing it from the air. This explains why the scientists have measured increasing levels of CO_2 in oceans.

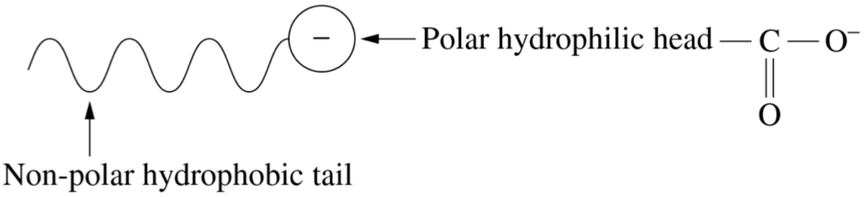
- However, this equilibrium is exothermic meaning that as temperature rises by LCP the reverse reaction is favoured, decreasing the amount of CO_2 dissolving in the oceans. If global temperatures continue to rise, oceans may release CO_2 rather than absorbing it.

Section II

Question 31 (a) (i)

Criteria	Marks
• Shows the structure of a soap molecule using a labelled diagram	2
• Provides some relevant information	1

Sample answer:

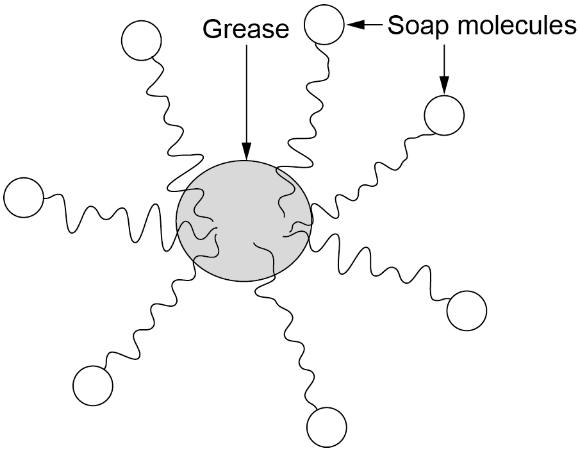


Question 31 (a) (ii)

Criteria	Marks
• Explains the cleaning action of soap	3
• Describes the cleaning action of soap	2
• Provides some relevant information	1

Sample answer:

When a soap molecule is in water and meets a grease or oil particle, a micelle is formed.



This whole ball of soap and grease is a micelle. All the non-polar ends of the soap molecule are dissolved into the grease with dispersion forces (which is non-polar). The polar heads of the soap are soluble in the polar solvent, water, through attractive forces such as non-dipole forces and dipole-dipole/hydrogen bonding to form a micelle which can be lifted away by the water. The water and the grease form an emulsion.

Question 31 (b) (i)

Criteria	Marks
• Relates a property of sulfuric acid to a condition for its safe transport and storage	2
• Provides some relevant information	1

Sample answer:

Concentrated sulfuric acid is mostly molecular, meaning there are very few H^+ ions, as it does not dissociate. Therefore, if there is no water, it will not react with metal, and can be safely stored and transported in steel or metal tanks.

Question 31 (b) (ii)

Criteria	Marks
• Explains observations for both reactions • Includes relevant equations	4
• Describes the investigations and observations made when sulfuric acid acts as an oxidant and as a dehydrating agent • Includes one relevant equation	3
• Outlines the investigations and/or observations made when sulfuric acid acts as an oxidant and/or as a dehydrating agent	2
• Provides some relevant information	1

Sample answer:

As an oxidising agent: when a metal is placed in dilute sulfuric acid, the metal reacts and a colourless gas is produced. The dilute acid is reduced (gains electrons) and causes the metal to be oxidised (loses electrons).

$Mg(s) \rightarrow Mg^{2+} + 2e$

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

As a dehydrating agent: when concentrated sulfuric acid is added to sucrose, a black mass rises up out of the container. When the water molecules are removed, a black mass of carbon remains.

$C_{12}H_{22}O_{11}(s) \rightarrow 12C(s) + 11H_2O(g)$

Question 31 (c) (i)

Criteria	Marks
• Justifies TWO relevant conditions	3
• Justifies ONE relevant condition	2
• Provides some relevant information	1

Sample answer:

Adding excess chloride ion, such as adding sodium chloride solution, will shift the equilibrium position towards the right to minimise the change. This position is away from Cl ion (on the left) and will increase the concentration of $[CoCl_4]^{2-}$, which is blue.

Changing the temperature by heating the solution, will drive the reaction to the right, as the reaction is endothermic, and therefore the equilibrium position will shift to counteract that change. This will increase the concentration of the blue $[CoCl_4]^{2-}$.

Question 31 (c) (ii)

Criteria	Marks
• Provides correct steps in the calculation of the equilibrium concentration of HI	4
• Solves equilibrium expression, using appropriate equilibrium concentrations	3
• Provides some relevant calculations steps	2
• Provides some relevant information	1

Sample answer:

$H_2 + I_2 \rightleftharpoons 2HI$

$$K = 64 = \frac{[HI]^2}{[H_2][I_2]}$$

	H_2	I_2	HI
Initial	0.20	0.20	0
Change	x	x	$2x$
Equilibrium	$0.20 - x$	$0.20 - x$	$2x$

Calculate x $\quad 64 = \frac{(2x)^2}{(0.20 - x)(0.20 - x)}$

$64(0.20 - x)^2 = (2x)^2$

Take $\sqrt{\ }$ $\quad = 8(0.20 - x) = 2x$

$1.6 - 8x = 2x$

$x = 0.16$

Therefore [HI] = 0.32 mol L^{-1}

Question 31 (d)

Criteria	Marks
• Explains how environmental issues associated with the industrial production of sodium hydroxide and sodium carbonate can be addressed • Includes relevant chemical equations	7
• Describes how environmental issues associated with the industrial production of sodium hydroxide and sodium carbonate can be addressed • Includes at least one relevant chemical equation	6
• Describes how environmental issues associated with the industrial production of sodium hydroxide and/or sodium carbonate can be addressed	4–5
• Outlines environmental issue(s) and/or solution(s) associated with the industrial production of sodium hydroxide and/or sodium carbonate	2–3
• Provides some relevant information	1

Sample answer:

Sodium carbonate is produced by the Solvay process. Limestone is obtained from quarries and used to make CaO and CO_2. Brine (salt solution) has ammonia bubbled into it and then in a tower, CO_2 is bubbled through the ammoniated brine, producing $NaHCO_3$. The $NaHCO_3$ is heated to make Na_2CO_3.

$CaCO_3\ (s) \rightarrow CaO(s) + CO_2(g)$

$NH_3(g) + H_2O(l) + NaCl(aq) \rightarrow NH_4OH(aq) + NaCl(aq)$

$NH_4OH(aq) + NaCl(aq) + CO_2(g) \rightarrow NaHCO_3(aq) + NH_4Cl(aq)$

$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$

Environmental issues associated with Na_2CO_3 include the production of $CaCl_2$ as waste for which there is little market demand and so it is disposed of in landfill or in the rivers. This has caused rivers to silt up. To address this, plants have been sited near the ocean, where $CaCl_2$ can be disposed of with little adverse effect.

Ammonia is a toxic air pollutant and can cause respiratory distress. It can be recovered for reuse, but it should be monitored carefully in case of leaks. The process is exothermic and releasing cooling water into waterways is thermal pollution which can cause the dissolved oxygen to drop and will affect aquatic life in the waterway. This can be addressed by cooling the water in towers or ponds before release.

Sodium hydroxide, NaOH, can be manufactured by the diaphragm process.

Anode: $2Cl^- \rightarrow Cl_2(g) + 2e^-$

Cathode: $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-$

The diaphragm cell in the past had a porous membrane made of asbestos. The use and maintenance of asbestos membranes has caused lung cancer in workers. To address this, other methods have been used and the asbestos diaphragm phased out.

The mercury cell manufactures NaOH and it uses toxic mercury to form an amalgam with Na:

$2Cl^- \rightarrow Cl_2(g) + 2e^-$

$Na^+ + e^- \rightarrow Na(s)$ (Na/Hg amalgam)

$Na(s) + 2H_2O \rightarrow 2NaOH + H_2$ (Hg is recovered)

Mercury is toxic and bioaccumulates in aquatic organisms. These concerns have been addressed by using the membrane process. The membrane process uses an ion selective membrane which allows migration of the Na ions, but not the Cl ion. It uses no mercury or asbestos.

Question 32 (a) (i)

Criteria	Marks
• Identifies THREE appropriate variables	2
• Identifies an appropriate variable	1

Sample answer:

Composition of electrode, the voltage and surface area of electrodes

Answers could include:

Distance apart of electrodes

Question 32 (a) (ii)

Criteria	Marks
• Correctly calculates minimum voltage	3
• Provides some relevant steps to calculate minimum voltage	2
• Provides some relevant information	1

Sample answer:

At the anode, bromide ions are oxidised.

$2Br^- \rightarrow Br_2(aq) + 2e^-$ -1.10 V

At the cathode, water would be reduced.

$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-$ -0.83 V

Therefore, total cell voltage is $-1.10 - 0.83 = -1.93$ V
Therefore, a voltage greater than 1.93 V is required to drive this cell.

Question 32 (b) (i)

Criteria	Marks
• Outlines a suitable procedure that could be used to compare corrosion rates of iron and steel	2
• Provides some relevant information	1

Sample answer:

A small sample of iron is placed in a test tube and covered with water. A sample of mild steel is treated in the identical way. Both samples are left for three weeks and observations made daily.

Question 32 (b) (ii)

Criteria	Marks
• Explains the process of rusting • Includes equations for the reactions that occur at the anode and cathode	4
• Describes the process of rusting and includes a relevant equation OR • Explains the process of rusting without providing any correct equations	3
• Outlines the process of rusting	2
• Provides some relevant information	1

Sample answer:

Rusting is the corrosion of iron to form hydrated iron(III) oxide.

Iron will rust when it is in contact with both oxygen and water. Impurities in the iron, eg carbon, act as the cathode.

In the process of the rusting of iron:

The iron is the anode and is oxidised:
$Fe \rightarrow Fe^{2+} + 2e^-$

The reduction of oxygen occurs at the cathode:
$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

Electrons move from the anode to the cathode through the iron. The anode and the cathode may be separated by some distance. Insoluble iron(II) hydroxide is formed and the iron(II) ions are further oxidised to produce hydrated iron(III) oxide, or rust.

Question 32 (c) (i)

Criteria	Marks
• Explains how the rusticles were formed • Identifies the anode and cathode reactions	3
• Explains how the rusticles were formed without providing any equations OR • Outlines how the rusticles were formed with ONE relevant equation	2
• Provides some relevant information	1

Sample answer:

Rusticles are formed by bacterial corrosion. This corrosion is caused by anaerobic bacteria that obtain their energy by reducing sulfates to sulfides. The reduction half reaction at the cathode is:

$SO_4^{2-}(aq) + 5H_2O(l) + 8e^- \rightarrow HS^-(aq) + 9OH^-(aq)$

The oxidation half reaction at the anode is:

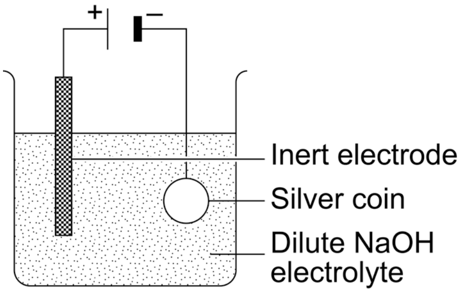
$Fe(s) \rightarrow Fe^{2+} + 2e^-$

The Fe^{2+} ions then react with the HS^- ions and the OH^- ions to form both iron(II) sulfide and iron(II) hydroxide.

Question 32 (c) (ii)

Criteria	Marks
• Compares TWO methods of restoring tarnished silver • Includes relevant chemistry	4
• Describes TWO methods of restoring tarnished silver	3
• Identifies TWO methods of restoring tarnished silver OR • Outlines ONE method of restoring tarnished silver	2
• Provides some relevant information	1

Sample answer:

Abrasive cleaning	**Electrolytic cleaning**
Mechanical process	Chemical process  Electrolysis will cause the silver sulfide to be reduced to silver metal. $Ag_2S(s) + 2e^- \rightarrow 2Ag(s) + S^{2-}(aq)$
Fast and inexpensive	Slower, expensive
Requires simple equipment	Requires specialised equipment
Fine detail is lost	Fine detail is restored

Question 32 (d)

Criteria	Marks
• Shows thorough understanding of advances in chemistry relevant to corrosion protection • Relates advances in chemistry to improved corrosion protection of steel ships • Includes a relevant equation	7
• Shows sound understanding of advances in chemistry relevant to corrosion protection • Links advances in chemistry to improved corrosion protection • Includes a relevant equation	6
• Shows an understanding of advances in chemistry relevant to corrosion protection and/or methods of corrosion protection including underlying chemistry	4–5
• Outlines method(s) of corrosion protection and/or advances in chemistry	2–3
• Provides some relevant information	1

Sample answer:

Painting ships to protect from rust has been used for over a hundred years but with advanced understanding of polymers, new polymer-based paints have been developed, which bond extremely strongly to the steel making it impermeable to air and water. These paints contain additives that react with surface atoms of the steel to form a layer of a very insoluble ionic substance called pyroaurite. These paints are comparatively cheap but they can be damaged and protection ceases.

Understanding of the chemistry of surface alloys has led to new alloys that have been recently developed. By bombarding the ship's hull with a plasma stream containing nickel and chromium the surface of the steel becomes like stainless steel and is very resistant to corrosion due to the passivating properties of the chromium. This is a much more expensive method but is resistant to most scrapes and bumps.

The work of scientists like Volta and Faraday explains the chemistry behind galvanic cells and electrolysis, leading to the technology of galvanic protection which is another way ships can be protected with sacrificial electrodes. By attaching blocks of zinc or magnesium at regular intervals on the hull, the iron can be protected. This occurs because the more reactive metal oxidises eg $Zn \rightarrow Zn^{2+} + 2e^-$, which gives the electrons to the iron which stops or even reverses rusting, that is, $Fe^{2+} + 2e^- \rightarrow Fe$. This is relatively cheap but the blocks of zinc need regular replacement and they only protect the steel for several metres around their location.

Question 33 (a) (i)

Criteria	Marks
• Identifies TWO main stages of cellular respiration and the location where each occurs	2
• Provides some relevant information	1

Sample answer:

- Glycolysis – cytoplasm
- The tricarboxylic acid cycle (answers could include TCA cycle or Krebs cycle or Citric acid cycle) – mitochondria

Answers could include:

- The cytochrome chain (answers could include oxidative phosphorylation or electron transfer) – mitochondria.

Question 33 (a) (ii)

Criteria	Marks
• Describes the first stage of cellular respiration	3
• Outlines a stage of cellular respiration	2
• Provides some relevant information	1

Sample answer:

Glycolysis, the first stage of cellular respiration is an anaerobic process.

Glycolysis involves the 6-carbon molecule glucose being broken down to two 3-carbon pyruvate molecules.

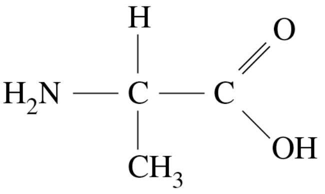
2 ATP molecules must be used to split glucose into the 2 pyruvates but the glycolysis reaction produces four ATP, resulting in a net gain of two ATP.

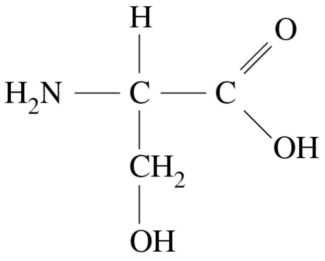
Glycolysis also results in the production of 2 NADH molecules, which are used in the electron transport chain to produce more ATP.

Question 33 (b) (i)

Criteria	Marks
• Draws correct structural formulae of the TWO amino acids	2
• Draws partially correct structural formulae OR • Draws ONE correct structural formula	1

Sample answer:





Question 33 (b) (ii)

Criteria	Marks
• Explains how forces and bonds are responsible for the shape of the protein molecule	4
• Describes forces and/or bonds responsible for the shape of a protein	3
• Outlines some factors that contribute to protein structure	2
• Provides some relevant information	1

Sample answer:

The overall three-dimensional shape of an entire protein molecule is the tertiary structure which is determined by the bonds that form between the side-chain groups of the amino acids.

Hydrophobic side-chains tend to fold inwards to the interior of the protein molecule where they are shielded from the aqueous medium and can interact with each other.

The formation of disulfide bridges is an important aspect of the stabilisation of protein tertiary structure, allowing different parts of the protein chain to be held together covalently.

Hydrogen bonds may form between different side-chain groups and can bring together two parts of a chain that are some distance away in terms of sequence of amino acids.

Electrostatic forces between positively and negatively charged sites on amino acid side-chains also help to stabilise the tertiary structure of a protein.

Question 33 (c) (i)

Criteria	Marks
• Describes how glucose monomers combine to form a branched polymer of glycogen	3
• Outlines formation of glycogen from glucose monomers	2
• Provides some relevant information	1

Sample answer:

Glucose is a six-carbon ring structure with two sites at which additional glucose molecules can bond to form a condensation polymer. Glycogen is a polymer of glucose residues which can be linked to form either *α*– (1,4) – or *α*– (1,6) – glycosidic bonds.

Question 33 (c) (ii)

Criteria	Marks
• Provides correct steps in calculation of oxygen available • Provides equation for respiration • Makes relevant decision as to whether oxygen supply is adequate	4
• Provides some correct steps in calculation of oxygen available • Makes relevant decision as to whether oxygen supply is adequate AND/OR provides equation for respiration	2–3
• Provides some relevant information	1

Sample answer:

Equation for respiration:

$C_6H_{12}O_6(aq) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$

300 kJ ÷ (2997 – 181) kJ mol^{-1} glucose required = 0.1065 mol

0.1065 × 6 = 0.64 mol oxygen required

In a 5-minute run 5 × 3.5 L = 17.5 L O_2 available
Mol O_2 = 17.5 ÷ 24.79 = 0.71 mol available

Therefore oxygen supply is adequate.

Question 33 (d)

Criteria	Marks
• Shows a thorough understanding of the structure of muscle cells and its function in relation to gentle exercise and sprints • Relates the structure of muscle cells to the function it performs in gentle exercise and in sprints	7
• Shows a sound understanding of the structure of muscle cells and its function in relation to gentle exercise and sprints • Links the structure of muscle cells to the function it performs in gentle exercise and in sprints	6
• Describes the structure of muscle cells and its function in relation to gentle exercise and/or sprints OR • Outlines structural features of muscle cells and their function in relation to gentle exercise and sprints	4–5
• Outlines a structural feature of muscle cells and/or function in relation to gentle exercise and/or sprints	2–3
• Provides some relevant information	1

Sample answer:

Skeletal muscle is composed of muscle fibres, each of which is a single cell. Cells are long, cylindrical in shape and have many nuclei. There are two types of muscle cells: type 1 (slow twitch) muscle cells which are mainly used for gentle exercise and type 2 (fast twitch) muscle cells which are used in fast, vigorous exercise such as sprints.

Both types of muscle cell are bundles of about one thousand fibrils, consisting of thick and thin filaments. The thick filaments consist of a protein called myosin and the globular heads of the myosin project to form crosslinks with a protein called actin contained in the thin filaments. In a relaxed muscle, the actin and myosin are prevented from coming into contact by two other proteins, troponin and tropomyosin, which are located in the thin filaments.

Whether sprinting or exercising gently, muscle contraction starts when an electrical impulse causes release of calcium ions in the muscle. The calcium ions cause the troponin-tropomyosin complex to change shape and expose a site on the actin where myosin can bind. This allows the thin actin filaments and the thick myosin filaments to slide past each other, so that the filaments overlap to a greater extent than when the muscle is relaxed. This is called the ‘sliding filament model’ and occurs in both types of muscle.

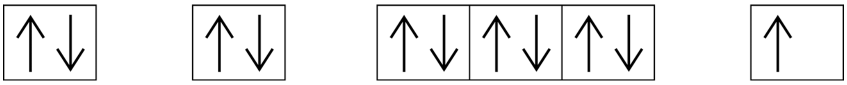
Although the basic mechanism for contraction is the same in gentle exercise and sprints, gentle exercise involves type 1 muscles. These are designed to contract slowly and steadily and as such contain fewer contractile fibres. As these muscles undergo aerobic respiration, they have a rich blood supply to supply adequate O_2 and many mitochondria, obtaining most of their ATP through oxidative phosphorylation. They use a variety of food sources to obtain energy such as glucose, fatty acids and amino acids.

Sprinting, however, involves type 2 muscles. These are designed to contract relatively rapidly and so contain many contractile fibres. Type 2 muscles require maximum energy in a short time which is supplied by anaerobic glycolysis and thus have a reduced blood flow (hence O_2) with few mitochondria. They use available glucose and stored glycogen as their energy sources. The formation of lactic acid (with its resulting pH drop) causes muscle fatigue and cramps, thus limiting the time a sprint can be maintained.

Question 34 (a) (i)

Criteria	Marks
• Correctly draws diagram to show the electron configuration of sodium	2
• Provides some relevant information	1

Sample answer:



Question 34 (a) (ii)

Criteria	Marks
• Explains filling of sub-shells with reference to the relative energy levels of shells and sub-shells	3
• Shows an understanding of the order of filling shells and sub-shells	2
• Provides some relevant information	1

Sample answer:

Within an atom, there are major energy levels called shells which are numbered 1, 2, 3, 4. Within the shells are energy levels of similar energy called sub-shells (s, p, d, f).

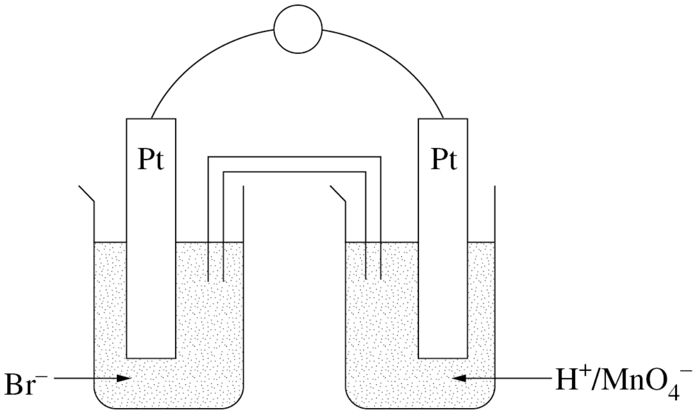
Some sub-shells are higher in energy than sub-shells of the next shell. For example, the d sub-shell of the 3rd shell (3d) is higher in energy than the s sub-shell of the 4th shell (4s). The order of energies in the sub-shells is 1s>2s>2p>3s>3p>4s>3d>4p. Therefore the 4s will be filled before the 3d.

Question 34 (b) (i)

Criteria	Marks
• Outlines a procedure to determine the oxidising strength of potassium permanganate	2
• Identifies some features of a suitable procedure	1

Sample answer:

Set up a galvanic cell as shown in the diagram.



Repeat the procedure using fluoride and chloride solutions. Compare observations of colour change in each cell.

Question 34 (b) (ii)

Criteria	Marks
• Uses correct results to justify a conclusion • Includes correct half equations	4
• Describes observations of procedure • Writes correct half equation(s)	3
• Provides some observations of procedure AND/OR • Writes correct half equation(s)	2
• Provides some relevant information	1

Sample answer:

Observations: The $H^+/KMnO_4$ will decolourise and the Br^- will turn brown/orange.
If Cl^- is used, yellow-green chlorine gas is evolved, and the $H^+/KMnO_4$ will decolourise.
In F^-, no change is observed.

Conclusion: $KMnO_4$ is strong enough to oxidise bromide and chloride, but not fluoride.

Justification:

$$MnO_4^- + 8H^+ + 5e^- \longleftrightarrow Mn^{2+} + 4H_2O \qquad E^0 = 1.51\text{ V}$$

$$Cl^- \longleftrightarrow \frac{1}{2}Cl_2(g) + e^- \qquad = -1.36\text{ V}$$

$$F^- \longleftrightarrow \frac{1}{2}F_2(g) + e^- \qquad = -2.89\text{ V}$$

Question 34 (c) (i)

Criteria	Marks
• Clearly shows the distinguishing feature(s) of each of the spectra	3
• Outlines feature(s) of an absorption spectrum and/or an emission spectrum	2
• Provides some relevant information	1

Sample answer:

- An absorption spectrum is the result of white light first passing through a substance in the vapour phase, producing a pattern of dark lines across a continuous spectrum when viewed through a spectrometer. The spectrum produced has certain wavelengths missing because they have been absorbed by the atoms of the vaporised element.

- An emission spectrum is produced when light from an excited atom is passed through a narrow slit and then a prism. The visible light emitted from an excited atom gives a pattern of coloured lines superimposed on a dark background.

Question 34 (c) (ii)

Criteria	Marks
• Explains the uses of infrared light and UV light in determining the chemical composition and concentration of pigments	4
• Outlines how infrared light and ultraviolet light are used to determine the chemical composition and/or concentration of pigments	3
• Identifies features of infrared light and/or ultraviolet light that lead to identification of pigments	2
• Provides some relevant information	1

Sample answer:

Both infrared (IR) light and ultraviolet (UV) light can be used to identify pigments and UV light is useful to determine the concentration of pigments.

IR radiation changes the colour of some substances. For example, zinc oxide, in the presence of oxygen, changes from white to lemon-yellow, thus aiding detection of pigments containing zinc and oxide. Similarly, red copper (1) oxide is decomposed to black copper (11) oxide with IR radiation.

IR absorption spectroscopy allows for identification of functional groups within a compound. Matching the spectrum of an unknown compound with standard spectra of known substances allows for identification of certain molecules containing known functional groups.

When UV light is shone onto some substances they absorb the light, causing them to fluoresce. For example, zinc oxide fluoresces a yellow colour and green malachite (containing copper) fluoresces a dirty mauve colour, thus allowing for identification of these chemicals.

The absorbance of UV light is directly proportional to the concentration of the substance, therefore allowing determination of the concentration. As for IR, characteristic patterns of absorbance of UV light at different wavelengths can be used to identify pigments.

Question 34 (d)

Criteria	Marks
• Explains procedures used by Aboriginal people and an ancient culture to prepare and attach pigments to surfaces • Includes the chemical composition of the pigments	7
• Describes procedures used by Aboriginal people and an ancient culture to prepare and attach pigments to surfaces • Includes chemical compositions of the pigments	6
• Describes procedure(s) used by Aboriginal people and/or an ancient culture to prepare and/or attach pigments to surfaces • Includes chemical composition of at least one pigment	4–5
• Outlines procedure(s) used by Aboriginal people and/or an ancient culture to prepare and/or attach pigments to surfaces AND/OR • Identifies the chemical composition of pigments	2–3
• Provides some relevant information	1

Sample answer:

Aboriginal cultures have used ochres for rock art and body paint for thousands of years. Pigments, such as yellow ochre, derived from rock minerals containing various hydrated iron oxides, as well as white clays and black charcoal were ground up and mixed with a liquid binder. Binders included egg, animal fat, sap, honey or wax. The liquid binder is needed for the pigment to spread and adhere to the surface. The advantage of using a binder is that the insoluble pigment particles can adhere to each other and the surface as it dries. White clays are generally from minerals such as gypsum ($CaSO_4 \cdot 2H_2O$), while yellow ochre is $Fe_2O_3 \cdot H_2O$.

Because egg as a binder is tough and long-lasting and the pigments used are chemically inert and unaffected by light, heat and water, Aboriginal art has survived for thousands of years. However most ancient Aboriginal art survives best in caves or under rock shelves where it is protected from the elements.

Ancient Egyptian cultures also used pigments for art and cosmetics. They carefully selected the ores, ground it very finely and sieved it, so it could be used as eye paint. They used copper minerals, such as malachite (green), $CuCO_3 \cdot Cu(OH)_2$ and azurite, blue. Binders such as oil, resins and saliva were used. Resins from coniferous trees and beeswax were used to adhere the pigments to surfaces. Plant-based pigments were also used such as indigo blue or pink madder lake and used as dyes for fabrics and in paints. Cosmetics used included kohl from a mixture of powdered Sb_2S_3, MnO_2, burnt almonds, lead oxide and black CuO in a saliva binder. Lead sulfide and charcoal were also used as mascara. They also used elemental gold both as thin sheets and in powdered form mixed with oils, resins or saliva to bind them to the skin.

Ancient Egyptians also found a method of dissolving vegetable dyes in water and fixing the colour onto an insoluble white powder such as chalk or gypsum which was then extracted and dried.

Question 35 (a) (i)

Criteria	Marks
• Correctly identifies the part labelled *A* • Outlines the function of the part labelled *A*	2
• Provides some relevant information	1

Sample answer:

A is a magnet. It is required to separate/bend the stream of charged particles.

Question 35 (a) (ii)

Criteria	Marks
• Outlines advantages of using mass spectrometry for analysis of a compound	3
• Identifies some advantages of mass spectrometry OR • Outlines an advantage	2
• Provides some relevant information	1

Sample answer:

The mass spectrometer is able to quickly identify components of a mixture or components in a compound by their mass/charge ratio. Mass spectrometers are able to identify different isotopes of elements in a compound which allows the compound to be matched to a sample. Mass spectrometry is both qualitative and quantitative, requires only small quantities and is accurate, fast and sensitive.

Question 35 (b) (i)

Criteria	Marks
• Outlines a suitable chemical test	2
• Provides some relevant information	1

Sample answer:

When Tollen's reagent is added to samples of glucose (a reducing sugar) and sucrose (a non-reducing sugar), and warmed, the glucose solution will darken but there will be no change to the sucrose solution.

Answers could include:

When Benedict's reagent is added to samples of glucose (a reducing sugar) and sucrose (a non-reducing sugar), and warmed, the glucose solution will form an orange/red/brown/green precipitate.

Question 35 (b) (ii)

Criteria	Marks
• Explains how structures of a reducing sugar and/or a non-reducing sugar relate to observations • Includes a relevant chemical equation	4
• Describes structures of sugars • Relates observations during a test to the structure	3
• Outlines structural feature(s) of sugar(s) AND/OR • Identifies observation(s) during a positive test	2
• Provides some relevant information	1

Sample answer:

In alkaline conditions as present in Tollen's/Benedict's/Fehling's reagents, reducing sugars, such as glucose, can convert from a ring formation to a chain formation, exposing a carbonyl group or a primary alcohol group.

This carbonyl group is easily oxidised by Ag^+/Cu^{2+} ions. The reduction of Ag^+/Cu^{2+} causes an observable colour change to form a red/orange/brown/green precipitate in the presence of a reducing sugar.

Eg Tollen's:

$$\underset{\text{colourless}}{\text{R-CHO} + 2Ag^+ + 3OH^-} \rightarrow \underset{\text{black ppt or silver mirror}}{2Ag(s) + \text{R-COO}^- + 2H_2O}$$

OR

Eg Benedict's or Fehling's:

$$\underset{\text{blue}}{\text{R-CHO} + 2Cu^{2+} + 5OH^-} \rightarrow \underset{\text{red/orange/green/brown}}{Cu_2O(s) + \text{R-COO}^- + 3H_2O}$$

Non-reducing sugars, such as sucrose, cannot convert to an open chain structure to expose a carbonyl group as their anomeric carbons are 'locked' into the glycosidic linkage R—O—R. Therefore there is no observed change in the test for the sucrose solution.

Equations could include:

$$\text{Cu2+} + \text{1e} \rightarrow \text{Cu+1} \text{ or } \text{Ag+1} + \text{1e} \rightarrow Ag(s)$$

Question 35 (c) (i)

Criteria	Marks
• Demonstrates a clear understanding of how differences in the structure of DNA is used in forensic investigations	3
• Demonstrates some knowledge of DNA structure and its usefulness in forensic investigations	2
• Provides some relevant information	1

Sample answer:

DNA molecules consist of a double helix with a deoxyribose – phosphate backbone and 4 nitrogenous bases that hydrogen bond to each other in the middle of the helix. The sugar phosphate backbone is identical in every individual, however, the order of the nitrogenous bases differs from person to person. The DNA contains coding sections (exons) which are very similar between people and non-coding sections (introns) which are very different from person to person. Differences in non-coding sections can be analysed to produce a DNA fingerprint which is unique to an individual. Close relatives have similarities in their intron structure and this can also be used in forensic investigations.

Question 35 (c) (ii)

Criteria	Marks
• Explains how DNA fragments can be separated by electrophoresis • Demonstrates a clear understanding of how a DNA profile links an individual to an evidence sample	4
• Outlines use of electrophoresis to separate DNA fragments AND/OR • Outlines use of DNA profiles to match samples to individuals	2–3
• Provides some relevant information	1

Sample answer:

Electrophoresis can be used to analyse DNA samples. The introns in the DNA molecules are cut out by restriction enzymes, producing a series of fragments. The fragments are negatively charged, and so will migrate towards the positive terminal of a gel in an electrophoresis tank. Smaller fragments will migrate through the gel more easily and quickly than larger fragments, causing a separation.

Each individual has introns of different lengths and so will produce a unique separation with electrophoresis. The bands produced on the gel can be visualised by using fluorescent or radioactive probes. No two people will produce the same pattern of bands so individuals can be accurately identified.

Question 35 (d)

Criteria	Marks
• Shows how emission spectroscopy and chromatography are similar and/or different in the analysis of small samples in forensic investigations • Shows a thorough understanding of emission spectroscopy and chromatography in this aspect	7
• Shows how emission spectroscopy and chromatography are similar and/or different in the analysis of small samples in forensic investigations • Shows a sound understanding of emission spectroscopy and chromatography in this aspect	6
• Describes emission spectroscopy and/or chromatography in relation to the analysis of small samples in forensic investigations	4–5
• Outlines features of emissions spectroscopy and/or chromatography	2–3
• Provides some relevant information	1

Sample answer:

Atomic Emission Spectroscopy is used to identify and quantify metal ions in samples. It involves producing an atomic vapour of the sample by heating it in a flame. The sample is then further heated to a very high temperature producing a hot plasma of atoms. Electrons in these atoms absorb energy and move to higher energy levels. These unstable, excited electrons then decay back to lower energy levels emitting light of specific frequencies. The various wavelengths are detected by a photomultiplier. As every atom has unique energy levels, the resulting spectrum can provide both qualitative and quantitative data about the metal ions present in a sample as the intensity of each band is related to its concentration.

Gas/Liquid Chromatography and HPLC are separation techniques based on a substances relative attraction for a stationary and a mobile phase. If a substance is more attracted to the stationary phase than the mobile phase then it will not travel very far on the chromatogram. If it is more attracted to the mobile phase then it will travel a long way on the chromatogram. The resultant peaks produced on a chromatogram can be used to identify the components of a sample (as each substance will have a specific retention time). The area under the peaks can be used to calculate the concentration of each component.

Similarities	Differences
Both only require very small samples	Chromatography is a separation technique based on solubility in stationary and mobile phases.
Both provide qualitative and quantitative data	AES is not a separation technique but compares the spectra produced when excited electrons decay to their ground state
Both techniques are very sensitive and can detect nanogram amounts of a substance	Paper chromatography is not used in forensic investigations as it is not sensitive or quantitative
Both GLC and AES involve destruction of the sample by heating to a high temperature	HPLC is a non destructive test
Can analyse multiple components of a mixture	AES can only identify elements in a mixture, HPLC and GLC can identify compounds in a mixture
	AES cannot be used for organic substances whereas HPLC and GLC can be used for organic substances.

2018 HSC Chemistry Mapping Grid

Section I
Part A

Question	Marks	Content	Syllabus outcomes
1	1	9.4.2.2.1	H3
2	1	9.4.5.2.3	H4
3	1	9.3.5.3.1, 9.3.5.2.4, 9.3.5.2.5	H8, H9
4	1	9.4.3.2.2	H1
5	1	9.2.2.2.5	H5, H9
6	1	9.3.4.2.7, 9.3.4.3.5	H3, H4
7	1	9.3.2.2.2, 9.3.2.3.2	H6, H8, H9
8	1	9.3.3.2.7, 9.3.3.3.4	H6, H8
9	1	9.3.4.2.1, 9.3.4.3.1	H1, H2
10	1	9.2.3.2.1, 9.2.3.2.2, 9.2.3.3.1	H8, H9
11	1	9.2.1.2.8	H9
12	1	9.2.4.2.3	H6, H14
13	1	9.3.5.2.3, 9.3.5.3.1	H8, H9
14	1	9.4.4.2.9, 9.4.4.3.2	H13
15	1	9.3.2.2.4, 9.3.4.2.9	H8
16	1	9.4.3.2.1, 9.4.3.3.1, 9.4.3.3.2, 9.4.5.3.1	H10, H11, H12
17	1	9.3.2.2.5, 9.3.4.2.9	H13
18	1	9.3.3.2.3, 9.3.3.2.5, 9.3.3.2.6	H10
19	1	9.2.4.3.1, 9.2.4.3.4, 9.2.4.2.5	H13, H14
20	1	9.4.5.2.1, 9.4.5.3.1	H10, H12, H13

Section I
Part B

Question	Marks	Content	Syllabus outcomes
21 (a)	1	9.2.1.2.2	H9
21 (b)	2	9.2.1.2.7	H13
22	4	9.4.3.3.1, 9.4.3.2.1	H8, H11, H13
23 (a)	2	9.3.5.2.2, 9.3.5.2.4	H13
23 (b)	4	9.3.5.3.1, 9.3.5.2.5, 9.3.5.2.6	H9, H11
24 (a)	1	9.2.3.2.6	H13
24 (b)	3	9.2.3.3.4	H9, H10
25	4	9.4.2.2.5, 9.4.2.2.7, 9.4.2.2.8	H8
26 (a)	2	9.2.5.2.4	H1, H3, H4
26 (b)	5	9.2.5.2.5, 9.2.5.2.6, 9.2.5.3.2	H4, H5
27 (a)	1	9.4.4.2.9	H9
27 (b)	4	9.4.4.2.10, 9.4.4.3.3	H3, H4, H5
28 (a)	3	Graph drawing	H13

Question	Marks	Content	Syllabus outcomes
28 (b)	1	Analyse graph	H14
28 (c)	4	9.2.3.2.7	H10
29 (a)	2	9.3.4.2.8	H10, H11, H14
29 (b)	3	9.3.4.2.8, 9.3.4.3.3	H10
29 (c)	2	9.3.1.3.2	H14
30	7	9.3.2.2.3, 9.3.2.2.4, 9.3.2.2.5, 9.4.1.2.3, 9.4.4.2.2	H1, H2, H4, H5, H8

Section II

Question	Marks	Content	Syllabus outcomes
Question 31		**Industrial Chemistry**	
31 (a) (i)	2	9.5.5.2.3	H13
31 (a) (ii)	3	9.5.5.2.3, 9.5.5.2.4	H13
31 (b) (i)	2	9.5.3.3.3	H4
31 (b) (ii)	4	9.5.3.3.2, 9.5.3.2.6	H11
31 (c) (i)	3	9.5.2.2.1	H11
31 (c) (ii)	4	9.5.2.2.2, 9.5.2.3.3	H14
31 (d)	7	9.5.4.2.3, 9.5.6.2.4, 9.5.6.3.3	H4, H7
Question 32		**Shipwrecks, Corrosion and Conservation**	
32 (a) (i)	2	9.6.3.3.1	H11, H12
32 (a) (ii)	3	9.6.3.2.1	H8, H12
32 (b) (i)	2	9.6.2.3.1	H11
32 (b) (ii)	4	9.6.2.2.4, 9.6.2.3.2	H2
32 (c) (i)	3	9.6.6.2.1, 9.6.6.2.2	H8
32 (c) (ii)	4	9.6.7.2.5, 9.6.7.3.1	H3
32 (d)	7	9.6.4.2.1, 9.6.4.2.3, 9.6.4.2.4, 9.6.4.3.1, 9.6.4.3.4	H1, H3
Question 33		**The Biochemistry of Movement**	
33 (a) (i)	2	9.7.1.3.2, 9.7.7.2.1, 9.7.8.2.4	H7, H8
33 (a) (ii)	3	9.7.7.2.1, 9.7.7.2.2, 9.7.7.2.3	H9
33 (b) (i)	2	9.7.4.3.1, 9.7.4.2.3	H13
33 (b) (ii)	4	9.7.4.2.4, 9.7.4.2.5	H9
33 (c) (i)	3	9.7.2.3.1, 9.7.2.2.2, 9.7.2.2.3	H9
33 (c) (ii)	4	9.7.10.3.1, 9.7.8.2.5	H8, H9
33 (d)	7	9.7.5.2.2, 9.7.5.2.1, 9.7.5.2.3, 9.7.5.3.1, 9.7.5.3.4	H13
Question 34		**The Chemistry of Art**	
34 (a) (i)	2	9.8.3.2.4, 9.8.3.3.2	H6
34 (a) (ii)	3	9.8.3.2.5, 9.8.3.2.6, 9.8.3.2.1, 9.8.3.2.4	H6
34 (b) (i)	2	9.8.4.2.4, 9.8.4.3.4	H11, H14
34 (b) (ii)	4	9.8.4.2.4, 9.8.4.3.4, 9.8.4.3.3	H14

Question	Marks	Content	Syllabus outcomes
34 (c) (i)	3	9.8.2.2.4	H3
34 (c) (ii)	4	9.8.2.2.8, 9.8.2.2.9	H1
34 (d)	7	9.8.1.2 (all), 9.8.1.3 (all)	H3, H4, H8
Question 35		**Forensic Chemistry**	
35 (a) (i)	2	9.9.5.2.3	H2, H3
35 (a) (ii)	3	9.9.5.2.3, 9.9.1.2.2	H4, H9, H11
35 (b) (i)	2	9.9.2.3.1	H2, H11
35 (b) (ii)	4	9.9.2.3.2, 9.9.2.2.2, 9.9.2.2.3	H8, H13, H14
35 (c) (i)	3	9.9.4.2.1, 9.9.4.2.2	H4
35 (c) (ii)	4	9.9.3.2.5, 9.9.3.3.5, 9.9.4.2.3	H1, H3, H14
35 (d)	7	9.9.1.2.1, 9.9.1.3.1, 9.9.1.3.2, 9.9.5.2.1	H1, H3, H4, H11