BOARD OF STUDIES
NEW SOUTH WALES

# 2013 HSC Chemistry
# Marking Guidelines

## Section I, Part A

### Multiple-choice Answer Key

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

## Section I, Part B

### Question 21 (a)

| Criteria | Marks |
|---|---|
| • Provides a reason for the use of acids as a food preservative related to properties of acids | 2 |
| • Provides a reason for the use of acids | 1 |

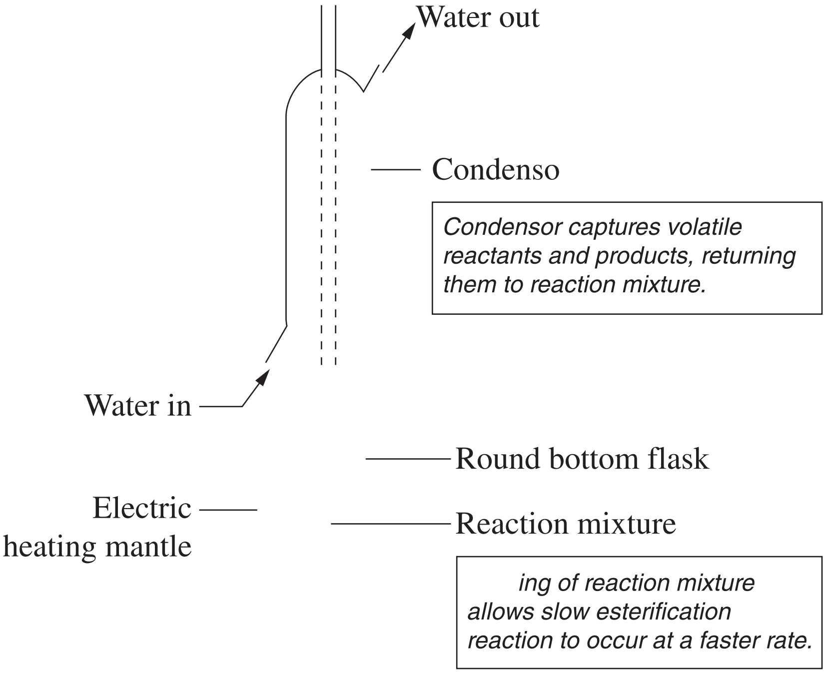
***Sample answer:***

Many microorganisms that cause spoilage of food cannot survive in low pH conditions. The acid added to a food prevents survival of these microorganisms by creating a low pH.

### Question 21 (b)

| Criteria | Marks |
|---|---|
| • Explains correctly the reasons for refluxing<br>AND<br>• Includes a well labelled correct diagram | 4 |
| • Describes a reason for refluxing<br>AND<br>• Includes a well labelled correct diagram | 3 |
| • Outlines a reason for refluxing<br>AND<br>• Includes a substantially correct diagram | 2 |
| • States a reason for refluxing<br>OR<br>• Includes a diagram recognisable as refluxing apparatus | 1 |

***Sample answer:***



*Condensor captures volatile reactants and products, returning them to reaction mixture.*

*ing of reaction mixture allows slow esterification reaction to occur at a faster rate.*

## Question 22 (a)

| Criteria | Marks |
|---|---|
| • Correctly identifies the name of Precipitate 2 | 1 |

***Sample answer:***

Barium Sulfate.

## Question 22 (b)

| Criteria | Marks |
|---|---|
| • Provides a correct, balanced net ionic equation | 2 |
| • Provides a partially correct net ionic equation | 1 |

***Sample answer:***

$Pb^{2+}(aq) + 2Cl^{-}(aq) \rightarrow PbCl_2(s)$

## Question 22 (c)

| Criteria | Marks |
|---|---|
| • Suggests a suitable test<br>AND<br>• Provides the observation expected | 2 |
| • Suggests a suitable test<br>OR<br>• Provides the observation expected | 1 |

***Sample answer:***

The remaining metal ion is $Cu^{2+}$ which can be tested by a flame test. When present $Cu^{2+}$ copper will turn the flame blue-green.

***Answers could include:***

- Tests for $Pb^{2+}$ or $Ba^{2+}$ if answers to (a) and (b) have been incorrect
- Other possible tests for $Cu^{2+}$, with their positive results

## Question 23 (a)

| Criteria | Marks |
|---|---|
| • Correct, balanced equation including solid states<br>AND<br>• All mole quantities correctly calculated<br>AND<br>• Calculation steps shown and correct significant figures used | 5 |
| • Substantially correct response with one minor error in:<br>– Equation, or<br>– Calculation, or<br>– Significant figures | 4 |
| • Substantially correct equation<br>• Attempts calculations with some working shown | 2–3 |
| • Some relevant information provided | 1 |

***Sample answer:***

$Pb(s) + 2AgNO_3(aq) \rightarrow Pb(NO_3)_2(aq) + 2Ag(s)$

$$n_{Pb} = \frac{20.72\ \text{g}}{207.2\ \text{g mol}^{-1}} = 0.1000\ \text{mol}$$

$n_{Ag} = 0.100\ \text{L} \times 1.00\ \text{mol L}^{-1} = 0.100\ \text{mol}$

Mole ratio Pb : $AgNO_3$ is 1 : 2

$\therefore$ 0.100 mol $AgNO_3$ and 0.0500 mol Pb used

Moles of remaining ions and solids

$Pb^{2+}(aq) = 0.0500$ mol
$Ag^{+}(aq) = 0$ mol
$NO_3^{-}(aq) = 0.100$ mol
$Pb(s) = 0.0500$ mol
$Ag(s) = 0.100$ mol

### Question 23 (b)

| Criteria | Marks |
|---|---|
| • Identifies an appropriate species in the mixture<br>AND<br>• Relates the species to an appropriate potential health/environmental problem(s) | 2 |
| • Identifies an appropriate species in the mixture<br>OR<br>• Identifies potential health/environmental problem | 1 |

***Sample answer:***

The reaction mixture contains lead, which is a heavy metal. Heavy metals are toxic to animals, including humans.

***Answers could include:***

Responses related to nitrates in mixture, with reference to environmental issues.

### Question 24 (a)

| Criteria | Marks |
|---|---|
| • Correctly explains the effect of decreasing the volume of the reaction vessel | 2 |
| • States an effect of decreasing the volume of the reaction vessel | 1 |

***Sample answer:***

Decreasing the volume of the reaction vessel will increase the pressure. This will drive the reaction to the right hand side as there are fewer moles of gas on this side of the equation.

### Question 24 (b)

| Criteria | Marks |
|---|---|
| • Correctly explains the effects of adding a catalyst to this reaction | 2 |
| • States ONE effect of adding a catalyst in general terms<br>OR<br>• States no overall change | 1 |

***Sample answer:***

Adding a catalyst to the equilibrium mixture will have no visible effect on the reaction mixture. This is because a catalyst will speed up the rate of both the forward and the reverse reactions.

## Question 25

| Criteria | Marks |
|---|---|
| • Clearly articulates that indicators work through equilibrium processes, linking cause and effect through Le Chatelier's principle<br>• Includes a chemical equation, correctly using the symbols given | 4 |
| • Some links made between the action of indicators and equilibrium reactions, with reference to the symbols given<br>OR<br>• Correct equations and use of symbols for an acid and base showing the action of the indicator without reference to equilibrium | 3 |
| • Describes the action of indicators without the use of a chemical equation or reference to equilibrium | 2 |
| • States one relevant concept | 1 |

***Sample answer:***

An indicator needs to change colour in different pH conditions. The solution would have the equilibrium:

$$\underset{\text{red}}{\text{HInd}(aq)} + H_2O(l) \rightleftharpoons \underset{\text{green}}{\text{Ind}^-(aq)} + H_3O^+(aq)$$

When a base is present, the concentration of $H_3O^+$ will be reduced. Le Chatelier's principle predicts the equilibrium will shift to the right, increasing the ionisation of the indicator. This shift causes the green colour to dominate.

Alternatively, when an acid is present the increased concentration of $H_3O^+$ will shift equilibrium left and the red colour will dominate.

***Answers could include:***

Separate equations to illustrate the response to an acid and a base.

## Question 26

| Criteria | Marks |
|---|---|
| • Response includes a detailed description of the composition and design of microscopic membrane filters. Comprehensively links the purification of contaminated water to this composition and design | 4 |
| • Response includes a description of the composition and design of microscopic membrane filters, and relates this to how these filters purify contaminated water | 3 |
| • Response includes a description of the composition and design of microscopic membrane filters<br>OR<br>• Includes a brief outline of the composition or design of microscopic membrane filters with reference to how they purify contaminated water | 2 |
| • Response gives a description of filtration<br>OR<br>• Response gives some features of the design or composition of membrane filters | 1 |

***Sample answer:***

These filters consist of a thin film of polymer eg polypropylene, with tiny pores (typically about 0.2 $\mu$m in size). The polymer is rolled into a thin, hollow tube and large numbers are bundled together to form a filtration unit. Dirty water flows along the outside of the tube, under pressure. Small particles, such as water molecules and ions, can pass through the pores while larger particles such as bacteria and protozoa are trapped by the membrane.

***Answers could include:***

Other feasible polymers. A labelled diagram.

## Question 27

| Criteria | Marks |
|---|---|
| • Calculates moles of ethanol<br>AND<br>• Calculates heat transferred<br>AND<br>• Correctly identifies temperature change from graph<br>AND<br>• Appropriately calculates specific heat capacity including units | 4 |
| • Calculations substantially correct | 3 |
| • At least ONE substantially correct calculation is given | 2 |
| • Some relevant data is given | 1 |

***Sample answer:***

$${}^{n}C_2H_5OH = \frac{m}{M} \qquad = \frac{0.259\ \text{g}}{46.068\ \text{g mol}^{-1}} \qquad = 0.00562212\ \text{mol}$$

$$Q = \rho\ H_{C_2H_5OH} \times n \qquad = 1367\ \text{kJ mol}^{-1} \times 0.00562212\ \text{mol}$$

$$= 7.68543\ \text{kJ} \qquad = 7685.43\ \text{J}$$

$$C = \frac{q}{m \times \Delta t}$$

$$= \frac{7685.43\ \text{J}}{0.120\ \text{kg} \times 30\ \text{K}} \qquad = \frac{7685.43\ \text{J}}{3.600\ \text{kg K}}$$

$$= 2134.84\ \text{J kg}^{-1}\ \text{K}^{-1}$$

$$= 2.13 \times 10^3\ \text{J kg}^{-1}\ \text{K}^{-1}$$

**Question 28 (a)**

| Criteria | Marks |
|---|---|
| • Identifies the mistake made<br>AND<br>• Provides a proposed change that would improve the validity of the result | 2 |
| • Identifies the mistake made | 1 |

***Sample answer:***

Instead of blowing through the pipette, student should have touched the end of pipette to surface of flask to draw out the liquid.

**Question 28 (b)**

| Criteria | Marks |
|---|---|
| • Relates correctly the decreased number of moles caused by both steps to a decrease in volume of HCl to produce an overall increase in calculated concentration | 3 |
| • Identifies both mistakes and relates them to a reduction of moles<br>OR<br>• Relates reduced moles of one step to increased HCl concentration as calculated | 2 |
| • Identifies the reduced number of moles caused by either step<br>OR<br>• Identifies both mistakes | 1 |

***Sample answer:***

In step 2, rinsing the pipette with water would decrease the number of moles of $Na_2CO_3$ it contains. This would be compounded by not filling to the mark made in step 3, resulting in the pipette having fewer moles of $Na_2CO_3$.

Hence, a lower volume of the HCl would be added from the burette, but the student would think that there were more moles of HCl in this volume. So, they will calculate the concentration of the acid solution to be higher than the actual value.

## Question 29

| Criteria | Marks |
|---|---|
| • Determines that the reaction will not be spontaneous<br>AND (ONE of the following)<br>– Refers to explicit $E^{\ominus}$ values from standard potential table<br>OR<br>– Justifies response using oxidation strength<br>OR<br>– Justifies response using position on the periodic table and electronegativities | 2 |
| • Determines that the reaction will not be spontaneous<br>AND<br>• Partially justifies response appropriately<br>OR<br>• Determines that the reaction will be spontaneous<br>AND<br>• Provides a logical justification | 1 |

***Sample answer:***

No, the reaction will not occur spontaneously. With reference to the standard potential table:

$$\begin{array}{ll} 2\text{Cl}^-(aq) \rightarrow \text{Cl}_2(g) + 2e^- & E^{\ominus} = -1.36\text{ V} \\ \text{Br}_2(l) + 2e^- \rightarrow 2\text{Br}^- & E^{\ominus} = +1.08\text{ V} \\ \hline & \underline{E^{\ominus} = -0.28\text{ V}} \end{array}$$

The negative $E^{\ominus}$ suggests that the reaction will go from right to left spontaneously, not left to right.

***Answers could include:***

1. Referral to chlorine being a stronger oxidant than bromine
2. Referral to periodic table and chlorine being more electronegative than bromine

## Question 30

| Criteria | Marks |
|---|---|
| • Correctly identifies the decrease in ozone between 1979–1994 and accounts for the change<br>• Includes relevant equations to show conversion of ozone to oxygen<br>• Correctly identifies the increase in ozone between 1994–2012 and accounts for the change<br>• Response should demonstrate coherency and present information in a logical way | 6 |
| • Correctly identifies the changes between 1979–1994 and 1994–2012 and accounts for the changes<br>• Includes relevant equations for converting ozone to oxygen | 4–5 |
| • Correctly identifies the changes between 1979–1994 and 1994–2012 with some attempt to account for the changes | 2–3 |
| • Some relevant information provided | 1 |

***Sample answer:***

The concentration of ozone above the South Pole decreased between 1979–1994. The decrease in ozone concentration was attributed to the prevalence of CFCs in the atmosphere. CFCs react (photo dissociate) to form chlorine radicals which are included in the conversion of ozone to molecular oxygen.

$$CCl_3F(g) + \text{uv} \rightarrow CCl_2F\bullet(g) + Cl\bullet(g)$$

$$Cl\bullet(g) + O_3(g) \rightarrow ClO\bullet(g) + O_2(g)$$

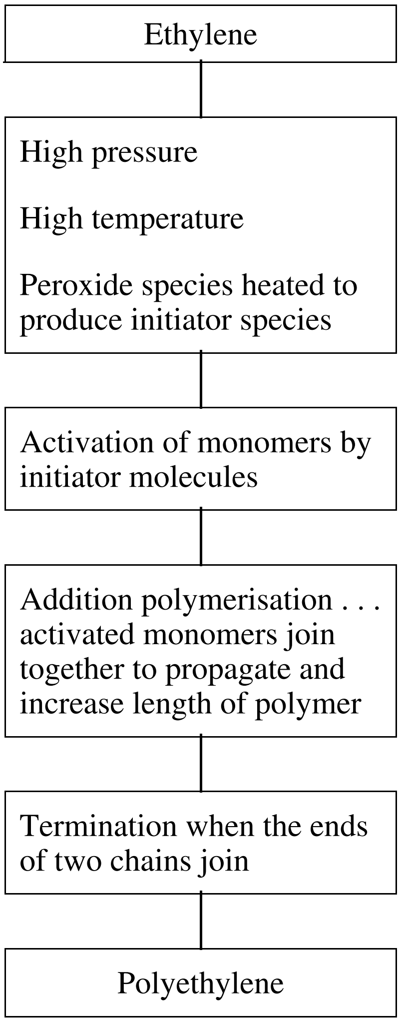
Since 1994 the concentration has begun to increase. A possible reason to explain this increase is the introduction of international agreements such as the Vienna Convention and the Montreal Protocol. These international agreements mandated a replacement of CFCs due to their ozone depletion potential (ODP). Alternatives to CFCs include HCFCs and HFCs which have a significantly lower ODP. The replacement of CFCs has resulted in a reduction in their atmospheric levels since the international agreements were enforced. This has seen the atmospheric concentration of ozone begin to increase, as shown by the 2012 ozone map.

## Question 31 (a)

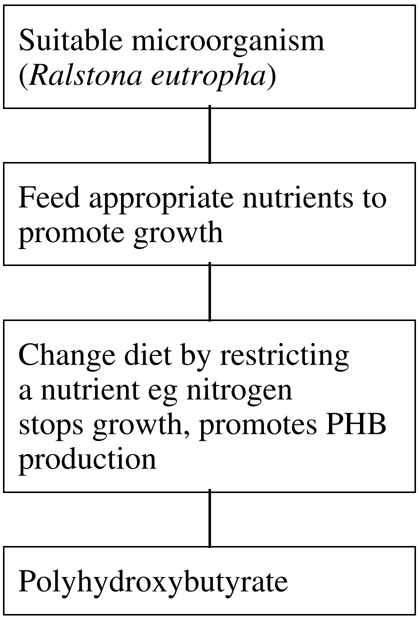
| Criteria | Marks |
|---|---|
| • Provides correct processes for both materials | 5 |
| • Provides substantially correct series of steps for both materials | 4 |
| • Provides a correct series of steps for one material with all conditions<br>OR<br>• Provides a partially correct series of steps for both materials | 3 |
| • Provides a limited series of steps for one material<br>OR<br>• Provides relevant information for both materials | 2 |
| • Provides some relevant information | 1 |

***Sample answer:***

Production of LDPE



Production of PHB



***Answers could include:***

- HDPE
- Other ways to produce biopolymer

### Question 31 (b)

| Criteria | Marks |
|---|---|
| • Links the uses of a recently developed biopolymer to its properties<br>AND<br>• Clearly uses this link to justify the use over fossil fuel polymers mentioning problems/disadvantages of the fossil fuel polymers | 3 |
| • Outlines properties of a recently developed biopolymer and gives one disadvantage or property of fossil fuel polymers<br>OR<br>• Links the use of recently developed biopolymer to some of its properties and attempts to justify the use of biopolymers over fossil fuel polymers | 2 |
| • Refers to a use or a property of a recently developed biopolymer<br>OR<br>• Refers to a fossil fuel polymer | 1 |

***Sample answer:***

PHB (polyhydroxybutyrate) is a recently developed biopolymer used in the manufacture of medical supplies, nappies, plastic bottles and plastic packaging. The fact that it is biodegradable, biocompatible and a renewable resource produced from microorganisms distinguishes this biopolymer from the ‘fossil fuel’ polymers that have been traditionally used for these purposes to date. These fossil fuel polymers lack these properties and thus add significantly to problems such as non-biodegradable landfill and the accelerating use of non-renewable fossil fuel resources.

***Answers could include:***

There are other recently developed, named biopolymers.

## Section II

### Question 32 (a)

| Criteria | Marks |
|---|---|
| • Thorough explanation of the processes linking the structure of the surfactant to its ability to form an emulsion in water with grease | 3 |
| • Identifies the structure of the surfactant<br>AND<br>• Identifies the emulsifying property of the surfactant | 2 |
| • Identifies some features of the structure of the surfactant<br>OR<br>• Identifies that an emulsion is formed | 1 |

***Sample answer:***

Soap has a hydrophilic, negatively charged polar head and a long, hydrophobic non-polar tail. When a mixture of soap and water is added the non-polar tails of the soap will dissolve in the grease. When enough soap has surrounded the grease, the particle is lifted off the surface. The negatively charged heads of the soap prevent individual grease droplets recombining, effectively forming an emulsion of grease in water, allowing the grease to be removed from the surface.

***Answers could include:***

Other surfactants instead of soap.

### Question 32 (b) (i)

| Criteria | Marks |
|---|---|
| • Correct answer with relevant correct working shown | 3 |
| • Correct equilibrium expression with incorrect concentration values substituted in<br>OR<br>• Substantially correct equilibrium expression with correct concentration values substituted in | 2 |
| • At least one correct equilibrium concentration<br>OR<br>• Substantially correct equilibrium expression | 1 |

***Sample answer:***

| | HI | $H_2$ | $I_2$ |
|---|---|---|---|
| Initial | 0.60 | 0 | 0 |
| Used/made | 0.50 | 0.25 | 0.25 |
| Equilibrium | 0.10 | 0.25 | 0.25 |

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

$$= \frac{0.25 \times 0.25}{(0.10)^2}$$

$$= 6.25$$

### Question 32 (b) (ii)

| Criteria | Marks |
|---|---|
| • Relates the cooling to equilibrium position to drive reaction to left and correctly indicates the purple colour due to $I_2$ will fade | 2 |
| • Statement that colour will fade<br>OR<br>• Statement that equilibrium will shift to left<br>OR<br>• Correct interpretation of incorrect statement | 1 |

***Sample answer:***

Since the reaction as written is endothermic, cooling the reaction vessel will drive the reaction to the left, reducing the concentration of purple $I_2$. Hence, contents of vessel will change to a lighter shade of purple.

## Question 32 (c) (i)

| Criteria | Marks |
|---|---|
| • Includes a correct reason for use of limestone as a source of $CaCO_3$<br>• Includes a correct equation | 2 |
| • States that limestone is a raw material<br>OR<br>• Substantially correct equation | 1 |

***Sample answer:***

The major constituent of limestone is $CaCO_3$ which is a raw material for the Solvay process.

$$CaCO_3(s) + 2NaCl(aq) \rightarrow CaCl_2(aq) + Na_2CO_3(s)$$

***Answers could include:***

Limestone heated to produce $CO_2$ that is used in the Solvay process.

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

## Question 32 (c) (ii)

| Criteria | Marks |
|---|---|
| • Demonstrates relationships between several of the key requirements to appropriate locations and provides specific explicit reasons for a preferred location | 3 |
| • Identifies some links between requirements and locations | 2 |
| • States at least two requirements of the Solvay process | 1 |

***Sample answer:***

Main requirements for the Solvay process include availability of raw materials (limestone and brine) and disposal of waste $CaCl_2$, as well as some generalised requirements such as labour, access to markets.

While location *B* is close to the limestone deposit, it would be difficult to transport brine to *B*, and there is no easy way to dispose of waste. Location *A* would be preferred, as it is relatively easy to transport solid limestone to *A* by rail. Brine can easily be obtained from the ocean and waste $CaCl_2$ can be easily disposed of in the ocean. As well, *A* is close to the labour source of Port City, which would also have facilities to ship the product ($Na_2CO_3$) to markets.

## Question 32 (d) (i)

| Criteria | Marks |
|---|---|
| • Hazard identified related to products formed in experiment<br>AND<br>• A method of reducing the risk described | 2 |
| • Hazard identified<br>OR<br>• A method of reducing risk | 1 |

***Sample answer:***

Chlorine gas is produced in this reaction which is toxic. The reaction must be carried out in the fume cupboard.

***Answer could include:***

Explosive mixture of $H_2$ and $Cl_2$
Electrical hazards

### Question 32 (d) (ii)

| Criteria | Marks |
|---|---|
| • Includes details of all THREE products of electrolysis with descriptions of tests/observations to identify the products | 3 |
| • Identification of TWO products of electrolysis with descriptions of tests/observations to identify the products | 2 |
| • Identification of at least TWO products of NaCl electrolysis<br>OR<br>• Description of a test to identify ONE product | 1 |

***Sample answer:***

| *Product of electrolysis of 4.0 mol $L^{-1}$ NaCl* | *How Identified* |
|---|---|
| $Cl_2$ gas | • Bubbling at anode and<br>• Universal indicator added was bleached colourless from green near anode by $Cl_2$<br>• Colourless $I^-$ ions added were oxidised to brown $I_2$ molecules near anode by $Cl_2(g)$. Prescence of $I_2$ confirmed by adding starch (blue/black colour) |
| $H_2$ gas | • Bubbling at cathode and<br>• Gas collected pop test |
| $OH^-$ ions | • Universal indicator changed from green to purple near cathode indicating $OH^-$ ion present |

***Answer could include:***

Description of identification of products for a dilute NaCl solution ($H_2(g)$, $OH^-$, $O_2(g)$, $H^+$).

## Question 32 (e)

| Criteria | Marks |
|---|---|
| • Coherent, concise response with no irrelevant extraneous information<br>• Includes relevant equation<br>• Thorough description of second step in process relating several factors to maximisation of yield<br>• Clearly relates manipulation of reaction to reduction of environmental impact | 7 |
| • Includes relevant equation<br>• Thorough description of second step in process relating several factors to maximisation of yield<br>• Clearly relates manipulation of reaction to reduction of environmental impact | 6 |
| • Sound description of how several factors related to maximise yield are manipulated<br>• Identifies that the process reduces environmental impact | 4–5 |
| • Process is described including some reaction conditions<br>• An environmental issue identified | 2–3 |
| • One aspect of the production of sulfuric acid is identified<br>OR<br>• Environmental issue identified | 1 |

***Sample answer:***

Maximising yield in the production of sulfuric acid occurs mainly in the second step of the contact process where sulfur dioxide is converted to sulfur trioxide.

The nature of this exothermic step requires a careful manipulation of the reaction conditions of concentration, pressure and temperature so that yield is maximised without comprising reaction rate. In addition, this manipulation also reduces the amount of $SO_2$ released into the atmosphere (a major environmental concern leading to formation of acid rain) and helps to dispose of waste heat produced in all steps in the process.

In the second, yield-determining step, the following reaction occurs:

$$SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g).$$

To maximise yield, the initial air used contains about 30%–50% more oxygen than is required to fully convert sulfur to $SO_3$. This increased concentration of $O_2(g)$ forces reaction to right, maximising yield. In addition, the reaction is carried out at about 1.5 atm. Since there is a 1.5 : 1 ratio of gas particles reactants : products the reaction is also forced to the right to reduce pressure, maximising yield.

The initial gas stream at the beginning of this step is at 1000°C after combustion of sulfur. This is too high to produce effective yield in the exothermic reaction above. The gas stream is cooled (heat exchanged, with heat used to liquefy sulfur in first step, which reduces heat released from process) to about 550°C.
At this lower temperature, the gas stream passes over a bed of $V_2O_5$ catalyst, which produces a relatively rapid 70% conversion of $SO_2$ to $SO_3$. The gas stream is then further cooled to

400°C and passed over a second catalytic bed, producing overall 97% conversion at the lower temperature. In the past, 3% $SO_2$ released was considered acceptable. However, now it is not permitted to release $SO_2$ at this concentration into the atmosphere.

So, after conversion of $SO_3$ to $H_2SO_4$ (via oleum), the remaining gas stream is passed over a final bed of $V_2O_5$ to produce a 99.7% conversion. 0.3% $SO_2$ released is considered acceptable.

### Question 33 (a)

| Criteria | Marks |
|---|---|
| • Provides a clearly reasoned answer, identifying the treatment as electrolysis and the need to prevent further damage | 3 |
| • States ONE reason with supporting statement<br>OR<br>• States reasons for using the electrolysis | 2 |
| • States ONE reason for the electrolysis<br>OR<br>• Identifies the treatment as electrolysis | 1 |

***Sample answer:***

This process would be used to remove salt from the artefact. This can be done because electrolysis can be used to remove chloride ions without damaging the artefact.

***Answer could include:***

- Reasons about cleaning and stabilising a metal artifact
- Correct half-equations/equations to support the answer

### Question 33 (b) (i)

| Criteria | Marks |
|---|---|
| • Correctly balanced equation | 2 |
| • Equation is substantially correct, with only minor errors | 1 |

***Sample answer:***

$$\mathrm{Sn}(s) + \frac{1}{2}\mathrm{O_2}(g) + \mathrm{H_2O}(l) \rightarrow \mathrm{Sn^{2+}}(aq) + 2\mathrm{OH^-}(aq)$$

***Answer could include:***

Other acceptable equations for the degradation of tin under those conditions.

### Question 33 (b) (ii)

| Criteria | Marks |
|---|---|
| • Clearly identifies corrosion as a redox reaction<br>• Provides half-equations to illustrate electron movement<br>• Summarises the essential nature of the electron transfer | 3 |
| • Summarises the essential nature of the electron transfer without correct equations<br>OR<br>• Uses redox terms and equations, but fails to clearly articulate the need for electron transfer | 2 |
| • Identifies corrosion as a redox reaction<br>OR<br>• Provides a simple statement identifying the transfer of electrons in corrosion reaction | 1 |

***Sample answer:***

Corrosion reactions are examples of redox reactions, where a metal will be oxidised and lose electrons. The transfer of electrons is essential to these reactions occurring as the oxidation and reduction processes need to be paired.

For example:

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

$\frac{1}{2} O_2(g) + H_2O + 2e^- \rightarrow 2OH^-$

Without the movement of electrons corrosion would not occur.

***Answer could include:***

- Any suitable example to show the loss and gain of electrons
- Discussion of electrolyte present

## Question 33 (c) (i)

| Criteria | Marks |
|---|---|
| • Answer between 10.0 and 11.8 mg $L^{-1}$ with units | 2 |
| • Answer between 9.2 and 12 mg $L^{-1}$ with units<br>OR<br>• Answer between 10.0 and 11.8 without units | 1 |

***Sample answer:***

The solubility of oxygen at 4°C was found to be 11.0 mg $L^{-1}$.

***Answer could include:***

4°C → 11 mg $L^{-1}$.

## Question 33 (c) (ii)

| Criteria | Marks |
|---|---|
| • Outlines a range of factors which affect oxygen concentration in the ocean<br>• Links the effects to different ocean depths | 3 |
| • Provides some information on a factor affecting oxygen concentration linked to ocean depth<br>OR<br>• Identifies a range of factors affecting oxygen concentration in oceans | 2 |
| • Identifies a factor affecting oxygen concentration | 1 |

***Sample answer:***

The factors affecting the concentration of dissolved oxygen at increasing ocean depths include:

- The temperature of the water which decreases at depth
- Currents of dense cold water with high oxygen concentrations at great depth
- Minimal mixing of surface water with water at intermediate depth
- Use of oxygen by organisms at different rates at different depths
- Little/no replacement of oxygen by photosynthesis due to lack of light at depth

***Answer could include:***

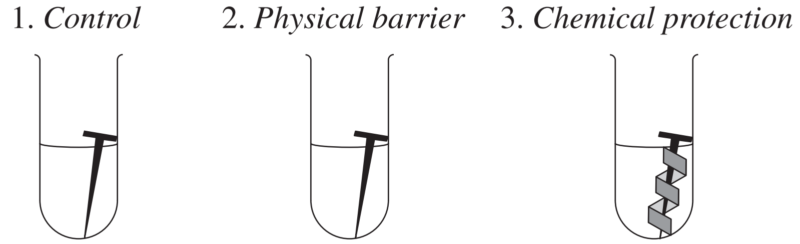
- References to anaerobic/aerobic bacteria
- More information on solubility of oxygen at the surface of the ocean

## Question 33 (d) (i)

| Criteria | Marks |
|---|---|
| • Experimental design includes a control and at least two methods of preventing corrosion<br>• Treatment of variables clear, test is valid<br>• Diagram included aids understanding | 3 |
| • Clear description of experimental design, with control, lacking a diagram<br>OR<br>• Includes diagram in description of experimental design, but lacking control or with an error in the treatment of variables | 2 |
| • Minimal description of experiment, without control or with errors in treatment of variables<br>OR<br>• Attempted diagram conveying some information about experimental procedure | 1 |

***Sample answer:***

**Experimental Set up**



An untreated nail in salt solution

Nail painted, allowed to dry before placement in salt solution

Nail wrapped with magnesium ribbon

*NB: Equal volumes of same concentration solution in all test tubes.*
*All test tubes the same size.*

To test the effectiveness of corrosion prevention, a control is needed as shown above. The samples would need to be observed each day over a week-long period, identifying signs of rusting for each nail and drawing comparisons to that seen on the control.

***Answers could include:***

- Any specific examples of paints/resins/other coatings used to provide a physical barrier to protect the nail
- Any other metals added which would oxidize in place of the iron nail
- Applying a small current to the nail – provided the experimental set up appears feasible under school laboratory conditions
- More than three examples
- Any variations to equipment identified, provided a control is used and fair testing conditions are clear

## Question 33 (d) (ii)

| Criteria | Marks |
|---|---|
| • Provides reasons for using iron, making reference to preventing corrosion | 2 |
| • Provides some relevant information | 1 |

***Sample answer:***

The expected results would show that iron can be protected by painting, galvanising or using a sacrificial anode. As these methods prevent corrosion it is reasonable to use iron in ocean-going vessels since it is also strong, relatively cost-effective and easily available.

## Question 33 (e)

| Criteria | Marks |
|---|---|
| • Coherent, concise response with no irrelevant, extraneous information<br>• Proposes one of the four scientists studied<br>• Justifies their choice with reference to the work of the other three OR the historical context of the research<br>• Demonstrates an understanding of redox reactions<br>• Discusses changes in scientific thinking | 7 |
| • Proposes one of the four scientists studied<br>• Justifies their choice with reference to the work of the other three OR the historical context of the research<br>• Demonstrates an understanding of redox reactions<br>• Discusses changes in scientific thinking | 6 |
| • Proposes one of the four scientists studied<br>• Justifies their choice with reference to EITHER the work of the other three OR the historical context of the research chosen<br>• Identifies changes in scientific thinking<br>• Demonstrates some understanding of redox reactions | 4–5 |
| • Proposes one of the four scientists studied<br>AND<br>– Makes some comparisons between the work of the scientists<br>OR<br>– Demonstrates an understanding of redox reactions through a description of the scientist's work | 2–3 |
| • Suggests either Galvani, Volta, Davy or Faraday | 1 |

***Sample answer:***

Our understanding of redox reactions has been the result of many scientists' work, including Galvani, Volta, Davy and Faraday. Arguably the work of Davy in identifying the connections between reactions and electricity most changed the direction or nature of scientific thinking in this area as his experiments were later used to develop the idea of electron transfer.

Prior to Davy, Galvani and Volta had worked on generating electric currents. While their work prompted further investigation, this continued along the direction of finding materials to generate electricity. Davy was able to recognise that the reactions were the source of the electric current and that the reactions involved decomposition. In this way he changed the direction of scientific thinking to electrolysis and was able to discover new elements (Mg, Ca, Ba).

Faraday was able to build on Davy's work and develop ways to quantify the relationship between the reactions and electricity in devising his laws of electrolysis. In this he continued and extended Davy's work, making very valuable contributions to our understanding, but not really changing the direction of scientific thinking.

While the term ‘redox reaction’ would not have been used at the time, the work of Davy has had the most significant impact on scientific thinking in this area, laying the foundations for qualitative and quantitative relationships between chemical reactions and electricity, later able to be identified as electron transfer reactions as more became known about structure and the nature of ionic substances.

***Answers could include:***

- Proposals for Galvani, Volta or Faraday which adequately argue for changes in scientific thinking resulting from their work

### Question 34 (a)

| Criteria | Marks |
|---|---|
| • Correctly identifies part X (phosphate groups) as the most biologically important<br>AND<br>• Relates hydrolysis of ATP (cleavage of phosphate groups) to the production of energy that is used by the organism<br>AND<br>• A relevant equation | 3 |
| • Correctly identifies part X<br>AND<br>• Relates hydrolysis of ATP to the production of energy<br>OR<br>• A relevant equation | 2 |
| • Correctly identifies part X<br>OR<br>• Relates hydrolysis of ATP to the production of energy<br>OR<br>• A relevant equation | 1 |

***Sample answer:***

Part X is the most biologically important part of ATP (phosphate groups). ATP hydrolysis involves the breaking of the high energy bonds between phosphate groups which releases energy used primarily to ‘drive’ all other biochemical reactions. (It also produces metabolic heat that helps maintain body temperature.)

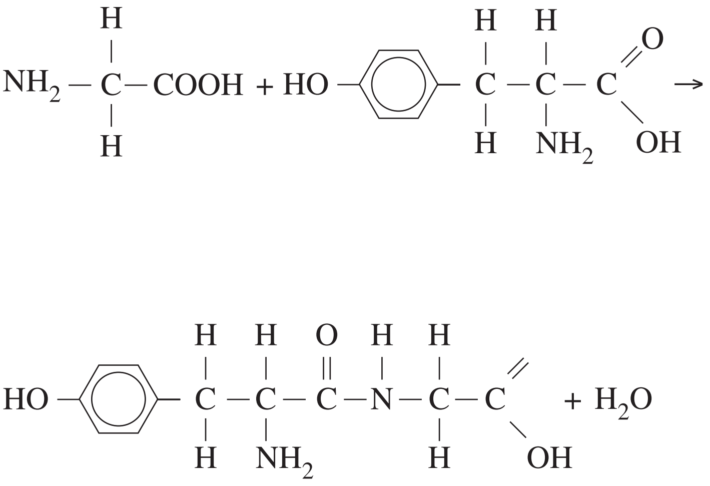
$\text{ATP} \rightarrow \text{ADP} + \text{Pi} + \text{energy}$

$\text{ATP} \rightarrow \text{AMP} + \text{PPi} + \text{energy}$

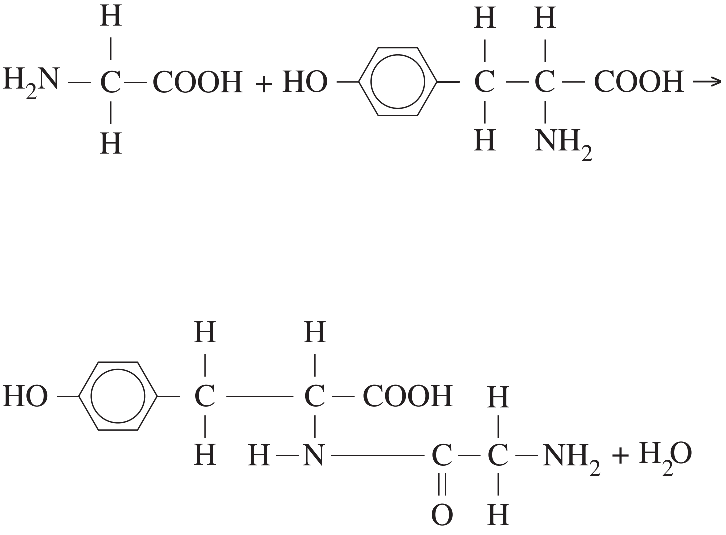
## Question 34 (b) (i)

| Criteria | Marks |
|---|---|
| • Correctly draws the structural formulae including the missing amine functional group on glycine AND includes water as a product | 2 |
| • The structural formulae are correct except for the missing amine functional group<br>OR<br>• The amine group (on glycine) has been included | 1 |

***Sample answer:***



***Answers could include:***



## Question 34 (b) (ii)

| Criteria | Marks |
|---|---|
| • Defines primary structure<br>AND<br>• Relates 3D shape to forces between side chains<br>AND<br>• States at least THREE of the forces between side chains | 3 |
| • Defines primary structure<br>AND<br>• States 1 or 2 of the forces between side chains<br>OR<br>• Relates shape to forces between side chains | 2 |
| • Defines primary structure<br>OR<br>• Mentions side chains<br>OR<br>• Names a force between side chains | 1 |

***Sample answer:***

The primary structure of a protein is the sequence of amino acids that make up the protein. They are primarily linked by peptide bonds between carboxyl and amino functional groups.

However, the 3D shape of a protein is determined by side chains on the amino acid molecules. The sequence of amino acids will determine the side chains available to form subsidiary bonding between molecules.

Linkages include disulfide bridges, hydrogen bonding and electrostatic attractions which are all important in determining secondary shapes such as spirals, coils and sheets. The final ‘tertiary’ structure will be dependant upon these forces and any hydrophobic interactions caused by non-polar side chains.

## Question 34 (c) (i)

| Criteria | Marks |
|---|---|
| • Calculates moles of glucose correctly<br>AND<br>• Calculates energy correctly | 2 |
| • Calculates moles of glucose correctly but incorrectly calculates energy<br>OR<br>• Calculates moles incorrectly and there is no follow through error | 1 |

***Sample answer:***

$M_{C_6H_{12}O_6} = 180.156$ g

$n_{C_6H_{12}O_6}$ required by the astronaut $= \dfrac{36.0 \text{ g}}{180.156 \text{ g mol}^{-1}} = 0.19982682$ mol

Energy required (used) by astronaut $= 0.19982682 \text{ mol} \times 2816 \text{ kJ mol}^{-1}$
$= 562.712$ kJ
$= 563$ kJ

## Question 34 (c) (ii)

| Criteria | Marks |
|---|---|
| • Equation for oxidation of glucose correct<br>AND<br>• Volume of oxygen correctly calculated | 3 |
| • One of the above<br>OR<br>• Equation AND moles oxygen incorrect but no follow through error | 2 |
| • Equation substantially correct<br>OR<br>• Moles of oxygen correct | 1 |

***Sample answer:***

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

$n_{O_2}$ consumed by astronaut $= 6 \times n_{C_6H_{12}O_6} = 6 \times 0.1998$ mol
$= 1.1988 \text{ mol hr}^{-1}$

$V_{O_2} = n_{O_2} \times 24.79 \text{ L mol}^{-1} = 1.19881 \text{ mol} \times 24.79 \text{ L mol}^{-1} = 29.7 \text{ L}$

## Question 34 (d) (i)

| Criteria | Marks |
|---|---|
| • Detail of controlled procedure (identifying or implying that temperature is the independent variable and identifying suitable dependent variable) | 3 |
| • Some details included indicative of a controlled procedure | 2 |
| • States some relevant information | 1 |

***Sample answer:***

- Six separate water baths were prepared at different temperatures; 0°C, 20°C, 40°C, 60°C, 80°C and 100°C
- One test tube containing 5 mL of hydrogen peroxide (1%) was placed in each of the water baths, allowing the hydrogen peroxide substrate to reach the desired temperature
- Identical pieces of potato were used as a source of catalase. One piece of potato was put into each of the test tubes containing the hydrogen peroxide substrate at different temperatures
- The height of the column of oxygen gas (bubbles) consequent upon 'mixing' the potato and hydrogen peroxide substrate was measured after 5 minutes

***Answers could include:***

- Other catalase experiments using commercially obtainable catalase or other sources
- Rennin/milk investigation(s)

## Question 34 (d) (ii)

| Criteria | Marks |
|---|---|
| • Relates the shape of the curve (peak, left/right of peak) to enzyme activity and denaturation | 2 |
| • Relates part of the curve to appropriate enzyme activity | 1 |

***Sample answer:***

The curve peaks at a particular temperature which corresponds to the optimal activity of the enzyme. Below this optimal temperature, molecule motion of both enzyme and subtrate decreases resulting in fewer molecule collisions and less enzyme activity. This corresponds to the part of the curve to the left of the peak. To the right of the peak, the curve drops steeply, corresponding to enzyme denaturation above optimal temperature.

## Question 34 (e)

| Criteria | Marks |
|---|---|
| • Coherent, concise response with no irrelevant extraneous information<br>• Clear judgement related to the scientific accuracy of the statement<br>• Judgement based upon structure of fibre on biopsy<br>• Relates this structure to slow or fast twitch metabolism<br>• Relates fibre metabolism to suitability for sprinting or marathon running | 7 |
| • Clear judgement related to the scientific accuracy of the statement<br>• Judgement based upon structure of fibre on biopsy<br>• Relates this structure to slow or fast twitch metabolism<br>• Relates fibre metabolism to suitability for sprinting or marathon running | 6 |
| • A judgement is given based upon structure of fibre and relates this structure to fast or slow twitch metabolism<br>OR<br>• Clearly relates fibre metabolism to suitability for sprinting or marathon running | 4–5 |
| • A judgement is given based on brief discussion of fibre types<br>OR<br>• Fibre metabolism is discussed | 2–3 |
| • A judgement is given<br>OR<br>• Different fibre types are mentioned | 1 |

***Sample answer:***

The given statement is scientifically accurate. Skeletal muscle is comprised of different fibre types. It is the quantity and organisation of these in each of us that determines our genetic predisposition to a particular activity. A muscle biopsy would enable a prediction to be made with regard to that genetic predisposition.

Type 1 muscle fibres are red fibres with a good blood supply. They have a relatively good oxygen supply as well as a large supply of mitochondria and so they are well suited to aerobic respiration. This being the case, there is a plentiful, constant supply of ATP which is conducive to keeping these ‘slow twitch’ fibres contracting effectively over long periods of time. Biopsies of people with large proportions of these types of muscle fibres are consistent with people that are not particularly fast runners but can continue activities that require endurance, like marathon running. Enzyme profiles from these fibres are consistent with both carbohydrate and lipid metabolism over long time periods.

Type II muscle fibres are rapidly contracting ‘white fibres’ with a relatively poor blood supply. They have fewer mitochondria and that, in combination with less oxygen, leads to the fibres’ energy requirements being supplied largely through anaerobic respiration. Rapid glyolysis occurs with the formation of smaller numbers of ATP molecules, a metabolic pathway conducive to short, intensive bursts of activity such as sprinting.

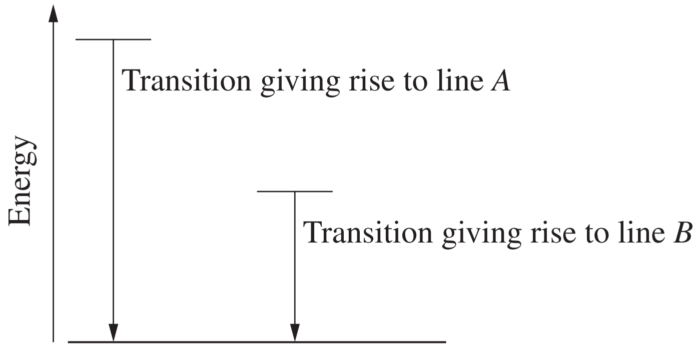
Muscle tissue biopsy can determine an individual’s overall percentage fibre makeup and could thus be used to determine that individual’s genetic suitability for a particular activity, sprinting or marathon running.

### Question 35 (a)

| Criteria | Marks |
|---|---|
| • Concepts of transition between discrete energy levels is articulated<br>• Concept of emission lines being a transition from higher to lower energy level is articulated<br>• An energy level diagram shows (approximately) correct relative size of transitions (Note: transitions do not need to end at the same lower energy state) | 3 |
| • A substantially correct energy level diagram<br>• One other concept included | 2 |
| • One of the concepts is articulated<br>OR<br>• A substantially correct energy level diagram | 1 |

***Sample answer:***

The metal ions in the solution gain energy from the components of the flame and are electronically excited, ie electrons are promoted to higher energy states. The electrons fall back to lower energy states, releasing energy as photons. The lines observed through the spectroscope are therefore emission lines. Because the electron energies are quantised, and transitions between states are restricted to well-defined energies, the energy released is well defined, thus the emission is seen as lines and not a continuous spectrum. Line *A* is the blue end of the spectrum, meaning the transition is of high energy (shorter wavelength) and line *B* is at the red end of the spectrum, meaning the transition is of low energy (longer wavelength).



### Question 35 (b) (i)

| Criteria | Marks |
|---|---|
| • Correctly identifies Ra as an s-block element<br>• Appropriately justifies this by reference to valence shell electrons | 2 |
| • Correctly identifies Ra as an s-block element | 1 |

***Sample answer:***

Ra (radium) is an s-block element. Its valence electrons are in the s orbital.

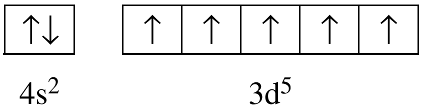
***Answers could include:***

Full electron configuration showing the valence shell as $7s^2$.

### Question 35 (b) (ii)

| Criteria | Marks |
|---|---|
| • Correct orbital diagram, showing correct occupancy of *d* sub-shell<br>• Appropriate description of Hund's rule<br>• Connection of orbital diagram to Hund's Rule | 3 |
| • Two of above points | 2 |
| • One of above points | 1 |

***Sample answer:***



Hund's rule states that every orbital in a subshell is occupied with one electron before any orbital is doubly occupied. In this example Hund's rule is illustrated by the 3*d* sub-shell having 5 electrons in 5 different orbitals.

***Answers could include:***

Other orbital diagrams are possible, but must show a *d* sub-shell.

## Question 35 (c) (i)

| Criteria | Marks |
|---|---|
| • Identifies +2 as the oxidation state<br>• Provides an appropriate justification | 2 |
| • Identifies +2 as the oxidation state<br>OR<br>• Provides an appropriate justification | 1 |

***Sample answer:***

The oxidation state of nickel is +2. The overall charge of the complex is –3, and each cyanide ion carries a –1 charge, giving a total of –5 from the cyanides. The means that the nickel must be +2 to give the overall charge of –3.

## Question 35 (c) (ii)

| Criteria | Marks |
|---|---|
| • Includes a Lewis structure of cyanide that includes at least lone pair of electrons on carbon and negative charge<br>• Appropriately includes description of bonding through carbon atom<br>• Includes coordinate covalent OR Lewis acid/base bond term | 3 |
| • Two of the above | 2 |
| • One of the above | 1 |

***Sample answer:***

$:C \equiv N:^{-}$

The cyanide ion has lone pairs of electrons at both the carbon and nitrogen. The diagram indicates that the carbon of the cyanide ion forms a coordinate covalent bond through this lone pair to the nickel ion.

***Answers could include:***

Use of Lewis acid/base terminology rather than coordinate covalent bond.

## Question 35 (d) (i)

| Criteria | Marks |
|---|---|
| • Provides a detailed procedure for a controlled investigation | 2 |
| • Outlines a procedure, lacking detail<br>OR<br>• Provides a procedure with variables confused | 1 |

***Sample answer:***

- Prepare identical concentrations of potassium permanganate, potassium chromate and iron(II) sulfate
- Add approximately 1 mL of iron(II) sulfate to a test tube
- Add up to 20 drops of potassium permanganate solution drop wise, tapping the side of the test tube to ensure mixing
- Record all observed colour changes
- Repeat for adding potassium permanganate to the potassium chromate

## Question 35 (d) (ii)

| Criteria | Marks |
|---|---|
| • Draws an appropriate conclusion<br>• Has correct description of outcome of the investigation<br>• Has substantially correct half-equations | 3 |
| • Draws an appropriate conclusion<br>AND<br>• Has correct description of the outcome of the investigation OR has substantially correct half-equations | 2 |
| • Draws an appropriate conclusion<br>OR<br>• Has correct description of the outcome of the investigation and conclusion<br>OR<br>• Has substantially correct half-equations | 1 |

***Sample answer:***

Potassium permanganate solution was added drop wise to a solution of potassium chromate. The $KMnO_4$ solution decolourised as it was added, and the $K_2Cr_2O_7$ solution gradually changed from orange to green as the dichromate was reduced to $Cr^{3+}$. This shows that $KMnO_4$ is a stronger oxidiser than $K_2Cr_2O_7$.

$$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$$

$$Cr_2O_7^{7-}(aq) + 14H^+(aq) + 6e^- \rightarrow 2Cr^{3+}(aq) + 7H_2O(l)$$

***Answers could include:***

Any valid half-equation for other systems.

**Question 35 (e)**

| Criteria | Marks |
|---|---|
| • Coherent, concise response with no irrelevant extraneous information<br>• Includes relevant description of principles<br>• Relates methods to analysis of pigments | 7 |
| • Includes relevant description of the principles<br>• Relates methods to analysis of pigments | 6 |
| • Sound description of the principles<br>• Identifies some factors related to analysis of pigments | 4–5 |
| • Basic description of the principles<br>• Identifies some factors related to analysis of pigments | 2–3 |
| • Some principles given<br>OR<br>• Identifies some factors related to analysis of pigments | 1 |

***Sample answer:***

Infrared and ultraviolet spectroscopies can be used to analyse pigments in paints. Both techniques rely on absorption of radiation to determine if a pigment is present, and where on the object the pigment is found. In both cases the absorption of the radiation results in the excitation of the pigment molecule to a higher energy state allowing for analysis.

Infrared and ultraviolet spectroscopies are commonly used in reflectance mode. The radiation penetrates the layers of paint. Infrared can penetrate the painting to the underlying base coat, while ultraviolet tends to reflect off the surface layer. Infrared is particularly sensitive to carbon-containing pigments such as charcoal and graphite, so it can be used to detect under-drawings or initial sketches.

The reflectance spectrum contains the radiation not absorbed by the pigments, and is therefore the complement of the absorption spectrum.

In general, infrared spectroscopy is a non-destructive method, especially when used in reflection mode, but some pigments may be heat sensitive and could change colour under intensive irradiation. Ultraviolet light may cause some degradation of pigments so should be used with caution.

## Question 36 (a)

| Criteria | Marks |
|---|---|
| • Identifies that illicit drugs (methcathinone – C and MDMA – D) are present in the sample mixture<br>• Clearly explains how the information could be used | 3 |
| • Identifies that illicit drugs (methcathinone – C and MDMA – D) are present in the sample mixture<br>• Outlines how the information could be used | 2 |
| • Provides some relevant information | 1 |

***Sample answer:***

Comparison between the standard and sample chromatograms indicates that the sample from the suspected drug laboratory contains Methcathinone and MDMA. This result confirms the drugs were being manufactured. Having established this result the forensic chemist may be requested to present this evidence in court. This will require the chemist to demonstrate the sample has not been contaminated and the chain of custody has been maintained at all times.

***Answers could include:***

Students may refer to the drugs as Drug C and Drug D.

## Question 36 (b) (i)

| Criteria | Marks |
|---|---|
| • Correctly identifies all three polysaccharides | 2 |
| • Correctly identifies one polysaccharide | 1 |

***Sample answer:***

X – Starch

Y – Glycogen

Z – Cellulose

### Question 36 (b) (ii)

| Criteria | Marks |
|---|---|
| • Identifies the main component of the selected polysaccharide and explains how its structure determines the main function | 3 |
| • Describe how its structure (linear vs branched) determines the main function | 2 |
| • Identifies the main function or structure | 1 |

***Sample answer:***

*Starch*

Starch is a polysaccharide that contains a mixture of the branched amylopectin and unbranched amylose. The highly branched nature of amylopectin results in starch being readily broken down into glucose which represents an energy source. Due to the branched structure of amylopectin, starch is utilised as a storage polysaccharide by plants.

***Answers could include:***

*Glycogen*

Glycogen is a polysaccharide containing highly branched glucose units. The high levels of branching result in glycogen being readily broken down into glucose by various enzymes which is used as energy source. For this reason it is utilised as a storage polysaccharide in animals.

*Cellulose*

Cellulose is a polysaccharide formed by the linkage of the glucose units. The orientation of the units results in a linear chain, which allows other chains to closely pack with hydrogen bonds forming between linear chains. This increases the strength of cellulose and accounts for its low solubility and its function as a structural polysaccharide in plants.

### Question 36 (c) (i)

| Criteria | Marks |
|---|---|
| • Correctly identifies mercury as the contaminant and appropriately justifies answer | 2 |
| • Correctly identifies mercury as the contaminant<br>OR<br>• Provides an appropriate justification | 1 |

***Sample answer:***

It can be concluded that the river sample contains mercury because the spectral lines of the river sample match the spectral lines provided by mercury.

## Question 36 (c) (ii)

| Criteria | Marks |
|---|---|
| • Outlines an appropriate procedure<br>AND<br>• Identifies and addresses potential hazards | 3 |
| • Identifies an appropriate procedure and identifies a potential hazard<br>OR<br>• Correctly outlines an appropriate procedure without explicit identification of potential hazards | 2 |
| • Includes a brief, incomplete description of procedure<br>OR<br>• A suitable safety precaution | 1 |

***Sample answer:***

A spectral tube containing the element was connected to a high voltage power supply. The power was switched on and the light produced was viewed through a spectroscope. The power supply must be switched off when connecting or disconnecting the spectral tube to avoid the potential for electrical shock.

***Answers could include:***

A flame test was carried out by heating a small sample of the metal salt in a blue Bunsen flame (Note: NOT mercury or lead if metal salt named). The coloured flame produced was viewed through a spectroscope. This experiment should be carried out in a fume cupboard.

(OR) Safety precautions could include taking care not to break the spectral tube if it contained mercury or lead.

## Question 36 (d) (i)

| Criteria | Marks |
|---|---|
| • Correctly describes a test for organic substances<br>AND<br>• States the positive result | 2 |
| • Identifies a test for organic substances | 1 |

***Sample answer:***

If the substance burns in air to produce carbon, or carbon monoxide or carbon dioxide and water, it can be said to be organic.

***Answers could include:***

A simple test would be to combust the compound in plenty of oxygen. If it burns, producing carbon dioxide and water, it can be said to be organic.

### Question 36 (d) (ii)

| Criteria | Marks |
|---|---|
| • Correctly produces a sequence of tests that could be used to distinguish between three of the named classes of compounds | 3 |
| • Produces a sequence of tests that could distinguish between two of the named classes of compounds | 2 |
| • States a test that could identify one of the classes of compounds | 1 |

***Sample answer:***

Alkanoic acids, alkanes and alkenes are easily distinguished from each other. First, test the three samples with universal indicator. The alkanoic acid will turn the indicator red whereas the other two samples will be neutral and therefore green. To distinguish between an alkene and an alkane, add 10 drops of bromine water to a small sample of the compound. The alkene will rapidly decolourise the bromine water. The remaining sample will be the alkane.

***Answers could include:***

- Alkanoic acids can be distinguished from the other three classes by pH measurement
- Alkenes can be distinguished from the other three classes by the rapid decolourisation of bromine water
- Alkanols can be distinguished from alkanes by their reaction with a acidified potassium permanganate. The purple $MnO_4^-$ is reduced to the colourless $Mn^{2+}$ ion
- Alkanes can be identified by the fact that they will not react with any of the substances mentioned above.

Note: Answers may include a rice grain size piece of sodium metal to identify alkanols. Hydrogen gas is slowly produced. This would have been done as a demonstration.

## Question 36 (e)

| Criteria | Marks |
|---|---|
| • Coherent, concise response with no irrelevant or extraneous information<br>• Demonstrates an extensive knowledge and understanding of both techniques<br>• Presents a valid argument for why chromatography was selected<br>• Includes advantages of chromatography with specific reference to its usefulness in forensic chemistry | 7 |
| • Demonstrates an extensive knowledge and understanding of both techniques<br>• Presents a valid argument for why chromatography was selected<br>• Includes advantages of chromatography with specific reference to its usefulness in forensic chemistry | 6 |
| • Demonstrates a sound knowledge and understanding of both separation techniques<br>AND<br>• Presents a valid argument for why chromatography was selected OR includes advantages of chromatography with some reference to its usefulness in forensic chemistry | 4–5 |
| • Demonstrates a sound knowledge and understanding of separation techniques | 2–3 |
| • Demonstrates a basic knowledge of a separation technique | 1 |

***Sample answer:***

Chromatography is a separation technique based on the different solubilities of compounds in the stationary and the mobile phase. The stationary phase may be either a solid or liquid, while the mobile phase may be a liquid or a gas. The degree of solubility of a substance is determined by the polarity of the substance and the phases. Chromatographic separations are often improved by altering the mobile phase used which is typically a mixture of solvents. In contrast, electrophoretic separations are based on the charge and size of the components in the mixture. The pH of the electrophoresis solution (buffer) can be altered to change the charge on the substance to improve the separation. This differs from chromatography which relies on solubility differences in the various phases.

As chromatography has been selected as the preferred technique, it would indicate that the explosive residue components were not charged and therefore not suitable for analysis by electrophoresis.

Chromatography is an extremely useful technique in forensic chemistry as it can assist in identifying all individual components in a complex mixture found at a crime scene. This information can be used as collaborative evidence to link, or dismiss, a suspect to a crime scene. Chromatography is also a very sensitive technique which is useful for a forensic chemist as they often encounter very small sample sizes.

# Chemistry

## 2013 HSC Examination Mapping Grid

**Section I**
**Part A**

| Question | Marks | Content | Syllabus outcomes |
|---|---|---|---|
| 1 | 1 | 9.4.2.2.2 | H8 |
| 2 | 1 | 9.4.3.2.2 | H3, H6 |
| 3 | 1 | 9.4.4.2.1.0 | H4 |
| 4 | 1 | 9.2.1.2.1 | H10, H12.4b |
| 5 | 1 | 9.2.5.3.1, 8.3.3.2.3 | H6 |
| 6 | 1 | 9.3.2.2.1, 9.3.2.2.2 | H6 |
| 7 | 1 | 9.4.1.2.3, 9.2.1.3.1 | H9, H13 |
| 8 | 1 | 9.3.3.2.2 | H9 |
| 9 | 1 | 9.2.1.2.5 | H9 |
| 10 | 1 | 9.3.2.2.4 | H8, H10 |
| 11 | 1 | 9.2.3.2.7 | H7 |
| 12 | 1 | 9.2.4.3.1, 9.2.4.2.4 | H7 |
| 13 | 1 | 9.2.2.2.4 | H4, H9 |
| 14 | 1 | 9.3.3.2.5 | H10 |
| 15 | 1 | 9.3.2.2.9 | H10, H12.4b |
| 16 | 1 | 9.4.4.2.4 | H6 |
| 17 | 1 | 9.3.3.2.2, 9.3.3.2.6 | H10 |
| 18 | 1 | 9.3.5.2.2, 9.3.5.2.4, 9.3.5.2.5, 9.2.1.2.2, 9.2.1.2.3, 9.2.3.2.2 | H9 |
| 19 | 1 | 9.3.1.3.1, 9.3.1.2.2, 9.3.4.2.8 | H10, H11 |
| 20 | 1 | 9.4.4.2.6 | H6 |

**Section I**
**Part B**

| Question | Marks | Content | Syllabus outcomes |
|---|---|---|---|
| 21 (a) | 2 | 9.3.3.3.5 | H4 |
| 21 (b) | 4 | 9.3.5.2.6, 9.3.5.3.1 | H8, H11.3a, H13 |
| 22 (a) | 1 | 9.4.3.2.1, 9.4.3.2.1 | H6, H14 |
| 22 (b) | 2 | 9.4.3.2.1, 9.2.1.3.1 | H10, H14 |
| 22 (c) | 2 | 9.4.3.2.1, 9.4.3.3.1 | H6, H14 |
| 23 (a) | 5 | 9.2.4.2.2, 9.4.5.2.1, 9.4.5.3.1, 8.3.4.3.3, 8.4.4.3.4 | H10 |
| 23 (b) | 2 | 9.4.3.3.2, 9.4.5.3.2 | H4, H11.3b, H12.1c,d |
| 24 (a) | 2 | 9.3.2.2.4, 9.4.2.2.9 | H8 |
| 24 (b) | 2 | 9.3.2.2.4 | H8 |
| 25 | 4 | 9.3.1.3.1, 9.3.4.2.3, 9.3.4.2.5, 9.3.2.2.4 | H8, H13.1d, H14.1g |

| Question | Marks | Content | Syllabus outcomes |
|---|---|---|---|
| 26 | 4 | 9.4.5.2.4 | H3, H13 |
| 27 | 4 | 9.2.3.2.7 | H7, H10, H13 |
| 28 (a) | 2 | 9.3.4.2.8 | H11.2c, H11.2d, H12.1a |
| 28 (b) | 3 | 9.3.4.2.8, 9.3.4.3.3 | H2, H12.1a, H12.4a |
| 29 | 2 | 9.2.4.3.4 | H7, H12.3c, H14.1d |
| 30 | 6 | 9.4.4.3.1, 9.4.4.3.3, 9.4.4.2.10-11 | H4, H8, H13.1e |
| 31 (a) | 5 | 9.2.1.2.6, 9.2.2.3.1 | H3, H9, H13 |
| 31 (b) | 3 | 9.2.2.3.1 | H4, H9 |

**Section II**

| Question | Marks | Content | Syllabus outcomes |
|---|---|---|---|
| **Question 32** | | **Industrial Chemistry** | |
| (a) | 3 | 9.5.5.2.3, 9.5.5.5.4 | H8, H9 |
| (b) (i) | 3 | 9.5.2.2.2, 9.5.2.3.3 | H10, H13.1c, H13.1d |
| (b) (ii) | 2 | 9.5.2.2.1, 9.5.2.2.3 | H7, H8 |
| (c) (i) | 2 | 9.5.6.2.1, 9.5.6.2.3 | H8, H10 |
| (c) (ii) | 3 | 9.5.6.3.3, 9.5.6.2.4 | H14.1b, H14.1c, H14.1h |
| (d) (i) | 2 | 9.5.4.3.1 | H11.2e, H11.3b, H12.1d |
| (d) (ii) | 3 | 9.5.4.3.1, 9.5.4.3.2 | H7 |
| (e) | 7 | 9.5.3 | H2, H3, H4, H8, H10 |
| **Question 33** | | **Shipwrecks, Corrosion and Conservation** | |
| (a) | 3 | 9.6.7.2.3, 9.6.7.2.4 | H7, H8 |
| (b) (i) | 2 | 9.6.1, 9.6.3 | H10, H13.1d |
| (b) (ii) | 3 | 9.6.1.2.2 | H8 |
| (c) (i) | 2 | 9.6.5.2.1 | H8, H14.1 |
| (c) (ii) | 3 | 9.6.5.2.3 | H8, H14.1e |
| (d) (i) | 3 | 9.6.4.3.3 | H8, H11.1e, H11.2b, H11.3a, H13.1e |
| (d) (ii) | 2 | 9.6.4.3.1, 9.6.2.2.2 | H3, H8, H14.1c |
| (e) | 7 | 9.6.1.3.1, 9.6.1.2.4 | H1, H2, H7, H8, H13.1a, H14.1h, H14.3b |

| | | | |
|---|---|---|---|
| **Question 34** | | **The Biochemistry of movement** | |
| (a) | 3 | 9.7.1.2.2, 9.7.1.3.1 | H7, H9 |
| (b) (i) | 2 | 9.7.4.2.2, 9.7.4.2.3 | H10, H13.1d, H13.1e |
| (b) (ii) | 3 | 9.7.4.2.5 | H9 |
| (c) (i) | 2 | 9.7.7.8.1, 9.7.8.3.2 | H9, H10, H12.3c, H12.4b, H13.1d |
| (c) (ii) | 3 | 9.7.8.2.5 | H12.3c, H12.4b, H13.1d |
| (d) (i) | 3 | 9.7.4.3.2 | H9, H11.1b, H11.2a-b-c |
| (d) (ii) | 2 | 9.7.4.3.2, 9.7.4.2.6 | H8, H9 |
| (e) | 7 | 9.7.5.3.1, 9.7.8, 9.7.10 | H2, H7, H8 |
| **Question 35** | | **The Chemistry of Art** | |
| (a) | 3 | 9.8.2.2.3, 9.8.2.2.7 | H6, H7, H13.1e |
| (b) (i) | 2 | 9.8.3.2.6 | H6 |
| (b) (ii) | 3 | 9.8.3.3.2, 9.8.4.3.1 | H6, H13.1e |
| (c) (i) | 2 | 9.8.5.2.3, 9.8.4.3.3 | H6 |
| (c) (ii) | 3 | 9.8.5.2.4, 9.8.5.3.1 | H6, H8, H13.1d, H13.1e |
| (d) (i) | 2 | 9.8.4.3.4, 9.8.4.2.4, 9.8.4.3.2 | H8, H11.1b, H11.2c |
| (d) (ii) | 3 | 9.8.4.3.4, 9.8.4.2.4, 9.8.4.3.3 | H8, H14.1a-b-d-e |
| (e) | 7 | 9.8.2.2.4, 9.8.2.3.3, 9.8.2.2.9 | H3, H6, H11.1a, H11.3a |
| **Question 36** | | **Forensic Chemistry** | |
| (a) | 3 | 9.9.5.2.2, 9.9.5.3.1 | H9 |
| (b) (i) | 2 | 9.9.2.2.2, 9.9.2.2.4 | H9, H14.1a |
| (b) (ii) | 3 | 9.9.2.2.4, 9.9.2.3.2 | H9, H14.1h |
| (c) (i) | 2 | 9.9.6.3.2, 9.9.6.2.5 | H6, H14.1b |
| (c) (ii) | 3 | 9.9.6.3.1, 99.9.6.2.5 | H6, H11.3a-b, H11.2c-e |
| (d) (i) | 2 | 9.9.1.2.2, 9.9.1.3.3 | H8, H9 |
| (d) (ii) | 3 | 9.9.1.2.3, 9.9.1.3.3 | H8, H9, H11.2d |
| (e) | 7 | 9.9.3.2.5, 9.9.3.2.6, 9.9.5.2.2, 9.9.5.3.1 | H3, H4, H9, H11.3a, H11.3c<br>H14.2a-b, H14.3b |