BOSTES | BOARD OF STUDIES TEACHING & EDUCATIONAL STANDARDS NSW

2016 HSC Chemistry
Marking Guidelines

IMPORTANT:
This resource was developed to support a previous version of the syllabus.
It may contain content that differs from the current syllabus.

Section I, Part A

Multiple-choice Answer Key

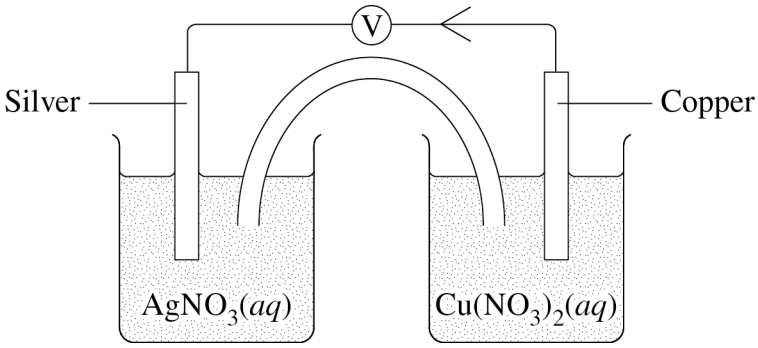
Question	Answer
1	D
2	D
3	C
4	C
5	B
6	A
7	B
8	D
9	D
10	C
11	D
12	C
13	A
14	B
15	A
16	B
17	D
18	B
19	C
20	A

Section I, Part B

Question 21 (a)

Criteria	Marks
• Correctly indicates direction of electron flow	1

Sample answer:



Question 21 (b)

Criteria	Marks
• Correctly completes table with appropriate unit for cell potential	4
• Provides a substantially correct table	3
• Provides a partially correct table showing some understanding of the galvanic cell	2
• Provides some relevant information	1

Sample answer:

Anode half equation	$Cu(s) \rightarrow Cu^{2+} + 2e^-$
Cathode half equation	$Ag^+ + e^- \rightarrow Ag(s)$
Overall cell equation	$Cu(s) + 2Ag^+ \rightarrow Cu^{2+} + 2Ag(s)$
Overall cell potential	$(-0.34) + 0.80 = 0.46V$

Question 22 (a)

Criteria	Marks
• Identifies a safety issue	1

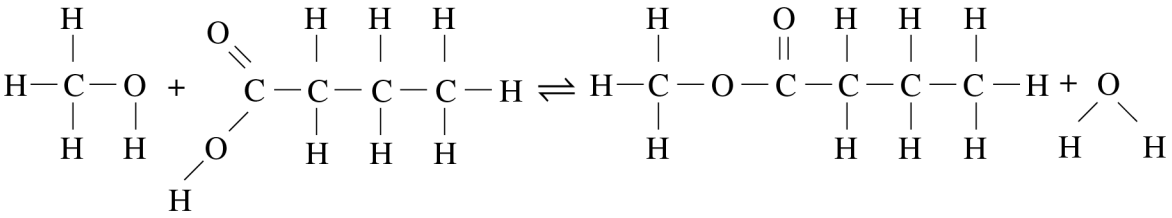
Sample answer:

One of the reactants is flammable.

Question 22 (b)

Criteria	Marks
• Provides a correct equation using structural formulae	2
• Provides a correct structural formula for one organic reactant or product OR • Provides a word equation	1

Sample answer:



Question 22 (c)

Criteria	Marks
• Provides a valid justification	2
• Shows some understanding of refluxing	1

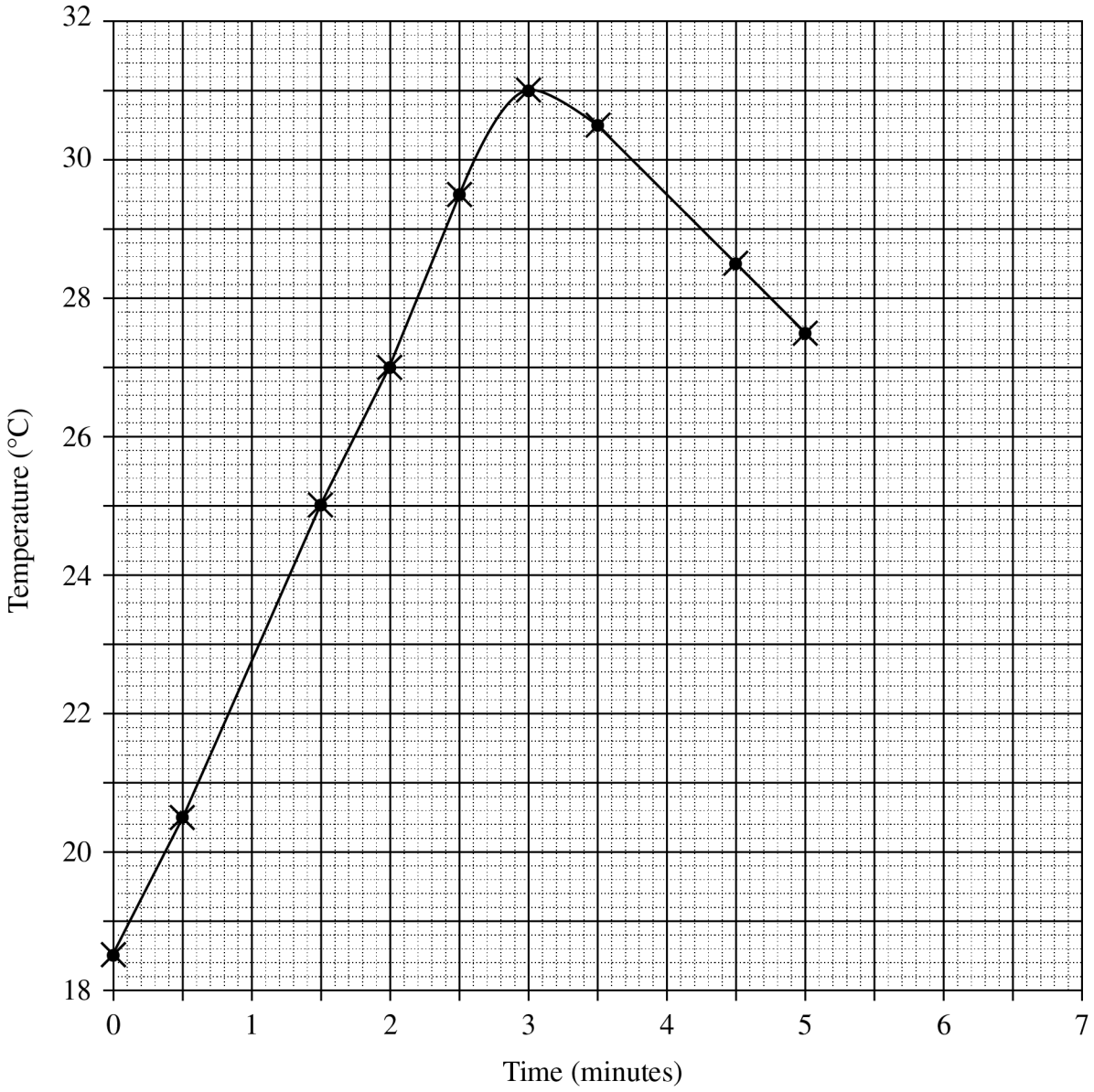
Sample answer:

Esterification is a slow reaction. Heating the reaction makes it go faster. However, the reactants and products of esterification have relatively low boiling points. The condenser (*X*) prevents the loss of these volatile substances by condensing them back into the reaction mixture and allows for the reaction to proceed at higher temperatures.

Question 23 (a)

Criteria	Marks
• Labels axes appropriately • Provides correct units • Plots data correctly • Draws curve of best fit	3
• Provides a substantially correct graph	2
• Provides a partially correct graph	1

Sample answer:



Question 23 (b)

Criteria	Marks
• Provides a correct answer with relevant working and includes appropriate unit (sig figs not required)	3
• Provides a correct answer without units OR • Provides a substantially correct answer	2
• Includes a correct step	1

Sample answer:

From graph, $\triangle T = 31.0 - 18.5 = 12.5°C$

Mass of ethanol burnt = 236.14 – 235.56 = 0.58 g

$$\text{moles ethanol} = \frac{m}{M} = \frac{0.58}{(2\times 12.01 + 6\times 1.008 + 16.00)} = 0.0126\,\text{mol}$$

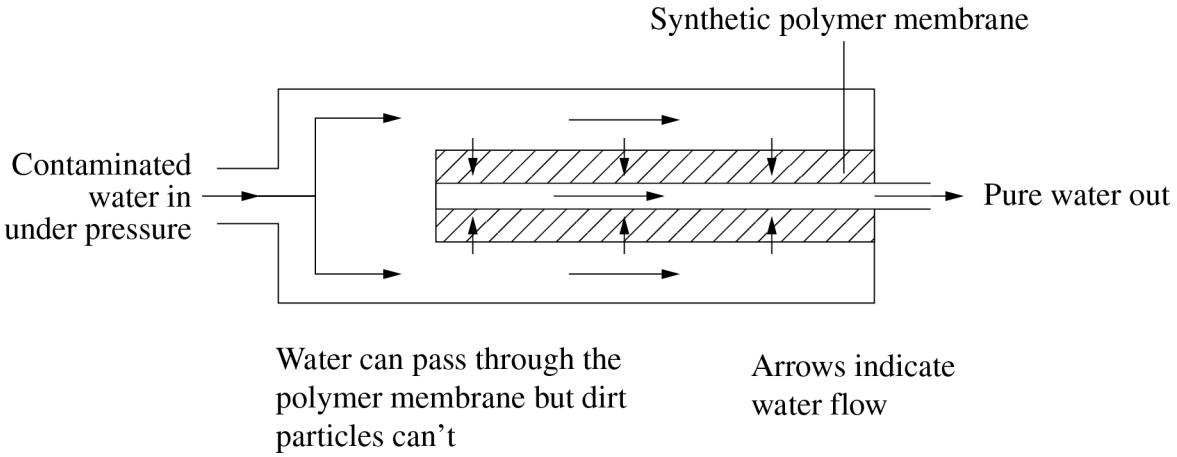
$$\text{energy released} = n \times 827 = 0.0126 \times 827 = 10.420\,\text{kJ}$$
$$= 10420\,\text{J}$$

$$\triangle H = mC\triangle T \quad m = \frac{\triangle H}{C\triangle T} = \frac{10420}{4.18\times 10^3 \times 12.5}$$
$$= 0.199\,\text{kg}$$

Question 24 (a)

Criteria	Marks
• Explains the operation of a microscopic membrane filter in relation to purifying water • Identifies that pressure is required • Includes a correct, labelled diagram	4
• Outlines some operation of a microscopic membrane filter in relation to purifying water • Includes a diagram	3
• Identifies some features of a microscopic membrane filter	2
• Provides some relevant information	1

Sample answer:



A microscopic membrane filter is made up of a synthetic polymer in the shape of a cylinder which has small pores through it. Contaminated water is passed through the outside of the synthetic polymer under pressure. The pores in the polymer are only small enough to let the water particles through and not the contaminating particles. The cleaned water moves through to the centre of the hollow part of the cylinder and moves out of the filter.

Question 24 (b)

Criteria	Marks
• Demonstrates an understanding of the process of eutrophication • Relates dissolved oxygen levels to the extent of eutrophication	3
• Demonstrates an understanding of the process of eutrophication	2
• Provides some relevant information	1

Sample answer:

Eutrophication is the enrichment of a body of water with nutrients that causes uncontrolled microbial growth, eg algal blooms, to occur. When the algal blooms die, their decomposition uses up the oxygen dissolved in the water. The extent of eutrophication can be determined by measuring the dissolved oxygen levels. The lower the oxygen levels, the greater the extent of eutrophication.

Question 25

Criteria	Marks
• Justifies whether the level of CO is dangerous with relevant calculations (sig figs not required)	4
• Provides a substantially correct CO level and calculations OR • Provides a correct CO level and justification but no working	3
• Provides some correct steps in the calculation of CO level	2
• Provides some relevant information	1

Sample answer:

Volume of garage is 1.0×10^5 L = 100000 L

6.0 kg octane = 6000 g $n = \dfrac{m}{M} = \dfrac{6000}{114.224} = 52.53$ moles

Molar ratio from equation is 1 : 8 $\therefore 8 \times 52.53$ moles of carbon monoxide are produced = 420.23 moles.

$m = n \times M = 420.23 \times 28.01 = 11771$ g

$[CO] = \dfrac{11771}{100000} = 0.118 \text{ g L}^{-1}$

Therefore the level of carbon monoxide is dangerous as it is more than 0.100 g L^{-1}.

Question 26 (a)

Criteria	Marks
• Provides correct explanation	2
• Provides some relevant information	1

Sample answer:

Cellulose is a condensation polymer because when its monomers are joined together, water is produced.

Question 26 (b)

Criteria	Marks
• Justifies research related to current issues with plastics and solutions using biopolymers	4
• Explains current issues with plastics and/or solutions involving biopolymers	3
• Outlines a problem with current plastics OR • Outlines a solution using biopolymers OR • Identifies a problem AND a solution	2
• Provides some relevant information	1

Sample answer:

Most plastics made from petrochemicals resist biodegradation. These plastics remain in the ecosystem for a long time and cause damage to biota. Biopolymers are produced by micro-organisms and are biodegradable and cause less damage to biota. Research into the production of these biopolymers should continue because replacing non-biodegradable plastics with biopolymers would reduce the negative impact on the ecosystem. Research is needed because, at present, the properties of these biopolymers do not allow them to completely replace plastics sourced from fossil fuels.

Answers could include:

- Responses related to reduced availability of fossil fuels
- Volume of production.

Question 27

Criteria	Marks
• Provides correct answer with THREE significant figures	4
• Provides correct answer with incorrect significant figures OR • Provides substantially correct answer with THREE significant figures	3
• Provides some relevant steps	2
• Provides a relevant step	1

Sample answer:

$$Al + 3HCl \rightarrow AlCl_3 + \frac{3}{2}H_2$$

$$\text{Moles gas} = \frac{0.150}{24.79} = 6.05 \times 10^{-3}\,\text{mol}\,H_2\,\text{gas}$$

$$H_2 : Al = \frac{3}{2} : 1 \quad \therefore \frac{2}{3} \times 6.05 \times 10^{-3}\,\text{mol}\,Al$$

$$\text{Mass Al} = n \times M = \frac{2}{3} \times 6.05 \times 10^{-3} \times 26.98 = 0.109\,\text{g (3 sig figs)}$$

Question 28 (a)

Criteria	Marks
• Identifies correct time with appropriate justification	2
• Identifies correct time OR • Provides some justification	1

Sample answer:

At two minutes since the concentrations have stopped changing.

Question 28 (b)

Criteria	Marks
• Identifies decomposition as endothermic • Relates changes to the concentrations of reactants and product in the graph to an increase in temperature • Demonstrates an understanding of Le Chatelier's principle	3
• Provides a reason for the endothermic nature of the decomposition	2
• Provides some relevant information	1

Sample answer:

The decomposition of phosgene is endothermic. According to Le Chatelier's principle, if the temperature is increased, the system will try to overcome the changes to re-establish a new equilibrium position. From the graph, $COCl_2$ concentration decreases while CO and Cl_2 concentrations increase after the temperature increases, showing that the decomposition is endothermic, forcing the reaction to the right as heat is absorbed.

Question 29 (a)

Criteria	Marks
• Provides correct reason and substance used	2
• Provides correct substance	1

Sample answer:

Water should be used to rinse the conical flask as this will not change the number of moles of Na_2CO_3 placed in it.

Question 29 (b)

Criteria	Marks
• Provides correct answer with relevant working	4
• Provides a substantially correct answer with relevant working	3
• Provides some relevant steps	2
• Provides a relevant step	1

Sample answer:

$HCl + NaOH \rightarrow H_2O + NaCl$

n (NaOH) = cV

$= 0.250 \times 0.0295$

$= 7.375 \times 10^{-3}$ $\therefore$ n (HCl) = 7.375×10^{-3} after reaction with seashell

Original HCl = cV

$= 0.200 \times 0.0500 = 0.0100$ moles

$\therefore$ HCl used $= 0.0100 - 7.375 \times 10^{-3}$

$= 2.625 \times 10^{-3}$ moles used

$2HCl + CO_3^{2-} \rightarrow H_2O + CO_2 + 2Cl^-$

$HCl : CO_3^{2-} = 2 : 1$

$$\therefore n\ CO_3^{2-} = \frac{2.625 \times 10^{-3}}{2}$$

$$= 1.3125 \times 10^{-3}$$

$$m = 1.3125 \times 10^{-3} \times 60.01$$

$$= 0.07876\ g$$

$$= \frac{0.07876\ g}{0.145\ g} \times 100\% = 54.3\%.$$

Question 30

Criteria	Marks
• Links uses of CFCs to ozone depletion • Includes relevant equations • Explains steps taken to reduce problem of ozone depletion	7
• Links uses of CFCs to ozone depletion • Includes relevant equations • Outlines steps taken to reduce problem and explains at least one step	6
• Identifies uses of CFCs • Includes relevant equation(s) • Outlines steps taken to reduce problem	4–5
• Identifies relevant step(s) taken to reduce problem AND/OR • Identifies use(s) of CFCs AND/OR • Provides relevant equation(s)	2–3
• Provides some relevant information	1

Sample answer:

CFCs mainly used during 1960–1980s in air-con, aerosols, refrigeration. They are generally stable but once exposed to higher intensity of UV in stratosphere destroy ozone as follows:

$CCl_3F + UV \rightarrow CCl_2F\bullet + Cl\bullet$

$Cl\bullet + O_3 \rightarrow ClO\bullet + O_2$

$ClO\bullet + O\bullet \rightarrow Cl\bullet + O_2$

The Cl• regenerated can cause destruction of many thousands of O_3 molecules.

Steps taken in response to ozone depletion include international agreements such as:

1987 – Montreal Protocol leading to

- guidelines to decrease CFC usage by phasing out manufacture of CFCs
- identification and introduction of alternative chemicals, such as HCFCs, HFCs.

HCFCs have less capacity to destroy ozone in the stratosphere as the H–C bond makes them unstable in the troposphere. HFCs have no Cl atom and so cannot destroy ozone.

As a result, CFCs have decreased in stratospheric concentration reducing the amount of ozone depletion. Developed nations have eliminated the production and use of CFCs.

Section II

Question 31 — Industrial Chemistry

Question 31 (a) (i)

Criteria	Marks
• Identifies both substances	2
• Provides some relevant information	1

Sample answer:

A is superheated water.
B is a water/sulfur mixture.

Question 31 (a) (ii)

Criteria	Marks
• Relates properties of sulfur to the method of extraction	3
• Relates a property to the method of extraction OR • Identifies some properties	2
• Provides some relevant information	1

Sample answer:

In the Frasch process superheated water is pumped into the underground sulfur deposits. This causes the sulfur to melt as it has a lower mp than the temperature of the superheated water. At the same time compressed air is pumped into the deposit to force molten sulfur as an emulsion in the superheated water to the surface. Sulfur is insoluble in water and the water is evaporated off at the surface leaving virtually pure sulfur behind.

Question 31 (b) (i)

Criteria	Marks
• Provides a correct procedure for the school laboratory context • Addresses a safety issue	3
• Provides a substantially correct procedure for the school laboratory context	2
• Provides some relevant information	1

Sample answer:

1. Use fume cupboard or well ventilated lab due to production of Cl_2 gas
2. Add 5 drops of phenolphthalein to a 3.0 mol L^{-1} NaCl solution
3. Fill voltameter with NaCl solution
4. Connect to DC power supply on a 6.0 V setting
5. Make observations at the electrodes as the electrolysis occurs.

Answer could include:

Other methods of electrolysing the solution.

Question 31 (b) (ii)

Criteria	Marks
• Provides correct method and result to identify one product • Provides correct chemistry for each electrode reaction	4
• Provides a substantially correct method to identify one product • Provides substantially correct chemistry for each electrode	3
• Outlines a method to identify a product AND/OR • Outlines some chemistry involved	2
• Provides some relevant information	1

Sample answer:

Anode – Cl^- ions are oxidised to Cl_2 gas

$$Cl^-(aq) \rightarrow \frac{1}{2}Cl_2(g) + e^-$$

Cathode – water is reduced to H_2 gas

$$H_2O(l) + e^- \rightarrow \frac{1}{2}H_2(g) + OH^-(aq)$$

To test for Cl_2 gas at anode, trap gas in an inverted test tube.

Place moist starch/iodide paper in the tube.

If Cl_2 gas present paper will turn dark brown/black.

Question 31 (c) (i)

Criteria	Marks
• Links pressure and temperature changes correctly to change in equilibrium position • Identifies impact on K value	3
• Relates changes in equilibrium to Le Chatelier's principle	2
• Provides some relevant information	1

Sample answer:

Decrease in volume (causes increase in pressure)	*Decrease in temperature*
• System adjusts to decrease pressure by Le Chatelier's principle • Equilibrium moves to reactant side as less moles of gas will reduce pressure • No change to K when equilibrium re-established	• Systems adjusts to increase temperature by Le Chatelier's principle • Equilibrium moves to reactant side to produce more heat • K will be lower when the new equilibrium is established

Question 31 (c) (ii)

Criteria	Marks
• Provides correct answer and working (significant figures not required)	4
• Provides substantially correct answer with working	3
• Provides some relevant steps	2
• Provides a relevant step	1

Sample answer:

$$NH_4HS(s) \rightleftharpoons NH_3(g) + H_2S(g)$$

$$\text{n } NH_3 = 0.0328 = \text{n } H_2S$$

$$[NH_3] = [H_2S] = \frac{0.0328}{3}$$

$$= 0.0109$$

$$K = [NH_3][H_2S]$$

$$= 0.0109 \times 0.0109$$

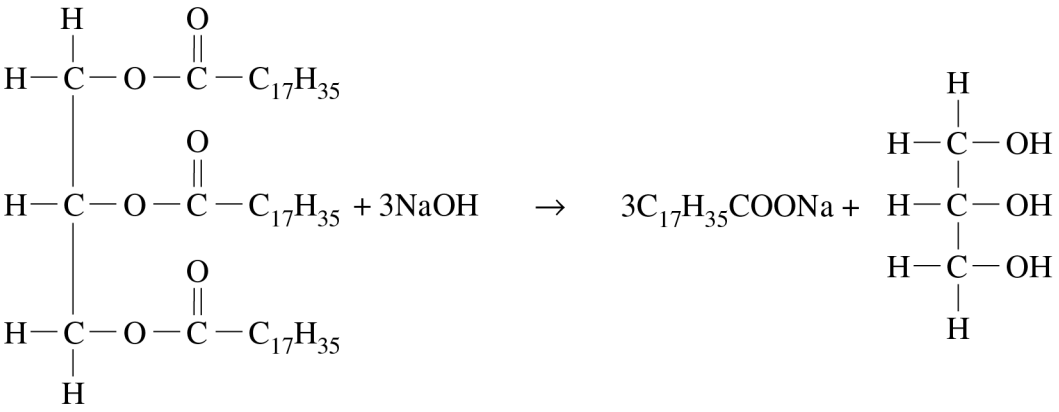
$$= 1.20 \times 10^{-4}$$

Question 31 (d)

Criteria	Marks
• Provides comprehensive details of similarities and differences between laboratory and industrial methods • Provides justifications for the differences in the production methods • Provides a correct chemical equation	6
• Outlines similarities and differences between the methods • Provides some justification for the differences in the methods • Provides a substantially correct equation	5
• Outlines steps in both the industrial and laboratory methods or some justification for the differences in the methods • Provides a relevant equation	4
• Outlines some steps in the process of saponification OR • Provides features of the production methods	3
• Outlines a step in the process of saponification OR • Provides features of the production method(s)	2
• Provides some relevant information	1

Sample answer:

Saponification is the conversion of a fat or oil to soap and glycerol using an alkali.



In a school laboratory, olive oil is heated over a water bath with concentrated NaOH solution and ethanol. This is stirred continuously until a creamy emulsion forms. Concentrated sodium chloride solution is added to the cooled mixture to precipitate the soap. The solid soap is removed from the mixture, and allowed to dry.

In industry, cheap bulk fats instead of pure, expensive oils are heated in large vats in a small excess of NaOH solution. Close to the stoichiometric volume of NaOH is used to reduce cost and wastage. The soap is still salted out using brine with the excess brine being recovered for reuse. The glycerol by-product is recovered and most is sold to other industries to recover costs. A small amount is incorporated into the soap for moisturising. The soap also has other substances such as perfumes added to it, and pH adjusted for domestic use, before being coloured and pressed into blocks.

Question 32 — Shipwrecks, Corrosion and Conservation

Question 32 (a) (i)

Criteria	Marks
• Identifies the type of cell • Provides a valid reason	2
• Provides some relevant information	1

Sample answer:

As there is a power source connected to the cell it is an electrolytic cell.

Question 32 (a) (ii)

Criteria	Marks
• Describes a relevant process occurring at X in terms of electron transfer • Provides a relevant chemical equation	3
• Outlines a relevant process	2
• Provides some relevant information	1

Sample answer:

At the anode, X, chloride ions are releasing electrons to the positive terminal of the power pack, causing them to be oxidised to chlorine atoms.

$$Cl^- \rightarrow \frac{1}{2}Cl_2(g) + e^-$$

Answers could include:

Oxidation of water to oxygen gas.

Question 32 (b) (i)

Criteria	Marks
• Describes an experiment that would test the effect of temperature on the rate of corrosion, including method and equipment/chemicals • Addresses safety and reliability	3
• Describes an appropriate experiment and/or identifies a safety issue and/or addresses reliability	2
• Provides some relevant information	1

Sample answer:

Identical iron nails were placed in test tubes containing the same amount of water. The test tubes were placed in water baths of different temperatures for a period of a week and periodically observed to record the amount of corrosion. Care had to be taken in handling the test tubes in the water baths at elevated temperatures to avoid the risk of burns. Three test tubes were placed in each temperature water bath so that reliability could be addressed by effectively repeating the experiment.

Question 32 (b) (ii)

Criteria	Marks
• Links the results of the investigation to low corrosion rates at depth • Links another factor to rates of corrosion	4
• Links the results of the investigation to low corrosion rates at depth and identifies another factor OR • Outlines the results of the investigation and links another factor to rates of corrosion	3
• Outlines the results of the investigation and/or outlines another factor	2
• Provides some relevant information	1

Sample answer:

In this investigation the results showed that the rate of corrosion of iron nails increased at higher temperature. In the ocean, temperature decreases with depth, so iron wrecks at great depths would be expected to corrode slower than wrecks in shallower, warmer water. However, for corrosion to occur, oxygen needs to be present as well. While oxygen dissolves better in colder water, there is little oxygen available at depths due to poor mixing with the surface, depletion by marine animals and lack of photosynthesis by plants in the deep ocean. It was predicted that due to low temperatures and low oxygen levels, corrosion should be very slow at great depth.

Question 32 (c) (i)

Criteria	Marks
• Provides an explanation and a correct example	3
• Outlines how passivating metals work and gives a correct example	2
• Provides some relevant information	1

Sample answer:

Passivating metals such as aluminium are reactive metals that form a protective surface coating of an unreactive substance. Aluminium readily reacts with oxygen to form a layer of unreactive aluminium oxide that then prevents reactive substances such as oxygen reacting with aluminium below the surface layer.

Question 32 (c) (ii)

Criteria	Marks
• Explains how sacrificial electrodes protect iron vessels, including an example • Includes relevant chemistry	4
• Links use of sacrificial electrode to the protection of the vessel, including an example • Provides some chemistry	3
• Outlines a way that sacrificial electrodes are used to protect vessels • Provides an example of a sacrificial electrode	2
• Provides some relevant information	1

Sample answer:

Unprotected iron vessels in seawater will rapidly undergo corrosion as solid iron is oxidised to Fe^{2+} by oxygen.

$Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$
$O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$

This leads to the formation of rust. To prevent the oxidation of iron, a sacrificial anode is used made of a more reactive metal than iron (eg zinc). This will oxidise preferentially to the iron, donating electrons to any Fe^{2+} ions that form, converting them back into solid iron. The zinc will eventually be used up, requiring the anode to be replaced. Seawater acts as the electrolyte for this reaction.

The zinc electrode is only able to protect the iron within a few metres of it, so a large vessel would require many sacrificial anodes.

Question 32 (d)

Criteria	Marks
• Explains the processes used to restore the cannons • Includes the chemistry involved in the processes	6
• Explains most of the processes used • Includes most of the chemistry involved	5
• Describes most of the processes used • Provides some of the chemistry involved	4
• Outlines some of the processes used • Provides some of the chemistry involved	3
• Outlines some of the processes used OR • Provides some of the chemistry involved	2
• Provides some relevant information	1

Sample answer:

Iron cannons submerged in salt water on a coral reef will require the removal of coral growths, removal of chloride salts and oxides of iron and the preservation of the restored iron.

Coral growths are made of mainly calcium carbonate. They can be removed relatively easily by tapping with a hammer. Remaining carbonate can be removed by treatment with dilute acid to dissolve the carbonates.

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

Removal of chlorides is important, as when dried, the salt crystals can expand, potentially damaging the metal of the cannon. Leaching out chlorides can be achieved by placing the cannon in a dilute sodium hydroxide solution for an extended period of time but this is often ineffective, as insoluble Fe(OH)Cl is often left over and can react with water to form hydrochloric acid, which can damage the iron.

$$Fe(OH)Cl(s) + H_2O(l) \rightarrow Fe(OH)_2(s) + HCl(aq)$$

It is more effective to use electrolysis to remove the chloride in the alkaline solution, by using the cannon as the cathode and using a stainless steel anode, where hydroxide is oxidised to oxygen. $4OH^-(aq) \rightarrow O_2(g) + 2H_2O(l) + 4e^-$

At the cathode, $Fe(OH)Cl(s) + 2e^- \rightarrow Fe(s) + OH^-(aq) + Cl^-(aq)$. The Cl^- and OH^- ions migrate towards the anode, away from the iron cannon. This process also converts any deposits of hydroxides or oxides of iron back to solid iron.

Once the iron cannon has been restored, it can be coated in wax to preserve it by preventing contact with oxygen in the air.

Question 33 — The Biochemistry of Movement

Question 33 (a) (i)

Criteria	Marks
• Correctly identifies both covalent bonds	2
• Correctly identifies one of the covalent bonds	1

Sample answer:

X is a peptide bond, *Y* is a disulfide bond.

Question 33 (a) (ii)

Criteria	Marks
• Explains how the increase in temperature results in loss of enzyme activity	3
• Outlines how the increase in temperature results in loss of enzyme activity	2
• Provides some relevant information	1

Sample answer:

When ribonuclease is heated to 65°C, the heat energy is transferred to the KE of the atoms. Consequently, this leads to greater vibrations that are able to break bonds between amino acid side chains that hold the structure of the enzyme together. The breaking of these bonds leads to changes in the structure of the enzyme and hence, denaturation. As a result, the active site of the enzyme is lost and it can no longer bind to its substrate. Therefore, the enzyme loses its activity.

Question 33 (b) (i)

Criteria	Marks
• Describes relevant benefits	3
• Identifies relevant benefits OR • Describes a relevant benefit	2
• Provides some relevant information	1

Sample answer:

Molymod models allowed us to see that glycogen is a polymer of glucose molecules. It allowed us to see the bonding between glucose molecules. It also allowed a spatial representation of the overall polymer structure.

Question 33 (b) (ii)

Criteria	Marks
• Demonstrates substantial understanding of the process of the polymerisation of glucose into glycogen	4
• Demonstrates sound understanding of the process of the polymerisation of glucose into glycogen	3
• Demonstrates some understanding of the process of the polymerisation of glucose into glycogen	2
• Provides some relevant information	1

Sample answer:

Glycogen is a polymer of α-glucose. The α-glucose molecules link together in a condensation reaction to form α(1–4) glycosidic linkages. These α linkages result in a floppy chain of glucose. In addition, glycogen molecules form α(1–6) glycosidic linkages which result in branching of the polymer. The resulting structure is an amorphous and highly branched polymer.

Question 33 (c) (i)

Criteria	Marks
• Calculates the mass of glucose needed to supply the energy	3
• Provides a substantially correct answer	2
• Provides a relevant step	1

Sample answer:

Energy required $= 55 \times 240$
$= 13\ 200$ kJ

Moles glucose $= \dfrac{13\ 200}{2800}$
$= 4.714$ mol

1 mol glucose $= 180.156$ g

Mass of glucose $= 180.156 \times 4.714$
$= 849$ g

Question 33 (c) (ii)

Criteria	Marks
• Demonstrates substantial understanding of how fats are oxidised to produce ATP	4
• Demonstrates sound understanding of how fats are oxidised to produce ATP	3
• Demonstrates some understanding of how fats are oxidised to produce ATP	2
• Provides some relevant information	1

Sample answer:

Fats are triacylglycerides (TAGs). Fats can be oxidised to release energy by first breaking it down to glycerol and fatty acids. The glycerol is then converted to either glucose or pyruvate. The glucose produced from glycerol is also converted to pyruvate by glycolysis. The pyruvate is then converted to Acetyl CoA, which also produces carbon dioxide. The fatty acids from the breakdown of fats are oxidised to also produce Acetyl CoA. The Acetyl CoA undergoes oxidative carboxylation which produces $NADH + H^+$ and $FADH_2$. $NADH + H^+$ and $FADH_2$ then undergo oxidative phosphorylation to produce ATP, the usable form of chemical energy in cells.

Question 33 (d)

Criteria	Marks
• Explains the relationship between muscle type and exercise • Outlines differences in the appearance and metabolism of Type 1 and Type 2 muscles	6
• Relates Type 1 to gentle exercise and Type 2 to sprinting • Outlines differences in the appearance and metabolism of Type 1 and Type 2 muscle cells	5
• Relates Type 1 to gentle exercise and Type 2 to sprinting AND • Outlines differences in the appearance or metabolism of Type 1 and Type 2 muscle cells	4
• Relates Type 1 to gentle exercise and Type 2 to sprinting OR • Outlines difference(s) in the appearance and/or metabolism of Type 1 and Type 2 muscle cells	3
• Identifies the types of muscle cells OR • Outlines Type 1/Type 2 muscles	2
• Provides some relevant information on muscle cells	1

Sample answer:

Humans need both Type 1 and Type 2 muscles in order to carry out our normal everyday activities. The Type 1 muscle cells make up slow twitch muscles that are responsible for slow but longer duration activities such as gentle exercise. The Type 2 muscle cells make up fast twitch muscles that are responsible for fast but shorter duration activities such as sprinting.

The difference between the two types of muscles is indicated by their appearance. Type 1 muscles appear red whereas the Type 2 muscles are white because Type 1 muscles have much greater numbers of mitochondria while Type 2 muscles have very few. Due to the abundance of mitochondria, ATP that is used to contract Type 1 muscle is produced by aerobic respiration. Aerobic respiration produces a lot of ATP but takes a considerable amount of time to do so, hence the force generated by the contraction of the muscle is not as strong, but the force can act for a longer duration.

Due to the lack of mitochondria, the ATP used to contract Type 2 muscle is produced by anaerobic respiration which produces fewer ATP molecules, but the rate at which it is produced is faster. Hence the force of contraction is stronger, but the duration of action is much shorter.

In conclusion, humans need both Type 1 and Type 2 muscles in order to facilitate the different types of activities that they carry out such as sprinting or gentle exercise.

Question 34 — The Chemistry of Art

Question 34 (a) (i)

Criteria	Marks
• Identifies name and valency of element	2
• Identifies name or valency of element	1

Sample answer:

Strontium, +2

Question 34 (a) (ii)

Criteria	Marks
• Provides an explanation for the production of the characteristic flame colour	3
• Demonstrates some understanding of how the flame colour is produced	2
• Provides some relevant information	1

Sample answer:

Electrons in the ground state exist at certain energy levels. When these electrons are excited by heat, they can move to higher energy levels, but cannot stay there. As these electrons come back to ground state, they emit a photon of specific wavelength in the visible spectrum, which is seen as a characteristic red colour.

Question 34 (b) (i)

Criteria	Marks
• Identifies a chemical used and explains a precaution taken to address an associated safety issue	3
• Identifies a chemical used and a safety issue associated with it	2
• Identifies a chemical used or a safety issue (includes precaution)	1

Sample answer:

Acidified potassium permanganate is a strong oxidising agent and can cause severe skin burns. Wear a laboratory coat to protect your skin and clothes.

Question 34 (b) (ii)

Criteria	Marks
• Identifies oxidation states of iron • Explains the removal of electrons from different energy levels • Explains the difference between the oxidation states of iron	4
• Identifies oxidation states of iron • Describes differences between the oxidation states	3
• Identifies an oxidation state of iron • Identifies the stability of the ion	2
• Provides some relevant information	1

Sample answer:

Iron has two oxidation states, +2 and +3. Electrons are removed from the orbital with the highest energy level, in this case 4s. As 4s and 3d orbitals have similar energies only a small additional amount of energy is required to remove the third electron compared to the second electron. The +3 oxidation state is a more stable state as when the electron is removed from the d orbital, it results in each of the five d orbitals having one electron in each. This is a relatively stable electronic configuration. Hence, iron can have both a +2 or +3 oxidation state as they are both stable.

Question 34 (c) (i)

Criteria	Marks
• Explains the need for the insolubility of pigments and relates this to examples of their use	3
• Explains a use OR • Identifies uses	2
• Provides some relevant information	1

Sample answer:

Pigments need to be insoluble so that they cannot be easily removed from surfaces like canvas, cave walls or living tissue in the case of cosmetics. This allows them to last longer without being dissolved in polar substances like water, or perspiration from the human body.

Question 34 (c) (ii)

Criteria	Marks
• Explains how infra-red spectroscopy is used to analyse and identify chemicals	4
• Outlines how infra-red spectroscopy is used to analyse and identify chemicals	3
• Outlines the comparison of a spectrum to its identification	2
• Provides some relevant information	1

Sample answer:

Bonds between certain atoms in a molecule will absorb specific wavelengths of IR radiation depending on the type of the bond (infra-red light is passed through a solution of the sample and analysed). Therefore, using the complete IR spectrum, the particular bonds in a molecule can be identified. The relative number of each specific bond can be determined by the degree of absorption.

A chemical in the pigment will have a characteristic spectrum that can be used for its identification, by comparison with published data.

Question 34 (d)

Criteria	Marks
• Identifies that transition metals have d orbitals which have similar energies • Describes a complex ion as a complex between a transition metal and a ligand • Describes how the formation of a complex with different ligands changes the energy level of the d-orbital • Explains how a change in the energy level of the d orbital results in the complex having different colours • Provides an example of different complexes of a named transition metal along with their colours	6
• Identifies that transition metals have d orbitals • Describes a complex ion as a complex between a transition metal and a ligand • Describes how a complex with different ligands results in the complex having different colours • Provides an example of different complexes of a named transition metal along with their colours	5
• Identifies a complex ion as a complex between a transition metal and a ligand • Identifies that complex ions with different ligands result in the complex having different colours • Provides an example of a coloured complex	4
• Identifies that complex ions form between transition metals and ligands • Provides an example of a coloured complex	3
• Identifies that complex ions form between transition metals and ligands OR • Provides an example of a coloured complex	2
• Provides some relevant information	1

Sample answer:

Transition metals are characterised as having d orbitals. The electrons in the d orbitals will have similar energies.

A ligand is an ion or molecule that binds to the central metal atom to form a complex ion. Ligands such as H_2O and NH_3 carry unshared electrons which can be donated to the metal ion. Different ligands have different effects on the energies of the d orbitals of the central ion. This then has an effect on the wavelength of light that is going to be absorbed in order to promote the electrons to higher energy levels.

The greater the resulting energy gap caused by the ligand, the shorter the wavelength of light absorbed, which will affect the colour of the light emitted. Hence different ligands will produce different colours when combined with the same transition metal.

For example Cu^{2+} can be a complex of $[Cu(H_2O)_6]^{2+}$ and be pale blue in colour whereas in $[Cu(NH_3)_4(H_2O)_2]^{2+}$ it will be dark blue.

Question 35 — Forensic Chemistry

Question 35 (a) (i)

Criteria	Marks
• Provides a description of chemical analysis that could be used to link a suspect's shoe to the shoe print at a crime scene	2
• Provides some relevant information	1

Sample answer:

Soil on the shoe could be analysed and compared to the analysis of soil in the print at the crime scene. If they match, this could link suspect to scene.

Question 35 (a) (ii)

Criteria	Marks
• Identifies ways that samples should be collected at a crime scene and links these with improving accuracy of evidence	3
• Outlines ways that samples should be collected at a crime scene OR • Identifies ONE way that samples should be collected at a crime scene and links this with improving accuracy	2
• Provides some relevant information	1

Sample answer:

It is very important that material collected at a crime scene is not contaminated by other material. Thus forensic officers would wear protective clothing such as masks, gloves etc to ensure that material from their clothes and shoes does not contaminate the sample.

It is also important that samples collected are not tampered with at any stage of the procedure. Thus all material must be photographed and recorded at the crime scene to prevent anybody tampering with it before the court case.

Question 35 (b) (i)

Criteria	Marks
• Describes a suitable procedure for separating a mixture using electrophoresis • Addresses a safety issue	3
• Outlines a suitable procedure • Outlines a safety issue	2
• Provides some relevant information	1

Sample answer:

1. A mixture of amino acids was dissolved in a pH 6.0 buffer.
2. A line was drawn halfway down a length of filter paper.
3. The mixture of amino acids was spotted onto the line to provide an intense spot.
4. The filter paper was slowly soaked in buffer and placed on a support with buffer in wells at either end.
5. Electrodes were attached to either end of the wet paper and connected to a power supply (36 Volts).
6. The power supply was turned on and the electrophoresis was allowed to proceed for 45 minutes.
7. The mixture of amino acids was made visible using ninhydrin solution.
8. SAFETY – the apparatus uses high voltage. Switch off all electricity before attempting to touch the equipment.

Question 35 (b) (ii)

Criteria	Marks
• Correctly describes characteristics of the amino acids that allow them to be separated by electrophoresis • Links these to the movement of the amino acids in the electric field	4
• Correctly identifies characteristics of the amino acids and links these to the movement of the amino acids in the electric field OR • Correctly describes the characteristics of the amino acids that allow them to be separated by electrophoresis	3
• Correctly identifies characteristics of amino acids OR • Outlines some characteristics of amino acids and links these to the movement of amino acids in the electric field	2
• Provides some relevant information	1

Sample answer:

Amino acids consist of a central carbon atom with an amino group, a carboxyl group, a hydrogen atom and a variable side chain attached. The side chains may also contain carboxyl groups and amino groups. Each amino acid has a specific isoelectric point that is the pH at which the amino acid is neutral and has no net positive or negative charge.

Amino acids with neutral side chains (*Y*) will be uncharged at pH 6.0 and will not move in an electric field. Amino acids with amino groups in their side chain will be positively charged at pH 6.0 (*Z*) and will move towards the negative terminal. Amino acids with carboxyl groups in their side chain will be negatively charged at pH 6.0 (*X*) and will move towards the positive terminal.

Question 35 (c) (i)

Criteria	Marks
• Correctly identifies the TWO metal ions • Provides a correct justification	3
• Correctly identifies the TWO metal ions OR • Correctly identifies ONE of the metal ions • Provides a correct justification	2
• Provides some relevant information	1

Sample answer:

The two metal ions present in the paint are strontium and copper. This is known because the spectral lines in the mixture line up and exactly match the spectral lines of both copper and strontium.

Question 35 (c) (ii)

Criteria	Marks
• Describes how an atomic emission spectrum is produced • Describes how spectra can be used in forensic analysis	4
• Outlines how an atomic emission spectrum is produced • Describes how these spectra can be used in forensic analysis OR • Describes how an atomic emission spectrum is produced • Outlines how these spectra can be used in forensic analysis	3
• Describes how an atomic emission spectrum is produced OR • Outlines how an atomic emission spectrum is produced • Outlines how this spectrum can be used in forensic analysis	2
• Provides some relevant information	1

Sample answer:

The material to be analysed must be atomised and vaporised and so it is dissolved in solution and a sample aspirated into an argon gas stream in the spectrometer. The sample is heated to a high temperature and the electrons in the sample absorb energy and move to higher, excited energy levels in the atom. These unstable electrons move back to lower energy states, emitting light of characteristic frequencies as they do so. As each different element has energy levels that are unique, these frequencies of light are different for each element and a unique spectral pattern is produced. These spectral patterns can be used to identify the mixture of ions present in a sample by comparison to standards.

Question 35 (d)

Criteria	Marks
• Provides a thorough explanation of how technology uses DNA features and relates this to improved accuracy in the analysis of evidence presented in criminal cases	6
• Provides a sound explanation of how technology uses DNA to improve accuracy in criminal cases	5
• Outlines how technology uses DNA to improve accuracy with some explanation	4
• Outlines how technology utilises DNA to improve accuracy OR • Describes DNA features	3
• Identifies features of DNA and/or shows some understanding of technology	2
• Provides some relevant information	1

Sample answer:

Each DNA molecule is able to replicate itself exactly when provided with the correct enzymes, temperatures and compounds. This is used in the technique of polymerase chain reaction where a small sample of DNA can be amplified many times by heating and cooling cycles in the presence of nucleotides and DNA polymerase enzyme. This has improved the sensitivity and accuracy of forensic analysis and allows the scientists to use extremely small samples of DNA as evidence.

DNA consists of two sections, exons that are the genes that code for proteins, and introns that are the DNA sections between genes. Exons are very similar in length between individuals, however, introns are extremely variable in length. The DNA is cut into sections using restriction enzymes, placed on an agarose gel and a voltage applied. Because the phosphate groups are negatively charged, the DNA fragments move towards the positive terminal. The smaller fragments move faster than the larger fragments and so a distinct pattern is produced on the gel. This DNA fingerprint can be used to establish relationships between people and can be used to identify individuals as each person has a unique DNA fingerprint. This allows forensic scientists to very accurately identify suspects from samples of hair or skin and can also rule out innocent suspects from a criminal case with absolute certainty. This technology has allowed forensic scientists to use very small sample sizes to achieve very accurate identification of individuals.

2016 HSC Chemistry
Mapping Grid

Section I
Part A

Question	Marks	Content	Syllabus outcomes
1	1	9.2.1.2.7	H9
2	1	9.4.5.3.2, 9.4.3.3.2	H4
3	1	9.3.5.2.2	H9
4	1	9.2.1.2.8	H4, H9
5	1	9.2.3.2.3	H9, H6
6	1	9.3.4.2.4	H6, H8
7	1	9.3.1.2.2, 9.3.1.3.3	H3, H4
8	1	9.4.5.2.1, 9.4.5.3.1, 9.1.11.2.b,c	H4, H6, H11
9	1	9.2.5.2.2	H3, H6
10	1	9.3.4.2.5, 9.3.4.2.3	H4, H6
11	1	9.4.4.2.9, 9.4.4.3.2	H9
12	1	9.3.3.2.5, 9.3.3.3.7	H10
13	1	9.4.3.2.1, 9.4.3.3.1	H2, H4, H6, H8
14	1	9.3.2.2.4	H8
15	1	9.2.1.2.3, 9.2.1.3.2, 9.2.3.2.3	H9
16	1	9.2.4.2.4, 9.2.4.3.4	H2, H6, H8
17	1	9.2.1.2.5, 9.2.1.3.3	H3, H9
18	1	9.3.3.3.7, 9.3.3.2.5	H10
19	1	9.4.3.3.3	H8, H10
20	1	9.4.3.2.2, 9.4.3.3.5	H3, H14

Section I3, 4, 5, 6, 14
Part B

Question	Marks	Content	Syllabus outcomes
21 (a)	1	9.2.4.2.5	H3, H7
21 (b)	4	9.2.4.2.4, 9.2.4.2.6, 9.2.4.3.4	H7, H8, H10
22 (a)	1	9.3.5.2.4, 9.3.5.3.1, 11.2e, 11.3a, 11.3b, 12.1b, 12.1d	H11
22 (b)	2	9.3.5.2.4	H4, H6, H8, H9, H13
22 (c)	2	9.3.5.2.6, 9.3.5.3.1	H8, H9, H11
23 (a)	3	9.2.3.3.6, 13.1f,g	H13
23 (b)	3	9.2.3.2.7, 9.2.3.3.6, 13.1d	H9, H10, H13
24 (a)	4	9.4.5.2.4, 9.4.5.3.3	H3, H4, H5 H13
24 (b)	3	9.4.5.2.1, 9.4.5.3.2	H4
25	4	9.4.1.2.3	H4, H8, H9, H10, H13, H14
26 (a)	2	9.2.2.2.4, 9.2.2.2.3, 9.2.2.2.2	H9

Question	Marks	Content	Syllabus outcomes
26 (b)	4	9.2.2.3.1	H3, H4, H5, H9, H13
27	4	9.3.2.2.9	H8, H10
28 (a)	2	9.3.2.2.4, 9.3.2.2.3	H6, H8, H13
28 (b)	3	9.3.2.2.4, 9.3.2.2.3	H8, H13
29 (a)	2	9.3.4.3.3, 9.3.4.2.8, 11.3a	H11, H12, H14
29 (b)	4	9.3.4.3.3	H8, H10, H13, H14
30	7	9.4.4.2.10, 9.4.4.2.11, 9.4.4.3.1, 9.4.4.3.3	H1, H3, H4, H13, H14

Section II

Question	Marks	Content	Syllabus outcomes
Question 31		**Industrial Chemistry**	
31 (a) (i)	2	9.5.3.2.2	H3, H4
31 (a) (ii)	3	9.5.3.2.2	H3, H4
31 (b) (i)	3	9.5.4.3.1	H2, H11
31 (b) (ii)	4	9.5.4.3.1, 9.5.4.2.2	H7, H8
31 (c) (i)	3	9.5.2.2.1, 9.5.2.2.3	H7, H8
31 (c) (ii)	4	9.5.2.3.3, 9.5.2.2.2	H10
31 (d)	6	9.5.5.2.1, 9.5.5.2.2, 9.5.5.3.2	H4, H11, H13
Question 32		**Shipwrecks, Corrosion and Conservation**	
32 (a) (i)	2	9.6.3	H4, H7
32 (a) (ii)	3	9.6.3.2.1	H7, H8
32 (b) (i)	3	9.6.5.3.1, 11.1a, 11.2c, 11.3b, 12.1b	H2, H8, H11, H12
32 (b) (ii)	4	9.6.5.2.1, 9.6.5.2.2, 9.6.5.2.4, 9.6.6, 9.6.5.3.2	H4, H8
32 (c) (i)	3	9.6.2.2.1	H3, H4, H8
32 (c) (ii)	4	9.6.4.2.3, 9.6.4.2.4, 9.6.4.2.2, 9.6.4.3.4	H3, H4, H8
32 (d)	6	9.6.7	H4, H8, H13
Question 33		**The Biochemistry of movement**	
33 (a) (i)	2	9.7.4.2.3, 9.7.4.2.5	H6
33 (a) (ii)	3	9.7.4.3.2, 9.7.4.2.5, 9.7.4.2.6	H8
33 (b) (i)	3	9.7.2.3.1	H2, H14
33 (b) (ii)	4	9.7.2.2.2, 9.7.2.2.3	H7, H9
33 (c) (i)	3	9.7.7.3.1	H7, H10
33 (c) (ii)	4	9.7.3.2.5, 9.7.3.2.6, 9.7.6, 9.7.7	H7, H9, H13
33 (d)	6	9.7.5.2.1, 9.7.5.2.4, 9.7.5.3.1, 9.7.8, 9.7.10	H1, H8, H13
Question 34		**The Chemistry of Art**	
34 (a) (i)	2	9.8.3.2.4	H6
34 (a) (ii)	3	9.8.3.2.5, 9.8.4.2.4	H6, H7
34 (b) (i)	3	9.8.4.3.2, 9.8.4.2.4	H2, H7, H11

Question	Marks	Content	Syllabus outcomes
34 (b) (ii)	4	9.8.4.2.3	H6
34 (c) (i)	3	9.8.1.2.2	H4, H6
34 (c) (ii)	4	9.8.2.2.8	H3, H4, H6, H14
34 (d)	6	9.8.5	H3, H4, H6
Question 35		**Forensic Chemistry**	
35 (a) (i)	2	9.9.1.2.4	H4
35 (a) (ii)	3	9.9.1.2.1	H2, H12, H14
35 (b) (i)	3	9.9.3.3.5 11.1a, 11.2c, 11.3b	H2, H11, H12
35 (b) (ii)	4	9.9.3.2.2, 9.9.3.2.5	H4, H6
35 (c) (i)	3	9.9.6.3.2, 14.1a	H14
35 (c) (ii)	4	9.9.6.2.1, 9.9.6.2.2, 9.9.6.2.4, 9.9.6.2.5	H4, H7
35 (d)	6	9.9.4.2.1, 9.9.4.2.2, 9.9.5.3.1, 9.9.1.2.5	H1, H3