BOSTES | BOARD OF STUDIES TEACHING & EDUCATIONAL STANDARDS NSW

2014 HSC Chemistry Marking Guidelines

Section I, Part A

Multiple-choice Answer Key

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

Section I, Part B

Question 21

Criteria	Marks
• Clearly shows how processes *A* and *B* are similar and/or different in producing the element	3
• Outlines some features of both processes OR • Describes one process	2
• Identifies a feature of process *A* or process *B*	1

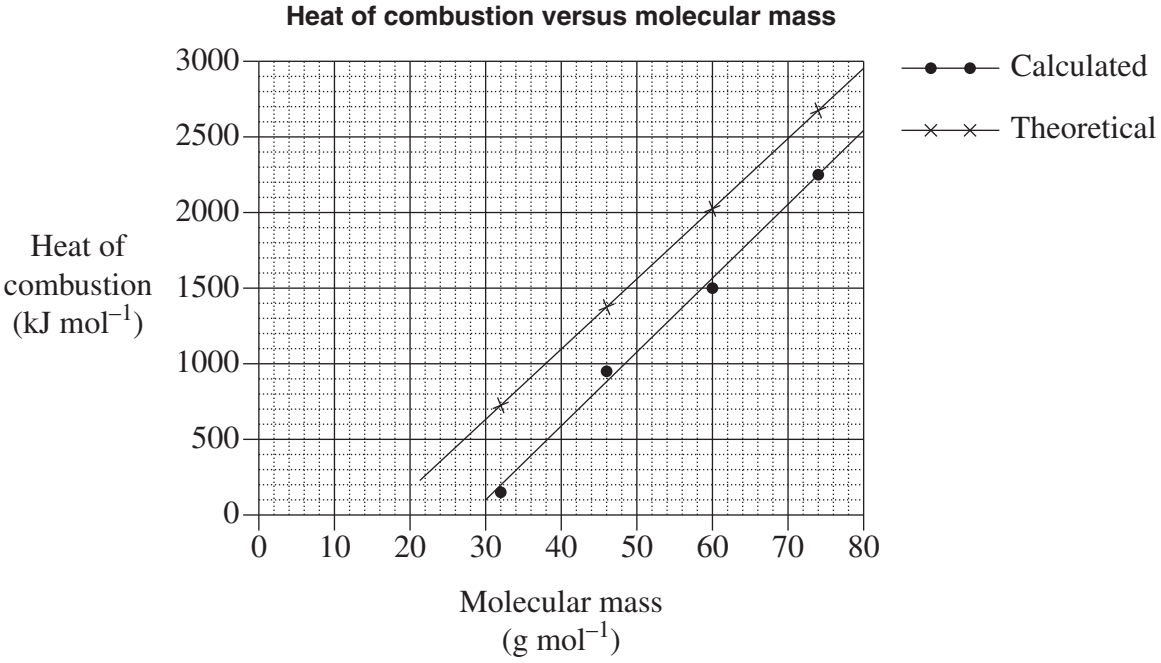
Sample answer:

Process *A* takes place in a nuclear reactor while process *B* is in an accelerator. In a nuclear reactor, the target nucleus is bombarded with neutrons which produces an unstable radioisotope which then decays by beta emission to produce the element. In an accelerator, the target nucleus is bombarded with a helium atom producing the same element.

Question 22 (a)

Criteria	Marks
• Correctly draws the TWO line graphs with appropriate scale and label/key	3
• Draws TWO lines of best fit on the same axes OR • Correctly draws ONE line graph on appropriate scale OR • Correctly plots all points on appropriate scale	2
• Chooses appropriate scale OR • Correctly plots some points	1

Sample answer:



Question 22 (b)

Criteria	Marks
• Identifies issues and provides points for and/or against the validity of the investigation	3
• Identifies issue(s) and/or provides point(s) for and/or against the validity of the investigation	2
• Identifies a strength or a limitation of this investigation	1

Sample answer:

Overall this is a valid investigation to show a relationship between ΔH and molecular mass. This is supported by obtaining a similar trend in the theoretical and experimental data. However, the quantitative values are inaccurate because of heat loss to the surroundings. The error is systematic as shown by the consistent difference in experimental and theoretical values, indicating variables were controlled.

Question 23 (a)

Criteria	Marks
• Correctly identifies a contaminant	1

Sample answer:

Lead ions

Answers could include:

phosphate, hydrogen ions

Question 23 (b)

Criteria	Marks
• Relates a property of a contaminant to the need to monitor its levels	2
• Identifies an effect of a contaminant in water systems	1

Sample answer:

Lead is a heavy metal. It can accumulate in a biological system. Ingestion of lead can cause brain damage.

Question 24

Criteria	Marks
• Describes a sequence of tests that distinguish between the three anions including a positive test for each • Provides one correct equation	5
• Outlines tests that distinguish between two of the anions including positive tests and provides one correct equation OR • Describes a sequence of tests that distinguish between the three anions	3–4
• Identifies one test and provides one substantially correct equation OR • Outlines a test that distinguishes between two of the anions including a positive test	2
• Identifies a test to identify an anion OR • Provides one substantially correct equation	1

Sample answer:

Add acid such as nitric acid. If bubbles are produced, carbonate is present. Add excess acid to remove all carbonate. Then add Ba^{2+} such as barium nitrate. If a precipitate forms, sulfate is present. Add Ba^{2+} until no more precipitate forms. Filter to remove sulfate. Lastly add silver nitrate. If precipitate forms, chloride is present.

Equation: $Ag^{+}(aq) + Cl^{-}(aq) \rightarrow AgCl(s)$

Question 25 (a)

Criteria	Marks
• Provides reasons for monitoring	2
• Outlines ONE reason for monitoring	1

Sample answer:

This reaction should be monitored to reduce release of toxic pollutants, eg CO(*g*) and C(*s*) into the atmosphere and to maximise the efficiency of the process by adjusting the oxygen input.

Question 25 (b)

Criteria	Marks
• Correctly calculates the mass of soot	2
• Uses mole ratio to calculate moles of C OR • Correctly uses $n \times M$ to calculate mass	1

Sample answer:

$$\text{moles (C)} = 3 \times 4.2 \text{ mol}$$
$$= 12.6 \text{ moles} = 13 \text{ moles}$$

$$\therefore \text{ mass (C)} = 12.6 \text{ mol} \times 12.01 \text{ g/mol}$$
$$= 151.33 \text{ g} = 150 \text{ g} = 1.5 \times 10^2 \text{ g}$$

Question 26 (a)

Criteria	Marks
• Correctly names any ester that can be safely manufactured in a school laboratory	1

Sample answer:

Methyl butanoate

Question 26 (b)

Criteria	Marks
• Identifies potential hazards associated with both reactants and catalyst • Provides thorough and concise description of control methods for the hazards	5
• Identifies potential hazards associated with both reactants and catalyst • Outlines control methods for the hazards	4
• Identifies potential hazards for the experiment • Outlines control methods for the hazards	3
• Identifies potential hazards(s) and/or control method(s) for the experiment	2
• Identifies a potential hazard or a control method for the experiment	1

Sample answer:

Methanol is flammable and toxic. Use a hot plate and water bath to keep it away from a naked flame. Butanoic acid can cause burns when in concentrated form. It has a strong odour that can cause irritation to the throat. Use eye and skin protection and use a fume cupboard. Concentrated H_2SO_4 can cause severe burns and has noxious fumes. Use small quantities, eye and skin protection (gloves) and a well-ventilated area or fume cupboard.

Question 27 (a)

Criteria	Marks
• Provides reasons for the reduction in hardness	2
• Identifies that the equilibrium shifts to the left OR • Identifies a decrease in solubility of Ca^{2+} OR • Shows a basic understanding of Le Chatelier's Principle	1

Sample answer:

According to Le Chatelier's Principle, an increase in temperature will favour the endothermic process (to the left) in order to partially counteract the increase in temperature. This will reduce the calcium ion concentration and so reduce the hardness.

Question 27 (b)

Criteria	Marks
• Identifies features of atomic absorption spectroscopy that could be used to measure the effectiveness of heating water • Describes a method for measuring the effectiveness of heating water using atomic absorption spectroscopy • Indicates how $[Ca^{2+}]$ determines the effectiveness of heating water	4
• Identifies features of atomic absorption spectroscopy that could be used to measure the effectiveness of heating water • Outlines some steps for measuring the effectiveness of heating water using atomic absorption spectroscopy	3
• Identifies features(s) of atomic absorption spectroscopy that could be used to measure the effectiveness of heating water AND/OR • Outlines step(s) for measuring the effectiveness of heating water	2
• Identifies a feature of atomic absorption spectroscopy OR • Identifies a step in measuring the effectiveness of heating water	1

Sample answer:

Use atomic absorption spectroscopy to measure $[Ca^{2+}]$. To do this prepare a series of Ca^{2+} standard solutions. Use atomic absorption spectroscopy to measure the absorbance and use this data to plot a calibration curve.

Next, measure the absorbance of two water samples – one before heating and one after.

Use the calibration curve to calculate $[Ca^{2+}]$ in each sample. If heating water is an effective method to reduce hardness, the $[Ca^{2+}]$ for the heated sample will be less.

Question 28 (a)

Criteria	Marks
• Provides reasons for the colour change	2
• Identifies the correct observed colour change OR • Outlines some chemistry in relation to the copper half-cell	1

Sample answer:

The blue solution becomes lighter in colour. Since copper is at the cathode, copper ions come out of solution to produce copper metal. The lighter colour is therefore a result of the reduced concentration of copper ions in the solution.

Question 28 (b)

Criteria	Marks
• Correctly identifies metal *X* with logical justification	3
• Incorrect identification of metal *X* but includes the correct balanced net ionic equation or two correct half equations OR • Identifies metal *X* with some justification (eg incomplete equation)	2
• Correctly identifies metal *X* OR • Shows a valid step to justify/determine metal *X*	1

Sample answer:

$E^\circ = E_{anode} + E_{cathode}$

$2.02 = E_{anode} + 0.34$

$E_{anode} = 2.02 - 0.34$

$= 1.68$ V (metal *X* is Al)

Answers could include:

Anode: $Al(s) \rightarrow Al^{3+} + 3e^- \quad (\times 2)$

Cathode: $Cu^{2+} + 2e^- \rightarrow Cu(s) \quad (\times 3)$

$$2Al(s) + 3Cu^{2+}(aq) \rightarrow 2Al^{3+}(aq) + 3Cu(s)$$

Question 29

Criteria	Marks
• Makes an informed judgement • Identifies features required in the model, features of the experiment and limitations of the experiment • Clearly relates features of the experiment to the features required in the model • Supports judgement with relevant chemical notation (eg equations)	5
• Identifies features of the model and feature(s)/limitation(s) of the experiment • Relates feature(s) of the experiment to feature(s) of the model AND/OR supports judgement with some relevant chemical notation (eg an equation)	4
• Identifies feature(s) of the model and feature(s)/limitation(s) of the experiment • Links a feature of the experiment to a feature of the model	3
• Identifies feature(s) of the model AND/OR feature(s) of the experiment AND/OR limitation(s) of the experiment	2
• Identifies a feature of the model OR a feature of the experiment OR a limitation of the experiment	1

Sample answer:

This is a suitable model for the formation of acid rain for a school laboratory. Although it is smaller in scale and the environmental factors are limited, it still has many features in common. The burning of sulfur represents combustion of fossil fuels that contain sulfur

$$S(s) + O_2(g) \rightarrow SO_2\ (g)$$

The addition of water represents the interaction of SO_2 with rain

$$H_2O(l) + SO_2(g) \rightarrow H_2SO_3(aq)$$

The litmus paper represents the effects of acid rain. It does not account for natural sources of SO_2 or simulate the real effects.

Question 30 (a)

Criteria	Marks
• Correctly calculates the moles of NaOH	1

Sample answer:

$n(\text{NaOH}) = cV = 0.0500 \text{ mol/L} \times 1.00 \text{ L} = 0.0500 \text{ mol}$

Question 30 (b)

Criteria	Marks
• Correctly calculates percentage of CO_2 by mass to 3 significant figures	4
• Correctly calculates mass of CO_2 OR • Shows the correct process for calculating the percentage of CO_2 by mass	3
• Identifies moles of NaOH in excess and uses this to calculate a mass of CO_2 OR • Correctly calculates moles of NaOH used to neutralise CO_2	2
• Correctly calculates moles ($n = cV$) for the acid	1

Sample answer:

$n(\text{HCl}) = cV = 0.0276 \text{ mol/L} \times 1.00 \text{ L} = 0.0276 \text{ mol}$ used to titrate excess NaOH

Therefore moles NaOH used to neutralise $CO_2 = 0.0500 \text{ mol} - 0.0276 \text{ mol} = 0.0224 \text{ mol}$

From the equation: $n(CO_2) = \frac{1}{2} \times n(\text{NaOH}) = 0.0112 \text{ mol}$

Mass $(CO_2) = n \times M = 0.0112 \text{ mol} \times 44.01 \text{ g/mol} = 0.493 \text{ g}$

% of dry ice by mass $= \frac{0.493 \text{ g}}{0.616 \text{ g}} \times 100\% = 80.0\%$

Question 31

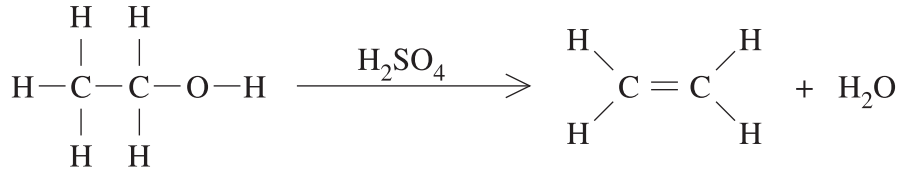
Criteria	Marks
• Identifies TWO uses of ethanol • Demonstrates a thorough understanding of the relevant chemical concepts and the impacts on society of the TWO uses • Makes an informed judgement of the impacts on society of the TWO uses • Demonstrates clear links between the underlying chemistry and each use of ethanol • Includes relevant and correct chemical equations • Demonstrates coherent and logical progression and correct use of chemical terms	7
• Identifies TWO uses of ethanol • Demonstrates a sound understanding of the relevant chemical concepts and the impacts on society of the TWO uses • Provides some links between the underlying chemistry and each use of ethanol • Includes at least ONE relevant and correct chemical equation • Demonstrates some correct use of chemical terms	5–6
• Identifies TWO uses of ethanol • Demonstrates some understanding of their impacts on society • Outlines some underlying chemistry of at least ONE of the uses	3–4
• Outlines an impact on society of ONE use of ethanol OR • Outlines an implication for society of ethanol production OR • Outlines some underlying chemistry of ONE use of ethanol	2
• Identifies an implication for society of ethanol use OR • Identifies a relevant chemical concept OR • Identifies a use of ethanol OR • Draws a relevant diagram OR • Provides a relevant equation	1

Sample answer:

Ethanol can be used as a solvent for a wide range of substances including polar and non-polar substances. This is because ethanol is a polar molecule and the –OH group allows for hydrogen bonds to form between ethanol and other substances. Hence it is miscible with water. However, the non-polar end of the molecule can form a solution with non-polar substances. There has been a positive impact on the health of society from this use as some

medicines can be dissolved in ethanol and then diluted for appropriate doses and administered to those who have difficulty swallowing such as children and the elderly.

Ethanol can also be used as a source of ethylene. Ethanol is dehydrated by heating it with concentrated sulfuric or phosphoric acid.



Ethylene is then used as a starting material for several important plastics. The impact on society has been the development of the plastics industry from ethylene, which has usually been sourced from fossil fuels but its conversion from ethanol which can be sourced from biomass has introduced a renewable source of raw material to support the plastics industry. However some fossil fuels are still used in this process.

In my opinion, there have been positive impacts on society overall from these two uses of ethanol.

Answers could include:

Understanding chemical concept	*Application/development of technologies*	*Impact on society*
Hydrogen bonding and polarity affect properties of substances. Ethanol can form hydrogen bonds with many other substances. Therefore miscible with water. Also has non-polar end which will form solution with non-polar substances.	Both polar and non-polar substances are soluble in ethanol.	Many medicines, food flavourings and colourings that do not dissolve easily in water can be dissolved in ethanol first and available as liquids. This makes medicines more available to elderly, children, those with difficulty swallowing. Easier to dilute for different doses.
Fermentation is a process that can produce an alkanol eg fermentation of glucose forms ethanol *(Equation)*	Ethanol can be produced by fermentation of glucose. Development of fermentation industry	Enables formation of ethanol as a fuel for transport from biomass / as part of alcoholic beverages for human consumption. Provides a source of fuel from renewable sources to replace fossil fuels.
Combustion of ethanol produces heat.	Ethanol can be used as a fuel.	Ethanol can supplement or replace petrol in car engines. If formed from biomass provides an alternative to fossil fuels.

Understanding chemical concept	*Application/development of technologies*	*Impact on society*
Addition reactions: splitting the double bond of an alkene allows for addition of a molecule to form a larger molecule. *(Equation)*	Ethanol can be produced by addition of water to ethylene.	
Some reactions are reversible. *(Equation)*	Ethylene is made from ethanol by dehydration. Ethanol is dehydrated by heating it with concentrated sulfuric or phosphoric acid which acts as a catalyst.	Ethanol from renewable sources can be converted to ethylene for other uses such as making polymers, fumigants, anti-freeze. Has provided plastics industry / way of getting rid of pests / preventing freezing of valuable liquids at low temperatures.

Section II

Question 32 (a)

Criteria	Marks
• Makes correct observations with reference to a property of sulfuric acid • Correctly identifies how sulfuric acid should be transported • Clearly relates the transportation method to the observations	3
• Makes correct observations with reference to a property of sulfuric acid OR • Identifies how sulfuric acid should be transported with clear links to observations made and some understanding of a property of sulfuric acid/the container material chosen	2
• Provides a property of sulfuric acid OR • Correctly states how sulfuric acid should be transported OR • Identifies a suitable transportation method based on observation(s) made	1

Sample answer:

From the diagram, there is no bubbling when concentrated sulfuric acid is added to steel or glass. This is because the acid in concentrated form is virtually all molecular. In contrast, there is bubbling when dilute acid is added to the steel surface. This is because dilute acid has a greater concentration of hydrogen ions than the concentrated acid. As steel has the advantage of strength over glass, sulfuric acid should therefore be transported in concentrated form in steel containers.

Question 32 (b) (i)

Criteria	Marks
• Explains the effect on the yield of NO(g) in terms of Le Chatelier's principle	2
• States that the forward reaction is favoured OR • Identifies the effect on the yield of NO(g)	1

Sample answer:

As the reaction is endothermic, an increase in temperature will favour the forward reaction according to Le Chatelier's principle. The yield of NO(g) will therefore increase.

Question 32 (b) (ii)

Criteria	Marks
• Correctly calculates the concentration of NOCl(g)	3
• Identifies the correct concentration of NO and recognises the correct equilibrium constant equation OR • Gives an incorrect concentration of NO but correctly applies the equilibrium constant equation to calculate a concentration of NOCl(g)	2
• Identifies the correct concentration of NO OR • Recognises the correct equilibrium constant equation	1

Sample answer:

$$2\text{NOCl}(g) \rightleftharpoons 2\text{NO}(g) + \text{Cl}_2(g)$$

[Equilibrium] (mol L^{-1}) x 0.34 0.17

$$K = \frac{\left[\text{NO}(g)\right]^2 \left[\text{Cl}_2(g)\right]}{\left[\text{NOCl}(g)\right]^2}$$

$$\left[\text{NOCl}(g)\right]^2 = \frac{(0.34)^2(0.17)}{0.028}$$

$$= 0.702$$

$$\therefore \left[\text{NOCl}(g)\right] = \sqrt{0.702}$$

$$= 0.84 \text{ mol L}^{-1}$$

Question 32 (c) (i)

Criteria	Marks
• Clearly shows how the energy transformations in galvanic and electrolytic cells are different	2
• Identifies the energy transformation for ONE type of cell OR • Gives the TWO forms of energy involved in the transformations without relating to the cell	1

Sample answer:

Both cells convert one form of energy to another. In galvanic cells, chemical energy is converted to electrical energy. In electrolytic cells, electrical energy is converted to chemical energy.

Question 32 (c) (ii)

Criteria	Marks
• Identifies the correct cell and relates the chemistry at the anode and cathode to the industrial production of sodium hydroxide	3
• Identifies the correct cell and gives the chemistry at the anode and cathode without relating the chemistry to the production of NaOH OR • Relates the chemistry at the anode and cathode to the production of NaOH but an incorrect cell is identified	2
• Identifies the correct cell OR • Gives the correct chemistry at either electrode OR • Gives a correct reason which supports the production of NaOH	1

Sample answer:

Cell *Y* will produce sodium hydroxide. The products at the anode and cathode are a result of the electrolysis of aqueous concentrated sodium chloride.

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

Cathode: $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$

Overall: $2Cl^-(aq) + 2H_2O(l) \rightarrow Cl_2(g) + H_2(g) + 2OH^-(aq)$

Additional to $H_2(g)$ being produced at the cathode, OH^- is also a product. OH^- ions can react with Na^+ ions to produce NaOH.

Question 32 (d) (i)

Criteria	Marks
• Outlines a valid procedure specifying chemicals used, equipment and relative amounts	2
• Identifies some features of a valid procedure	1

Sample answer:

Add 2 g of $NaHCO_3(s)$ to a test tube: clamp the test tube to the retort stand at an angle. Place a delivery tube fitted with a stopper at the mouth of the test tube. Immerse the other end of the tube into a test tube half-filled with limewater. Place a Bunsen burner under the test tube containing the $NaHCO_3(s)$ and heat for five minutes.

Question 32 (d) (ii)

Criteria	Marks
• Describes TWO limitations	3
• Describes ONE limitation OR • Identifies TWO limitations	2
• Identifies ONE limitation	1

Sample answer:

Two limitations associated with the modelling of this step include the recycling of $CO_2(g)$ and in identifying the final product $NaHCO_3(s)$.

In the laboratory the product $CO_2(g)$ is detected by the limewater turning cloudy. The $CO_2(g)$ was not recovered/recycled as is the case in industry.

The second limitation is not knowing when the reaction reached completion. Both $NaHCO_3(s)$ and $Na_2CO_3(s)$ are white solids thus there is difficulty knowing when all the $NaHCO_3(s)$ has decomposed to $Na_2CO_3(s)$.

Question 32 (e)

Criteria	Marks
• Demonstrates a thorough understanding of the structure and composition of soaps and detergents • Demonstrates a thorough understanding of their uses and impacts on the environment • Clearly relates uses and impacts on the environment of soaps and detergents to their structure and composition • Provides a coherent and concise response with no irrelevant, extraneous information	7
• Demonstrates a good understanding of the structure and composition of soaps and detergents • Demonstrates a good understanding of their uses and impacts on the environment • Links uses and impacts on the environment of soaps and detergents to their structure and composition	6
• Outlines the structure and composition of soaps and/or detergents • Identifies use(s) and impact(s) on the environment of soaps and/or detergents	4–5
• Demonstrates some understanding of the structure and/or composition and/or uses and/or impacts on the environment of soaps and/or detergents	2–3
• Identifies structure of soap or detergent OR • Identifies the composition of soap or a detergent OR • Identifies a use of soap or detergent OR • Identifies an impact on the environment of soap or detergent	1

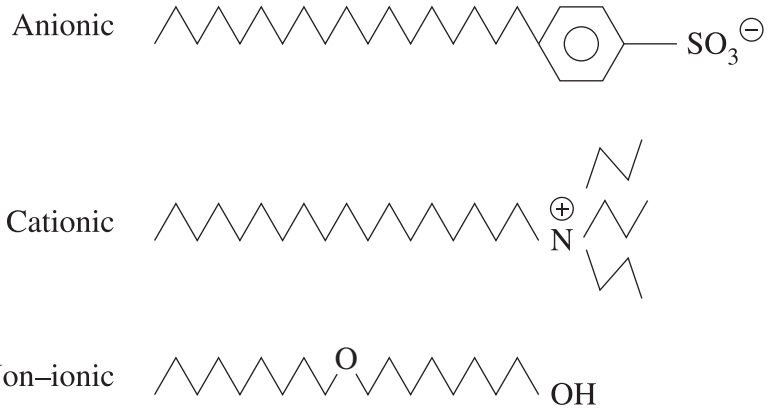
Question 32 (e) (continued)

Sample answer:

Soaps contain a long non-polar hydrocarbon chain and a polar anionic carboxylate end.

Detergents are similar in structure but differ in chemical composition. There are three classes of detergents.

Anionic detergents contain a non-polar hydrocarbon chain and a polar benzene sulphonate end. The cationic detergents have ammonium as their polar end while non-ionic detergents have the hydroxyl group.



Both soaps and detergents are used widely as cleaning agents. Detergents, however, vary slightly in their uses. Anionic detergents are used in dishwashing liquids and laundry detergents. Cationic are used in hair conditioners and fabric softeners. Non-ionic are used in front-loading washing machines and dishwashers.

Soaps are biodegradable. Soaps, however, do not lather in hard water. Early detergents were branched which contributed to poor biodegradability. This led to excessive frothing in rivers. Today, detergents are straight hydrocarbon chains which make them biodegradable.

In addition, detergents often contain builders which enhance their cleaning ability by softening the water. The problem with builders is their contribution to eutrophication which is detrimental to aquatic ecosystems.

The similar structure of soaps and detergents allows both to be effective cleaning agents with detergents having less of an impact on the environment.

Question 33 (a)

Criteria	Marks
• Outlines TWO reasons	3
• Outlines ONE reason OR • Identifies TWO corrosion protection measures/reasons	2
• Identifies ONE corrosion protection measure/reason	1

Sample answer:

The polymer layer protects the steel by providing a physical barrier to oxygen and water. The zinc layers on both the inside and outside of the steel act as a sacrificial anode because zinc is a stronger reductant than iron.

Answers could include:

Corrosion protection measures may include measures such as sacrificial anode and physical barrier.

Question 33 (b) (i)

Criteria	Marks
• Correct equation	2
• Equation with Fe, H_2O and O_2 as reactants OR • Equation with hydrated iron(III) oxide as product	1

Sample answer:

$4Fe(s) + 3O_2(g) + xH_2O(l) \rightarrow 2Fe_2O_3.xH_2O(s)$

Answers could include:

x may be 1 or 2.

Question 33 (b) (ii)

Criteria	Marks
• Explains thoroughly a difference in rates of corrosion between acidic and neutral conditions	3
• Identifies reasons OR • Explains ONE reason	2
• Identifies a reason OR • Identifies the reduction half equation in either acidic or neutral conditions	1

Sample answer:

Under acidic conditions, non-passivating metals such as iron corrode faster because the dissolved oxygen is a stronger oxidant in the presence of hydrogen ions.

$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$ $\quad E = 0.40$ V

$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$ $\quad E = 1.23$ V

Hydrogen ions can also oxidise metal directly (without oxygen). At low pH values, the hydrogen ions are at higher concentrations and this increases the reaction rate.

Question 33 (c) (i)

Criteria	Marks
• Accounts for the positively sloping lines, the drops to zero and the reduction over time	2
• Identifies a reason for a change in Cl^- concentration	1

Sample answer:

The chloride ion concentration initially increases as Cl^- ions leach out of the artefact. This drops to zero when the water is changed. Over time the $[Cl^-]$ reduces as salt is removed from the artefact.

Question 33 (c) (ii)

Criteria	Marks
• Provides a clear explanation of the potential damage to the artefact	3
• Shows some understanding of the process that occurs when a saturated solution evaporates OR • Relates damage to the failure to remove dissolved salts	2
• Identifies that the artefact will be damaged OR • Identifies that the artefact is saturated with salts	1

Sample answer:

Wooden artefacts from long-submerged wrecks may be saturated with dissolved chlorides. If the artefact was left to dry rather than removing the chloride salts as described in the procedure, the salts would crystallise as the saturated solution evaporates. This will cause damage to the structure or appearance of the wooden artefact.

Question 33 (d) (i)

Criteria	Marks
• Correctly identifies the variables to be kept constant	2
• Identifies a variable to be kept constant	1

Sample answer:

Temperature, salt concentrations of the water and the surface area of the iron

Question 33 (d) (ii)

Criteria	Marks
• Describes TWO limitations	3
• Describes ONE limitation OR • Identifies TWO limitations	2
• Identifies ONE limitation	1

Sample answer:

Measuring corrosion rates by weighing the mass loss is difficult because:

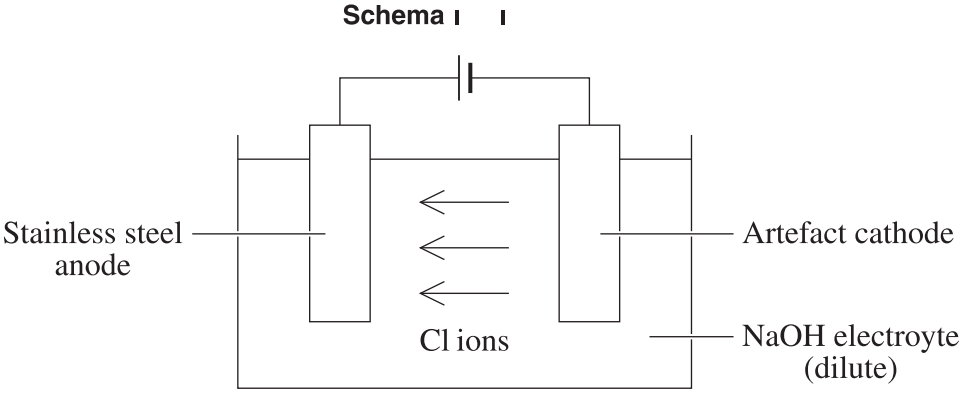
- mass changes will be small and may not be detectable using the equipment in a school laboratory
- the corrosion products adhere loosely to the iron, so need to be completely removed without damaging the iron.

Question 33 (e)

Criteria	Marks
• Demonstrates a thorough understanding of a range of factors that affect electrolytic reactions • Demonstrates a thorough understanding of the cleaning and stabilising of a metal artefact using electrolysis • Clearly relates the need to consider a range of factors to the cleaning and stabilising of a metal artefact using electrolysis • Supports explanation with relevant chemical notation such as equations or half equations • Provides a coherent and concise response with no irrelevant, extraneous information	7
• Demonstrates a good understanding of factors that affect electrolytic reactions • Demonstrates a good understanding of the cleaning and stabilising of a metal artefact using electrolysis • Supports response with relevant chemical notation such as equations or half equations	6
• Outlines factors that affect electrolytic reactions • Outlines the electrolytic cleaning and/or stabilising of a metal artefact • Supports response with chemical notation such as a relevant equation or half equation	4–5
• Outlines factor(s) that affect electrolytic reactions AND/OR • Outlines feature(s) of the electrolytic cleaning process of a metal artefact AND/OR • Outlines feature(s) of the stabilising process of a metal artefact	2–3
• Identifies a factor that affects electrolysis OR • Identifies a feature in the electrolytic cleaning or stabilising of a metal artefact	1

Sample answer:

Iron artefacts can be stabilised by using electrolysis to remove chloride ions.



Anode:	$2OH^- \rightleftharpoons \frac{1}{2}O_2 + H_2O + 2e^-$	–0.40 V
Cathode:	$2H_2O + 2e^- \rightleftharpoons H_2 + 2OH^-$	–0.83 V
Overall:	$H_2O \rightleftharpoons H_2 + \frac{1}{2}O_2$	$E^\circ = -1.23$ V

Knowledge of electrolysis is important to prevent damage to the artefact or hazards for conservators.

1. Nature of electrolyte – the electrolyte chosen should be passivating to the metal and produce non-toxic products. Evolving gas at the cathode will aid in removing corrosion. Sodium hydroxide is suitable for this.

2. Concentration of the electrolyte – as the reaction proceeds Cl^- ions are drawn from the artefact, and $[Cl^-]$ increases. The reaction needs to be monitored to prevent the unwanted reaction at the anode.

$$Cl^- \rightleftharpoons \frac{1}{2}Cl_2 + e^- \qquad E^\circ = -1.40 \text{ V}$$

3. Nature of electrodes – since the artefact is used as the cathode, its chemical composition must be determined to prevent any unwanted reactions. Likewise, the anode must be inert, otherwise it may be electroplated on the artefact. Usually a flexible stainless steel mesh is used. This has the advantages of being inert and able to be shaped to keep the distance between the electrodes constant.

4. Current and voltage applied – excessive current can cause rapid bubbling on the cathode, destroying the artefact, and higher voltages can cause unwanted reactions such as the production of $Cl_2(g)$.

Question 34 (a)

Criteria	Marks
• Correct description of the two steps in correct order	3
• Correct description of one step OR • Identifies the two steps	2
• Identifies one step	1

Sample answer:

Step 5: The endoplasmic reticulum releases calcium ions over the actin and myosin

Step 6: Tropomyosin moves to allow the crossbridge of the myosin to make contact with troponin (on the actin)

Question 34 (b) (i)

Criteria	Marks
• Names an enzyme and outlines its function	2
• Names an enzyme OR • Outlines a general function of enzymes	1

Sample answer:

The function of the enzyme catalase is to speed up the decomposition of hydrogen peroxide to form water and oxygen $2H_2O_2(l) \xrightarrow{\text{catalase}} 2H_2O(l) + O_2(g)$

Question 34 (b) (ii)

Criteria	Marks
• Provides a clear explanation of how a change in pH can affect the shape and structure of an enzyme with reference to the nature of the bonds responsible for protein folding	3
• Shows some understanding of the forces responsible for protein folding • Identifies changes in ionisation in response to pH changes	2
• States one cause of protein folding OR • Identifies that changes in pH are associated with changes in ionisation of amino acids	1

Sample answer:

The secondary and tertiary structures of a protein depend on electrostatic forces, hydrogen bonding and disulfide bridges between amino acid side chains as well as the hydrophobic nature of parts of the molecule.

Changes in pH cause the side chains of amino acids to change their degree of ionisation which alters hydrogen bonding between parts of the molecule and changes the hydrophobic tendency of the side chains causing a change in shape of the molecule.

Question 34 (c) (i)

Criteria	Marks
• Provides a clear explanation of an advantage of branching	2
• Identifies a feature of branching	1

Sample answer:

Branching creates a lot of endings which can be attacked by enzymes and provides for rapid release of glucose when required.

Answers could include:

– Branches in the glycogen molecule help keep the polymer soluble.
– Branches create endings which provide for rapid re-synthesis of glycogen to store glucose.

Question 34 (c) (ii)

Criteria	Marks
• Correctly calculates the number of glucose monomers in an average glycogen molecule as represented in the graph	3
• Shows substantial understanding of the calculation process	2
• Identifies correct average molecular mass of glycogen OR • Correctly calculates the molecular mass of glucose OR • Recognises glycogen is a condensation polymer by subtracting the molecular mass of water from the mass of glucose	1

Sample answer:

Calculated molecular mass of glucose = 180.16 g/mol
Calculated molecular mass of water = 18.02 g/mol
Average molecular mass of glycogen = 400 000 g/mol (from graph)

Because glycogen is a condensation polymer, each monomer unit has mass 180.16 g/mol – 18.02 g/mol = 162.14 g/mol with the exception of the terminal glucose monomer.

Therefore there are $\frac{400\,000}{162.14} = 2467$ monomer units in an average glycogen molecule or 2500 to 2 significant figures.

OR taking terminal glucose into account, there are $\frac{399982}{162.14} = 2467$ monomer units in an average glycogen molecule or 2500 to 2 significant figures.

Question 34 (d) (i)

Criteria	Marks
• Identifies the essential features	2
• Identifies ONE essential feature	1

Sample answer:

Fatty acids have a long hydrocarbon chain and a COOH group at one end which should be included.

Answers could include:

- Hydrocarbon chain of unsaturated fatty acids will include double bonds between two or more carbon atoms.
- The number of double bonds will affect the flexibility of the hydrocarbon chain.
- The COOH group will lose a H^+ when it ionises

Question 34 (d) (ii)

Criteria	Marks
• Describes TWO limitations	3
• Describes ONE limitation OR • Identifies TWO limitations	2
• Identifies ONE limitation	1

Sample answer:

The limitations of molecular models include: a model is usually a fixed structure with atoms set in fixed positions whereas data suggests the relationship between atoms in a molecule is dynamic and atoms move. Secondly, bond lengths are fixed by rods between atoms, though it is recognised that the distances between atoms shift and bonds are not solid rod-like structures.

Question 34 (e)

Criteria	Marks
• Demonstrates a thorough understanding of how energy production is carried out in mitochondria • Clearly relates mitochondria damage to ATP production and reduced energy output of the cell • Provides a coherent and concise response with no irrelevant, extraneous information	7
• Demonstrates a good understanding of how energy production is carried out in mitochondria • Links mitochondrial damage to changes in production and reduced energy output of the cell	6
• Demonstrates a sound understanding of the biochemical pathways releasing energy in the cell and in the mitochondria	4–5
• Demonstrates some understanding of the biochemical pathways releasing energy in the cell	2–3
• Provides some relevant information	1

Sample answer:

Production of energy in a cell relies on cellular respiration where breakdown of a molecule of glucose results in the production of 38 molecules of ATP.

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{energy}$$

Respiration can be divided into three stages: glycolysis which occurs in the cytoplasm, the TCA (Krebs) cycle and oxidative phosphorylation both of which occur in the mitochondria.

The TCA cycle and oxidative phosphorylation produce most of the ATP from one glucose molecule, and therefore if these stages are not working properly due to mitochondrial damage, ATP production will be severely reduced.

In the TCA cycle, the carbon–carbon bonds and the carbon–hydrogen bonds are oxidised to produce ATP and two high energy compounds NADH and $FADH_2$ which are later oxidised to release their energy during oxidative phosphorylation (electron transport chain), finally producing 36 molecules of ATP.

Thus, damage to mitochondria may damage the ability of a cell to complete the TCA cycle and successfully feed high energy compounds into oxidative phosphorylation, or compromise enzymes responsible for catalysing oxidation of NADH or $FADH_2$. The result would be reduced energy output of the cell.

Question 35 (a)

Criteria	Marks
• Explains the trend, with specific reference to the larger increase between third and fourth ionisation being related to the number of outer shell electrons	3
• Identifies the general increasing trend in energy and the significantly higher increase between the third and fourth ionisation OR • Explains one of the above features of the trend	2
• Identifies a feature of the trend	1

Sample answer:

The ionisation energies for aluminium increase as successive electrons are removed.

Of particular note is the significantly higher increase between the third and fourth ionisation. The higher fourth ionisation energy indicates this electron being removed from an inner shell, confirming aluminium has three outer shell electrons.

Question 35 (b) (i)

Criteria	Marks
• Outlines how pigments are prepared and applied to cave walls	2
• Identifies how a pigment is prepared or applied to cave walls	1

Sample answer:

After obtaining a pigment from ochres or charcoal, prepare the pigment by mixing it with a suitable medium such as wax, resin or gum to form a paint that can be brushed on to a cave wall.

Question 35 (b) (ii)

Criteria	Marks
• Describes the chemical composition and respective colour of three pigments used by Aboriginal people	3
• Describes the chemical composition of three pigments used by Aboriginal people OR • Describes the chemical composition and respective colour of two pigments used by Aboriginal people	2
• Provides some relevant information about colours or chemical composition of pigments used by Aboriginal people	1

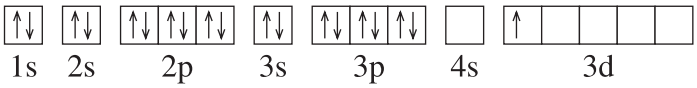
Sample answer:

Aboriginal people used earth colours extensively including red, yellow, black and white. The chemical composition of these pigments include hydrated iron oxides (red), aluminium silicon oxide (white) and manganese dioxide (black).

Question 35 (c) (i)

Criteria	Marks
• Writes a valid configuration identifying the removal of three electrons and the orbitals from which they are removed	2
• Identifies that three electrons are removed	1

Sample answer:



Answers could include:

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^1$

Question 35 (c) (ii)

Criteria	Marks
• Explains why II and III are invalid with reference to the electrons in the corresponding configuration	3
• Identifies a reason for both states OR • Provides an explanation for either state II or state III	2
• Identifies a reason	1

Sample answer:

II violates the Pauli exclusion principle as the electrons in the 4s sub-shell have the same set of Quantum numbers.

III violates Hund's rule as the 3d electrons are paired in an orbital while empty orbitals remain.

Question 35 (d) (i)

Criteria	Marks
• Outlines a valid procedure	2
• Identifies some features of a valid procedure	1

Sample answer:

Chromium is a transition metal that can investigated. This involves heating a solution of dichromate ions dissolved in ethanol. The procedure relies upon observation of any colour change.

Question 35 (d) (ii)

Criteria	Marks
• Describes TWO limitations	3
• Describes ONE limitation OR • Identifies TWO limitations	2
• Identifies ONE limitation	1

Sample answer:

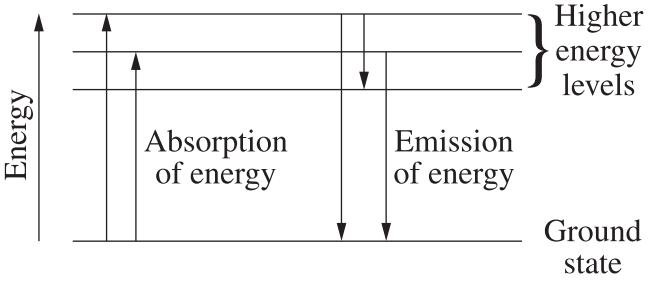
The colour change may not be visible due to reagents obscuring the change. The colour change does not confirm the actual oxidation state, simply that it is changing.

Question 35 (e)

Criteria	Marks
• Demonstrates a thorough understanding of the relationship between electrons and colour • Clearly relates the energy levels of electrons to colours observed • Provides a coherent and concise response with no irrelevant, extraneous information	7
• Demonstrates a good understanding of the relationship between electrons and colour • Links the energy levels of electrons to colours observed	6
• Demonstrates a sound understanding of the relationship between electrons and colour • Outlines how energy levels of electrons affect colours observed	4–5
• Demonstrates some understanding of the relationship between electrons and colour	2–3
• Provides some relevant information	1

Sample answer:

Electrons are important for determining colours. This is due to the orbitals that electrons can move between having different energy levels. Electrons in lower energy orbitals can absorb energy of a particular wavelength and move to a higher energy level, while electrons in higher energy levels can emit energy when moving to lower levels.



In an absorption process, the colour observed is the complement of the colour corresponding to the wavelength absorbed.

In an emission process, the colour observed corresponds to the energy of the emitted photons. This colour is observed as electrons return to lower energy levels, emitting quanta of energy. Higher energy transitions correspond to the colour blue, lower energy corresponds to red.

The role of electrons is of particular importance in determining the colour of transition metals. Particular transition metals exist as a range of colours depending on their oxidation states. This is due to the different arrangement of filled and unfilled orbitals.

Electrons also determine the colour of ions in flame tests. This is also due to the release of energy as electrons move to lower energy levels.

Question 36 (a)

Criteria	Marks
• Explains TWO errors	3
• Identifies error(s) and/or possible consequence(s)	2
• Identifies an error or a possible consequence of an error	1

Sample answer:

The forensic scientist is not wearing gloves and their hair is out and uncovered. These errors could result in contamination of the sample which makes the sample's integrity questionable.

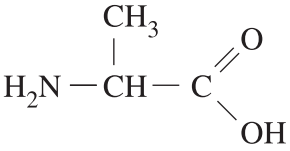
Answers could include:

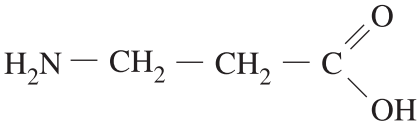
Risk of infection for the scientist

Question 36 (b) (i)

Criteria	Marks
• Correctly draws BOTH products	2
• Correctly draws one product OR • Provides substantially correct drawings of both products OR • Provides the names of both products	1

Sample answer:





Question 36 (b) (ii)

Criteria	Marks
• Describes how protein hydrolysis is used in forensic analysis including a relevant technique and the information that would be obtained	3
• Identifies a technique that could be used and how it would be useful	2
• States ONE way in which protein hydrolysis can be useful in forensic analysis OR • Identifies a relevant technique that could be used in forensic analysis	1

Sample answer:

By breaking down proteins into amino acids, electrophoresis can be carried out on the sample, using different buffers to identify the amino acids in the sample and so identify the protein and/or where it originated.

Question 36 (c) (i)

Criteria	Marks
• Correctly identifies the unknown substance with justification using the table provided	2
• Correctly identifies the unknown substance OR • Shows some understanding of using the table to identify the unknown substance	1

Sample answer:

Cocaine – because all the fragments are contained within the sample spectrum.

Question 36 (c) (ii)

Criteria	Marks
• Describes the benefits and/or application(s) of mass spectrometry in analysing forensic evidence	3
• Identifies application(s) and/or benefit(s) of mass spectrometry OR • Describes an application or a benefit of mass spectrometry	2
• Identifies an application of mass spectrometry OR • Identifies a benefit of using mass spectrometry	1

Sample answer:

Mass spectrometry is highly accurate and requires only a small amount for analysis. MS can be combined with gas chromatography where the GC–MS 'fingerprint' allows the sample to be analysed and compared to reference samples for definitive identification. For example, detecting the source of an oil spill by comparing with oil sources.

Question 36 (d) (i)

Criteria	Marks
• Outlines a valid procedure identifying the mixture to be separated, the solvent and the stationary phase	2
• Identifies some features of a valid procedure	1

Sample answer:

Take a handful of spinach leaves and grind in a pestle and mortar with about 10mL acetone. Filter and use a capillary tube to place a concentrated spot of the filtrate 2 cm from the bottom of a long strip of filter paper. Place 20mL of a suitable solvent (ethanol, petroleum ether, water etc) in the bottom of a 100mL measuring cylinder. Place the filter paper in the measuring cylinder so that only 1 cm of the bottom of the filter paper is in the solvent. Allow the solvent to move up the filter paper until it reaches the top. Remove, dry and observe separation.

Question 36 (d) (ii)

Criteria	Marks
• Describes TWO limitations	3
• Describes ONE limitation OR • Identifies TWO limitations	2
• Identifies ONE limitation	1

Sample answer:

This procedure separates the different pigments in a mixture but does not actually identify what the pigments are, therefore no qualitative analysis can be done. The procedure does not allow determination of how much of each pigment is in the mixture therefore no quantitative analysis can be done.

Answers could include:

- Limitations on the types of solvents
- Reproducibility
- Resolution of the separation

Question 36 (e)

Criteria	Marks
• Demonstrates a thorough understanding of the principles related to evidence collection and analysis, and the limitations of DNA evidence • Provides a coherent and concise response with no irrelevant, extraneous information	7
• Demonstrates a good understanding of the principles related to evidence collection and analysis, and the limitations of DNA evidence	6
• Demonstrates a sound understanding of evidence collection and analysis, and the limitations of DNA evidence	4–5
• Demonstrates some understanding of evidence collection and/or the limitations of DNA evidence	2–3
• Provides some relevant information	1

Sample answer:

There are several reasons why DNA evidence may be challenged. DNA evidence could be contaminated during collection or analysis if the crime scene examiner or analyst do not follow the appropriate guidelines. This will affect the interpretation of the results. The evidence could also be challenged if the chain of custody is compromised at any stage.

Further challenges may involve the confidence or likelihood of a match. The procedure of DNA analysis focuses on the non-coding (introns) DNA sequences. These vary between individuals, but will be similar if people are related. In the case of identical twins identical introns exist giving rise to identical DNA profiles. If the accused person has an identical twin the evidence is likely to be challenged.

Chemistry
2014 HSC Examination Mapping Grid

Section I
Part A

Question	Marks	Content	Syllabus outcomes
1	1	9.2.1.2.2	H9
2	1	9.4.4.2.1, 9.4.4.2.3	H4
3	1	9.4.4.2.9	H9
4	1	9.3.4.2.1, 9.3.4.2.2	H1, H2
5	1	9.2.1.2.5, 9.2.1.3.1	H8, H9
6	1	9.4.5.3.1, 9.4.5.3.2, 9.4.5.2.1	H4, H12.4, H14
7	1	9.3.1.3.3, 9.3.1.2.2	H2, H4, H14
8	1	9.3.3.2.4, 9.3.3.3.4	H10
9	1	9.4.4.2.9	H9
10	1	9.3.4.2.3	H8, H10
11	1	9.4.4.2.4, 9.4.4.2.5	H6, H13.1d, H13.1e, H14.3b
12	1	9.3.3.2.5, 9.3.3.2.7	H10
13	1	9.4.2.2.3, 9.4.2.2.9	H8
14	1	9.3.3.2.5, 9.3.3.3.7	H12.4b
15	1	9.3.2.2.9	H10, H12
16	1	9.2.4.2.3	H8
17	1	9.2.2.2.2, 9.2.2.2.3	H9
18	1	9.2.4.3.4	H8, H10
19	1	9.2.3.3.6	H7, H11.1c, H11.1d, H12.4b
20	1	9.4.2.2.9, 9.4.2.2.6	H7, H8, H10, H14.1a, H14.1g

Section I
Part B

Question	Marks	Content	Syllabus outcomes
21	3	9.2.5.2.2	H4
22 (a)	3	9.2.3.3.6	H10
22 (b)	3	9.2.3.3.6	H12, H14
23 (a)	1	9.4.5.3.3	H4
23 (b)	2	9.4.3.3.2, 9.4.5.3.2, 9.4.5.3.3	H4
24	5	9.4.3.2.1, 9.4.3.3.1	H11
25 (a)	2	9.4.1.2.3	H12
25 (b)	2	9.4.1.2.3	H9, H10
26 (a)	1	9.3.5.3.1 9.3.5.2.2	H9, H11

Question	Marks	Content	Syllabus outcomes
26 (b)	5	9.3.5.3.1	H9, H11
27 (a)	2	9.4.2.2.6, 9.4.5.2.1	H8, H14
27 (b)	4	9.4.5.2.1, 9.4.3.2.2	H4, H11, H12
28 (a)	2	9.2.4.2.4	H6
28 (b)	3	9.2.4.3.4	H10
29	5	9.3.2.2.6, 9.3.2.2.7, 9.3.2.2.8, 9.3.2.2.10	H11, H2, H4, H13
30 (a)	1	9.3.4.3.3	H10
30 (b)	4	9.3.4.3.3, 9.3.2.2.1, 9.3.2.2.5	H10, H12, H14
31	7	9.2.3.2.1,3,4,6,8; 9.2.3.3.1–6	H1, H3, H4, H8, H13

Section II

Question	Marks	Content	Syllabus outcomes
Question 32		**Industrial Chemistry**	
32 (a)	3	9.5.3.3.3	H6, H8, H9
32 (b) (i)	2	9.5.2.2.2.	H8, H9
32 (b) (ii)	3	9.5.2.3.4	H9, H10
32 (c) (i)	2	9.5.4.2.1	H7, H8
32 (c) (ii)	3	9.5.4.3.2	H6, H7, H8, H9
32 (d) (i)	2	9.5.6.3.1	H6–H12
32 (d) (ii)	3	9.5.6.3.1	H6–H10, H13, H14
32 (e)	7	9.5.5.2.3, 9.5.5.2.5, 9.5.5.2.6, 9.5.5.3.5	H1–H6, H8, H9
Question 33		**Shipwrecks, Corrosion and Conservation**	
33 (a)	3	9.6.4	H8
33 (b) (i)	2	9.6.2.2.4	H8, H13
33 (b) (ii)	3	9.6.2.2.4	H8, H13
33 (c) (i)	2	9.6.7.2.1, 9.6.7.3.1	H6, H12, H14
33 (c) (ii)	3	9.6.7.2.2	H4, H6, H14
33 (d) (i)	2	9.6.5.3.1	H11
33 (d) (ii)	3	9.6.5.3.1	H10–H12
33 (e)	7	9.6.3, 9.6.7	H4, H8, H14
Question 34		**The Biochemistry of movement**	
34 (a)	3	9.7.5.2.3, 9.7.5.2.4	H6, H13
34 (b) (i)	2	9.7.4.2.8, 9.7.4.3.2	H6, H9
34 (b) (ii)	3	9.7.4.2.4, 9.7.4.2.5, 9.7.4.3.2	H6, H9
34 (c) (i)	2	9.7.2.2.3	H6, H8, H9
34 (c) (ii)	3	9.7.2.2.3	H9, H10
34 (d) (i)	2	9.7.3.2.1, 9.7.3.3.1	H9
34 (d) (ii)	3	9.7.3.3.1	H8, H9, H12

Question	Marks	Content	Syllabus outcomes
34 (e)	7	9.7.1, 9.7.8, 9.7.9	H7, H8, H9
Question 35		**The Chemistry of Art**	
35 (a)	3	9.8.3.2.8, 9.8.3.3.1	H6, H13
35 (b) (i)	2	9.8.1.2.4	H4
35 (b) (ii)	3	9.8.1.3.1	H6
35 (c) (i)	2	9.8.3.2.2, 9.8.3.2.4, 9.8.3.2.5, 9.8.4.3.1	H6
35 (c) (ii)	3	9.8.3.2.1, 9.8.3.2.2, 9.8.3.2.5, 9.8.3.3.2	H6
35 (d) (i)	2	9.8.4.2.4, 9.8.4.3.2	H6, H11
35 (d) (ii)	3	9.8.4.2.4, 9.8.4.3.2	H6, H8, H12
35 (e)	7	9.8.2, 9.8.4.2.4	H6, H7
Question 36		**Forensic Chemistry**	
36 (a)	3	9.9.1.2.1, 9.9.1.1.1	H8, H9, H12, H14
36 (b) (i)	2	9.9.3.1.4	H9
36 (b) (ii)	3	9.9.3	H6, H9, H13
36 (c) (i)	2	9.9.5.1.3	H8
36 (c) (ii)	3	9.9.5.2.3, 9.9.5.3.1	H8, H9
36 (d) (i)	2	9.9.3.3.3	H9, H10, H11
36 (d) (ii)	3	9.9.3.3.3	H9, H10, H12
36 (e)	7	9.9.1, 9.9.4	H8, H9