

Exam Choice

2010 Chemistry Trial HSC examination. Marking Guidelines and model Answers.

Section I A Multiple Choice

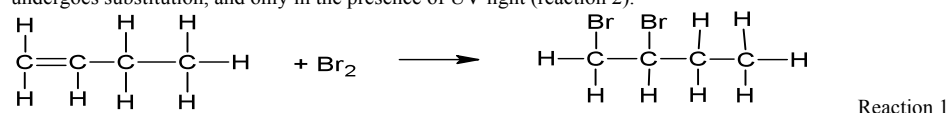
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A	A	C	C	D	C	A	C	D	C	A	A	D	B	B	B	D	B	C	B

Section I B

21.a.

Marking Guidelines	Marks
• Explains the different reactivities including a correct chemical equation.	2
• Explains the different reactivities.	1

Butane contains only a carbon-carbon single bond, whereas butene contains a carbon-carbon double bond. The double bond is much more reactive than the single bond. This is illustrated by the fact that 1-butene undergoes an addition reaction with $\text{Br}_2(\text{aq})$ (reaction 1), whereas butane undergoes substitution, and only in the presence of UV light (reaction 2).



21.b.

Marking Guidelines	Marks
• Gives the correct name for the product of the reaction identified in (a)	1

1,2 dibromobutane

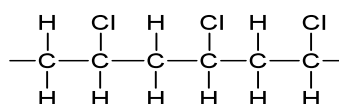
22.a.

Marking Guidelines	Marks
• Gives the systematic name of one monomer.	1

Chloroethene

22.b

Marking Guidelines	Marks
• Draws the structure of a segment of the polymer chain.	1



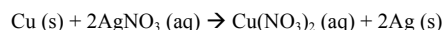
22.c.

Marking Guidelines	Marks
• Accounts for a use of the polymer in terms of its properties.	2
• Identifies a use OR a property of the polymer.	1

Poly(vinyl chloride) commonly used for waterproof clothing and shower curtains because it is water resistant and has a good tensile strength.

23.a.

Marking Guidelines	Marks
• Writes a balanced equation for the reaction.	1



23.b.

Marking Guidelines	Marks
• Correctly determines the concentration of both species, with sufficient working.	3
• Correctly determines the concentration of the nitrate ion AND	2
• Determines the moles of Ag^+ consumed in the reaction.	
• Correctly determines the concentration of the NO_3^-	1
• Calculates the initial moles of Cu or AgNO_3	

(i) $n(\text{NO}_3^-)$ remains unchanged as it is a spectator ion.

$$\therefore c(\text{NO}_3^-) = 0.50\text{M (2 sig figs)}$$

$$\text{(ii) } n(\text{Cu}) = m/\text{MM} = 1.15 / 63.55 = 0.0181 \text{ mol}$$

$$n(\text{AgNO}_3) = c \times V = 0.5 \times 0.1 = 0.05 \text{ mol}$$

1 mole Cu requires 2 moles of AgNO_3

$\therefore 0.0181 \text{ mol Cu}$ requires $0.03619 \text{ mol AgNO}_3$. Since mol of Ag we have exceeds that required, AgNO_3 is in excess and copper limits reaction and is totally consumed.

$\therefore 0.03619 \text{ moles of Ag}^+$ are consumed.

$$n(\text{Ag}^+)_{\text{remaining}} = n_{\text{initial}} - n_{\text{consumed}} = 0.05 - 0.03619 = 0.01381 \text{ mol}$$

$$\therefore c(\text{Ag}^+)_{\text{in remaining solution}} = n/V = 0.01381/0.1 = 0.14\text{M (2 sig figs)}$$

24.a.

Marking Guidelines	Marks
• Identifies an appropriate instrument to detect the radiation.	1

Geiger tube

24.b.

Marking Guidelines	Marks
• Correctly determines the concentration of both species, with sufficient working.	2
• Correctly determines the concentration of the nitrate ion AND	1
• Determines the moles of Ag^+ consumed in the reaction.	

In this application, some, but not all of the radiation must be able to pass through the foil so that the levels passing through can be detected on the other side. This allows for the thickness to be monitored.

A is an alpha emitter-these particles cannot penetrate the foil and thus this radioisotope is not suitable.

C is a gamma emitter and these particles would all pass through the foil-thus this radioisotope would not be suitable.

B emits beta particles-depending on the thickness, some would pass through whilst others would not-thus this would be a suitable radioisotope for this application.

25.

Marking Guidelines	Marks
• Describes the development and use of a named biopolymer and makes a judgement on its use based on described advantages and limitations of the biopolymer.	4
• Outlines a recent biopolymer AND identifies an advantage and limitation of the biopolymer	3
• Outlines the recent development of a named biopolymer	2
• Identifies a recently developed biopolymer or states an advantage or limitation of the biopolymers in general.	1

From the fractional distillation of crude oil, followed by thermal and catalytic cracking, we obtain ethylene which can be polymerised into a number of synthetic polymers. The polymers produced from these monomers have very useful properties, and have transformed the modern world. Products such as food wrapping, polystyrene insulation, PVC drainpipes, and all of the ubiquitous plastic around us, are relatively recent modern phenomena. The biggest issue with these plastics is that they are non-biodegradable, and contribute to the vast amount of landfill we generate, and also destroy habitat, both terrestrial and aquatic, killing large numbers of marine animals for example. Fossil fuels are also non-renewable resources and are therefore dwindling and becoming more expensive as a result.

Biopolymers are an alternative source of these materials, and one such biopolymer, polyhydroxybutanoate (PHB) already finds commercial applications. PHB is produced by fermentation, using the bacteria *Alcaligenes eutrophus*, by feeding it on a nutrient rich diet to increase its population, and then restricting the supply of nitrogen in its food. This causes it to produce PHB as an energy storage compound. Once the production of PHB is complete it is harvested by solvent extraction. PHB has properties similar to polypropene, and has found commercial use as plastic bottles and containers, for example for shampoo packaging. It has a high melting point, is strong, water resistant and relatively rigid, making it ideal for these sorts of applications. However it is also biodegradable, which means that once disposed of, and exposed to bacteria in the environment, it is broken down completely, eliminating the issue of land and sea pollution. It is also a renewable material since it is made by living organisms, eliminating the issue of dwindling fossil fuel resources. On the other hand, currently biopolymers are more expensive than polymers obtained from fossil fuels, but this will change as fossil fuels continue to dwindle and their price increases. As a result this biopolymer is an excellent alternative to some of the materials currently obtained from fossil fuels.

26.a.

Marking Guidelines	Marks
• Identifies the two species which would react to produce a basic salt.	1

NaOH and CH_3COOH

26.b.

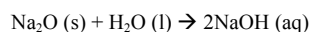
Marking Guidelines	Marks
<ul style="list-style-type: none"> Selects the correct species from the list and justifies selection, and outlines how the buffer should be prepared. 	2
<ul style="list-style-type: none"> Selects the correct pair of species which could make a buffer OR States that a buffer can be prepared by mixing equimolar amounts of a strong & weak acid 	1

Species (iii) and (vii) could form a buffer solutions as they contain a weak base (NH_3) and its conjugate acid (NH_4^+). The solution can be made by mixing equimolar amounts of NH_3 and NH_4Cl .

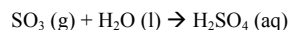
27

Marking Guidelines	Marks
<ul style="list-style-type: none"> Describes the trend in the acid-base nature of the oxides across the periodic table AND Writes TWO equations to show the acidic and basic nature of a non-metal & metallic oxide AND Identifies some oxides are amphoteric and gives an example. 	3
<ul style="list-style-type: none"> Outlines the trend in acid-base nature of the oxides across the periodic table, including knowledge of amphoteric oxides AND Writes ONE equation to show the acid or base nature of an identified oxide. 	2
<ul style="list-style-type: none"> Identifies the basic trend in the acid-base nature of the oxides across the periodic table OR Writes an equation to show the acid or base nature of an identified oxide. 	1

Elements towards the left of the periodic table (eg the Group I and II metals) form basic oxides. For example, sodium oxide produces a basic aqueous solution:



As you move towards the right of the periodic table, the oxides become increasingly acidic. For example, sulfur trioxide forms an acidic solution:



A few elements which show metallic and non-metallic properties (close to division between metals and non-metals) form amphoteric oxides, which can behave as acids and bases under different conditions eg Al_2O_3 .

28.a.

Marking Guidelines	Marks
<ul style="list-style-type: none"> Writes a correctly balanced equation for the reaction. 	1



28.b.

Marking Guidelines	Marks
<ul style="list-style-type: none"> Calculates the mass of copper required to produce the stated volume of NO_2 	2
<ul style="list-style-type: none"> Calculates the moles of NO_2. 	1

$$n(\text{NO}_2) = V/V_m = 1.5/24.79 = 0.061 \text{ mol}$$

$$n(\text{Cu}) = \frac{1}{2} \times 0.061 = 0.03 \text{ mol}$$

$$m(\text{Cu}) = 63.55 \times 0.03 = 1.92 \text{ g}$$

28.c.

Marking Guidelines	Marks
<ul style="list-style-type: none"> Produces a risk assessment for the procedure, including the major risks and associated controls. 	2
<ul style="list-style-type: none"> Identifies one risk associated with the demonstration. 	1

Concentrated HNO_3 is a highly corrosive chemical. Wear safety goggles and protective gloves when handling. NO_2 is a corrosive, acidic gas which irritates eyes and respiratory membranes. Thus experiment should be performed in a fume cupboard.

29.a.

Marking Guidelines	Marks
<ul style="list-style-type: none"> Draws a graph to effectively display the data provided, including drawing a smooth line of best fit through accurately plotted points. 	3
<ul style="list-style-type: none"> Draws an appropriately formatted graph with a major error. 	2
<ul style="list-style-type: none"> Plots the points on a basic graph. 	1

29.b

Marking Guidelines	Marks
<ul style="list-style-type: none"> Estimates the volume of NaOH needed to reach equivalence from the graph drawn. 	1

Approximately 22-23 mL

29.c.

Marking Guidelines	Marks
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• Calculates the correct concentration of sodium hydroxide using the estimate from (b).	2
• Calculates the moles of ethanoic acid in the conical flask	1

$n(\text{CH}_3\text{COOH}) = c \times V = 0.1 \times 0.025 = 0.0025\text{mol}$
 $n(\text{NaOH}) = 0.0025\text{mol}$
 $c(\text{NaOH}) = 0.0025 / 0.023 = 0.11 \text{ mol/L}$

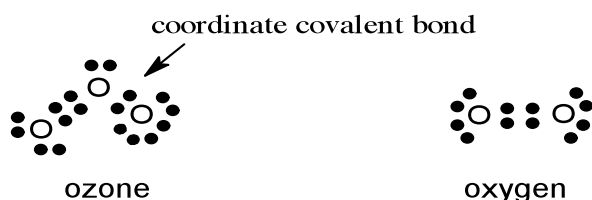
29.d.

Marking Guidelines	Marks
• Explains how an identified modification would improve the validity of the procedure.	2
• Identifies a modification which would improve the validity of the procedure.	1

The procedure as described is not valid because the range over which you measured pH as the NaOH was added was limited. This did not allow you to accurately measure the volume of NaOH required to reach equivalence. To improve the accuracy of the estimate, and hence the validity of the procedure, the student should collect pH measurements over smaller changes in NaOH addition, or use a pH probe, drop counter and data logger to complete the investigation.

30.

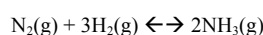
Marking Guidelines	Marks
• Draws correct electron dot diagrams, and explains a difference in one property with respect to different intermolecular forces.	3
• Draws correct electron dot diagrams, OR explains a difference in one property with respect to different intermolecular forces.	2
• Draws ONE correct electron dot diagram, OR identifies one difference in a physical property of ozone and oxygen.	1



Ozone has an uneven distribution of electrons, and as such is polar, whereas oxygen is non-polar. This results in stronger intermolecular forces for ozone (dispersion forces + dipole-dipole interactions) compared to oxygen (dispersion forces only). As a result the boiling point of ozone is higher than that of oxygen, since more energy is required to separate molecules from each other.

31.a.

Marking Guidelines	Marks
• Writes a correct equilibrium reaction for the Haber process (energy term not required).	1



31.b.

Marking Guidelines	Marks
• Thoroughly explains why temperature, pressure and the condition of the catalyst need to be monitored by referring to rate, yield, and Le Chatelier's Principle.	5
• Explains why temperature, pressure and the condition of the catalyst need to be monitored by referring to rate, yield, and Le Chatelier's Principle.	4
• Outlines the importance of any TWO of temperature, pressure and the condition of the catalyst referring to any TWO of rate, yield, and Le Chatelier's Principle.	3
• Outlines the importance of temperature OR pressure OR the condition of the catalyst referring to rate OR yield OR Le Chatelier's Principle.	2
• Identifies one correct aspect of the reaction conditions of the Haber process.	1

The Haber process is a delicate balancing act between rate and yield, and as a result, the reaction conditions need to be carefully monitored. Increasing the temperature of the reaction would increase the rate of ammonia formation, but because the forward reaction is exothermic, Le Chatelier's principle predicts that increasing the temperature will cause a shift to the left, decreasing the yield of ammonia. As a result, a compromise temperature is used, 500 °C, maximising both rate and yield. The pressure also needs to be carefully monitored. Le Chatelier's principle predicts an increase in the production of ammonia at higher pressure, because there are fewer moles of gas on the RHS. Thus an increased pressure, 200 atm, is used. This needs careful monitoring because decreases in the pressure will reduce the yield of ammonia, and because increases in pressure would be dangerous – reaction vessels have a maximum pressure limit beyond which they can explode. The catalyst used in the process also needs to be monitored. The catalyst is finely divided iron on Fe₃O₄. The catalyst increases the rate, by providing an alternative mechanism with a lower activation energy. Furthermore, in this case, the increase in rate allows a lower temperature to be used, which contributes to a greater yield. If the catalyst is poisoned (for example with CO) its effectiveness will be reduced, lowering the rate of the reaction. Thus the temperature, pressure and condition of the catalyst all need to be carefully monitored to maintain maximal rate and yield.

32.a.

Marking Guidelines	Marks
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• Identifies undissolved (or suspended) solids (or turbidity).	1
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undissolved (or suspended) solids (or turbidity)

32.b.

Marking Guidelines	Marks
• Calculates the concentration of dissolved solids in ppm.	2
• Calculates the mass of dissolved solids.	1

Mass of dissolved solids = $48.45 - 48.42 = 0.03 \text{ g} = 30 \text{ mg}$

Concentration in ppm = $130/147.5 \times 1000 = 203 \text{ ppm}$.

32.c.

Marking Guidelines	Marks
• Identifies CaCl_2 , justifies this conclusion using the results given, and includes an appropriate equation.	2
• Identifies CaCl_2 OR includes an appropriate equation.	1

A orange- red flame test indicates the presence of Ca^{2+} in the water, which formed the fine white ppt with SO_4^{2-} ($\text{Ca}^{2+} + \text{SO}_4^{2-} \rightarrow \text{CaSO}_4(\text{s})$). The ppt is fine because CaSO_4 is slightly soluble. The white precipitate with silver ions indicates the presence of chloride. Hence the substance is CaCl_2 . $\text{Ag}^+ + \text{Cl}^- \rightarrow \text{AgCl}(\text{s})$

32.d.

Marking Guidelines	Marks
• Describes the principles upon which AAS is based (absorption/emission of energy by electrons in discrete energy levels, AND that concentration is proportional to absorbance), • AND outlines its use (determining concentration using a light of specific wavelength • AND use of a calibration curve).	4
• Outlines the principles upon which AAS is based (absorption/emission of energy by electrons in discrete energy levels, • OR that concentration is proportional to absorbance), • AND outlines its use (determining concentration using a light of specific wavelength • AND use of a calibration curve).	3
• Outlines the principles upon which AAS is based (absorption/emission of energy by electrons in discrete energy levels, • OR that concentration is proportional to absorbance), • AND outlines its use (determining concentration using a light of specific wavelength • OR use of a calibration curve).	2
• Response contains one correct statement about the basis or use of AAS.	1

Atomic Absorption Spectroscopy (AAS) is based on the principle that electrons orbit the nucleus in fixed energy levels, and that they are excited to a higher energy level, or relax back to their ground state, by absorbing or releasing the exact energy difference between the two energy levels. AAS uses light of specific wavelengths to provide this energy. It is also based on the principle that generally, the higher the concentration of the absorbing species in a sample, the greater the intensity of the light absorbed by the sample. By using a lamp suitable for Ca analysis, and by calibrating the AAS using a series of standard Ca^{2+} solutions (with a range of values around the expected concentration of the sample), the student can measure the Ca^{2+} concentration. They measure the absorbance at a suitable wavelength, and convert this to a concentration in ppm using the calibration curve.

Section II. Options.

Question 33 – Industrial Chemistry

a.i.

Marking Guidelines	Marks
• Identifies glycerol.	1

glycerol.

a.ii.

Marking Guidelines	Marks
• Outlines the structure and properties of cationic detergents, and relate these to their uses.	2
• Identifies a structural feature (other than being cationic) OR a use of cationic detergents	1

Cationic detergents are quaternary ammonium salts, consisting of a non-polar, hydrophobic tail, and a cationic head. They are used in hair conditioners, and because they have antiseptic properties, in products such as nappy wash.

a.iii.

Marking Guidelines	Marks
• Describes the cleaning action of soaps, making reference to the hydrophobic and hydrophilic ends, and micelle formation, and includes a labelled diagram in the answer.	3
• Outlines the cleaning action of soaps, making reference to the hydrophobic OR hydrophilic ends, OR micelle formation, and includes a diagram in the answer.	2
• Response contains one correct aspect of the cleaning action of soap.	1

When soap particles dissolve in water, the hydrophobic tail dissolves in oil/fat particles, and the hydrophilic head in water. Agitation results in the soap particles surrounding the fat/oil particles in this fashion, resulting in the formation of 3D micelles. This disperses the fat/oil through the water, allowing it to be washed away.

b.i.

Marking Guidelines	Marks
• Writes the correct equilibrium constant expression.	1

$$K = \frac{[\text{N}_2\text{O}_5]^2}{[\text{NO}_2]^4 [\text{O}_2]}$$

b.ii.

Marking Guidelines	Marks
• Correctly deduces that the system is shifting to the right on the basis of the correct calculation of a reaction quotient (based on the equilibrium constant expression from b(i))	3
• Calculation or deduction contains one error.	2
• Calculation contains one correct step.	1

Q when the reaction was sampled

$$= 1.25^2 / (0.75 \times 1.55^4)$$

$$= 0.36.$$

Q < K, so the system is shifting to the right to reach equilibrium.

b.iii.

Marking Guidelines	Marks
• Explains the effect on the equilibrium position by making reference to Le Chatelier's principle and ΔH for the reaction.	2
• Identifies the effect on the equilibrium position with a limited explanation.	1

If the temperature is increased, Le Chatelier's Principle predicts that this will shift the equilibrium position to the left. This is because the forward reaction is exothermic.

c.i.

Marking Guidelines	Marks
• Identifies sodium chloride as the common starting material.	1

c.ii.

Marking Guidelines	Marks
• Describes the chemistry of the mercury process thoroughly, and includes an associated environmental impact.	3
• Outlines the chemistry of the mercury process and includes an associated environmental impact.	2
• Identifies one aspect of the mercury process.	1

The mercury process is an electrolytic method for the production of NaOH(aq) from brine solution. The cathode is flowing liquid mercury. Sodium ions are reduced to sodium metal, which is dissolved in the flowing mercury cathode, which is then pumped away. In a separate stage the amalgam is sprayed into water, and the sodium reacts with the water to produce NaOH(aq). The mercury is pumped back to the electrolysis stage. Chloride ions are oxidized to chlorine gas at the anode, which is an inert electrode. In this process, leaking of mercury into the environment was inevitable. Mercury is a very toxic metal which causes serious neurological defects, and death. Thus the environmental effects of this process were extreme, and unacceptable.

c.iii.

Marking Guidelines	Marks
• Outlines a suitable method, which includes reagents, equipment, and a method of reducing one risk associated with the procedure.	3
• Outlines a suitable method, with some omissions, including a safety precaution.	2
• Method includes a correct step, or an appropriate safety precaution.	1

- Solid sodium hydrogencarbonate was heated using a test tube in a stoppered side-arm test tube.
- The gas from the reaction was transferred to a second test tube containing limewater, via the side-arm.
- The limewater turned milky, indicating that CO₂(g) was produced.
- To avoid eye contact with hot solids we wore safety glasses.
- To avoid the possibility of dropping the glassware, all test tubes were clamped using retort stands.

d.

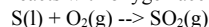
Marking Guidelines	Marks
• Describes the steps and chemistry of sulfuric acid production thoroughly, including chemical equations, and assesses the importance of the reaction conditions by referring to both rate and yield.	6
• Describes most of the steps and chemistry of sulfuric acid production, including chemical equations, and assesses the importance of the reaction conditions.	4-5
• Outlines the production of sulfuric acid, including one chemical equation.	2-3
• Response contains one correct aspect of sulfuric acid production.	1

The conversion of SO₂ to SO₃ is an equilibrium reaction, represented by:

2SO₂(g) + O₂(g) <-> 2SO₃(g), and the forward reaction is exothermic. Three of the reaction conditions are a moderately high temperature (approx. 600 °C), use of excess O₂(g), and the use of a catalyst, V₂O₅(s). A moderately high temperature is used because it achieves the best compromise between rate and yield – a high temperature is required to increase the rate, but a low temperature favours SO₃ formation

because the forward reaction is exothermic. Excess oxygen is used because Le Chatelier's Principle predicts that this will cause the equilibrium position to shift to the right, increasing the yield of SO_3 . A catalyst, pellets of solid V_2O_5 , is used, because this increases the rate of the reaction. Catalysts provide an alternative mechanism for the reaction, with a lower activation energy. Three catalyst beds are used, and the reaction mixture is passed over each of them, at successively lower temperatures, in turn. This is done to maximise both rate and yield.

Sulfuric acid is produced from elemental sulfur using the Contact Process. Molten sulfur is sprayed into air at high temperature, where it reacts with oxygen according to the equation:

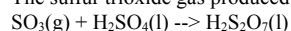


Reaction conditions in this step are very important – the sulfur is molten, and is sprayed into the oxygen in order to increase the surface area of the S and thus increase the rate of reaction. This reaction goes to completion.

The SO_2 is then reacted with O_2 to make SO_3 . This conversion is an equilibrium reaction:

$2\text{SO}_2\text{(g)} + \text{O}_2\text{(g)} \rightleftharpoons 2\text{SO}_3\text{(g)}$, and the forward reaction is exothermic. The reaction conditions used in this step are very important for maximising both rate and yield. A moderate temperature (600°C) is used because it gives a balance between rate and yield; high temperatures increase the rate, but low temperatures increase SO_3 formation, because the forward reaction is exothermic and low temperatures shift the equilibrium to the right. A catalyst is used because it increases the rate of reaction. The catalyst in this reaction is V_2O_5 (s). The reaction mixture is passed over three catalyst beds sequentially, each at a successively lower temperature. These lower temperatures are used to further increase the yield.

The sulfur trioxide gas produced is then reacted with conc. sulfuric acid, to make oleum:



The oleum is then diluted with water, to produce concentrated sulfuric acid.

This is also important because if SO_3 were to mixed immediately with water to make sulfuric acid, a fine mist of vaporised sulfuric acid would form, which can be very dangerous and difficult to handle.

Question 34 – Shipwrecks, Corrosion & Conservation

a.i.

Marking Guidelines	Marks
<ul style="list-style-type: none"> Outlines the experimental work of Galvani concerning muscle contraction in dead frogs, including aspects of his experimental design. 	2
<ul style="list-style-type: none"> Identifies a basic feature of Galvani's experimental work on muscle contraction. 	1

Galvani's experiments on electrical stimulation of muscle fibres involved observation of muscle contraction when he placed the ends of two wires (made of different metals) into the muscle of a dead frog.

a.ii.

Marking Guidelines	Marks
<ul style="list-style-type: none"> Identifies the source of the current as an electrochemical reaction. 	1

The actual source of electricity which triggered the muscle contraction was an electrochemical reaction

a.iii.

Marking Guidelines	Marks
<ul style="list-style-type: none"> Describes the work of Volta in producing the voltaic pile and explains the link between this work and the work of Davy in isolating some of the alkali metals. 	3
<ul style="list-style-type: none"> Outlines the work of Volta and later Davy in the creation and use of electric current to decompose compounds. 	2
<ul style="list-style-type: none"> Identifies one aspect of either the work of Volta or Davy. 	1

Volta disagreed with the conclusions made by Galvani (that the electricity he observed was created by the muscle) and instead suggested that it was the contact of the two different metals that was the source of the electric current Galvani observed.

Following on from this, he developed a device, known as a Voltaic pile, made of alternating copper and tin plates, each one separated by cardboard disc which had been soaked in a salt solution. This device was able to produce a sizeable current which Davy put to work, first electrolysis water. He then developed improved versions and used the current they produced to decompose many substances, including molten sodium & potassium hydroxides. These reactions produced sodium and potassium-they first alkali metals to be isolated.

b.i.

Marking Guidelines	Marks
<ul style="list-style-type: none"> Identifies Faraday as the scientist who developed the Laws of Electrolysis. 	1

Faraday

b.ii.

Marking Guidelines	Marks
<ul style="list-style-type: none"> Produces a valid and reliable procedure which would be useful in gathering data to test the hypothesis stated. 	3
<ul style="list-style-type: none"> Outlines a procedure which would be useful in gathering some data to test the hypothesis stated. 	2
<ul style="list-style-type: none"> Identifies one key aspect of the procedure. 	1

1. Clean and weigh two similarly shaped electrodes eg graphite electrodes

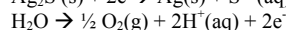
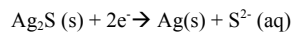
2. Make up a 0.01M solution of silver nitrate solution and pour the solution into a beaker.

3. Construct a cell consisting of the two electrodes inserted into the silver nitrate in the beaker and connect the electrodes to a 2V power supply.

- Keeping the voltage constant, turn on the power and leave for 2 min.
- Turn off the power, remove the negative electrode, now coated with silver and allow to dry. Weigh the dry electrode to determine the mass of solid deposited.
- Repeat step 2-5, but this time make up 0.05 and 0.1M solutions respectively.
- Repeat the entire process twice and average the results.

b.iii.

Marking Guidelines	Marks
• Writes two correctly balanced half-equations for the oxidation and reduction process.	2
• Writes one correctly balanced half-equation for either the oxidation or reduction process.	1



c.i.

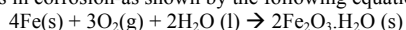
Marking Guidelines	Marks
• Identifies the correct relationship between water pressure and gas solubility.	1

As pressure (eg water pressure) increases, gas solubility will decrease.

c.ii.

Marking Guidelines	Marks
• Explains how at least THREE conditions may cause differences in the corrosion rates of the two shipwrecks.	3
• Describes TWO conditions that differ in the location of the shipwrecks and states how these differences may affect their rates of corrosion.	2
• Identify a factor/condition, apart from pressure, that would cause a difference in the rate of corrosion between the 2 shipwrecks.	1

Many factors affect the rate of corrosion of ship structures, including water temperature, gas solubility, salinity and pH levels and the presence of sulfate-reducing bacteria. Corrosion levels on a shipwreck on a shallow reef would be expected to be high. Higher water temperatures increase the rate of corrosion and the presence of high levels of dissolved oxygen (or contact with atmospheric oxygen) all aid in corrosion (as water and oxygen are reactants in corrosion-as shown by the following equation for the corrosion of Fe)



At increased depths, water temperature decreases and dissolved oxygen decreases (due to lack of aeration, high pressure and a lack of photosynthetic organisms in the water. One may expect that corrosion levels should thus decrease. However, the rate of corrosion of this shipwreck is likely to also be significant (if still less than the shallower wreck). The significant extent of corrosion is due to the often low pH environments caused by anaerobic, sulfate reducing bacteria. These bacteria produce acidic H_2S and the H^+ ions this produces in water speed up corrosion as oxygen is a stronger oxidising agent in acidic environments ($\text{O}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}$)

c.iii.

Marking Guidelines	Marks
• Provides a detailed reason for delaying the drying of a wooden artefact until after the salt is removed AND • Describes a method for restoring a wooden artefact which avoids damage due to salts.	3
• Provides a detailed reason for delaying the drying of a wooden artefact until after the salt is removed	2
• identifies one reason for delaying the drying of wooden artefacts OR • Identifies one method employed to restore wooden artefacts.	1

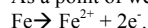
Wooden objects recovered from the shipwreck have been soaked for many years in saline water. Salts present in the water can cause significant damage to the artefact if they are present as the artefacts dry, and thus it is important to remove the salts prior to their drying. If present as the artefacts dry, salts such as NaCl damage the structure of the artefact as their crystals grow. Decolourisation can also occur due to the presence of dissolved salts during the drying stage. Thus to recover and restore a wooden artefact, scientists may immerse it in a solution of polyethylene glycol (PEG) over a number of weeks. The PEG penetrates the wood and replaces the water.

d.

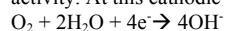
Marking Guidelines	Marks
• Explains in detail the chemistry of rusting, including relevant half-equations and the overall equation AND • Explains how THREE described techniques prevent or reduce rusting	6
• Explains the chemistry of rusting, including at least one relevant chemical equation AND outlines at least 2 techniques to prevent or minimise rusting.	4-5
• Outlines the basic chemistry involved in rusting OR • Outlines 2 or 3 techniques used to prevent or minimise rusting	2-3
• Identifies the basic reactants involved in the rusting of iron • OR Identifies a technique to prevent or minimise rusting • OR Writes a relevant half-equation or complete equation for the rusting process • OR Identifies one key reaction step in the formation of rust, either in words or as an equation.	1

Rusting is a chemical reaction between iron (or iron in steel), oxygen and water, forming a hydrated iron oxide ($\text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$), which is referred to simply as rust.

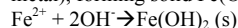
As a point of weakness in the metal structure, iron forms an anodic region, and is oxidised to Fe^{2+} .



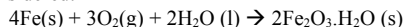
Electrons flow from this site to a site of high oxygen concentration, or an impurity or where iron may be in contact with a metal of lower activity. At this cathodic site, oxygen is reduced:



The oppositely charged Fe^{2+} and OH^- ions are attracted to each other and migrate through an aqueous environment (eg moisture on the metal), forming solid $\text{Fe}(\text{OH})_2$:



Upon further oxidation, the Fe^{2+} is oxidised to Fe^{3+} . The $\text{Fe}(\text{OH})_2$ undergoes partial dehydration to eventually form hydrated iron(III) oxide. The overall equation for the process can be considered:



In light of the above chemistry, there are several methods to reduce the rate of corrosion or prevent it for occurring.

Painting a piece of iron covers the underlying iron and prevents contact between the iron and oxygen and water. As long as the paint is not scratched or damaged in any way, corrosion should be prevented as the reactants required for the reaction are not present. Alternatively, the iron can be galvanised, which involves covering the iron structure with a layer of zinc, a more reactive passivating metal. The zinc itself forms a protective oxide coating, and as long as it remains intact the coating prevents contact between the iron and oxygen and water, much the same way as paint does. Galvanising, however, has an added advantage in that zinc, being more active than iron, will corrode in preference, acting as a sacrificial anode. This term refers to the process by which the more active metal oxidises in preference to a less active one, forming electrons and effectively keeping the less active metal in a continual state of reduction. This is a similar principle to attaching a block of an active metal such as zinc or magnesium to an iron structure (such as a pipeline).

Question 35 – The Biochemistry of Movement.

a.i.

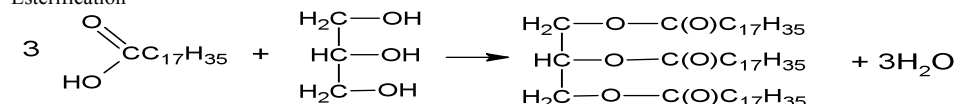
Marking Guidelines	Marks
• Identifies that glycerol is 1,2,3-propanetriol.	1

1,2,3-propanetriol

a.ii.

Marking Guidelines	Marks
• Identifies the reaction as esterification and writes a correct equation.	2
• Identifies the reaction as esterification OR writes a correct equation.	1

Esterification



a.iii.

Marking Guidelines	Marks
• Explains the implications of a diet low in fats in terms of two identified criteria.	3
• Explains the implications of a diet low in fats in terms of one identified criterion.	2
• Identifies one implication of a diet low in fats.	1

The metabolism of fats is in direct competition with the metabolism of glucose. Glucose is converted into pyruvate, and fats are converted into fatty acids. For further metabolism, both of these substrates must bind to coenzyme-A. Co-A is in finite supply in cells, and thus a diet low in fats will result in more rapid metabolism of glucose. Also, a diet low in fats will generate less ATP for other biochemical processes. Metabolism of stearic acid (C18) produces 146 (nett) ATP molecules, whereas metabolism of one glucose molecule only produces 38 molecules of ATP. Another implication of a diet low in fats, is much less energy storage in the body in the form of adipose tissue. The body converts glucose to glycogen for energy storage in muscles and the liver, but can only store enough glycogen for approximately 12 hours, whereas in 8 weeks worth of energy can be derived from stored adipose tissue. Extended physical activity, such as running requires a ready supply of free fatty acids in the body, because metabolism of fatty acids in muscles increases after approximately 5 minutes of exercise and exceeds carbohydrate metabolism after 30 minutes.

b.i.

Marking Guidelines	Marks
• Writes a method that allows the aim to be tested, and which includes specific instructions to ensure reliability and validity.	3
• Writes a method that allows the aim to be tested, and which includes an aspect of reliability or validity.	2
• Outlines a procedure which contains some correct steps.	1

Amylase is an enzyme present in saliva, which breaks down starch into glucose. To test the effect of pH of the activity of amylase, the following experiment was done.

- 3 mL of starch solution in a buffered solution of pH = 2 was transferred to each of three clean test tubes.
- To each test tube, 2 drops of aqueous iodine were added, producing a deep blue-black solution.
- 1 mL of amylase solution was added to each test tube and the tube mixed, and at the same time a stopwatch was started.
- The time taken for the blue-black colour to return to pale yellow/brown (signifying the breakdown of all of the starch to glucose) was timed, and the three times averaged.
- Steps 1 - 4 were repeated in buffered solutions at pH = 4, 6, 8 and 10.

c.i.

Marking Guidelines	Marks
• Identifies myosin and actin	1

Myosin and actin.

c.ii.

Marking Guidelines	Marks
• Explains the chemistry of muscle cell contraction.	3
• Outlines the chemistry of muscle cell contraction.	2
• Identifies one correct feature of the chemistry of muscle cell contraction.	1

The 'sliding filament model' explains how muscles contract. In this model, actin (in thin filaments) and myosin (in thick filaments) slide past each other and overlap, as the muscle contracts. Contraction begins when a nerve impulse is sent to a muscle, causing Ca^{2+} ions to be released from part of the sarcomere. These Ca^{2+} ions interact with proteins bound to actin, tropomyosin and troponin (which prevent it from interacting with myosin in relaxed muscle). This exposes a site on the actin proteins for myosin binding. ATP hydrolysis releases energy, changing the shape of the myosin head, so that it can bind to a more distant active site on actin. ADP release from myosin causes it, while bound to actin, to return to its original shape, which pulls the actin and myosin fibres past each other. Thus the areas of overlap between the filaments is reduced, and the muscle contracts.

c.iii.

Marking Guidelines	Marks
• Compares the appearance of type 1 and type 2 skeletal muscle cells AND accounts for the high % of type 2 cells in the legs of sprinters.	3
• Compares the appearance of type 1 and type 2 skeletal muscle cells OR accounts for the high % of type 2 cells in the legs of sprinters.	2
• Identifies ONE correct feature of type 1 OR type 2 muscle cells	1

Type I muscle cells are rich in myoglobin, which gives them a dark red colour, whereas type II cells are low in myoglobin, which gives them a whitish appearance. Type I muscle cells are known as 'slow twitch' fibres, and are used predominantly for endurance type activities, such as long distance running, or maintaining posture. Type II muscle cells, or 'fast twitch' fibres are predominantly used for rapid movement such as sprinting, or eye muscle movement. They obtain energy anaerobically, which makes them suitable for rapid action during which oxygen supplies are depleted. As a result they are abundant in the leg muscles of sprinters, which need a large amount of energy in a short period of time.

d.

Marking Guidelines	Marks
• Thoroughly describes the chemistry which occurs during oxidative phosphorylation and explains the role of NADH and FADH_2 in this process, including reference to the reduction of oxygen gas.	6
• Outlines the chemistry which occurs during oxidative phosphorylation and explains to the role of NADH and FADH_2 in this process.	4-5
• Outlines the chemistry which occurs during oxidative phosphorylation and makes reference to the role of NADH and FADH_2 in this process.	2-3
• Identifies a feature of oxidative phosphorylation.	1

Oxidative phosphorylation is the final step in the pathways involved in aerobic respiration, to produce ATP, and which occurs in mitochondria. ATP is the most important energy storage compound found in all living things, and is the molecule in which the energy derived from the metabolism of food is stored. Conversion of ATP to ADP is highly exothermic, and the energy released in this process is used in biochemical reactions throughout the body. Glucose, amino acids and fatty acids are converted into acetyl-CoA, which enters the TCA cycle for oxidative decarboxylation. Glycolysis (of glucose) produces NADH, and the TCA cycle produces both NADH and FADH_2 (both also produce ATP). NADH and FADH_2 are coenzymes, and the interconversion of their oxidised and reduced forms facilitates electron flow through the various metabolic pathways. Oxidative phosphorylation involves a series of 10 redox reactions. The oxidation of NADH and FADH_2 , with the release of electrons, is coupled to the formation of ATP from ADP. Three ATP molecules are produced in the oxidation of one NADH molecule, and two from each FADH_2 molecule. The final step in oxidation phosphorylation is the reduction of oxygen to water: $\text{O}_2(\text{aq}) + 4\text{e}^- + 4\text{H}^+(\text{aq}) \rightarrow 2\text{H}_2\text{O}(\text{l})$. The end result of aerobic respiration including oxidative phosphorylation, is the generation of 38 molecules of ATP per molecule of glucose metabolised.

Question 36 – The Chemistry of Art.

a.i.

Marking Guidelines	Marks
• Identifies the correct oxidation state	1

The oxidation state of X is +3.

a.ii.

Marking Guidelines	Marks
• Identifies the correct species with a correct justification and accounts for the high oxidation strength of the species identified.	2
• Identifies the correct species with a correct justification	1

The species with the highest oxidising strength is $\text{K}_2\text{X}_2\text{O}_7$. In this species, the oxidation state of the transition metal X is +6, which is higher than it is in the other compounds (+5 in X_2O_5 and +3 in X_2O_3). Species containing transition metals in high oxidation states act as powerful oxidising agents as they have a high affinity for electrons from other species. They attract these electrons, hence oxidising the species.

a.iii.

Marking Guidelines	Marks
• Explains for the ability of transition metals to form compounds with different oxidation states	3
• AND relates the configuration of copper to its ability of form compounds with multiple states as an example.	

<ul style="list-style-type: none"> Identifies the electron configuration of copper AND identifies that transition metals have electrons in closely spaced s and d orbitals 	2
<ul style="list-style-type: none"> Identifies the electron configuration of copper OR identifies that transition metals have electrons in closely spaced s and d orbitals 	1

One feature of the electron configuration common to many transition metals is that they contain electrons in both 4s and 3d orbitals which have very similar energy values. As such, one or more electrons from these levels can be used as the metals bond to other atoms, resulting in the metal being able to exhibit a variety of oxidation states. For example, Cu has the configuration: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$.

It can exist in the +1 state in compounds such as CuCl, in which the 4s electron is lost to the Cl atom, but it can also form compounds with an oxidation state of +2 (eg CuO) where the 4s and a 3d electrons are lost. It does not tend to exist in any higher oxidation states, as it has a relatively high nuclear charge which prevents more electrons from being taken by other atoms.

b.i.

Marking Guidelines	Marks
<ul style="list-style-type: none"> Describes an appropriate procedure, including one safety precaution, that the student could follow to observe a flame test. 	3
<ul style="list-style-type: none"> Outlines a basic procedure for conducting a flame test. 	2
<ul style="list-style-type: none"> Identifies one aspect of the procedure to conduct a flame test. 	1

One procedure the student may have followed it to dip the looped end of a platinum wire into potassium chloride have first dipping it into concentrated HCl to clean the loop and wet the surface. The loop containing the KCl would have then been placed into a non-luminous Bunsen flame and the colour of the flame observed. The procedure could be repeated with solid NaCl and $SrCl_2$. Safely glasses should be worn throughout the procedure.

b.ii.

Marking Guidelines	Marks
<ul style="list-style-type: none"> Describes the main features of the Bohr model and assesses the model for its ability to explain the different flame colours of the metals. 	3
<ul style="list-style-type: none"> Outlines the main features of the Bohr model, including quantisation of energy levels, movement between levels by absorption & emission of energy 	2
<ul style="list-style-type: none"> Identifies the Bohr model includes the concepts of quantised energy levels. 	1

The Bohr model of the atom was very successful in explaining the phenomena of flame colours. This was the first model to suggest that electrons were confined to only certain orbits around the nucleus. The model suggested that electrons could absorb specific amounts of energy to move from one orbit to a higher one, and that upon moving back to the lower, more stable state, the energy it emitted in the form of electromagnetic radiation. The energy of the radiation is equivalent to the energy difference between the two orbitals, and if that energy corresponds to em radiation with the visible spectrum, we may observe the radiation as the flame colour. Since atoms of different elements have different electron arrangements with different associated energies, this explains why the different elements tested have different flame colours. Although the current model of the atom differs from the Bohr model, which had to be updated to explain other observations, the Bohr was highly successful in explaining flame colours and emission spectra.

c.i.

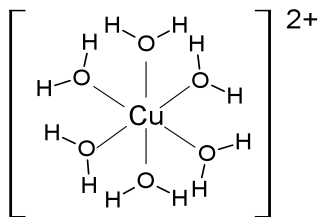
Marking Guidelines	Marks
<ul style="list-style-type: none"> Identifies a correct mineral and its colour 	1

Haematite is a mineral used to impart red in paints and cosmetics.

c.ii.

Marking Guidelines	Marks
<ul style="list-style-type: none"> Draws a Lewis diagram of the hexaaquacopper(II) ion AND Describes fully the bonding between the copper(II) ion and the water ligands 	3
<ul style="list-style-type: none"> Draws a Lewis diagram of the hexaaquacopper(II) ion AND Outlines the bonding within the ion. 	2
<ul style="list-style-type: none"> Draws a Lewis diagram of the hexaaquacopper(II) ion OR Identifies a feature of the bonding within the ion. 	1

The bonding within this complex ion is coordinate covalent bonding. The water molecules act as ligands, bonding to the central copper(II) ion via coordinate covalent bonds. These bonds form when the spare electron pair on each water molecule enter empty orbitals in the copper(II) ion, which does not contribute any electrons in the bonding.



c.iii.

Marking Guidelines	Marks
<ul style="list-style-type: none"> Describes TWO aspects of the procedure which make it ineffective as a model AND explains how it could be modified to make it an effective model. Answer must describe the definition of a paint. 	3
<ul style="list-style-type: none"> Outlines one aspect of the procedure which makes it ineffective as a model AND suggests a modification to the procedure which would make it a better model 	2
<ul style="list-style-type: none"> Identifies one aspect of the procedure which makes it ineffective as a model OR Identifies a modification to the procedure which would make it a better model. 	1

The procedure is not a valid one to model the paint making process by early Aboriginal people for a number of reasons. Firstly, copper minerals such as malachite or azurite were not readily available to these people and the colour blue did not feature in their art works. Also, the procedure produces a solution, since copper(II) sulfate is water soluble, and not a suspension, which would be needed to form a proper paint. Paints are made of insoluble materials being mixed with a liquid vehicle, such that the suspension produced has opacity when applied to the surface. The binder dries, leaving behind a coloured opaque covering on the surface. The solution produced by the student would have little opacity as it dried, with the water evaporating and leaving small particles of solid copper(II) sulfate behind, which would not adhere effectively to the surface. Thus a better model would be to mix some red ochre or other readily available mineral with some saliva or other naturally occurring binder and use the suspension produced to paint over a surface.

d.

Marking Guidelines	Marks
<ul style="list-style-type: none"> Describes and explains the relationship between the changing atomic structure of the elements in Period 3 AND the first ionisation trend AND electronegativity trend AND the block to which the element is assigned in the periodic table. 	5-6
Describes and explains the relationship between the changing atomic structure of the elements in Period 3 and at least TWO of the following: <ul style="list-style-type: none"> first ionisation trend electronegativity trend the block to which the element is assigned in the periodic table. 	4
Outlines the trend in each of the characteristics: <ul style="list-style-type: none"> ionisation energy electronegativity the block to which the element is assigned 	3
Outlines the trend in two of the following characteristics: <ul style="list-style-type: none"> ionisation energy electronegativity the block to which the element is assigned 	2
<ul style="list-style-type: none"> Identifies one trend in either ionisation energy or electronegativity or relates the electron configuration of an element to the block the element is assigned to in the periodic table. 	1

The changing nuclear charge and electron arrangement of the atoms of various elements significantly effects many properties of the element, including ionisation energy and electronegativity, and is also linked to the block of the periodic table in which the element is located.

First ionisation energy is the energy required to remove an outermost electron. As you move across period 3 an additional proton is added to the nucleus with each element, as an extra electron is added to the same energy level. The increasing nuclear charge attracts the electron to a greater extent, and as there is no additional shielding, the radius to atom decreases and a greater amount of energy is required to remove the electron. Thus the first ionisation energy increases across a period, reaching a maximum with argon.

Electronegativity is a quantity which has no units and is a value between 0 and 4 assigned to each element on the basis of how well they attract electrons from other atoms. Electronegativity is also closely related to atomic structure. As you move across the period and the nuclear charge increases and radius decreases, the ability of the nucleus to attract other electrons increases (smaller radius means the nucleus of the atom is closer to the electrons from other atoms). Thus electronegativity increases from Na to Cl. The electronegativity is also related to the electron configuration. As you move across the period, you move to a more stable configuration by accepting extra electrons to gain a stable octet of electrons-thus Cl with $3s^2 3p^5$ configuration will become more stable to accepting one more electron. The reason Ar is not assigned an electronegativity is that it already has a stable $s^2 p^6$ configuration and hence does not tend to bond to other atoms.

Finally, the block to which the elements are assigned corresponds to the outer electron configuration. Na and Mg are in the 's' block because the outer electrons are in 's' orbitals. The remaining elements are in the 'p' block because their valence electrons are in 'p' orbitals.

Question 37 – Forensic Chemistry.

a.i.

Marking Guidelines	Marks
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• Identifies the key difference between the two types of compound.	1
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Organic compounds are based on carbon atoms (other than carbonates and hydrogen carbonates) whereas inorganic compounds usually contain a metal cation and a non-metallic anion.

a.ii.

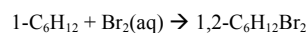
Marking Guidelines	Marks
• Outlines the chemical principle upon which emission spectroscopy is based.	2
• Identifies one aspect of the principle upon which emission spectroscopy is based.	1

Emission spectroscopy is based on the principle that electrons occupy orbitals of specific energies. They absorb a specific quantum of energy when they are excited energy level, and they release the same amount of energy when they relax back to the ground state.

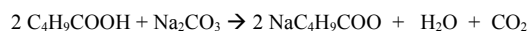
a.iii.

Marking Guidelines	Marks
• Outlines a sequence of tests and shows how the compounds could be distinguished, and includes two relevant chemical equations.	3
• Outlines a sequence of tests which correctly distinguishes between two of the compounds, and includes one relevant chemical equation.	2
• Outlines a sequence of tests which correctly distinguishes between two of the compounds, OR includes one relevant chemical equation.	1

First add aqueous bromine to a sample of the chemicals. The one which turns the orange 'bromine water' colourless is the alkene:



To a new sample of the two remaining chemicals, add a few drops of concentrated $\text{Na}_2\text{CO}_3(\text{aq})$. The mixture which produces gas bubbles is the alkanoic acid:



The remaining compound is the alkanol.

b.i.

Marking Guidelines	Marks
• Identifies the general formula of carbohydrates.	1



b.ii.

Marking Guidelines	Marks
Writes a method that includes: - two specific reagents – sugars: one reducing and one non-reducing sugar - one specific reagent for doing the test: either Benedict's solution or Tollen's reagent - correct steps to test the hypothesis - identifies the result that will allow the hypothesis to be refuted • includes one measure to ensure the procedure is safe.	3
• Response contains most of the above.	2
• Response contains some aspects of the above.	1

1. Prepare solutions of equal concentrations, in distilled water, of glucose and sucrose.
2. Transfer 1 mL of each solution to separate test tubes.
3. Add 1 mL of Benedict's solution (alkaline Cu^{2+}) to each test tube.
4. Heat the test tubes in a hot water bath for 10 minutes.
5. Observe any colour change.

The glucose is a reducing sugar and will change the colour of the Benedict's solution from pale blue to brick red/orange. The sucrose is not a reducing sugar and will not change the colour of the solution. To avoid skin contact (alkaline solutions are caustic) wear gloves. To avoid eye contact with the caustic alkaline solution, or the hot solutions, wear safety glasses.

b.iii.

Marking Guidelines	Marks
•	2
•	1

The carbohydrates found in plants and animals differ. Plants contain both starch and cellulose, whereas animals contain glycogen. All three of these carbohydrates are polymers of glucose.

c.i.

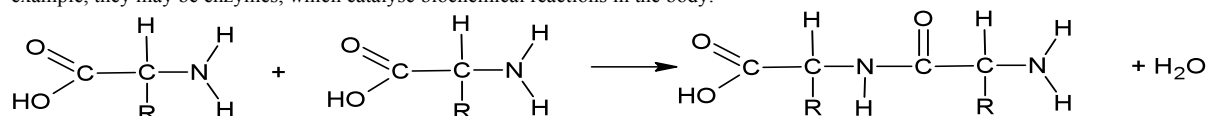
Marking Guidelines	Marks
• Outlines the implications of a destructive test by identifying that it will reduce opportunities for further testing.	1

A destructive test changes the nature of the sample, so that it cannot be used for further testing. This reduces the opportunity for further testing on that material – a serious implication if only a small amount is available.

cii.

	Marking Guidelines	Marks
	<ul style="list-style-type: none"> Describes general structures, functions and composition of proteins, including an equation showing a peptide bond. 	3
OR	<ul style="list-style-type: none"> Describes general structures, functions and composition of proteins. 	2
OR	<ul style="list-style-type: none"> Describes two of the structure, function or composition of proteins, AND includes an equation showing a peptide bond. 	1
OR	<ul style="list-style-type: none"> Describes two of the structure, function or composition of proteins writes an equation showing a peptide bond. 	1

Proteins are polymers made from amino acids, joined by peptide bonds. Proteins may have a fibrous structure, and these are used for structural purposes such as skin and hair. Proteins may also have a globular shape, and these perform many functions in the body. For example, they may be enzymes, which catalyse biochemical reactions in the body.



c.iii.

	Marking Guidelines	Marks
	<ul style="list-style-type: none"> Explains how electrophoresis works in terms of an electric field, migration of charged species, and migration rates, AND outlines how the origin of a sample can be identified. 	3
	<ul style="list-style-type: none"> Outlines how electrophoresis works and outlines how the origin of a sample can be identified. 	2
	<ul style="list-style-type: none"> Outlines how electrophoresis works 	1

Electrophoresis works by applying an electric field across a solid support matrix, such as a wet filter paper or a polyacrylamide gel. The sample is applied to the support, and the components of the mixture in the sample migrate towards the electrodes at different rates, depending on their size and charge, which for proteins, is affected by the pH of the solution. After separation, the protein bands are stained. Because different animal species have different protein compositions, the electrophoresis pattern that results from the separation of the proteins in a sample can be used to identify the origins of a sample.

d.

	Marking Guidelines	Marks
	<ul style="list-style-type: none"> Fully describes the structure of DNA (identifying sugar, phosphate and base groups) and explains three features of DNA which make it useful in crime scene analysis. 	6
	<ul style="list-style-type: none"> Describes some features of the structure of DNA, and explains two features of DNA which make it useful in crime scene analysis. 	4-5
	<ul style="list-style-type: none"> Identifies features of the structure of DNA, and identifies a feature of DNA which make it useful in crime scene analysis. 	2-3
	<ul style="list-style-type: none"> Response includes one correct feature of DNA or its analysis. 	1

DNA is a biopolymer made from many repeating nucleotides. A nucleotide is composed of a sugar (deoxyribose), a phosphate group, and a base (adenine, thymine, guanine or cytosine). The nucleotides are joined as shown in the diagram below, via the phosphate groups. Two long chains of DNA together form a double helix structure, which are held together by hydrogen bonds between complementary bases (A-T, G-C) (also shown below). It is the sequence of bases on the polymer chain which gives rise to an organism's genetic code.

Tissue samples found on modern crime scenes are much more useful than they used to be, because modern forensic scientists are able to analyse the DNA found in tissue samples. DNA is unique to each individual, and so can be used to identify, or exclude, specific individuals by comparing the DNA found at a crime scene with a DNA database, or DNA obtained from an individual. DNA tends to resist degradation, and can be analysed in very minute amount. Both of these characteristics also make it useful in crime scene analysis. Identification using DNA analysis is much more accurate than by techniques previously available

