

Exam Choice

2007 Chemistry Trial HSC examination. Marking guidelines and sample answers.

Section I Part A Multiple Choice

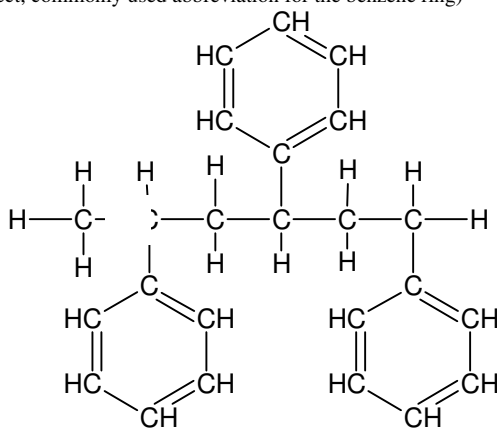
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
D	A	C	A	B	D	D	D	C	C	A	C	C	D	D

Section I Part B

Question 16 (a) H9

Draws the structure of polystyrene showing 3 repeating units.	2
Draws the structure of polystyrene with one minor error.	1

sample answer: (should except any correct, commonly used abbreviation for the benzene ring)



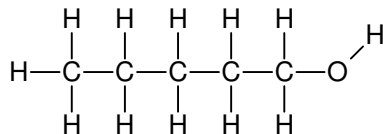
Question 16 (b) H4, H13

Identifies one use of polystyrene and explains this use in terms of two of its properties.	2
Identifies one use of polystyrene and explains this use in terms of one property.	1

Polystyrene is able to have gas bubbles injected into it, which make it a low density, lightweight, insulating material. Thus, this form of PS finds uses as take away cups for hot drinks.

Question 17 (a) H9

Draws the structural formula for 1-pentanol.	1
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Question 17 (b) H7, H10, H14

Correctly calculates enthalpy of combustion and includes working. Answers must include units and be quoted to three or four significant figures.	3
Correctly calculates enthalpy of combustion including working. Units, significant figures unimportant.	2
Correctly does one part of the calculation.	1

$$q = mC\Delta T$$

$$q = 250 \times 4.18 \times 28$$

$$= 29260 \text{ J} = 292.6 \text{ kJ}$$

$$n = 1.55/88.151$$

$$n = 0.01758$$

$$\text{Heat of combustion} = q/n$$

$$= 292.6 / 0.01758$$

$$= 1664 \text{ kJ/mol}$$

$$= 1660 \text{ kJ/mol}$$

Question 17 (c) H7, H10, H14

identifies that 1-pentanol's heat of combustion will be higher than ethanol's	1
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The heat of combustion for 1-pentanol will be higher than for ethanol.

Question 17 (d) H7, H9, H14

Explains why the experimental values for 1-pentanol will be lower than the literature value.	2
Identifies that 1-pentanol's heat of combustion will be lower than the literature value.	1

The experimental heat of combustion for 1-pentanol will be lower than the literature value because the experimental system will lose heat to the surroundings, ie it will not be adequately insulated.

Question 18 H3, H4, H7

<ul style="list-style-type: none"> fully compares the lead acid cell with one other type of cell, including the chemistry, impact on society, and on the environment includes anode and cathode half equations 	5-6
compares the lead acid cell with one other cell in terms of two of chemistry, impact on society, and impact on the environment	3-4
identifies two aspects of one cell OR identifies one aspect of each cell	2
identifies one aspect of either cell	1

	lead-acid battery	hydrogen fuel cell
introduction	<ul style="list-style-type: none"> lead-acid batteries are used to provide electricity to start a car engine, and to power accessories such as lights 	<ul style="list-style-type: none"> used to provide a constant source of electricity supporters see them replacing the fossil-fuel based internal combustion engine in motor vehicles
chemistry	<ul style="list-style-type: none"> the electrodes are lead grids the anode contains metallic lead the cathode contains PbO₂ the electrolyte is approx. 4M H₂SO₄ <p>anode: $\text{Pb(s)} + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{PbSO}_4(\text{s}) + 2\text{e}^-$</p> <p>cathode: $\text{PbO}_2(\text{s}) + 4\text{H}^+(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) + 2\text{e}^- \rightarrow \text{PbSO}_4(\text{s}) + 2\text{H}_2\text{O(l)}$</p> <p>overall: $\text{Pb(s)} + \text{PbO}_2(\text{s}) + 4\text{H}^+(\text{aq}) + 2\text{SO}_4^{2-}(\text{aq}) \rightarrow 2\text{PbSO}_4(\text{s}) + 2\text{H}_2\text{O(l)}$</p>	<ul style="list-style-type: none"> the electrodes are made of graphite the electrolyte can be KOH(aq) the electrodes are coated with a catalyst such as solid Pt fuels (hydrogen and oxygen) must be constantly supplied <p>anode: $\text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq}) \rightarrow 2\text{H}_2\text{O(l)} + 2\text{e}^-$</p> <p>cathode: $\text{O}_2(\text{g}) + 2\text{H}_2\text{O(l)} + 4\text{e}^- \rightarrow 4\text{OH}^-(\text{aq})$</p> <p>overall: $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O(l)}$</p>
impact on society	<ul style="list-style-type: none"> huge – have been partly responsible for the ease of use and widespread adoption of motor vehicles 	<ul style="list-style-type: none"> essentially none on consumers at this stage although potentially huge in the future large impact considering they have been partly responsible for space exploration
impact on environment	<ul style="list-style-type: none"> the battery itself has a moderate environmental impact – rechargeable so not frequently disposed of; improper disposal releases lead into the environment (neurotoxin) by helping the widespread adoption cars, they have had a huge negative impact on the environment (CO₂ from burning petrol, NOx emissions, CO emissions) 	<ul style="list-style-type: none"> from a “use” point of view they are beneficial to the environment – water is the only product of the operation of the H₂ fuel cell there are environmental costs associated with their production, H₂ and O₂ generation and storage non-fossil fuel based methods of production and generation of H₂ would result in massive environmental improvements

Question 19 H6, H7

Identifies neutron bombardment, bombardment with nuclei, the apparatus used and the reasons for this, and gives an example of each.	3
Outlines neutron bombardment, and gives an example OR Outlines bombardment with other nuclei, and gives an example OR Outlines neutron bombardment and bombardment with nuclei, without correct examples.	2
Identifies neutron bombardment, or bombardment with nuclei.	1

There are two general methods for producing transuranic and commercial radioisotopes: bombardment of target nuclei with neutrons, and with other nuclei. Because neutrons are uncharged, there is no repulsive force to be overcome between them and the target nucleus, hence this process can be done in a nuclear reactor. An example is the production of Fe-59 by neutron bombardment of Fe-58. Bombarding target nuclei with other nuclei, for example alpha particles, requires a cyclotron. This is because alpha particles are positively charged, and in order to combine them with the target nuclei, they must be accelerated to high velocity, in order to overcome the repulsive force between them and the target nuclei, both being positive charged. This is done in a particle accelerator (cyclotron). An example of this is the production of P-30 from Al-27 by bombardment with alpha particles.

Question 20 H10, H11, H14

Identifies that using a pH probe is more effective and justifies their choice using characteristics of both acids and both tests.	3
Identifies that using a pH probe is more effective and provides some justification.	2
Identifies that using a pH probe is more effective.	1

Using a pH probe is more effective. This is because both acids are monoprotic and the same concentration. Thus they will both require the same volume to reach an endpoint in a titration. As a result the titration will not be able to distinguish between the two acids. Using a pH probe will determine that although both acids are the same concentration, one will have a higher pH than the other. This is because ethanoic acid is weak whereas HCl is strong. The pH of 0.1M HCl is 1, whereas that of ethanoic acid is greater than 1. The pH probe will be able to distinguish them whereas the titration will not.

Question 21 (a) H12

Identifies the volumetric (or bulb) pipette.	1
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volumetric (or bulb) pipette.

Question 21 (b) H9, H10, H14

Correctly calculates the mass (in mg) of ascorbic acid in the 25 mL of orange juice.	2
Answer contains one calculation error.	1

$n(\text{iodine}) = C \times V = 5.00 \times 10^{-3} \times 0.00915 = 4.575 \times 10^{-5} \text{ mol.}$
 $n(\text{ascorbic acid}) = 4.575 \times 10^{-5}.$
 $m(\text{ascorbic acid}) = 4.575 \times 10^{-5} \times MM = 0.008046 \text{ g} = 8.05 \text{ mg.}$

Question 21 (c) H13

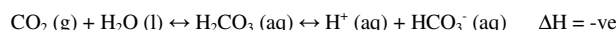
Identifies that the claim is valid and shows reasoning to support this.	1
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$m(\text{ascorbic acid}) \text{ in } 100 \text{ mL} = 100/25 \times 8.05 = 32.2 \text{ mg.}$
 This is greater than half the recommended daily intake.
 Therefore the claim is valid.

Question 22 H7, H8, H13

Identifies THREE conditions which affect the solubility of CO ₂ gas in water. AND Explains how a change in both conditions causes the effect in solubility. AND Supports their answer with a balanced equation.	4-5
Identifies at least TWO conditions which affect the solubility of CO ₂ gas in water. Supports their answer with a balanced equation. OR Explains how a change in ONE identified condition affects the solubility of CO ₂ Supports their answer with a balanced equation	2-3
Identifies a condition which affects the solubility of CO ₂ gas OR Writes a balanced equation representing the solubility of CO ₂	1

Carbon dioxide is partially soluble in water. When it is bubbled through water, the following reversible reaction occurs:



Once sealed, a carbonated beverage represents an equilibrium system as long as the conditions it is placed under are held constant. If conditions such as temperature and pressure are altered, they disturb the equilibrium and this affects the solubility of the CO₂ (g).

- Increasing the temperature of the beverage will disturb the equilibrium and favour the reverse, endothermic process. This releases some heat and thereby minimises the disturbance. As a result of this shift the solubility of the gas decreases. Decreasing the temperature on the system does the reverse and increases the solubility of the gas.
- Keeping the system at a higher pressure favours the reaction to the right, because this produces less moles of gas. Thus during production of the beverage, CO₂ is pumped into the drink at high pressure and the drink is then sealed. A decrease in pressure (eg by opening the bottle) causes a shift to the left, which produces more gas more moles of gas, thereby minimising the disturbance. This results in a decrease in the solubility of the CO₂ gas.

Question 23 (a) H9

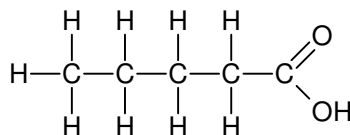
Identifies that the molecule is an ester.	1
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ester

Question 23 (b) H9, H13, H14

Correctly names AND draws an isomer of ethyl propanoate.	2
Correctly names OR draws an isomer of ethyl propanoate.	1

sample answer:



pentanoic acid

Question 23 (c) H10

Correctly calculates the volume of CO ₂ to three significant figures.	2
Calculation contains one error or is not quoted to three significant figures.	1

$2\text{H}^+ + \text{CO}_3^{2-} \rightarrow \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$
 $n(\text{CO}_2) = 0.5 \times n(\text{H}^+) = 0.5 \times 5.00 \times 10^{-3} = 2.50 \times 10^{-3}$
 $V(\text{CO}_2) \text{ at } 25^\circ\text{C, } 100 \text{ kPa} = n \times MV = 2.50 \times 10^{-3} \times 24.79 = 0.0620 \text{ L.}$

Question 24 (a) H4

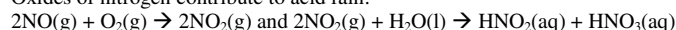
Identifies ozone.	1
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ozone

Question 24 (b) H4

Identifies that oxides of nitrogen contribute to acid rain, outlines one effect of acid rain and includes a correct chemical equation.	3
Identifies that oxides of nitrogen contribute to acid rain, outlines one effect of acid rain OR Identifies that oxides of nitrogen contribute to acid rain and includes a correct chemical equation.	2
Identifies that oxides of nitrogen contribute to acid rain.	1

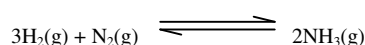
Oxides of nitrogen contribute to acid rain:



Acid rain has environmental and economic consequences. For example, it destroys foliage, which can destroy habitat, or reduce crop production.

Question 25 (a) H8, H10

Writes the correct equation for the synthesis of ammonia, including states.	1
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**Question 25 (b) H7, H8**

Explains why the rate increases when temperature is increased, by referring to particle theory, collision frequency and/or collision energy relative to activation energy. AND Explains why the yield of ammonia decreases when the temperature is increased, by referring to Le Chatelier's Principle and the exothermic nature of the forward reaction.	3
Explains why the rate of reaction is increased with increasing temperature. OR Explains why the yield of ammonia is decreased with increasing temperature.	1-2

When the temperature is increased, particles collide more frequently, and with more energy. Thus more collisions occur and more of these have at least the required activation energy. This increases the rate of reaction. However, the forward reaction is exothermic, so, according to Le Chatelier's Principle, when the temperature is increased the equilibrium position shifts to the left, decreasing the yield of ammonia.

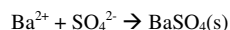
Question 26 (a) H14

Correctly identifies Pb^{2+}	1
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Pb^{2+}

Question 26 (b) H5, H8, H10

Writes the correct net ionic equation.	1
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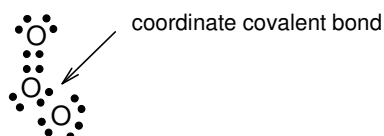
**Question 26 (c) H11, H13**

Justifies the order of adding HCl, and H_2SO_4 , and the addition of excess HCl to prevent precipitation of PbSO_4 .	3
Justifies the order of adding HCl and H_2SO_4 , and the addition of excess HCl to remove Pb^{2+}	2
Justifies the order of adding HCl and H_2SO_4 OR gives a justification of adding excess HCl.	1

The student knew there were two cations. The HCl was added first because from the list of possible cations, it precipitates only Pb^{2+} . If he had added H_2SO_4 first, it would have precipitated both the Pb^{2+} and the Ba^{2+} and there would have been no way of telling that both cations were in the ppt. HCl was added until ppt of the Pb^{2+} ceased in order to prevent remaining Pb^{2+} from precipitating with SO_4^{2-} , which would have provided a false positive in the sulfate precipitation test. The Pb^{2+} had to be removed to ensure that any precipitate in the sulfate test was not Pb^{2+} , but rather Ba^{2+} .

Question 27 (a) H6, H13

Draws a correct Lewis electron dot diagram of ozone and labels the coordinate covalent bond.	2
Draws a correct Lewis electron dot diagram of ozone	1

**Question 27 (b) H4**

Describes the occurrence and effects of ozone in the stratosphere, the troposphere, and gives an assessment of the health effects of	4
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ozone.	
Describes the occurrence and effects of ozone in the stratosphere and the troposphere. OR Describes the occurrence and effects of ozone in the stratosphere OR the troposphere, AND makes an assessment.	3
Describes the occurrence and effects of ozone in the stratosphere OR the troposphere.	2
Identifies that ozone occurs naturally in the stratosphere OR occurs as a pollutant in the troposphere.	1

Ozone occurs naturally in the stratosphere, where it absorbs UV radiation. This limits the amount of UV radiation reaching the earth's surface, where it can cause skin cancer. Thus ozone in the stratosphere is extremely important to human health, and steps have been taken to prevent its destruction. However, ozone occurs as a human-made pollutant in the troposphere, where it can lead to lung and eye irritation, and photochemical smog. These health effects are very detrimental, and thus ozone has a very damaging impact on human health when it occurs in the troposphere.

Question 28 (a) H3, H4, H14

Correctly identifies site B and justifies the choice on the basis of the phosphate concentration.	2
Correctly identifies site B but provides an incorrect justification.	1

Site B, because of the elevated phosphate concentration. This is added to the soil in fertiliser and runs off into waterways during rainfall.

Question 28 (b) H3, H4, H14

Correctly identifies site C and explains one impact that this would have on users.	2
Correctly identifies site C OR Outlines one impact of hard water on users.	1

Site C has hard water. Hard water makes it difficult for soap to lather, because the calcium and/or magnesium ions precipitate with soap ions. This reduces the cleaning capacity of soaps, making it hard for people to bathe, and to wash clothing.

Section II Options

Question 29 (a) (i) H8

Identifies calcium carbonate.	1
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CaCO₃ or calcium carbonate

Question 29 (a) (ii) H4

Identifies two factors that need to be considered AND explains why they are important.	3
Identifies two factors that need to be considered AND explains why one is important.	2
Identifies two factors that need to be considered.	1

Two factors which need to be considered when choosing a site for a Solvay plant are proximity to feedstocks, and waste disposal. Proximity to feedstocks is important because it minimises transportation costs. In the Solvay process concentrated salt water, and limestone, CaCO₃, are continuous requirements. To minimise transportation costs it is preferable that a plant be located so that one or both of these feedstocks is in close proximity. Waste disposal must be considered to protect the environment. CaCl₂(s) is produced by the process, and while some can be sold for de-icing roads, more is produced than can be sold for this purpose. It can be safely disposed of in the ocean, where it is rapidly diluted, but it cannot be disposed of safely in rivers and lakes. Dumping it as landfill is expensive, and can have detrimental effects on ecosystems as excessive levels of ions leach from the landfill site into the surrounding land and waterways.

Question 29 (a) (iii) H10, H14

Correctly calculates the volume of solution required, showing units and working, including the correct, balanced chemical equation (states not required).	3
Calculates the volume of solution required. Units OR working OR equation are omitted or contain one error.	2
Answer contains one correct step in the calculation OR answer contains the correct, balanced chemical equation.	1

$2\text{NaCl} + \text{CaCO}_3 \rightarrow \text{Na}_2\text{CO}_3 + \text{CaCl}_2$
 $\text{mass}(\text{Na}_2\text{CO}_3) = 5.0 \times 10^7 \text{ g}$
 $\text{moles}(\text{Na}_2\text{CO}_3) = 5.0 \times 10^7 / 106 = 471698 \text{ mol.}$
 $\text{moles}(\text{NaCl}) = 2 \times 471698 = 943396 \text{ mol.}$
 $\text{volume}(\text{NaCl}) = n/C = 943396/12 = 78616 \text{ L} = 79000 \text{ L (correct to 2 sig. fig. not necessary here).}$

Question 29 (b) (i) H12

Outlines the method fully, including reactants, conditions, processes and how the product was obtained.	3
Provides most of the important steps in the method.	2
Provides some important steps in the method OR identifies the reactants.	1

To make soap we mixed vegetable oil with concentrated sodium hydroxide solution and ethanol in a loosely covered beaker, and heated the mixture using a Bunsen burner. After the mixture had boiled for about 30 minutes we added solid sodium chloride and continued heating for about 10 minutes. When the mixture had cooled we filtered it to obtain the solid product, soap, which we washed with cold water. We tested the product by shaking one spatula full of it with water in a stoppered test tube, and observing whether or not a lather formed.

Question 29 (b) (ii) H13

Accounts for the cleaning action of soap by referring to the formation of an oil/water emulsion via micelle formation, and the polar (or hydrophilic head), and non-polar (or hydrophobic) tail of the soap ions. Answer may include a labelled diagram to convey this information.	3
Accounts for the cleaning action of soap by giving an outline of how soap ions interact with water and oil molecules to form micelles. Answer may include a labelled diagram to convey this information.	2
Identifies one correct aspect of the structure of soap ions.	1

Soap is a salt of a long chain fatty acid. When mixed with water it ionises to form a long chain fatty acid anion. This has a negatively charged "head" which is polar and hydrophilic, and a long, non-polar (hydrophobic) "tail". Soap ions clean in the following way:

- the hydrophobic tail dissolves in the fat/oil droplets
- the hydrophilic head dissolves in the bulk water in the mixture
- many soap ions surround each fat/oil droplet in this way, and agitation ensures that they do so to form a 3D, spherical structure called a micelle.
- the oil and water now form an emulsion, where the soap ions act as the emulsifier.
- the negatively charged heads of the soap ions repel each other and this prevents the micelles from clumping together.
- thus the fat/oil droplet is "solubilised" and can be rinsed off the surface being cleaned.

Question 29 (c) H6, H7, H8, H13

Provides a full description of the reactions and reaction conditions used in the Contact process and includes justifications for the conditions in the equilibrium step, AND for the production of oleum.	6-7
Provides a description of the reactions and reaction conditions used, and justifies the conditions used in the equilibrium step OR the production of oleum.	4-5
Describes the chemistry and steps involved in the Contact process.	3
Outlines one step in the process and provides one correct chemical equation.	2
Provides one correct chemical equation from the Contact process, or outlines one step.	1

Sulfuric acid is made in a multi-step process called the Contact Process. In the first step, elemental sulfur is converted to sulfur dioxide by burning molten sulfur in air, in an exothermic reaction which goes to completion: $S(l) + O_2(g) \rightarrow SO_2(g)$.

The second step, the oxidation of $SO_2(g)$ to $SO_3(g)$ is an equilibrium reaction: $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$. The forward reaction is exothermic. To maximise both rate and yield in this equilibrium reaction, reaction conditions are carefully controlled, and a catalyst, $V_2O_5(s)$ is used. The catalyst is in pellet form to increase its surface area and make it more effective at increasing the rate. A temperature of about 600 °C is used which provides for a rapid rate, but not 100% conversion of sulfur dioxide to sulfur trioxide. To further increase the yield an excess of oxygen gas is used, which shifts the equilibrium position to the right (consistent with Le Chatelier's principle). The reaction mixture is also passed over three separate beds of catalyst, each at a slightly lower temperature, at atmospheric pressure. This results in essentially complete conversion of the SO_2 to SO_3 , and therefore expensive high pressure equipment is not needed.

The SO_3 is then dissolved in concentrated sulfuric acid to produce oleum: $SO_3(g) + H_2SO_4(l) \rightarrow H_2S_2O_7(l)$. Water is added to the oleum to produce 98% sulfuric acid: $H_2S_2O_7(l) + H_2O(l) \rightarrow 2H_2SO_4(l)$. The final product is produced in this way because addition of SO_3 directly to H_2O to produce H_2SO_4 is highly exothermic and can produce a dangerous mist of H_2SO_4 . The heat produced by the process (in the oxidation of S and SO_2) is used to generate steam and electricity to reduce the operating costs of production.

Question 29 (d) (i) H7

Contrasts the function and energy requirements of both types of cell.	2
Contrasts the function OR energy requirements of both types of cell. OR Outlines the function and energy requirement of either cell.	1

A galvanic cell is used to provide electrical energy by separating the oxidation and reduction reactions of a spontaneous reaction, and causing electrons to flow through an external circuit. It has no external energy requirement. An electrolytic cell causes a spontaneous reaction to occur in reverse, and thus requires an input of energy.

Question 29 (d) (ii) H8

Explains the significance of electrolysis to the production of sodium hydroxide and includes a relevant balanced chemical equation.	3
Outlines the significance of electrolysis to NaOH production and includes a relevant chemical equation.	2
Outlines the significance of electrolysis to NaOH production OR includes a relevant, balanced chemical equation.	1

The production of sodium hydroxide is essentially the electrolysis of brine, as follows:
 $2Na^+(aq) + 2Cl^-(aq) + 2H_2O(l) \rightarrow H_2(g) + Cl_2(g) + 2Na^+(aq) + 2OH^-(aq)$. The oxidation of chloride ions to chlorine gas has a very negative electrode potential, and thus it is not spontaneous. Energy must be provided to do this. Similarly, to reduce water to hydrogen gas and hydroxide ions. The energy is provided as electricity, and thus electrolysis is fundamental to the process.

Question 30-Shipwrecks, Corrosion and Conservation

Question 30 (a) (i) H6

Identifies iron is in the +3 oxidation state in rust.	1
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Iron is in the +3 oxidation state in rust.

Question 30 (a) (ii) H4, H6, H8

Describes TWO methods of preventing corrosion of the pipe AND Explains how each method prevents corrosion.	3
Describes a method of preventing corrosion of the pipe AND Explains how each method prevents corrosion OR Outlines TWO methods of preventing corrosion of the pipe	2
Identifies one method of preventing corrosion of the pipe (eg galvanising)	1

The steel pipe could be galvanised by covering it with a layer of zinc. The covering prevents iron from coming into contact with oxygen and moisture, two components required for corrosion. If the zinc is scratched, the zinc is more active than the iron in the pipe and is oxidised in preference to it. The zinc produces electrons which are accepted by any Fe^{2+} ions, reducing them back to Fe. Therefore the iron is made the cathode in the 'cell' which has been formed and is protected from corrosion.

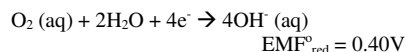
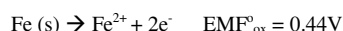
Another method of protection of the pipe is to apply an external voltage. In this case, the external source of electricity (eg a transformer) is connected to the pipe via a conductor. The electrons reduce any Fe^{2+} to Fe-again the pipe is maintained as the cathode.

Question 30 (a) (iii) H6, H8, H10

Writes half-equations for corrosion in both conditions AND calculates the EMF° in each condition.	3
Writes half-equations for corrosion in one condition AND calculates the EMF° under this condition OR Writes half-equations for corrosion in both conditions OR Calculates the EMF° under each condition	2
Writes the half-equation for either process OR Calculates the EMF of the cell	1

In non-acidic conditions:

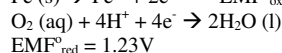
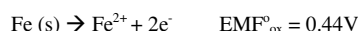
At the anode:



$$\text{EMF}^\circ_{\text{cell}} = 0.44 + 0.40 = 0.84\text{V}$$

In acidic conditions:

At the anode:



$$\text{EMF}^\circ_{\text{cell}} = 0.44 + 1.23 = 1.67\text{V}$$

Question 30 (b) (i) H12

Provides characteristics of a valid procedure to investigate the effect of concentration on the electrolysis products of a named solution Describes data to be collected in investigation	3
Outlines characteristics of procedure, including chemicals used and main steps followed.	2
Identifies the electrolysis product of a named solution (at either high or low concentration).	1

1. Produce or obtain a dilute solution (eg 0.1M) of potassium chloride solution and a more concentrated solution of the same compound (eg 1M).
2. Insert graphite electrodes into the dilute solution of KCl in a beaker and pass an electric current (from a power source) through the solution. Observe any changes and test any gases with a lit taper and/or glowing splint.
3. Repeat Step 2 with the 1M potassium chloride solution in a fume cupboard.

When the dilute solution was electrolysed, 2 colourless gases were produced. One made a glowing splint re-light. The other tested positive with the 'pop test'.

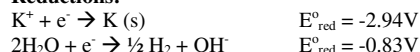
When the more concentrated solution was electrolysed, a colourless gas was produced at the negative electrode. The gas at the other electrode changed moist blue litmus paper red and then bleached it.

Question 32 (b) (ii) H6, H8, H14

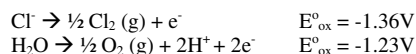
Accounts for the different products formed at the anode and cathode for both the dilute and concentrated solutions AND Provides half-equations for the processes that occur.	3
Accounts for the different products formed at the anode and cathode for EITHER the dilute or concentrated solutions, including half-equations OR Provides half-equations for the reactions occurring in electrolysis in both the dilute and concentrated solutions, without further explanation OR Accounts in general terms the reason why different gases form during electrolysis of the dilute and concentrated solutions, identifying the gases formed in each case, but without half-equations.	2
Provides one equation to explain the production of any gas at the anode or cathode for the dilute OR concentrated solution OR Identify one product forming at the anode or cathode in the dilute or concentrated solution	1

In a solution of KCl, the possible species which can be oxidised and reduced are:

Reductions:



Oxidations:



K^+ is too stable a species to undergo reduction, regardless of the concentration of the solution. Hence the H_2O is always reduced to hydrogen at the cathode.

Since the concentration of Cl^- is low in the 0.1M solution, and the oxidation of water requires less energy input than that of the Cl^- ion, the oxidation of water will occur at the anode, producing oxygen.

When the concentration of KCl increases, the water is still reduced in preference to the stable K^+ , hence hydrogen is produced at the cathode. However, at higher concentrations of Cl^- , because the E_{ox}° are close for Cl^- and H_2O , some Cl^- ions are oxidised to Cl_2 gas at the anode.

Question 30 (c) H6, H8, H13

Identifies and describes three factors which affect the extent of corrosion AND Explains why they affect the extent of corrosion and includes chemical equations AND Provides an assessment of the importance of each factor identified.	6-7
Identifies and describes two factors which affect the extent of corrosion AND Explains why they affect the extent of corrosion, including one chemical equation.	4-5
Identifies and describes one factor which affects the extent of corrosion	2-3
Identifies one factor which affects the extent of corrosion	1

Corrosion generally refers to the reaction of a metal with oxygen to form a metal oxide. The commonest example is rusting, in which hydrated iron(III) oxide is produced from iron by reaction with oxygen in the presence of water. Various factors affect the extent of this reaction, including:

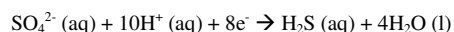
- presence of any dissolved ions in water and their concentration
- the pH of the water
- level of dissolved oxygen in water
- the presence of protective measures
- depth of the ocean in which wreck is located

The corrosion of iron-based artefacts will increase in the presence of dissolved ions such as sodium chloride. The presence of ions in solution increases the rate of charge transfer. Therefore, the higher the salinity levels of the water in which the wreck is located, the greater the extent of corrosion.

The pH of the aqueous environment is another important factor. Deep in the ocean the CO_2 concentration is higher, resulting in a lower pH. This facilitates the reduction of dissolved oxygen: $\text{O}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}$, and the facilitated electron transfer also therefore facilitates the oxidation of the metal. Also, hydrogen ions catalyse the overall rusting process. Thus pH is an important factor.

Another important factor is the amount of dissolved oxygen. If levels are high, this would increase the rate of corrosion. At great depths, conditions include little light, low temperatures and very low oxygen levels. Although one might expect little corrosion of iron in these conditions, studies of corrosion rates in wrecks such as the Titanic show higher than expected corrosion. In this case, corrosion is accelerated by lower pH and the presence of anaerobic sulfate-reducing bacteria.

These bacteria facilitate the following reaction:



The presence of protective measures is also of primary significance. Consider the extent of corrosion of an iron artefact without and with protection of some sort. Unprotected, the iron artefact will corrode rapidly. However, iron which is protected by, for example, a non-metallic coating such as paint will not corrode until the coating is breached. The extent of corrosion of an iron structure will be dramatically reduced if it is galvanised – covered with a protective layer of zinc. This is because zinc is a passivating metal, and once the surface has been oxidised, the zinc oxide surface layer protects the rest of the same from corrosion. Thus the presence of a protective measure is also key to considering the extent of corrosion.

Question Shipwrecks (d) (i) H1

Contrasts the inferences made by identifying the inferences of both Galvani and Volta AND associates the inferences with the correct scientist.	2
Identifies an inference of either Galvani or Volta.	1

Galvani inferred that the frog's muscle had generated an electric current, causing its contraction. Volta inferred that the electric current was generated by contact with wires of different metals.

Question Shipwrecks (d) (ii) H1, H3, H4

Explains how Volta's work improved our understanding of electron-transfer reactions, including a description of TWO developments made by Volta or as a consequence of his work.	3
Outlines TWO developments in our understanding of electron-transfer reactions attributed to Volta.	2
Outlines one development in our understanding of electron-transfer reactions attributed to Volta.	1

Volta's conclusion that the contraction of the frog's leg in Galvani's experiments were due to an electric current produced by contact between two different metals was found to be correct. He then used this concept in the development of a new electrical device, called a Voltaic Pile. This device produced current by contact between silver and zinc, each pair of metals separated by cardboard or cloth soaked in a salt solution. The development of this battery then allowed other scientists, including Davy, to improve upon its design and construct larger, more powerful batteries. Davy used one such battery to pass electricity through molten metal compounds, allowing the separation of these compounds and thus producing pure metals via electrolysis.

Therefore, Volta's work improved upon our understanding of redox reactions, both used in the production of electricity (in batteries) and as a consequence of his work, in the use of electricity in the isolation of metals via electrolysis.

Question 31 – Biochemistry of Movement Option**Question 31 (a) (i) H7, H14**

Identifies glycolysis.	1
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glycolysis

Question 31 (a) (ii) H9, H14

Identifies NADH (+H ⁺) and FADH ₂ as the two products and explains their role in oxidative phosphorylation.	3
Identifies NADH (+H ⁺) OR FADH ₂ and outlines its role in oxidative phosphorylation.	2
Identifies NADH (+H ⁺) and FADH ₂	1

The products P₁ and P₂ are NADH+H⁺ and FADH₂. The oxidative phosphorylation step in respiration requires both of these substances as reactants. They react with oxygen (in reactions catalysed by cytochrome chain enzymes) to produce water, releasing energy which is used to convert ADP to the energy storage compound ATP. A total of 5 ATP molecules is produced by the oxidation of NADH+H⁺ and FADH₂.

Question 31 (a) (iii) H8, H9

Accounts for the formation and effects of lactic acid in muscles during anaerobic glycolysis.	3
Outlines the formation OR effects of lactic acid in muscles during anaerobic glycolysis.	2
Identifies one feature of the formation or effects of lactic acid.	1

Lactic acid is formed in type 2 muscle cells, during anaerobic glycolysis. During sharp bursts of exercise, such as sprinting, when the oxygen supply to tissues is insufficient for aerobic glycolysis, lactic acid is formed from glucose via pyruvate. This provides a rapid release of energy over short periods, but also lowers the cellular pH. This results in impaired muscle contractions, which may be felt as cramping.

Question 31 (b) (i) H12

Outlines the method by including all important steps, the reactants, two variables to control, how the independent variable was changed, and how changes in the dependent variable were observed.	3
Outlines a method, making reference to how the independent variable was changed and what changes were observed.	2
Identifies how the independent variable was changed in the experiment.	1

Starch solutions of equal concentration were prepared using aqueous pH buffers at pH 4, 5, 6, 7 and 8 as the solvent. Equal volumes (5 mL) of these solutions were placed in separate test tubes, and 2 drops of iodine solution were added. 2 mL of 1% amylase solution was added to each test tube and the reaction mixture mixed thoroughly. The test tubes were maintained at a constant temperature using a water bath at 35 °C. The time taken for the colour of the iodine-starch complex (blue-black) to disappear (as the starch is broken down by the enzyme amylase) was recorded.

Question 31 (b) (ii) H13, H14

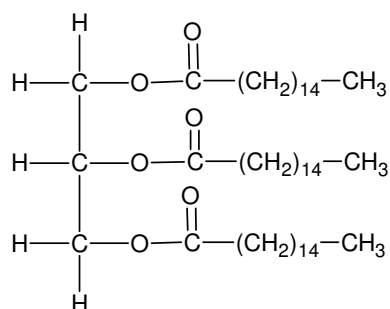
Identifies the difference in activity of the enzyme at different pH values and accounts for the difference in terms of the structure of the enzyme.	3
Identifies the results at different pH values and makes one statement about enzyme activity and pH.	2
States the results of the experiment OR Makes a general statement about enzyme activity and pH.	1

In our experiment we found that the time taken for the starch-iodine complex to decolourise was shortest (ie highest enzyme activity) at pH = 7. At pH values above and below this, the time was longer, indicating that enzyme activity was lower at pH above and below 7. This is because changes in pH change the H⁺ ion concentration in solution, and this disrupts the hydrogen bonding which maintains enzymes tertiary (eg globular) and secondary (ie sheet vs helix) structures. At extremely high or low pH it is also possible that the primary structure of the enzyme could change, by acid or base catalysed hydrolysis of the peptide bonds.

Question 31 (c) H8, H9, H13

Analyses the structure and role of TAGs in maintaining human health, AND includes problems associated with excessively high or low levels of TAGs.	6-7
Outlines the structure and role of TAGs in maintaining human health, AND includes problems associated with excessively high or low levels of TAGs.	4-5
Outlines the structure OR role of TAGs.	2-3
Identifies one correct feature of the structure or role of TAGs.	1

TAGs are fats and oils. They are triacyl glycerides, or triesters of glycerol. Glycerol (1,2,3-propanetriol) can form a triester because it contains 3 hydroxy groups. An example of a TAG is glyceryl tripalmitate:



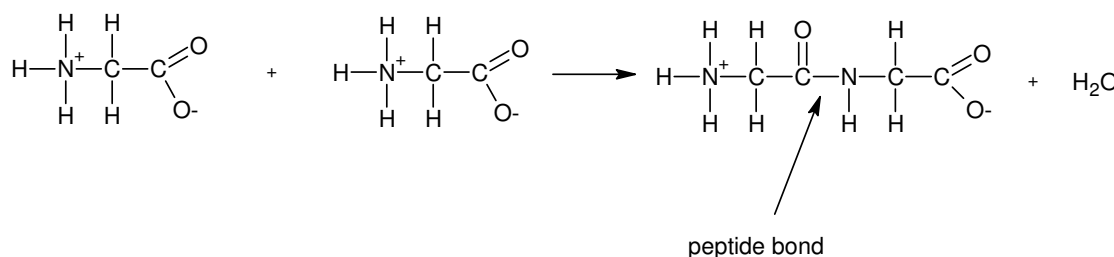
Like all esters, they contain the $\text{R}-\text{C}(\text{O})-\text{O}-\text{R}'$ functional group, and are water insoluble. TAGs are very high energy compounds because of the large number of C-C and C-H bonds they contain. They are used in the body as insulation (ie adipose tissue) and as energy storage. Whereas the body can only store enough glycogen (an energy storage polymer derived from glucose) for approximately 12 hours, it can store enough fat to provide energy for approximately 8 weeks. The TAGs important for human health contain fatty acids with 14 – 20 carbon atoms, and an even number of carbon atoms. The fatty acids may be saturated (single C-C bonds only), mono-unsaturated (one $\text{C}=\text{C}$ double bond), or poly-unsaturated (two or more $\text{C}=\text{C}$ double bonds).

TAGs provide the body with much more energy than glucose. Oxidation of glucose typically provides 17 kJ/g, whereas oxidation of fats provides 38 kJ/g. Thus they are an important source of energy, and humans derive approximately 30% of our daily energy needs from TAGs. Too much can lead to obesity whereas too little can result in inadequate adipose tissue, causing health issues and providing limited insulation.

Question 31 (d) (i) H8, H9

Outlines the chemistry involved in the formation of a peptide bond.	2
Identifies that a peptide bond is $\text{R}-\text{C}(\text{O})-\text{NH}-\text{R}'$ or equivalent.	1

A peptide bond is formed when two amino acids react to produce a peptide and water. Because amino acids are present as zwitterions, it is the $\text{R}-\text{COO}^-$ of one amino acid and the $\text{R}-\text{NH}_3^+$ of another amino acid that react, according to the following equation:



Question 31 (d) (ii) H9, H13

Explains factors that contribute to the primary, secondary, tertiary and quaternary structures of proteins.	3
Explains what is meant by the primary, secondary, tertiary and quaternary structure of a protein.	2
Identifies that proteins have a primary, secondary, tertiary and quaternary structure.	1

Proteins are amino acid polymers, and they have a primary, secondary and tertiary structure. The primary structure is the order of amino acids. There are 20 amino acids required in human biochemistry, and each has a different side chain, R, in the formula $\text{H}_3\text{N}^+-\text{CHR}-\text{CO}_2^-$. For a protein to be able to carry out its particular function the amino acids must be in the correct order, because of the effect of the side chains, R. The secondary structure of a protein refers to small-scale arrangements in the polypeptide chain, such as helices or sheet structures. These small-scale structural arrangements result from hydrogen bonding interactions between different sections of the polypeptide chain. Changing the order of amino acids will also change the secondary structure because there will be different interactions between different sections of the polypeptide chain. The side chains of amino acids also affects the tertiary structure. This is the overall shape of the protein, for example, globular. This shape is affected by the hydrogen-bonding between side chains at various places in the polypeptide chain, disulfide linkages between cysteine units (which contain S in the side chain), and hydrophobic interactions between side chains. Some proteins may form a quaternary structure, which occurs when two separate polypeptide chains, when in their tertiary structure, can fit together to form a larger unit, required for a specific biochemical function.

Question 32-The Chemistry of Art

Question 32 (a) (i) H6

Identifies the group to which element X belongs as group 3	1
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Group 3

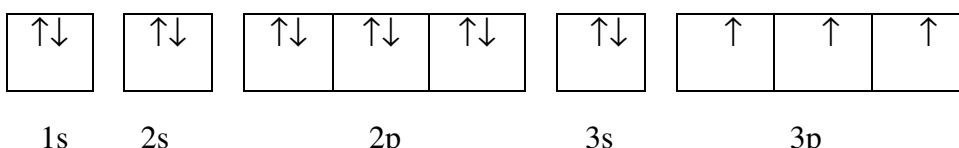
Question 32 (a) (ii) H14

Describes what is meant by the term successive ionization energy AND Relates understanding of successive ionisation energies to electron arrangement of atoms AND/OR Refers to data in graph to provide an example of how data on successive ionisation energies can be used to predict the atom has 3 electrons in its valence shell.	2-3
Provides a definition of the term successive ionisation energy OR Identifies element X has 3 electrons in the outer energy level OR	1

The successive ionisation energies of an element are a measure of the energy required to remove successive outermost electrons from the nucleus of atom or ion. They always increase for any particular element because it becomes more difficult to remove an electron from an increasingly positive nucleus. However, the increases in successive ionisation energies are not regular. Instead, for all elements within a particular group, there exists large 'jumps' between certain ionisation energies. In the example in (i), the large jump occurs between the 3rd and 4th successive ionisation energy. This supports the idea that electrons are arranged in shells and that for this element, there are 3 electrons in an outer shell. Once these are removed, the next ionisation energy is much larger as the electron must be removed from an inner shell, closer and more strongly bound to the nucleus. Elements in other groups have a different pattern to their successive ionisation energies as they have a different electron arrangement.

Question 32 (a) (iii) H6, H13, H14

Draws a correct orbital box diagram for phosphorus (may not be labeled) AND Relates the Pauli Exclusion Principle to the way electrons fill orbitals AND/OR Relates the Hund's Rule to the way electrons fill orbitals	2-3
Draws a correct orbital box diagram for phosphorus (may not be labeled) OR States either the Pauli Principle or Hund's rule	1



Pauli's exclusion principle states that each orbital (shown as a box) can hold a maximum of 2 electrons. Hund's rule states that for orbitals in the same sublevel (eg 3p), electrons will go into empty orbitals until each has 1 electron. Only then will the next electron fill an orbital.

Question 32 (b) (i) H12

Provides characteristics of a valid procedure to compare the oxidizing strength of potassium permanganate to other species with high oxidizing strength, including a knowledge of reactants used, some method of control (eg controlling quantities) AND Describes data to be collected in investigation	3
Outlines main characteristics of the procedure, including chemicals required and main steps followed	2
Identifies basic reactants used in the investigation (eg potassium permanganate and another species of high oxidising strength for comparison)	1

1. Acidify a small volume of potassium permanganate by adding a few drops of sulfuric acid to it.
2. Add 1mL samples of sodium bromide, sodium iodide and sodium chloride to separate test tubes.
3. To each test tube, add a few drops of acidified potassium permanganate.
4. Observe any change in the colour of the mixture to determine if the permanganate has been reduced, and hence has oxidized the other species.
5. Repeat the procedure with potassium dichromate instead of potassium permanganate.

Question 32 (b) (ii) H7, H8

Accounts for the difference in oxidizing strength of the two species by considering the oxidation state of the Mn in each compound	3
Identifies the oxidation state of Mn in both compounds AND States that the species containing a metal in a high oxidation state be a stronger oxidizing agent.	2
Identifies the oxidation state of Mn in either compound. OR States that the species containing a metal in a high oxidation state be a stronger oxidizing agent.	1

Species containing a metal in a high oxidation state are more powerful oxidizing agents compared to those containing the metal in a low oxidation state. For example, in KMnO_4 , the manganese is in the +7 state. In MnCl_2 it is in the +2 state. KMnO_4 is a very strong oxidizing agent, whereas MnCl_2 would not be an oxidizing agent.

When metals are present at high oxidation states, they often combine with electronegative elements such as oxygen. These oxygen-containing ions then readily accept electrons from other species, bring about their oxidation. In the process, the metal is reduced to a lower oxidation state.

Question 32 (c) H13, H14

Shows relationships between three identified factors which affect the colour of compounds AND Provides examples where each factor plays a role in determining the colour, using data from the table AND Provides a basic explanation of the origin of colour (in terms of absorption of a part of visible light by electrons moving to high energy states).	6-7
Shows relationships between two or three identified factors which affect the colour of compounds AND Provides examples where each factor plays a role in determining the colour, using data from the table	4-5
Outlines two factors that affect the colour of a metal-containing solution	3
Outlines one factor that affects the colour of a metal-containing solution OR Uses data from the table to identify two factors that affect the colour of a metal-containing solution	2
Identifies one factor that affects the colour of a metal-containing solution	1

Factors that affect the colour of chemicals include the nature of the metal, the oxidation state of the metal and presence and nature of and ligands attached to the metal ion.

Compounds containing metals outside of the transition block are generally white (eg NaCl, KNO₃, MgCO₃), whereas those containing metals from the Transition block are often coloured (eg all of the other compounds in the table). Transition metal ions often have unfilled d orbitals and the energy involved with moving electrons between these levels corresponds to light within the visible spectrum. Thus when light falls upon compounds containing these metal ions, a section is absorbed and hence the compounds appear coloured.

The oxidation state also plays a role in determining colour. MnO₄ is purple (the Mn is in the +7 state) whereas MnCl₂ (with the Mn in the +2 state) is pale pink. The electron arrangement of the Mn in the different oxidation states is different and this changes the way the electrons interact with light.

Similarly, the ligand surrounding the metal ion plays a role in determining the colour of the compound. In Cu(H₂O)₆²⁺ the ligands are water molecules. Ligands bind to the metal ion by coordinate covalent bonds. The shared pairs of electrons occupy the empty d orbitals of the metal ion and affect the energy differences between the d orbitals, and hence can change the colour. CuSO₄ without any water present is white but the presence of the ligands make it blue. When the ligands are different (eg in Cu(NH₃)₄(H₂O)₂²⁺) the colour of the solution changes (to deep blue). The different ligands affect the energy differences of the d orbitals and hence the colour.

Question 32 (d) (i) H6, H7

Describes a similarity and difference between the emission spectra and absorption spectra of an element	2
Identifies a feature of either the emission spectra or absorption spectra of an element	1

The emission spectra of an element is a series of coloured lines of specific wavelengths shown on a black background, each line corresponding to light of energy emitted when electrons fall back from an excited energy level to a lower energy level. By comparison, the absorption spectra is a series of dark lines on a continuous spectrum, each line at the same wavelength, corresponding to light absorbed by electrons going from lower to higher energy levels.

Question 32 (d) (ii) H3

Explains how the identified technique is useful in artwork analysis (must relate knowledge of technique to one specific use in artwork analysis).	3
Outlines an identified technique used in the analysis of materials in artworks.	2
Identifies an appropriate technique used to analysis of materials in artworks.	1

Laser microspectral analysis is one technique used in the analysis of pigments for art restoration. The technique relies upon a small paint sample being vaporised by a pulse of laser. The atoms in the vapour are excited electrically and the electrons move to higher electron shells. Upon returning to a lower state, the electrons emit radiation corresponding to the energy difference between the excited and lower energy level—that is an emission spectra, unique for each element, is produced. LMA can therefore be used to identify any metal in a paint sample and this can help identify the pigment used. A knowledge of the pigment is important in art restoration to ensure the correct pigment is used to make any modifications.

Question 33-Forensic Chemistry**Question 33 (a) (i) H14**

Identifies cadmium as the metal in the paint chip	1
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Cadmium

Question 33 (a) (ii) H6, H7

Relates the unique electron arrangement of elements to its production of a unique emission spectra AND Explains how the spectra is formed	3
Relates the unique electron arrangement of elements to its production of a unique emission spectra OR Outlines how the spectra is formed	2
Identifies electrons surround the nucleus of atoms in shells OR Identifies every element has a unique electron configuration OR	1

Electrons surrounding the nuclei of atoms are located in shells and each shell has an associated energy. The electrons in atoms may jump from lower energy to higher energy shells by absorption of radiation with an energy value exactly equal to the energy difference between the 2 shells it is moving between. When the electron absorbs this energy, it jumps to the higher shell. This is an unstable state and the electron will soon drop back to a lower level by emitting radiation of a distinct wavelength corresponding to the energy difference between the higher and lower shell. Scientists view this emission through a spectroscope. A series of coloured lines can be seen—each line represents radiation emitted when an excited electron falls to a lower shell. Since every element has a unique electron arrangement and the energy differences between shells is unique, each produces a unique emission spectra.

Question 33 (a) (iii) H3, H4

Accounts for the use of emission spectra in forensic investigations AND Explains a limitation of the technique	2-3
Identifies a use of emission spectra in a forensic investigation	1
Identifies a limitation of the use of emission spectra in forensic investigations	

The use of emission spectra in forensics provides a reliable method of identifying the elements present in a sample. Each element has a unique spectrum. The spectrum of the sample being tested is compared to those of the elements and using this method the elements in the sample are identified. The scientist may be able to infer from the elements present what the composition or identity of the sample is. The use of this technique alone has limitations. The sample must be excited (eg by heat) and the excitation requires the destruction of the sample. This means further testing must be done of other samples. In addition, the technique can only indicate which elements are present in a compound, but may not be able to reveal the actual composition of the sample (eg it cannot identify an organic compound, because most of these contain the same elements).

Question 33 (b) (i) H12

Provides characteristics of a valid procedure to distinguish between a reducing and non-reducing sugar, including chemicals required, main steps involved AND Describes data to be collected in investigation	3
Outlines characteristics of procedure, including chemicals used and main steps followed	2
Identifies the reducing and non-reducing sugar used in the investigation (eg glucose/sucrose) OR Identifies the reagent used to distinguish between the two groups of sugars (eg Benedict's reagent/Tollen's reagent).	1

1. Dissolve a small amount of a known reducing sugar (eg glucose) in water. Repeat with a known non-reducing sugar (eg sucrose).
2. Add a few drops of Benedict's reagent to a few mL of each sugar solution in a test tube.
3. Heat the test tubes gently.
4. Observe any colour changes which occur. The contents of the test tube with the reducing sugar will turn brick-red. The contents of the non-reducing sugar will not change.

Question 33 (b) (ii) H8, H9, H12

Accounts for the difference in reactions of reducing and non-reducing sugars with Benedict's (or Tollen's reagent) by describing the difference in the chemistry of the two groups AND Explaining why this leads to a colour change for the reducing sugar but not the non-reducing sugar	3
Outlines a chemical difference between reducing and non-reducing sugars OR Accounts for the colour change in the identified reagent in terms of oxidation and reduction	2
Identifies reducing sugars contain a carbonyl group OR non-reducing sugars do not contain this group OR States that reducing sugars reduce Cu^{2+} , causing a colour change	1

Reducing sugars such as glucose contain a reactive carbonyl ($\text{C}=\text{O}$) functional group within their structures. This makes them susceptible to oxidation by weak oxidizing agents such as the Cu^{2+} in Benedict's reagent. Upon addition of Benedict's reagent, the sugar reduce the blue Cu^{2+} ions to Cu^+ ions, which brick-red, and hence the colour changes. Non-reducing sugars do not have the carbonyl group and will not be oxidized by Cu^{2+} ions-hence no colour change is observed.

Question 33 (c) H13

Describes two forms of chromatography Provides examples of forensic investigations where each form it used AND Provides a judgment on one OR both forms of chromatography described	6-7
Describes two forms of chromatography AND Provides examples where each factor plays a role in determining the colour, using data from the table OR Describes one form of chromatography AND Provides an example of a forensic investigation in which it is used AND Makes a judgment on the use of the form of chromatography based on criteria	4-5
Outlines two forms of chromatography OR Describes in detail one form of chromatography	3
Outlines one form of chromatography OR Provides an example of the use of chromatography in forensic investigations.	2
Identifies one form of chromatography	1

The various forms of chromatographic techniques are used to separate small samples of mixture. All forms depend upon the components of the mixture having different affinities for a stationary and mobile phase. Forensic scientists make use of these techniques to analyse unknown samples found at crime scenes etc to help identify them. For example, at a scene of a fire, an unknown liquid may be analysed to determine if it could have been used as an accelerant, and if so, what composition it has. If a suspect's clothing is analysed and found to contain traces of this liquid, this provides evidence which could lead to their arrest. Therefore, various forms of chromatography often form an important part of a forensic investigation.

For forensic investigations, two main types of chromatographic techniques used include high performance liquid chromatography (HPLC) and gas-liquid chromatography (GLC)

HPLC relies upon the mixture components having different solubilities in both the mobile and stationary phases. The sample is injected into a column packed with tiny particles of silica covered with a liquid-this is the stationary phase. A pump pushes a solvent through the column at high pressure. A component with high solubility in the mobile phase (or low solubility in stationary phase) moves through the column faster than one with a lower solubility in the mobile phase. From the chromatograms produced by the instrument, not only can components be identified but their concentration estimated from the size of the peaks. It is typically used to analyse non-volatile substances such as carbohydrates, fats and polypeptides from proteins. It can also be used to detect traces of explosives

GLC is also widely used in forensic investigations, although the sample being analysed must readily vaporise below 250°C. The sample can be either in the form of a liquid or solution. It is injected into hot gas which causes it to vaporize. The sample moves through a column, in which the inside walls have been coated with a liquid stationary phase. The components repeatedly dissolve in the liquid stationary phase and vaporize back into a gas and separate out as they pass through the column. A detector indicates when a component leaves the column and compounds are identified by the time it takes for them to reach the detector (their retention time). The technique can be used to identify pesticide residue in foods and illegal drugs in athletes.

Both techniques are sensitive and can detect tiny amounts of substances (eg down to nanogram amounts). They are fairly quick and simple to carry out, but great care must be taken to avoid contamination in sample, resulting in incorrect analysis of mixtures. Another disadvantage is the considerable cost of the instrument.

Question 33 (d) (i) H9

Outlines features of the structure AND composition of DNA.	2
Identifies a feature of either the structure or composition of DNA.	1

DNA stands for deoxyribonucleic acid. The molecule is a biopolymer consisting of 2 strands of alternating phosphate and deoxyribose units, twisted around each other so that the molecule is in the shape of a double helix. The deoxyribose units on opposite strands are joined by nitrogen-containing base groups, of which there are four types-adenine, guanine, thymine and cytosine. Hydrogen bonding can form between bases-A always joins to T and C to G.

Question 33 (d) (ii) H4, H13

Explains two problems/limitations associated with the use of DNA in forensic investigations.	2-3
Identifies an issue associated with the use of DNA in forensic investigations.	1

One problem with the use of DNA is the maintenance of DNA data banks which are collections of DNA profiles compiled by law enforcement agencies. Samples of blood etc found at crime scenes can be analysed and the DNA found compared to DNA profiles in these data banks. However, there are social/ethical issues associated with the collection of DNA samples. Civil libertarians are concerned that the taking and storage of samples of DNA is an invasion of individual's privacy. Current laws in Australia only allow for voluntary taking of DNA samples, which may be done in an effort to prove the innocence of a suspect. Again, debate exists as to whether a person should be asked to provide DNA to prove their innocence.

In addition, if police find a sample of fluid from which DNA can be identified, they can only find a match if the offender's DNA is in the data base. Therefore, the fact that DNA samples are located and identified from a crime scene is no guarantee that a suspect can be identified. In addition, DNA is only found in some biological samples, including blood, semen, saliva and hair follicles.

Contamination of DNA evidence is also an issue with its use-the investigators at a crime scene and the scientist carrying out the analysis must take care not to contaminate any sample with their own DNA and instruments to analyse DNA must be carefully maintained to avoid any DNA contamination.

Another problem with the use of DNA is the fact that the analysis is time consuming and the equipment required is expensive, needing specialist technical staff to run.