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HSC Trial Examination 2002

Chemistry

Solutions and marking guidelines

 PO Box 214 St Leonards NSW 2065 Tel: (02) 9438 1386 Fax: (02) 9438 1385

Section I

Part A

Answer and explanation	Outcomes assessed
Question 1 A Since this is a weak acid, only a small proportion of molecules have ionised. Therefore, the majority of molecules have remained intact.	H2
Question 2 A The greater amount of gas was produced at lower temperature (indicating that it is an exothermic process) and higher pressure.	H7, H8
Question 3 D By adding more water, the solution must now be more dilute. Since the pH has decreased, the solution is also less alkaline.	H10
Question 4 D A. Copper (II) fluoride provides F^- ions and so equilibrium shifts to the left. B. Hydrogen chloride will dissolve in the water increasing the H_3O^+ concentration and so shift equilibrium to the left. C. Sodium hydroxide would provide OH^- ions; these would react with the H_3O^+; the equilibrium would shift to the right in an attempt to replace the H_3O^+. D. Cu^{2+} and NO_3^- ions do not affect any of the species present in this equilibrium.	H2, H8
Question 5 B The esters structure has double bonded oxygen on the single carbon; this C must be from the acid therefore the acid was methanoic acid. The other carbon chain in the ester contains 3 consecutive C atoms therefore this section was originally 1-propanol.	H9
Question 6 D As water flows, it mixes with air from the atmosphere. This allows oxygen to mix with the water and so increases the dissolved oxygen content of the water. The increased available oxygen in the water makes aerobic decomposition possible.	H8, H14
Question 7 B The presence of copper ions is possible due to the colour of the substance's solution and the colour produced by the flame test.	H8
Question 8 D No visible reaction with sodium chloride solution is a possible result for a range of different salt solutions. Many common copper salts are blue or green in colour to produce aqueous solutions of similar colours. The flame test for copper ions produces a green flame.	H8
Question 9 B It is the only process producing smaller molecules.	H9
Question 10 C By definition, oxidation always occurs at the anode, reduction at the cathode.	H8
Question 11 D Fermentation produces ethanol.	H4, H9

Part A (Continued)

Answer and explanation	Outcomes assessed
Question 12 A It is balanced for mass and atomic number. None of the others are balanced.	H10
Question 13 A Of the alternatives provided, this would be the most useful because the titration values were so close.	H12, H14
Question 14 C There must have been an error in preparation of the solutions as titration is a suitable method.	H11
Question 15 B Membrane filters have pores smaller than microorganisms. C is a true statement, but is not the reason why microorganisms are removed.	H3

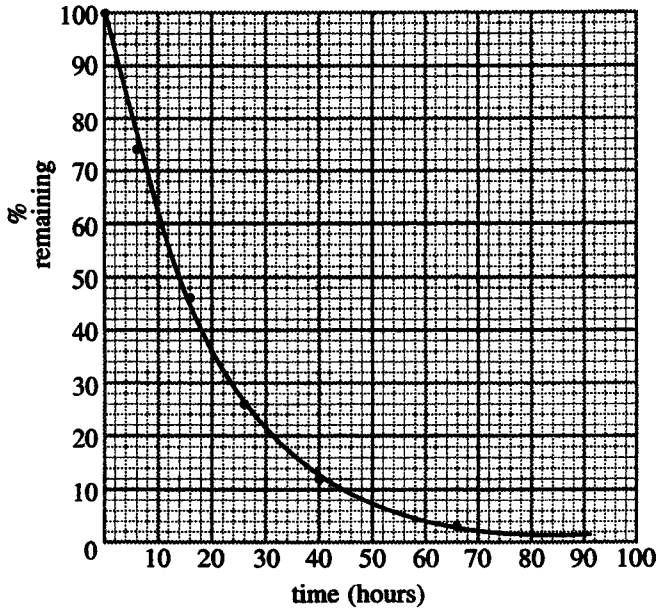
Part B

Sample answer	Syllabus outcomes and marking guide
Question 16	
This process makes use of an electric current that is supplied to reduce the ions of the metal that is to be purified. Therefore the production of the metal occurs at the cathode. Using copper refining as an example, blister copper, which is impure, is placed as the anode of such a cell. A sheet of pure copper is used as the cathode. The electrolyte used is copper sulfate solution. As the electric current flows, the metals at the anode oxidise; the copper oxidises as follows: $Cu_{(s)} \rightarrow Cu^{2+}_{(aq)} + 2e^-$ Therefore, copper acts as the reductant. Impurities in the blister copper, such as silver and gold, which require a greater voltage to oxidise, fall to the bottom of the cell as sludge. Other impurities that do oxidise, such as iron and zinc, remain in the electrolyte as ions. At the cathode, the solid copper is formed as follows: $Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$ Therefore, copper ions act as the oxidant.	H6, H7, H13 • Detailed outline of a process, identifying oxidant, reductant and electrolyte used AND using relevant equations . . . . . 4 • Detailed outline of a process AND either identifies oxidant, reductant and electrolyte used or uses relevant equations OR • Brief outline of a process, identifying oxidant, reductant and electrolyte used, AND using relevant equations . . . . . 3 • Brief outline of a process AND either identifies oxidant, reductant and electrolyte used or uses relevant equations . . . . . 2 • Brief outline of process 1
Question 17	
(a) $n(H_2) = \frac{4.68}{24.47} = 0.19$ mol	H10 • Correct calculation (with or without unit) 1
(b) by molar ratio, $NaOH : H_2 = 2 : 1$ $\therefore n(NaOH) = 2 \times 0.19 = 0.38$ mol $\therefore n(OH^-) = 0.38$ mol $[OH^-] = \frac{0.38}{1.2} = 0.32$ mol L^{-1} $pOH = -\log_{10}[0.32] = 0.50$ $\therefore$ pH of water = 13.50	H10 • Correct calculation showing appropriate working . . . . . 3 • Correct answer with incomplete working . . . . . 2 • Correct answer (no working) OR • Appropriate working with calculation error 1
Question 18	
(a) $H_2PO_4^- \rightleftharpoons HPO_4^{2-} + H^+$	H13 • Correct equation 1
(b) In a buffer solution, the concentration of the weak acid and its conjugate base is considerably greater than the concentration of the H^+. In this case if a small amount of acid were added, the extra H^+ added would react with the HPO_4^{2-} ion forcing the equilibrium to shift to the left. However, since the $[HPO_4^{2-}]$ is so much greater than the $[H^+]$, then the original amount of H^+ remains virtually unchanged. The volume change is very small and so the new $[H^+]$ is almost identical to what it was before the acid was added. Therefore, the pH remains almost the same.	H8 • Detailed explanation (cause and effect) with reference to the equation in part (a) . . . . . 3 • Brief explanation with reference to equation . . . . . 2 • Brief explanation with no reference to equation 1

Part B (Continued)

Sample answer	Syllabus outcomes and marking guide
Question 19	
(a) Sodium hydroxide deliquesces when exposed to moisture. Therefore as it is being weighed its mass increases as it absorbs moisture. Since it is not possible to know how much moisture it has absorbed, the mass measurement is inaccurate.	H11, H12 • Sodium hydroxide reacts with the atmosphere 1
(b) The sodium carbonate can be stored in a desiccator.	H12 • Keep sodium carbonate in a dry environment 1
(c) The accuracy of the titration will not be affected. This is because the moles of the reactant transferred from the pipette into the conical flask is unaffected by the volume of water already in that flask.	H10 • States moles of reactant is unaffected with explanation . . . . . 2 • States moles of reactant is unaffected with no explanation 1
(d) (i) The concentration of ions at the beginning of the titration is at a maximum, hence there is maximum electrical conductivity. As the solution from the burette is added, neutralisation begins to occur. This effectively decreases the concentration of the ions and therefore the electrical conductivity of the solution will also decrease.	H10 • Relates maximum conductivity to maximum concentration of ions AND relates decrease to decreasing concentration of ions . . . . . 2 • Relates maximum conductivity to maximum concentration of ion OR • Relates decrease to decreasing concentration of ions 1
(ii) At minimum electrical conductivity, the equivalence point has been achieved. However there are still ions present from the salt produced by the reaction, therefore there is still some conductivity possible.	H10 • Relates minimum conductivity to equivalence point and minimum concentration of ions 1
(iii) As solution from the burette is still being added to the reaction mixture, but there are no further ions available for reaction, the concentration of the ions in the solution increases and hence so does its electrical conductivity.	H10 • Relates increasing conductivity to increasing concentration of ions 1
Question 20	
(a) $[H_3O^+] = 10^{-3.5}$ mol L^{-1} (or 3.2×10^{-4} mol L^{-1})	H10 • Correct calculation 1
(b) HX is a weak acid, as the concentration of H_3O^+ is much lower than that of the acid, indicating that it has only partially ionised.	H2 • States HX is a weak acid AND has partially ionised since its pH is greater than 1 . . . . 2 • Poor explanation 1
(c) X^- is a strong conjugate base compared to the weak acid HX. X^- will then ionise water to produce OH^- ions, so the solution will be basic. $X^- + H_2O \rightarrow HX + OH^-$	H8 • States solution is basic AND shows production of OH^- ions . . . . . 2 • States solution is basic OR • Shows production of OH^- ions 1

Part B (Continued)

Sample answer	Syllabus outcomes and marking guide
Question 21	
(a)  half-life = 14 hours	H6 • Correct graph, fully labelled with plots visible AND correct half-life from curve . . . . . 3 • Poor curve or labelling AND correct half-life from curve . . . . . 2 • Curve only OR • Half-life only 1
(b) Yes, as the isotope has a short half-life (will not be in the body for long) and produces gamma radiation able to be detected outside the body (or which is able to kill cancerous cells).	H6, H8 • Yes, justified by short half-life AND a gamma emitter (which can either be detected or used to kill cancerous cells). . . . . 2 • Yes, and one correct justification. 1
(c) An isotope with short half-life that emits gamma rays, such as strontium-92 (half-life 2.7 hours), technetium-99m (half-life 6 hours), iodine-121 or 123.	H6 • An isotope with short half-life that emits gamma rays 1
Question 22	
Radioisotopes have impacted our lives significantly. The positive benefits include: • improved life-spans in humans by using caesium-137 to treat tumours and technetium-99 for imaging body systems; • improved environmental understanding by using scandium-46 to follow silt movement in rivers or californium-252 to find water in soil. Negative effects include: • cell mutation and genetic mutation; • warming of waterways from nuclear reactors; • nuclear war.	H4 • Analyses impact of radioisotopes AND has appropriate examples of positive and negative effects in industry and medicine. . . . . 4–5 • Examples of positive and negative uses in industry and in medicine; but little or no analysis OR • Analysis but insufficient examples . . . . . 2–3 • Some examples but not one of each for positive and negative OR • Some analysis with no examples 1

Part B (Continued)

Sample answer	Syllabus outcomes and marking guide
Question 23	
Thermoplastic polymers have weak dispersion forces between their chains, leading to lower melting points and allowing the polymer to be easily moulded and reshaped by simply heating it until it is soft enough. The chains slide easily past each other due to the lack of strong forces between them. Examples include polystyrene and polyethene, which are used for food storage and containers. The containers are easily shaped while heated in the moulds.	H3, H9 • States heating disrupts the weak forces between chains, allowing chains to slide past each other AND remoulding is possible through heating AND names an example AND relates its use to the property ..... 4 • States heating disrupts the weak forces between chains, allowing chains to slide past each other AND remoulding is possible through heating OR • Names an example AND relates its use to the property ..... 3 • Gives some indication of softening being related to forces between chains, but lacks detail AND gives an example ..... 2 • Names and example..... 1
Question 24	
A natural biopolymer is cellulose. A biopolymer which is produced synthetically is rayon, made from regenerated cellulose (wood pulp or cotton). The purified cellulose is treated with NaOH and broken up, then further reacted with CS_2 and NaOH to form a viscose solution, which is forced though the holes of a spinneret whilst reacting with H_2SO_4. As they react, the fibres harden and are spun onto spools for use as fibres in fabrics. Biopolymers benefit society as they reduce our dependence on fossil fuels but are produced from living organisms. They are biodegradable, leading to less pollution in our environment.	H1, H4 • Names one natural biopolymer AND one artificially produced biopolymer AND describes production of artificial polymer AND explains the benefits of biopolymers for society ..... 4–5 • Names one natural biopolymer AND one artificially produced biopolymer AND partially describes production of artificial polymer AND partially explains the benefits of biopolymers for society..... 2–3 • Names one natural biopolymer AND one artificially produced biopolymer 1

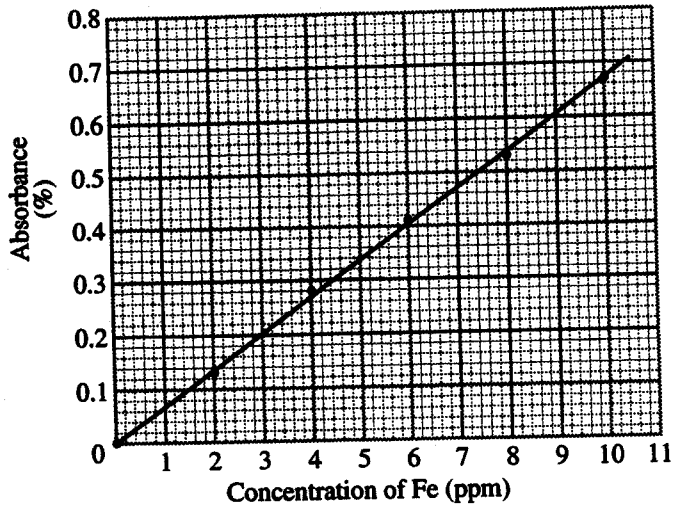
Part B (Continued)

Sample answer	Syllabus outcomes and marking guide
Question 25	
(a) There is a relatively high number of coliform bacteria in the water sample from the river. This large number of bacteria would require a large amount of oxygen and so a decreased amount of oxygen would be present in the water.	H8, H13 • Links low dissolved oxygen to high bacteria count AND therefore high demand for oxygen ..... 2 • States low dissolved oxygen due to high bacteria count OR • States a high demand for oxygen..... 1
(b) The high number of coliform bacteria require a large amount of oxygen, therefore the biochemical oxygen demand is relatively high. The demand will continue to increase as the bacteria reproduce. As a result, other organisms will die. There is also a possibility of eutrophication.	H8, H13 • Predicts biochemical oxygen demand will be high (and increase) AND that other organisms will suffer ..... 2 • Predicts biochemical oxygen demand will be high OR • Predicts other organisms will suffer..... 1
(c) Based on the values shown, this river would not provide an appropriate environment to grow oysters. The amount of oxygen is too low because the bacterial levels are too high. Also, these bacteria are toxic and so could infect the oysters; this could increase the risk of food poisoning.	H8, H13 • States that river is unsuitable for growing oysters with justification ..... 2 • States that river is unsuitable for growing oysters 1
Question 26	

Concentration	*Concentration in River A relative to River B*	*Explanation*
Dissolved O_2	higher	No eutrophication indicates lower oxygen requirement by aquatic organisms.
Phosphate ion	lower	Lack of phosphate would decrease the probability of eutrophication.
Lead ion	same	The presence of lead ions would have no effect on eutrophication.

H8
• Correctly predicts relative concentrations AND accounts for relative values 4
• Correctly predicts relative concentrations AND accounts for relative values of either oxygen or phosphate 3
• Predicts some relative concentrations AND partially accounts for relative values 2
• Partially completes table 1

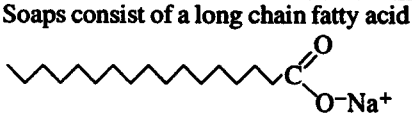
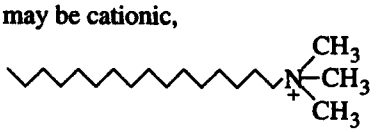
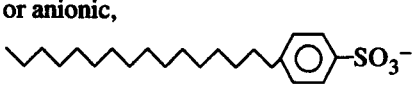
Part B (Continued)

Sample answer	Syllabus outcomes and marking guide
Question 27	
(a) 	H10 • Correct graph 1
(b)	H10 • Correct sample value, i.e. multiplying by the dilution factor. . . . . 2 • Reading values from graph 1
(c) The first two engines are showing little dissolved iron and as such have no problems but the third has a significant amount probably due to rusting of iron components in the engine.	H14 • Feasible hypothesis for all engines . . . . . 2 • Feasible hypothesis for any one engine . . 1

Engine number	*Absorbance* (%)	*Diluted [Fe]* (ppm)	*Sample [Fe]* (ppm)
X12	0.04	0.6	$20 \times 0.6 = 12$
X45	0.01	0.1	$20 \times 0.1 = 2$
X67	0.30	4.5	$20 \times 4.5 = 90$

Section II

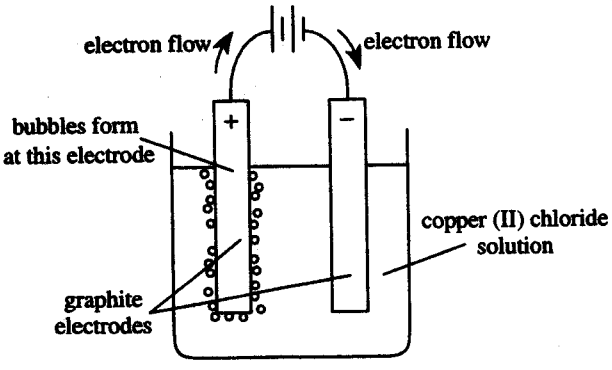
Question 28 Industrial Chemistry

		Sample answer	Syllabus outcomes and marking guide
(a)	(i)	$K = \dfrac{[N_2O_4]}{[NO_2]^2}$	H10 • Correct equilibrium expression (no units required). 1
	(ii)	An equilibrium constant is a constant at a particular temperature. If temperature is increased, exothermic reactions will have a decrease in the value of K_c and endothermic reactions will have an increase. For a temperature decrease the reverse is true.	H8, H10, H13 • States equilibrium constant value increases with temperature for an endothermic reaction and decreases for an exothermic reaction. . . . . 2 • Temperature changes the value of the equilibrium constant 1
(b)	(i)	$S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$ $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$ $SO_{3(g)} + H_2SO_{4(l)} \rightarrow H_2S_2O_{7(l)}$ $H_2S_2O_{7(l)} + H_2O_{(l)} \rightarrow 2H_2SO_{4(l)}$	H13 • Provides correct chemical equations for production of SO_2, conversion to SO_3, production of oleum AND dilution of oleum with water . . . . . 2 • Any two of the above equations. 1
	(ii)	The reaction is exothermic therefore lower temperatures favour the formation of SO_3. An excess of O_2 gas is used to drive the equilibrium to the right. Higher pressures favour the formation of SO_3 as the total number of molecules is reduced.	H7, H10, H11, H13 • Correctly identifies and describes two conditions used to maximise yield. . . . . 2 • Correctly identifies two conditions used to maximise yield OR • Identifies one condition and describes how it affects the yield 1
(c)		Soaps consist of a long chain fatty acid with a hydrophilic head,  whereas a synthetic detergent is industrially manufactured and may be cationic,  or anionic,  or non-ionic. Many detergents contained phosphates (e.g. $P_3O_{10}^{5-}$) as "builders" which aid in detergent action by acting as water softeners but cause problems in rivers as they promote algal growth. The algal growth leads to a depletion of oxygen in the river and eventually the water becomes "dead". Soaps tend to "break down" in the environment but early detergents were very persistent because they contained branched hydrocarbons. This cause excessive frothing which was unacceptable. Later detergents were developed with straight chain hydrocarbons which are more easily biodegradable.	H13, H16 • Describes the structure of a soap and a detergent AND compares the biodegradability of soap and detergent AND discusses the generational change of detergents AND discusses the problem of phosphate in waterways AND contrasts the effects of soap and detergent in the environment . . . . . 4–5 • Describes a soap and a detergent; discusses and compares an environmental impact of soap and detergent . . . . . 3 • Describes either a soap or a detergent; identifies an environmental issue. . . . . 2 • Describes either a soap or a detergent OR • Identifies an environmental issue with soap or detergents. 1

Question 28	Industrial Chemistry (Continued) Sample answer	Syllabus outcomes and marking guide
(d) (i)	The raw materials are sodium chloride (NaCl), limestone ($CaCO_3$) and ammonia (NH_3).	H13 • Correctly identifies raw materials 1
(ii)	Use a method to generate CO_2 (Kipps apparatus or similar) which is bubbled through a saturated solution of a mixture of NaCl and NH_4Cl. $Na_2CO_{3(s)}$ forms as a precipitate and is filtered using a funnel and filter paper.	H8, H13 • Identifies the equipment AND describes the reaction..... 2 • Identifies the equipment OR • Describes the reaction 1
(iii)	Production of CO_2 usually involves a concentrated acid. Gloves, protective coat and eye-wear should be worn. NH_3 is an irritant. Ensure the lab is well ventilated or preferably perform in a fumehood. Again appropriate protective clothing should be worn.	H3, H11 • Describes a safety risk relevant to the procedure AND suggests a safe working practice to minimise the risk ..... 3 • States one hazard AND one safe work practice ..... 2 • States one hazard OR • States one safe work practice..... 1
(e)	Mercury cell has a cathode of flowing mercury. Sodium ions are reduced to sodium atoms which form an amalgam. $2Na^+_{(aq)} + 2e^- + Hg_{(l)} \rightarrow 2Na(Hg)_{(l)}$ As it flows out of the cell, the amalgam is sprayed with water to produce NaOH. $2Na(Hg)_{(l)} + 2H_2O_{(l)} \rightarrow 2NaOH_{(aq)} + H_{2(g)} + Hg_{(l)}$ The Hg is reused and the H_2 collected. At the anode (graphite or coated titanium), chlorine is produced. $2Cl^-_{(aq)} \rightarrow Cl_{2(g)} + 2e^-$ In the membrane process, the anode and the cathode are separated by a water impermeable membrane made of a synthetic polymer. The membrane allows Na^+ ions to flow from the anode compartment, where brine is pumped through, to the cathode compartment which has a flow of water. The anode is made of titanium and chlorine gas is produced. $2Cl^-_{(aq)} \rightarrow Cl_{2(g)} + 2e^-$ The cathode is made of steel mesh and water is reduced. $2H_2O_{(l)} + 2e^- \rightarrow H_{2(g)} + 2OH^-_{(aq)}$ Both cells produce high quality pure NaOH. The mercury cell is being phased out due to the serious environmental impacts of the inevitable escape of mercury. Mercury accumulates in the food chain and causes many severe physiological problems. The membrane cell does not have any severe environmental impacts. The cost associated with the development of the polymer membrane have been the major drawback of this cell, but it is now becoming the favoured method of manufacture.	H3, H7, H8, H13 • Describes the operation of both cells in detail, including at least one correct chemical equation for the production of NaOH AND evaluates the value of each cell in terms of technical and environmental issues ..... 6–7 • Partially describes the operation of both cells AND identifies the technical and environmental issues for each cell.... 4–5 • Provides an overview of the operation of both cells OR • Provides an overview of the operation of one cell and an environmental issue associated with that cell OR • Discusses the environmental issues associated with each cell ..... 2–3 • Provides an overview of the operation of one cell OR • Identifies an environmental issue associated with one of the cells 1

Question 29 Shipwrecks and Salvage

	Sample answer	Syllabus outcomes and marking guide
(a)	One of: • *Galvani* is believed to be the first person to generate an electric current. He connected two different metallic wires together and placed the unjoined ends to a freshly extracted muscle from a frog leg. This forced the muscle to contract. This experiment shows that electrons can be transferred when two different metals are in contact with each other. • *Davy* used voltaic piles to decompose water. He also used very large voltaic piles to decompose molten sodium hydroxide and potassium hydroxide. These experiments showed that it is possible to decompose otherwise stable compounds if sufficient voltage is applied. • *Faraday* is credited as being the first person to use the terms cation and anion to describe the movement of charged particles through the electrolytes of cells. Determined the Laws of Electrolysis, including the 1st Law, which states the amount of product made at an electrode during electrolysis is proportional to the amount of electricity supplied.	H3, H13 • Describes what was done AND clear relationship to changed understanding of electron transfer reactions ..... 2 • Describes what was done 1
(b) (i)	A non-passivating metal is one which corrodes to produce an oxidised layer that does not prevent the further corrosion of the metal beneath this layer.	H13 • Correct definition 1
(ii)	The reduction half equation $2H_2O_{(l)} + O_{2(g)} + 4e^- \rightarrow 4OH^-_{(aq)}$ occurs more rapidly at pH < 7, because the presence of H^+ removes the OH^- and so drives the reaction forward.	H6, H13 • Explains why acidic environments accelerate corrosion with appropriate half equation ..... 2 • Explains why acidic environments accelerate corrosion OR • Gives appropriate half equation 1
(c)	The relevant half equations for each of the metals, including their E° values, are as follows: $Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e^-$ E° = 0.76 V $Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + 2e^-$ E° = 0.41 V $Sn_{(s)} \rightarrow Sn^{2+}_{(aq)} + 2e^-$ E° = 0.14 V If the iron were protected with zinc and some of the zinc were scratched off, the zinc would oxidise in preference to the iron, since it is a stronger reductant as evident from its greater E° value compared to that of iron. However, the oxidation of tin has a lower E° value than that for iron. Therefore iron is the stronger reductant and so it would oxidise, and hence corrode in preference to tin. Thus zinc would provide a more effective protective layer for the iron compared to tin.	H6, H8, H13 • States relevant half equations AND states correct metal with explanation linking to E° values ..... 4 • States relevant half equations AND states correct metal with partial explanation OR • States correct metal with explanation linking to E° values ..... 3 • States half equations AND states correct metal with no explanation OR • States correct metal with partial explanation ..... 2 • States half equations OR • States correct metal (no explanation) 1
(d) (i)	The overall cell voltage for this reaction is not a positive value, indicating that this process is not spontaneous.	H8 • Correctly links voltage and spontaneity of reaction 1

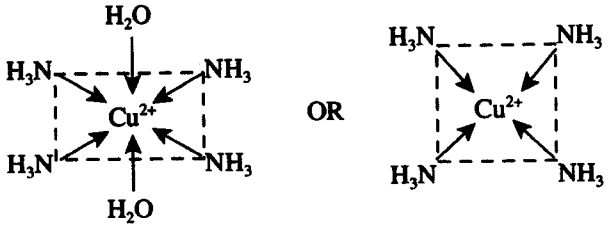
Question 29 Shipwrecks and Salvage (Continued) Sample answer	Syllabus outcomes and marking guide
(ii) Water would need to be heated until it boiled for a period of time. This would help remove any dissolved oxygen by allowing it to bubble off. This water could be poured into a clean test tube. A piece of clean, pure iron can be place into the water. The water would need to be sealed so that no atmospheric oxygen could dissolve in it. This can be done by covering the water with a layer of petroleum jelly and then a rubber stopper. The iron can then be monitored periodically to determine whether or not it would corrode in water that lacked oxygen.	H8, H11, H13 • Detailed description of sealed system using boiled water and clean pure iron monitored over time ..... 3 • Brief description AND some conditions ..... 2 • Brief description 1
(iii) When iron corrodes to form rust, it does so if the water contains oxygen. $Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + 2e^-$ $E° = 0.41$ V $2H_2O_{(l)} + O_{2(g)} + 4e^- \rightarrow 4OH^-_{(aq)}$ $E° = 0.40$ V Further reaction of the iron (II) hydroxide produced with oxygen produces rust.	H10, H13 • Correct half equations AND reaction voltage AND explanation refers to need for oxygen to be present ..... 3 • Correct half equations AND reaction voltage AND poor explanation OR • Explanation of need for oxygen to be present ..... 2 • Some relevant explanation 1
(e) (i) 	H13 • Correct diagram of equipment used showing correct direction of electron flow, polarity of electrodes AND formation of bubbles at appropriate electrode ..... 4 • Correct diagram of equipment used showing two correct features mentioned above ... 3 • Correct diagram of equipment used showing one correct feature mentioned above .... 2 • Correct diagram of equipment used 1
(ii) $2H_2O_{(l)} \rightarrow O_{2(g)} + 4H^+_{(aq)} + 4e^-$ The gas produced is oxygen.	H13 • Correct identification from half equation 1
(iii) The negative electrode has a shiny substance deposited on it. This is the result of the reduction of the copper (II) ions in the solution forming solid copper. The blue colour of the solution diminishes. The colour is the result of the dissolved copper (II) ions; however they are removed from the solution due to their reduction to form solid copper.	H6, H8, H13 • Names two changes AND gives correct explanation of each ..... 4 • Names two changes AND gives correct explanation of one change ..... 3 • Names two changes OR • Names one change with appropriate explanation ..... 2 • Names one change 1

Question 30 Biochemistry of Movement

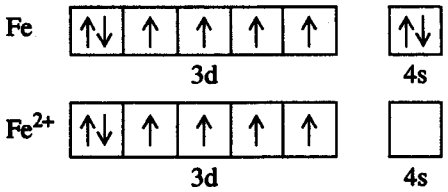
	Sample answer	Syllabus outcomes and marking guide
(a)	Carbon compounds like glucose burn in air to produce carbon dioxide, water and energy. The amount of energy released was measured by allowing the heat from the reaction to be transferred to a measured quantity of water and the temperature increase recorded. The increase in temperature was converted to joules using the specific heat of water and the equation $\Delta H = mC\Delta T$. Because the mass of glucose burnt was known, the heat of combustion can be calculated. Heat loss to the surroundings was minimised by reducing the distance from the burning glucose to the beaker and by sheltering the equipment from air movement. If all or most of the heat was transferred to the water then the results will accurate within the limits of experimental error.	H7, H11 • Justifies the appropriateness of the investigation plan in terms of the energy transfer occurring well linked to a clear description of the procedure ..... 3 • Demonstrates an understanding of the energy transfers occurring linked to a clear description of the procedure ..... 2 • Describes the procedure..... 1
(b)	Muscle contraction occurs when the ATP molecule bound to a myosin head breaks down to form ADP and P_i. The ADP and P_i remain attached to the head but cause it to reach across the gap between the actin and myosin fibres (high energy configuration). A cross bridge is formed when the myosin head binds with the binding site on the actin and the "power stroke" occurs when the ADP and P_i are released are the actin filament moves towards the H zone or centre of the sarcomere.	H7, H13 • Describes the cause of muscle contraction AND explains why ATP is consumed by the process ..... 4 • Describes the cause of muscle contraction AND partially explains why ATP is consumed by the process OR • Partially describes of the cause of muscle contraction AND explains why ATP is consumed by the process ..... 3 • Partially describes the cause of muscle contraction AND partially explains why ATP is consumed by the process ..... 2 • Partially describes the cause of the contraction movement in muscle OR • Partially explains why ATP is consumed by the process 1
(c) (i)	Oxygen is the final acceptor of electrons. It captures the electrons along with hydrogen nuclei to form water.	H7, H13 • Correctly identifies oxygen as the final electron acceptor 1
(ii)	The hydride ion, H^-, carries 2 electrons and is bonded to the NAD^+. When the bond is broken, H^+, $2e^-$ and NAD^+ are produced. The electrons are then transferred to the cytochrome chain. Demonstrated understanding of both the nature of the bond as being between NAD^+ and the hydride ion, H^-,	H7, H13 • Explains how hydrogen is bonded to NAD^+ AND what happens to the electrons when the bonds are broken ..... 2 • Explains how hydrogen is bonded to NAD^+ OR • Explains what happens to the electrons when the bonds are broken 1

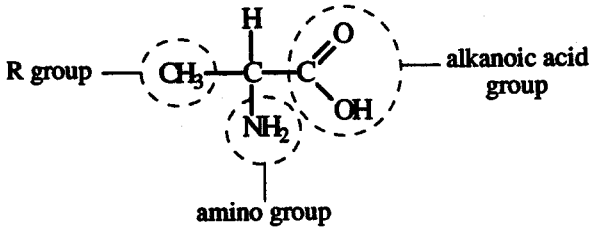
Question 30	Biochemistry of Movement (Continued) Sample answer	Syllabus outcomes and marking guide
(iii)	High energy electrons are released from NADH and $FADH_2$ that are oxidised by the reaction. The electrons are passed to the first protein complex in the cytochrome chain. As the electrons move to lower energy states along the cytochrome chain, the energy is used to pump hydrogen ions across the membrane into the inter membrane space against their concentration gradient. The H^+ ions flow back through the channels provided by ATP synthase along their concentration gradient, providing the electrochemical energy or proton motive force to combine ADP and P_i to form ATP.	H7, H13 • Explains how the oxidation of NADH and $FADH_2$ is linked to the production of phosphate bonds in ATP ..... 2 • Partially explains how the oxidation of NADH and $FADH_2$ is linked to the production of phosphate bonds in ATP .. 1
(d) (i)	Increased temperature denatures an enzyme by interfering with the secondary and tertiary structures. Hydrogen bonds of the secondary structure between CO groups of one amino acid and the NH group of another acid 3 or 4 amino acids ahead of it in the chain, are broken. When these hydrogen bonds are disrupted, the tertiary structure is affected as the CO and NH move from the inside to the outside of the molecule because of their polar nature.	H8, H13 • Identifies at least two changes that occur in bonding when enzymes are exposed to conditions outside their optimum range.. 2 • Identifies one change that occurs in bonding 1
(ii)	*The answers to this section are highly specific depending on the enzyme named. The example given is for chymotrypsin.* The active site in chymotrypsin contains a pocket that binds hydrophobic amino acids and breaks the peptide bond adjacent. Hydrophobic amino acids in the binding pocket interact with the hydrophobic side chains of the substrate and hold it in position for the reactions at the active site to take place. The active site itself consists of three amino acids: serine, histidine and aspartate. The serine transfers a proton to the adjacent histidine that allows the serine to react with peptide bond on the substrate and break it. The peptide remains attached to the serine until water donates an OH^- to the peptide and a H^+ to the histidine. When the histidine transfers the proton back to the serine the peptide is released. The role of the aspartate in the active site is to create the conformation that facilitates the movement of the proton from serine to histidine.	H8, H13 • Explains the specificity of the binding site of a named enzyme..... 2 • Partially explains the specificity of the binding site of a named enzyme 1
(iii)	ATP hydrolyses to form ADP, P_i and H^+ ions. Lactic acid produces H^+ that slows down the reaction due to a build up of products. Myosin binds with ATP and uses the energy from ATP hydrolysis to form a cross bridge with the actin filaments. The binding to actin causes ADP, P_i and H^+ to be released and create the conformational change in the myosin head that produces the "power stroke". If the concentration of H^+ ions is too high, the dissociation of ATP will be limited and the conformational change in the myosin head will not occur to create the power stroke. Further muscle contraction is prevented as the cross bridge does not dissociate.	H8, H13 • Explains the link between lactic acid and the impairment of muscle contraction in anaerobic respiration ..... 2 • Partially explains the link between lactic acid and the impairment of muscle contraction in anaerobic respiration..... 1

Question 30 Biochemistry of Movement (Continued)	
Sample answer	**Syllabus outcomes and marking guide**
(e) One possible direction for future research is to investigate the consumption of $NaHCO_3$ prior to exercise. The aim would be to absorb H^+ ions which inhibit muscle contraction. During anaerobic respiration, H^+ ions are produced. HCO_3^- ions from $NaHCO_3$ consumed by the athlete would act as a buffer in muscle fibres, absorbing the excess H^+ ions. HCO_3^- ions would thus aid the continuation of anaerobic respiration, and hence continued production of ATP for muscle contraction. This research would benefit athletes who undertake heavy exercise as most of the energy is supplied by glycolysis and anaerobic respiration in type 2 muscle cells containing few mitochondria. During light or endurance exercise, HCO_3^- may be of some value at the beginning of an exercise period when sugar catabolism outpaces the supply of oxygen from the blood until the lactate produced is carried away and recycled by the liver back to pyruvate. However, this research would be of limited value to athletes who carry out for light or endurance exercise as they rely on mitochondria and aerobic respiration. In muscles that are well supplied with blood, the H^+ ions are removed rapidly (muscle contraction is not affected), and glucose and oxygen are in constant supply for aerobic respiration.	H5, H14 • Identifies a possible future direction for chemical research AND evaluates the usefulness for the two extremes of exercise ..... 6–7 • Identifies a possible future direction for chemical research AND partially evaluates of the usefulness for the two extremes of exercise OR • Identifies a possible future direction for chemical research AND evaluates of the usefulness for one exercise extreme... 4–5 • Identifies a possible future direction for chemical research AND partially evaluates of the usefulness for one exercise extreme..... 2–3 • Identifies a possible future direction for chemical research..... 1

Question 31 Chemistry of Art Sample answer	Syllabus outcomes and marking guide
(a) Red ochre or yellow ochre from ochre mines. Rock is crushed and the powder is dispersed in saliva which is then sprayed or coated onto a surface, such as rock.	H13 • Names a pigment, e.g. red ochre or yellow ochre (or hydrated iron (III) oxide) AND mixes the finely crushed ochre with saliva AND coats the mixture onto a surface to dry . . . . . 3 • Names a pigment AND its preparation OR • Describes its application . . . . . 2 • Names a pigment OR • Describes its application 1
(b) The discrete lines in the hydrogen spectrum suggested that electrons are quantised and emit specific amounts of energy when moving from one energy level to a lower one. The electrons of similar energy exist in shells, and can only move to a shell closer to the nucleus by emitting photons of energy corresponding to the difference between the shells. Electrons moving from outer shells to the innermost shell emit energy corresponding to ultraviolet wavelengths and electrons moving to the second innermost shell from outer shells emit wavelengths corresponding to lines in the visible range.	H1, H2, H6 • Relates spectral lines to electron transitions between different energy levels AND states the first set is in the IR spectrum, the second set is the visible spectral lines (Balmer series) AND states discrete transitions demonstrate that electrons have specific amounts of energy . . . . . 4–5 • Relates spectral lines to electron transitions between different energy levels OR • States that transitions show that electrons exist in specific energy levels OR • Describes Bohr model . . . . . 2–3 • Partial description of Bohr model OR • Partial description of spectral lines 1
(c)  octahedral square planar Ammonia and water each have an unbonded pair of electrons which can be donated to empty of the Cu^{2+}. The arrangement of these ligands around the ion is octahedral. *Note: some texts use the explanation that the complex is in fact $Cu(NH_3)_4^{2+}$ hence a different structure will be drawn – this is quite acceptable.*	H6, H13 • Correctly draws complex AND explains in detail how the complex is able to form . . . . . 4 • Correctly draws complex AND partially explains how the complex is able to form . . . . . 3 • Correctly draws complex AND briefly explains how the complex is able to form . . . . . 2 • Correctly draws complex 1

Question 31 **Chemistry of Art (Continued)**

		Sample answer	Syllabus outcomes and marking guide
(d)	(i)	Fe is Ar [$3d^6 4s^2$], Fe^{2+} is Ar [$3d^6$]. The electrons lost are the outer 4s electrons. The remaining electrons in the d-orbital spread amongst the orbitals.  	H6, H13 • Shows correct configurations of Fe and Fe^{2+} AND has boxes correctly labelled with paired electron spins with 4s empty for Fe^{2+} ..... 3 • Correct for Fe but incorrect electrons removed for Fe^{2+} AND boxes match written configurations ..... 2 • Some correct information 1
	(ii)	$MnO_3^-{}_{(aq)} + 2H^+{}_{(aq)} + e^- \rightarrow MnO_{2(aq)} + H_2O_{(l)}$ Change in oxidation number from +5 to +4 allows d-orbital arrangements to change. As a result, different colours appear, as different wavelengths of light are absorbed and reflected.	H6, H13 • States correct half equation AND explains why the colours of the solutions are different ..... 3 • States correct half equation AND partially explains why the colours of the solutions are different OR • Explains why the colours of the solutions are different ..... 2 • States half equation OR • Partially explains why the colours of the solutions are different 1
(e)		Medieval paintings were produced on wood or canvas which was prepared in layers of ground mixtures of chalk in glue applied as a liquid and allowed to dry and then scraped smooth – known as gesso, upon which the paint layers of pure pigment in a binding medium such as egg yolk were placed. The protein in the egg hardened to produce a shiny, protective coating. Modern paintings often use mixtures of pigments directly in a vehicle such as linseed oil or acrylic media applied to the prepared surface. The vehicle evaporates leaving the protected surface. A non-destructive technique would be to use reflectance spectroscopy where white light is shone onto the sample and the reflected light is analysed. The spectrum obtained can be matched to pigments commonly used in a particular period and used to date the painting.	H1, H4, H13, H14 • Discusses in detail the major changes in materials used AND describes a non-destructive technique ..... 6–7 • Discusses in detail the major changes in materials used AND names a non-destructive technique OR • Some discussion of the major changes in materials used AND describes a non-destructive technique ..... 4–5 • Discusses in detail the major changes in materials used OR • Describes a non-destructive technique OR • Some discussion of the major changes in materials used AND names a non-destructive technique ..... 2–3 • Names a technique 1

Question 32		Forensic Chemistry Sample answer	Syllabus outcomes and marking guide
(a)	(i)	Heat sample in air. No residue indicates an organic substance.	H6, H9 • Names correct procedure and result. 1
	(ii)	Hydrocarbons: C_nH_{2n+2}; C_nH_{2n}; C_nH_{2n-2} OR Alkanols: $C_nH_{2n+1}OH$ OR Alkanoic acids: $C_{n-1}H_{2n-1}COOH$; $C_nH_{2n}O_2$	H9 • Correctly names one class of organic compounds AND gives correct corresponding formula. . . . . 2 • Correctly names one class of organic compounds OR • Gives correct formula for one class 1
(b)	(i)	A protein is a polymer of amino acid monomers linked by peptide bonds.	H13 • Gives correct definition 1
	(ii)		H13 • Correctly identifies and names 3 functional groups . . . . . 2 • Correctly identifies and names 2 functional groups 1
(c)	(i)	$CH_3(CH_2)_nCOOH$	H9 • Gives correct general formula 1
	(ii)	Animal fats contain saturated triglycerides; plants contain unsaturated fats.	H13 • Give clear statement of difference between plant and animal. . . . . 2 • Difference given for plant or animal 1
(d)	(i)	Cellulose or starch or glycogen.	H9 • Names a correct polysaccharide 1
	(ii)	Sample A contains maltose. Maltose is a reducing sugar which reacts with Tollen's reagent to form metallic silver, $Ag^+_{(aq)} + e^- \rightarrow Ag_{(s)}$ and Benedict's solution to form copper (I) oxide. $2Cu^{2+}_{(aq)} + H_2O_{(l)} + 2e^- \rightarrow Cu_2O_{(s)} + 2H^+_{(aq)}$	H13, H14 • Correctly names sample containing maltose AND gives correct justification, including word or symbol equations . . . . . 3 • Correctly names sample containing maltose AND gives correct justification or equations . . . . . 2 • Correctly names sample containing maltose. 1
(e)	(i)	Gaseous atoms need to be given extra energy by thermal or electrical means.	H6 • Identifies that extra energy is needed. . . . 1
	(ii)	Emission spectra are characteristic from each element and can be used to identify elements like a fingerprint. They can be used to determine concentrations of elements in soil, water, etc. after the production of a standard curve. A limitation is that the compounds containing the elements are not identified.	H11, H13 • Explains relationship between characteristic spectrum for an element and using this to identify the element a part of a sample . . 3 • Gives an explanation that is unclear or lacks detail . . . . . 2 • Describes an emission spectrum 1

Question 32	Forensic Chemistry (Continued) Sample answer	Syllabus outcomes and marking guide
(f) (i)	Important for items of economic, cultural or historical significance. Example: artworks, jewellery, historical artefacts.	H11, H13 • Relates value of what is being tested to need for non-destructive testing AND gives example. . . . . 2 • Gives poor explanation OR • Gives an appropriate example 1
(ii)	94	H13 • Gives correct relative molecular mass . . . 1
(iii)	Mass spectroscopy provides information about the atoms in a sample and is useful for analysing concentrations within a sample. Scanning tunnelling microscopy provides information about the surface and can identify individual atoms. Mass spectroscopy is destructive but uses very small samples. Scanning tunnelling microscopy is non-destructive, however fragile samples can be damaged. Examples of appropriate technique to use in certain situations, e.g. mass spectroscopy biological samples, scanning tunnelling microscopy artefacts.	H4, H11, H13 • Evaluates mass spectroscopy for analysis of small samples and compares it to scanning tunnelling microscopy . . . . . 4–5 • Describes each method and compares them OR • Evaluates mass spectroscopy only . . . . . 3 • Describes scanning tunnelling microscopy OR • Describes mass spectroscopy. . . . . 2 • Demonstrates some knowledge of spectroscopy techniques 1