2008 HSC Notes from the Marking Centre Chemistry

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2008 HSC NOTES FROM THE MARKING CENTRE CHEMISTRY

Introduction

This document has been produced for the teachers and candidates of the Stage 6 course in Chemistry. It contains comments on candidate responses to the 2008 Higher School Certificate examination, indicating the quality of the responses and highlighting their relative strengths and weaknesses.

This document should be read along with the relevant syllabus, the 2008 Higher School Certificate examination, the marking guidelines and other support documents which have been developed by the Board of Studies to assist in the teaching and learning of Chemistry.

General comments

In 2008, approximately 10 160 candidates attempted the Chemistry examination. The most popular options were Industrial chemistry (44.1%), Shipwrecks, Corrosion and Conservation (37.4%) and Forensic Chemistry (13.8%).

Teachers and candidates should be aware that examiners may write questions that address the syllabus outcomes in a manner that requires candidates to respond by integrating their knowledge, understanding and skills developed through studying the course, including the prescribed focus area and the first-hand investigations. This reflects the fact that the knowledge, understanding and skills developed through the study of discrete sections should accumulate to a more comprehensive understanding than may be described in each section separately. It is important to understand that the Preliminary course is assumed knowledge for the HSC course.

Teachers and candidates are reminded that mandatory skills content in Module 9.1 is examinable in both the core and option questions.

Teachers and candidates are also reminded that the answer space provided and the marks allocated are guides to the maximum length of response required. Candidates should use examination time to analyse the question, plan their responses carefully, and then work within that framework to produce clear, logical and concise responses. The response may include the use of dot points, diagrams and/or tables, as this will help avoid internal contradictions. This is particularly so in holistic questions which need to be logical, well constructed and relevant to the questions asked.

Better responses indicated that candidates are following the instructions provided on the examination paper. In these responses, candidates:

- set out all working for numerical questions
- thought carefully about the units to be used and the quantities to be substituted into formulae
- did not repeat the question as part of the response
- looked at the structure of the whole question and noted that in some questions the parts followed on from each other, for example responses in part (a) lead to the required response in part (b)

- used appropriate equipment, for example, pencils and a ruler to draw graphs. (A clear plastic ruler would aid candidates to plot points that are further from the axes and rule straight lines of best fit where relevant.)
- accurately transcribed and used values from the periodic table and data sheet for calculations
- included balanced chemical equations where appropriate.

In Section II, the option question is divided into a number of parts. Candidates should clearly label each part of the question when writing in their answer booklets. In part (d) of the 2008 option questions, the best responses presented ideas coherently and included the correct use of scientific principles and ideas. Candidates are strongly advised to answer the option they have studied in class.

Section I – Core

Part A – Multiple choice

Question	Correct response
1	A
2	B
3	A
4	C
5	C
6	D
7	D
8	D

Question	Correct response
9	D
10	B
11	A
12	A
13	C
14	B
15	B

Part B

Question 16

(b) Better responses included a clear outline of the procedure indicating the reagents used. Weaker responses incorrectly indicated the hydrocarbons as being in the aqueous state. A common misconception was that the hydrocarbon changed colour and not the bromine water.

Question 17

The better responses included the two features of the catchment and for each feature included a related contaminant and appropriate treatment for each contaminant. Weaker responses did not identify the features of the catchment. They did demonstrate an understanding of the process of water treatment but could not relate the treatment to a catchment feature. Some weaker responses showed evidence of rote learning rather than answering the question asked.

Question 18

(a) Weaker responses did not contain a correctly drawn Lewis dot structure or electron pairs.

(b) Better responses demonstrated an understanding of the relationship between the structure and bonding within molecules and their physical and chemical properties. The best responses linked both bonding and structure to two or more physical properties and a chemical property and included polarity, molar mass, intermolecular and intramolecular forces. Weaker responses could not link knowledge of structure and bonding to physical and chemical properties.

Question 19

(a) The best responses clearly plotted 0,0 (the origin), drew a line of best fit with a ruler and correctly identified the independent variable as the *x*-axis. The better responses plotted the points accurately by marking the point with a cross or circle and drew the line of best fit. They included scales that were linear and with clearly labelled axes.

(b) In better responses, candidates read a value from the graph and used this value in their calculation. Weaker responses showed a lack of understanding about the relationship between mg/100mL and mg. Weaker responses did not use the required value from the graph in the calculation or had incorrect units in the answer.

Question 20

(a) The best responses clearly set out all relevant working, showing the correct calculation of moles and left the rounding off until the last step. Weaker responses did not calculate the mass to two significant figures or had calculation errors in the second step.

(b) Weaker responses confused the atomic mass with molecular mass.

Question 21

(a) Better responses included a description of both the increasing and decreasing trends, referring directly to the graph and provided a reason for both trends. Weaker responses did not refer specifically to the graph and failed to distinguish between CFC concentration and CFC use or described the graph but did not explain the changes in concentration of CFCs.

(b) Better responses related CFCs to ozone depletion and discussed the effects of ozone depletion. Better responses discussed reasons for the monitoring of CFCs and related the issue of CFCs to the stratosphere or troposphere. Of the weaker responses that detailed the mechanism of ozone depletion, many demonstrated that it was poorly understood with some confusion about the relationship between ozone depletion and the greenhouse effect. Weaker responses referred to ozone in the atmosphere rather than in the stratosphere and troposphere as the syllabus details. Weaker responses were excessively long and did not use the number of lines as a guide to structuring the response.

Question 22

Better responses included relevant, balanced chemical equations for the processes named in the extract and fermentation. These equations were used to support the answer. Better responses also made a judgement that was well supported by chemistry as well as a discussion of carbon-neutrality and an explanation of other energy inputs (carbon dioxide outputs) involved in the production of bioethanol.

Weaker responses demonstrated an inability to balance equations, particularly the amount of oxygen in combustion. They also demonstrated a poor knowledge of the structure of ethanol. Weaker responses focused on the cost of bioethanol production rather than the energy comparisons and hence the effect of bioethanol production on global warming.

Question 23

The better responses included a balanced equation including states, reversible arrows and the negative ΔH. They also identified that the reaction was exothermic as well as identifying the conditions for temperature and pressure used. The better responses explained why the temperature and pressure values are used. The better responses explained the link between pressure and Le Chatelier's Principle using the moles ratio in gaseous terms as well as temperature and Le Chatelier's Principle (including rate of reaction as well as yield). The weaker responses referred to pressure as a reactant. Weaker responses included a detailed account of the Haber process but did not answer the question.

Question 24

(a) The weaker responses had difficulty performing the calculation.

(b) Weaker responses used 8000 mL, they did not show an understanding that mass not volume is needed in moles calculation. Better responses used the density to convert the volume to mass and then calculated the energy with the correct units. Weaker responses had difficulty with the calculations and made the mistake of assuming 80L = 80 kg.

Question 25

(a) The better responses clearly identified the correct electrodes and the electron flow in the wire. Weaker responses confused the Pt electrode, often giving $Cl_2(g)$ as the electrode which in turn involved $K(s)$.

(b) The better responses used chlorine gas in the net ionic equation. The weaker responses failed to reverse the nickel half equation from the data sheet and did not write a balanced net ionic equation. Some used half reactions for K. The weaker responses included electrons in the net ionic equation.

(c) Better responses used chlorine gas to calculate the correct value. Weaker responses did not realise that a negative standard cell potential value means that a cell would not generate a current.

(d) Better responses could explain the colour change in terms of increasing nickel ion concentration and recognised that there was no colour change in the right hand beaker. Weaker responses did not understand the role of the salt bridge and tried to explain the colour change in terms of the nickel ions going through the salt bridge making the right hand beaker slightly green without realising the build up of nickel ions in the left hand beaker would turn it dark green.

Question 26

Better responses defined a buffer in terms of being made up of comparable amounts of weak acid/bases and their conjugate pairs and indicate that buffers resist changes in pH. They provided a relevant natural example of a buffer and wrote an equation of the buffer system. Better responses used Le Chatelier's principle to explain the effects of extra acid or base to the buffer system indicating the correct shift of the equilibrium system. Mid-range responses either lacked a detailed explanation of the buffer system or did not define a buffer system as being made up of an acid/base and its conjugate pair. Weaker responses only stated that buffers minimised or kept constant changes in pH, and did not give an example of a natural buffer system or provided only one species of the buffer system.

Question 27

(b) Better responses specifically identified the ammonium or ethanoate ions and wrote the appropriate hydrolysis equation with either of the two mentioned species with water. Better responses correctly identified the hydronium or hydroxide ions produced as being responsible for the acidity or basicity respectively.

Question 28

(a) Better responses provided the correct formula for sodium carbonate and calculated the number of moles used. These candidates correctly calculated the concentration of the solution.

(b) Better responses correctly wrote a balanced chemical equation for the neutralisation reaction.

(c) Better responses showed clear working with the correct calculation of the number of moles of sodium carbonate used in the titration. Better responses correctly applied a 2:1 mole ratio of hydrochloric acid to sodium hydroxide and showed the calculation of hydrochloric acid calculation. The best responses did not round off at any step and gave answers correctly using four significant figures. Weaker responses could only show one correct step of the calculation. Weaker responses did not convert volume of solutions into litres or used the acid volume to calculate the number of moles of sodium hydroxide.

Section II – Options

Question 29 – Industrial Chemistry

(a)(i) Better responses correctly identified the fluids in the three pipes. Weaker responses indicated careless interpretation of the diagram which led to incorrect identification or swapping of the fluids in pipes 1 and 2.

(iii) Better responses identified specific environmental issues that directly related to the process. Weaker responses failed to articulate the specific issues.

(b)(i) The best responses included a good description of the procedure with a well-labelled diagram. Weaker responses provided poor diagrams or failed to identify essential equipment necessary for the procedure or confused galvanic cells with electrolytic cells.

(ii) Better responses associated the correct reactions for the anode and the cathode. Weaker responses contained incorrect equations or failed to link oxidation and reduction reactions to the correct electrode.

(c)(i) In the better responses, candidates recognised that the equilibrium expression had to be used to perform a calculation to determine if the system was at equilibrium. Weaker responses did not recognise that the container was 5.0 L, leading to an incorrect calculation of Q. Poorer responses made use of addition instead of multiplication of concentrations in the equilibrium expression or attempted to answer the question without referring to the data provided.

(ii) In the best responses, candidates provided explanations that made use of Le Chatelier’s principle. Better responses correctly explained the influence of pressure on the system and correctly related the endothermic reaction to the absorption of heat after increasing the temperature of the system. Weaker responses correctly identified the conditions required, but neglected to explain these conditions in terms of Le Chatelier’s principle, or simply stated Le Chatelier’s principle without relating it to the system involved.

(d) Better responses provided chemical structures of all the detergents, with correct uses and properties, as well as a historical account of the changes in structure due to environmental issues. Mid-range responses provided simplified structures, with uses and environmental concerns. Low-range responses did not identify correct uses of detergents or could not provide characteristics of detergents. Many low-range responses did not include relevant environmental issues related to the use of detergents. Many responses provided detailed information about eutrophication and/or micelle formation that was not required in the question.

Question 30 – Shipwrecks, Corrosion and Conservation

(a) (i) Most responses identified the suitable metal as being more active than Fe but not too reactive, for example Mg, Zn, Al. The better responses explained the chemical reason for this choice in terms of ‘sacrificial anode’ or ‘preferential oxidation of the metal leaving the iron as the cathode’. The better responses also included relevant equations, usually representing the oxidation of the suitable metal and the reduction of the Fe^{2+} ions. Some responses correctly used the Standard Reduction Potentials to explain why the chosen metal was oxidised in preference to the Fe and some identified that $H_2O(l)$ would be reduced if no Fe^{2+} ions were available.

(ii) Better responses identified and described one or two alternative methods for protecting the steel pipe including painting it in a variety of coatings, galvanising with Zn, applying voltage/impressed current and surface alloying. The better responses also clearly explained how this method achieved protection, usually in terms of providing a barrier to $O_2(g)$ and/or $H_2O(l)$.

(b)(i) The better responses clearly identified the named steel, for example stainless or mild, included a reasonable time frame, for example one day to several weeks, and made observations.

(ii) The better responses compared the degree of corrosion/rusting between the iron and the steel and also included relevant equations, usually the oxidation of Fe and the reduction of $H_2O(l)$ in the presence of $O_2(g)$.

(c)(i) The better responses clearly labelled the anode, cathode and direction of electron flow and clearly indicated that a power supply was necessary.

(ii) Better responses used relevant information on the data sheet and transcribed this data correctly.

(iii) The better responses clearly identified several relevant factors that affected the rate of electrolytic reaction.

(d) Better responses clearly indicated two Australian maritime archaeological projects, the processes used in the conservation and restoration of the named artefacts from these projects and why these processes were used. Better responses also clearly indicated similarities and/or differences in the processes used in the two projects. Weaker responses did not clearly identify an Australian project or confused the sequencing of steps for the conservation and restoration of a project or gave description of the process rather than why a particular process was used.

Question 31 – Biochemistry of Movement

(a)(ii) Weaker responses left out the term ‘aerobic’ when referring to respiration or confused this part of metabolism and gave glycolysis as an answer.

(iii) Weaker responses did not include the three main equations of oxidative phosphorylation and the equations in many responses were not balanced.

(b)(i) In the better responses, candidates articulated an experiment that showed correct experimental method that included replicates and controls, and named the equipment used and the reagents. Weaker responses named the wrong enzymes for the substrates they were using.

(ii) Better responses included a title on their graphs so that it was easy to identify what had been measured. In weaker responses, candidates were unsure of what to graph and invariably put the wrong labels on the axes and did not put the independent variable on the *x*-axis.

(d) In the better responses, candidates successfully analysed the change in focus from strenuous exercise to sprinting. These responses tended to produce excellent, coherent and logical responses that demonstrated a thorough knowledge of the chemistry of metabolic processes.

Question 32 – Chemistry of Art

(a) (i) Better responses correctly identified cobalt as belonging to the d-block of the Periodic Table, rather than being a transition metal element. Better responses also gave the correct electron configuration in terms of electron orbitals, while weaker responses merely considered the electron shell configuration.

(ii) Better responses explained the colour difference between the cobalt complexes as being due to the ligands present and the splitting of the d-orbitals, which affects the frequency of the absorbed light and hence, the colour. Weaker responses did not consider the role of the ligand or were unable to accurately relate the observed colour to the frequency of light absorbed.

(iii) Better responses related the colourless nature of zinc complexes to the fact that the d-orbital in zinc is full, as opposed to being only partially filled in true transition metals. Weaker responses merely stated that zinc was not a transition metal, without providing an accurate explanation.

(b) (i) Better responses considered an appropriate experiment, which enabled the oxidising strength of potassium permanganate solution to be demonstrated. Weaker responses tended to consider the role of potassium permanganate as an oxidising agent, without clearly stating how its strength could be considered. Weaker responses failed to mention the need to acidify the permanganate solution or who used HCl as the acidifying agent. Better responses included both the reagents and the equipment used to carry out the investigation.

(ii) Better responses gave both the permanganate equation, showing its role as an oxidising agent, and the corresponding reduction equation for the other species used in the investigation. Weaker responses only considered the permanganate equation or produced incorrect reduction equations.

(iii) Better responses identified that KBr and KI would undergo oxidation by the permanganate solution.

(c) (i) Better responses indicated that the expected absorption spectrum for the violet V^{2+} solution would require a consideration of the complementary colour principle. They also sketched a valid absorbance graph, appropriately labelling both axes. Weaker responses indicated a lack of awareness of the need to consider complementary colours or did not explain this principle.

(ii) Better responses balanced the equations for both charge and numbers of atoms and were able to produce a satisfactory net equation for the given colour change. Weaker responses did not correctly balance the given equations before appropriately adding them together.

(iii) Better responses identified the class of reaction given as oxidation-reduction. Weaker responses identified the reaction using a number of incorrect terms such as displacement, dehydration, ionic, covalent bonding and precipitation.

(d) Better responses produced a coherent and logical description of at least two methods that could be used to identify pigments and check the age of the painting. These could include IR and UV spectroscopy and LASER micro spectral analysis. Candidates needed to relate the described methods to the ability to use the pigments found to being able to estimate the age of the artwork, rather than merely describe the processes, which could be used for pigment identification. Weaker responses tended merely to describe the identification methods, in some cases in specific detail, without a consideration of the historical context of pigment use.

Question 33 – Forensic Chemistry

(a) (ii) Better responses showed a clear relationship between the technique, the piece of evidence and how the evidence was analysed with that technique. Weaker responses did not base the analysis on any instrumental technique, giving instead only a general description.

(b) (i) Better responses gave clear steps in the procedure. These responses identified the amounts and names of the sugars, the reagents and the equipment used. The better responses analysed the results and gave an explanation for differences between a reducing and non-reducing sugar. Weaker responses did not give clear steps in the procedure and were unable to give the reagent for the test.

(ii) Better responses identified the area on the reducing sugar that oxidises and the reagent that is being reduced. Weaker responses misused the terms ‘oxidising’ and ‘reducing’ or gave a general account of reducing sugars reacting with the reagent without mention of oxidation or reduction.

(iii) Weaker responses did not identify an instrument or listed more than one instrumental technique.

(c)(i) Weaker responses showed a misunderstanding of retention times and matched the height of the peak with the athlete’s sample.

(ii) Weaker responses did not identify properties of the compounds but described the two techniques. Some weaker responses showed a misunderstanding of the term ‘volatile’.

(iii) Better responses drew the mass spectrometer and described the operation with reference to the diagram. Weaker responses confused AES or AAS with mass spectrometry or did not make reference to the formation of positive ions or the electrical field.

(d) Better responses explained the principles and theory behind emission spectroscopy relating the theory to its use through a correct example. Weaker responses explained the theory but omitted how the information could be used to determine the origins of a mixture. Weaker responses focused on hydrogen but did not relate to its use in forensic chemistry.

Chemistry

2008 HSC Examination Mapping Grid

Question	Marks	Content	Syllabus outcomes
Section I Part A			
1	1	9.2.5.2.4	H7
2	1	9.3.2.2.9	H6, H12
3	1	9.4.4.2.6	H6
4	1	9.4.4.2.1	H6
5	1	9.2.3.2.3, 9.3.5.3.2	H9
6	1	9.2.3.3.6	H7
7	1	9.3.2.2.4	H8
8	1	9.3.4.2.1	H1, H8
9	1	9.3.2.2.6, 9.4.4.2.2	H8
10	1	9.2.3.3.6, 9.2.3.2.9, 12.4(b)	H7, H9, H12
11	1	9.3.5.2.3	H9
12	1	9.4.5.3.3, 12.3(c)	H8, H12
13	1	9.2.4.2.2, 9.2.4.2.4, 12.3(c)	H8, H12
14	1	9.3.3.2.5, 12.4(b)	H10, H12
15	1	9.4.3.3.3, 12.4(b)	H10, H12
Section I Part B			
16 (a)	2	9.2.1.2.2	H9
16 (b)	3	9.2.1.3.2, 13.1(d)	H8, H9, H13
17	5	9.4.5.2.3, 9.4.5.3.3, 9.4.5.1, 14.2(b)	H4, H14
18 (a)	2	9.4.4.2.5, 13.1(e)	H6, H13
18 (b)	3	9.4.4.2.6, 14.1(f)	H6, H8, H14
19 (a)	3	9.4.3.3.5, 13.1(f), 13.1(g)	H13
19 (b)	2	9.4.3.2.1, 9.4.3.3.5, 12.3(c), 12.4(b), 13.1(d)	H12, H13
20 (a)	2	9.3.2.2.9, 12.4(b)	H12
20 (b)	1	9.3.2.2.9, 12.3(c), 14.1(f)	H12, H14
21 (a)	2	9.4.4.2.8, 14.1(a), 14.3(b)	H4, H8, H9, H14
21 (b)	2	9.4.4.2.10, 9.4.4.2.11, 14.3(c)	H3, H4, H14
22	5	9.2.3.2.4, 9.2.3.2.8, 9.2.3.3.3	H3, H4, H5, H7
23	4	9.3.2.2.3, 9.3.2.2.4, 9.4.2.2.4, 9.4.2.2.5, 9.4.2.2.6, 9.4.2.2.7	H2, H3, H8
24 (a)	1	9.2.3.2.7, 9.2.3.2.8, 12.3(c), 12.4(b)	H12

Question	Marks	Content	Syllabus outcomes
24 (b)	2	9.2.3.3.3, 12.3(c), 12.4(b)	H12
24 (c)	2	9.3.2.3.9, 12.3(c), 12.4(b)	H12
25 (a)	1	9.2.4.2.5, 9.2.4.2.6, 12.3(c)	H7, H12
25 (b)	1	9.2.4.2.3, 13.1(d)	H10, H13
25 (c)	1	9.2.4.3.4, 12.3(c), 12.4(b)	H12
25 (d)	2	9.2.4.2.1, 9.2.4.2.3, 14.1(d)	H7, H14
26	4	9.3.4.2.3, 9.3.4.2.5, 9.3.4.2.9, 14.3(b)	H8, H14
27 (a)	2	9.3.4.2.4	H6, H8
27 (b)	2	9.3.4.2.3, 9.3.4.2.4, 14.1(a)	H6, H8, H14
28 (a)	2	9.3.4.3.3, 12.4(b), 13.1(d)	H12, H13
28 (b)	1	9.3.4.2.3, 9.3.4.3.3, 13.1(d)	H8, H10, H13
28 (c)	3	9.3.4.3.3, 12.4(b), 14.1(f)	H12, H14
Section II **Question 29 — Industrial Chemistry**			
29 (a) (i)	2	9.5.3.2.2, 14.1(b)	H3, H14
29 (a) (ii)	2	9.5.3.2.2, 14.3(d)	H14
29 (a) (iii)	2	9.5.3.2.2	H4
29 (b) (i)	3	9.5.4.3.1, 12.1	H6, H7, H8, H12
29 (b) (ii)	2	9.5.4.3.1, 9.5.4.2.2, 13.1(d)	H8, H13
29 (b) (iii)	1	9.5.4.2.3, 11.3(a), 14.2(a)	H11, H14
29 (c) (i)	3	9.5.2.2.1, 9.5.2.2.2, 9.5.2.3.3, 12.4(b), 14.1(c)	H8, H10, H12, H14
29 (c) (ii)	3	9.5.2.2.1, 9.5.2.2.3, 14.1(g)	H8, H10, H14
29 (d)	7	9.5.5.2.5, 9.5.5.2.6, 9.5.5.3.5, 14.3(b)	H1, H3, H4, H9, H14
Section II **Question 30 — Shipwrecks, Corrosion and Conservation**			
30 (a) (i)	3	9.6.4.2.3, 9.6.4.2.4, 14.1(g)	H6, H7, H8, H14
30 (a) (ii)	3	9.6.4.2.1	H6, H7, H8
30 (b) (i)	3	9.6.2.3.1, 12.1	H6, H7, H8, H12
30 (b) (ii)	2	9.6.2.2.4, 9.6.2.3.2, 13.1(d)	H6, H8, H13
30 (b) (iii)	1	9.6.2.2.3, 9.6.2.3.3	H3, H6, H8
30 (c) (i)	2	9.6.3.2.1, 13.1(e)	H13
30 (c) (ii)	2	9.6.3.2.1, 13.1(d)	H8, H10, H13
30 (c) (iii)	2	9.6.3.2.2, 9.6.3.3.1	H8
30 (d)	7	9.6.7.1, 9.6.7.2.1, 9.6.7.2.2, 9.6.7.2.3, 9.6.7.2.4, 9.6.7.2.5, 9.6.7.3.1, 14.3(b)	H2, H3, H4, H5, H7, H8, H14

Question	Marks	Content	Syllabus outcomes
Section II **Question 31 — The Biochemistry of movement**			
31 (a) (i)	1	9.7.9.3.1, 14.1(g), 14.1(h)	H14
31 (a) (ii)	2	9.7.1.3.1, 9.7.1.3.2, 9.7.9.3.1, 14.1(h)	H14
31 (a) (iii)	3	9.7.9.2.1, 9.7.9.2.2, 9.7.9.2.3, 9.7.9.2.4, 14.1(e), 14.1(g), 14.1(h)	H7, H14
31 (b) (i)	3	9.7.4.3.2, 12.1, 12.2(b)	H8, H12
31 (b) (ii)	2	9.7.4.3.2, 13.1(f), 14.1(a)	H8, H9, H13, H14
31 (b) (iii)	1	9.7.4.2.7	H9
31 (c) (i)	1	9.7.2.2.1, 9.7.3.2.1. 9.7.4.1, 12.3(c)	H12
31 (c) (ii)	2	9.7.1.1, 9.7.2.1, 12.4(b), 13.1(d)	H12, H13
31 (c) (iii)	3	9.7.2.1, 9.7.7.1, 9.7.8.1, 9.7.8.3.1, 9.7.9.1, 14.1(b)	H7, H9, H14
31 (d)	7	9.7.2.2.3, 9.7.3.2.5, 9.7.10.2.1, 14.3(b)	H3, H7, H8, H9, H14
Section II **Question 32 — The Chemistry of Art**			
32 (a) (i)	2	9.8.3.1, 9.8.3.2.4, 9.8.3.3.2	H6, H13
32 (a) (ii)	3	9.8.4.2.3, 9.8.4.2.4	H6, H14
32 (a) (iii)	1	9.8.2.2.7, 9.8.3.2.5	H6
32 (b) (i)	3	9.8.4.3.4, 12.1	H8, H12
32 (b) (ii)	2	9.8.4.3.3	H8, H10, H13
32 (b) (iii)	1	9.8.4.2.5, 9.8.4.3.4, 12.3(c)	H6, H8, H12
32 (c) (i)	3	9.8.2.2.9, 13.1(e)	H13
32 (c) (ii)	2	9.8.4.2.3	H10, H13
32 (c) (iii)	1	9.8.4.3.3	H8
32 (d)	7	9.8.1.2.7, 9.8.1.3.3, 14.3(b)	H3, H4, H14
Section II **Question 33— Forensic Chemistry**			
33 (a) (i)	2	9.9.1.2.4, 9.9.4.3.1, 12.3(c)	H12
33 (a) (ii)	4	9.9.4.2.2, 9.9.5.3.1, 11.1(a), 11.3(b), 11.3(c)	H11
33 (b) (i)	3	9.9.2.3.1, 12.1	H8, H12
33 (b) (ii)	2	9.9.2.2.3	H9
33 (b) (iii)	1	9.9.5.2.2, 11.3	H9, H11
33 (c) (i)	1	9.9.5.2.2, 9.9.5.3.1, 12.3(c), 14.1(a)	H12, H14
33 (c) (ii)	2	9.9.5.2.2, 14.2(d)	H14
33 (c) (iii)	3	9.9.5.2.3, 13.1(e)	H3, H13
33 (d)	7	9.9.6.2.3, 9.9.6.3.2, 14.3(b)	H3, H14

Section I, Part B

Question 16 (a)

Outcomes assessed: H9

MARKING GUIDELINES

Criteria	Marks
• Identifies BOTH products 1 and 2 as octane and ethene • Classifies product 1 as alkane, product 2 as alkene	2
• Identifies BOTH products 1 and 2 as octane and ethene OR • Classifies product 1 as alkane, product 2 as alkene OR • Identifies either product 1 and its series OR product 2 and its series	1

Sample answer:

	C_8H_{18}	C_2H_4
Name of compound	Octane and isomers	Ethene Ethylene
Name of series	Alkanes	Alkenes

Question 16 (b)

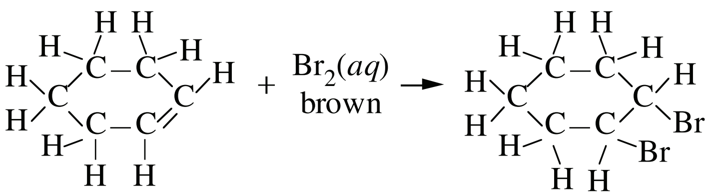
Outcomes assessed: H8, H9, H13

MARKING GUIDELINES

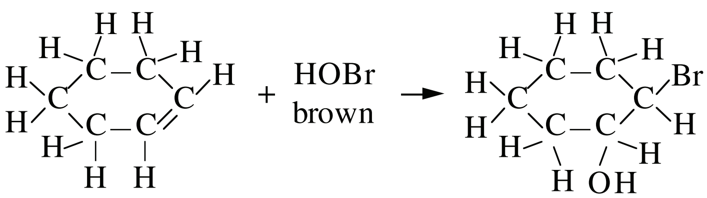
Criteria	Marks
• Outlines procedure for investigation using appropriate example of alkane/alkene for the laboratory (ethane/ethene not valid) • Writes correct chemical equation to describe addition reaction of appropriate alkene • Shows that there is no reaction with alkane	3
• Writes correct equation for the addition reaction of bromine to appropriate alkene OR • Identifies appropriate examples of reactants and outlines procedure	2
• States bromine water is added to reactants OR • Identifies the alkene makes brown colour disappear	1

Sample answer:

- In fume hood equal volumes (~1 mL) of cyclohexane (alkane) and cyclohexene (alkene) were placed into separate test tubes.
- Bromine water was added drop wise with mixing. Cyclohexene decolourised bromine water brown – colourless even when more drops were added. Cyclohexane did not affect the bromine water, no reaction.



1,2-dibromo-cyclohexane



colourless

Question 17

Outcomes assessed: H4, H14

MARKING GUIDELINES

Criteria	Marks
• Identifies TWO catchment features • Identifies TWO sources of contamination related to the features • States appropriate method(s) of treatment for identified contamination	4–5
• Identifies a catchment feature • Identifies a source of contamination related to the feature • States an appropriate method of treatment for identified contamination	3
Any TWO of the following: • Identifies a catchment feature • Identifies a source of contamination • States method of treatment	2
• Identifies a catchment feature OR • Identifies a source of contamination OR • States a method of treatment	1

Answers could include:

Possible catchment features

- Forest
- Forest with timber harvesting/clearing
- Farmland issues
  - Dairying, other stock
  - Intensive – horticultural
  - Intensive – piggery/chicken
- Geological
  - Limestone, salt
- Mining
  - Coal/other minerals, open cast/possible contamination sources
- Forest
  - Faecal matter, wild animals/birds
  - Leaf litter
- Harvested forest
  - Soil run off with disturbance
  - Leaf litter disturbance
- Farmland
  - Faecal matter
  - Fertilizer run off or leaching
  - Soil run off
  - Salinity
  - Limestone – hardness – salinity
- Mining
  - Acid mine waste, soil disturbance

Possible treatments

- Screening
- Oxidation (of Fe/Mn/organics) by aeration, or chlorine or MnO_4^-
- Flocculation – for turbidity and also traps faecal contamination
- Sedimentation
- Filtration
- Final pH balancing
- Disinfection Cl_2, UV or ozone; Cl_2 may include NH_3

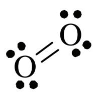
Question 18 (a)

Outcomes assessed: H6, H13

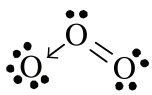
MARKING GUIDELINES

Criteria	Marks
• Shows correct electron dot structure for both ozone and oxygen molecules	2
• Shows correct electron dot structure for oxygen molecule OR • Shows correct electron dot structure for ozone molecule	1

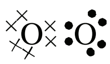
Sample answer:



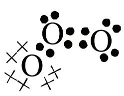
O_2 (oxygen)



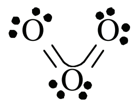
O_3 (ozone)



O_2



or



resonance structure

O_3

Question 18 (b)

Outcomes assessed: H6, H8, H14

MARKING GUIDELINES

Criteria	Marks
• Relates the nature of bonding of O_2 and O_3 to molecular shape, and chemical reactivity • Relates the polarity or MW of both O_2 and O_3 molecules to intermolecular forces and resultant physical properties	3
• Describes intramolecular and intermolecular forces of O_2 and O_3 OR • Describes the chemical and/or physical properties of O_2 and O_3 related to structure or bonding	2
• Describes structure and bonding of either O_2 or O_3 OR • Describes a physical or chemical property of either O_2 or O_3 related to structure or bonding	1

Question 18 (b) (continued)

Sample answer:

Physical = solubility, density, mp/bp
Chemical = reactivity, stability, bleaching, toxicity, correct u/v
Ozone is a polar molecule, asymmetrical molecule, due to loan pair of electrons whereas oxygen is non-polar. Hence intermolecular forces in ozone are much stronger than the dispersion forces between O_2 molecules. Therefore O_3 has higher mp/bp than O_2. Oxygen has a strong, relatively stable double bond, whereas the bonds in O_3 are more reactive due to them being between a single and a double bond. Hence O_3 is a more reactive molecule, a stronger oxidising agent.

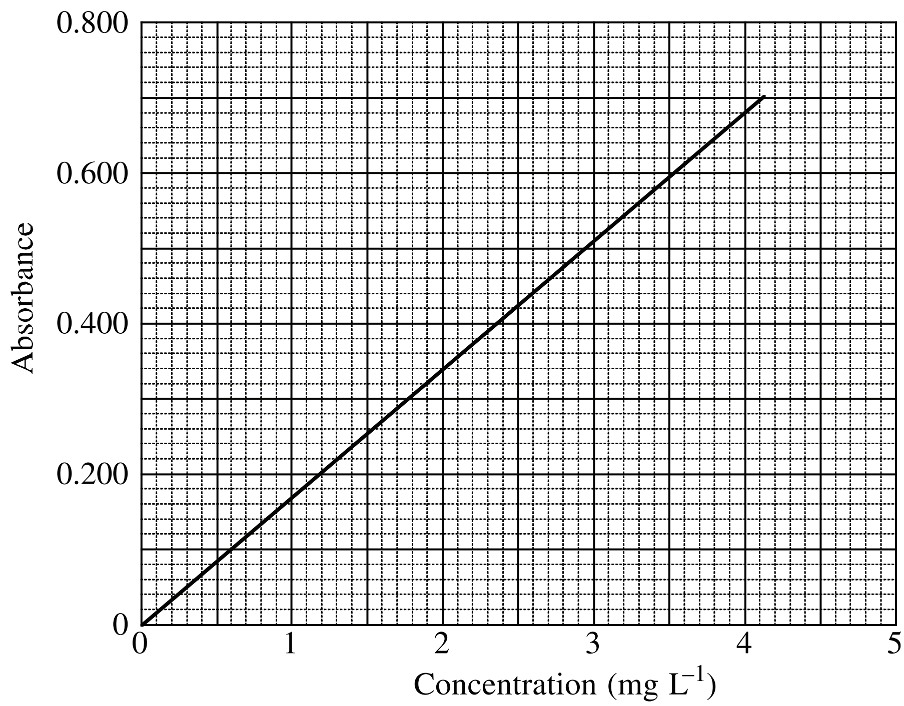
Question 19 (a)

Outcomes assessed: H13

MARKING GUIDELINES

Criteria	Marks
• Selects appropriate X and Y scales • Correctly labels both axes • Correctly plots points and draws correct straight line – ruler	3
• As for 3 marks but graphed with axes reversed OR • As for 3 marks but not labeled OR • As for 3 marks but incorrectly plots points	2
• Selects appropriate scales OR • Correctly plots points without scales or labels	1

Sample answer:



Question 19 (b)

Outcomes assessed: H12, H13

MARKING GUIDELINES

Criteria	Marks
• Correctly calculates value from correct reading from graph	2
• States correct value from graph OR from ratio calculation OR uses correct method from incorrect value	1

Sample answer:

$$1.65 \text{ mg L}^{-1} \text{ from graph} = \frac{1.65 \text{ mg} \times 100 \text{ mL}}{1000 \text{ mL}} \qquad \pm 0.05 \text{ mg L}^{-1}$$

$$\text{mg per tablet} = \frac{1.65 \text{ mg}}{1 \text{ L}} \times 100 \text{ mL}$$

$$= 0.165 \text{ mg/tablet}$$

Question 20 (a)

Outcomes assessed: H12

MARKING GUIDELINES

Criteria	Marks
• Calculates correct molar mass	2
• Calculates correct moles	1

Sample answer:

1 mol gas occupies 24.79 L
X mol gas occupies 15.0 L

$$\text{Mol gas} = \frac{15.0}{24.79} = 0.605 \qquad MM = \frac{1.22 \times 24.74}{15} = 2.029$$

$$\text{Molar mass} = \frac{\text{mass}}{\text{mol}} = \frac{1.22}{0.605}$$

$$= 2.02 \text{ g}$$

Question 20 (b)

Outcomes assessed: H12, H14

MARKING GUIDELINES

Criteria	Marks
• Identifies gas as hydrogen OR • Identifies correct gas from mass calculated in part (a)	1

Sample answer:

Hydrogen

Question 21 (a)

Outcomes assessed: H4, H8, H9, H14

MARKING GUIDELINES

Criteria	Marks
• Identifies a difference between pre 1993 AND post 1993 and gives a reason for BOTH parts of the graph (upward and downward trends)	2
• Identifies a difference between pre 1993 and post 1993 OR • Gives a reason for ONE part of graph (upward and downward trends)	1

Sample answer:

CFC-11 is a chlorofluorocarbon compound. It was once used for many different applications, resulting in emissions into the atmosphere. Since 1987 there has been a series of agreements to phase out the use of CFCs. The rise in the graph prior to 1993 reflects both the emissions of CFC-11 and the fact that it does not decompose in the troposphere. The downward trend after 1993 represents the effect of the ban on manufacture and use of CFCs and the slow transport of CFC-11 to the stratosphere.

Montreal Protocol has lead to a stability of CFCs in the troposphere.

Question 21 (b)

Outcomes assessed: H3, H4, H14

MARKING GUIDELINES

Criteria	Marks
• Identifies that CFC-11 is involved in ozone depletion • Gives reason for monitoring	2
• Identifies that CFC-11 is involved in ozone depletion	1

Sample answer:

CFC-11 is a chlorofluorocarbon compound, a class of molecules responsible for the destruction of ozone and the formation of the “ozone hole”. CFC-11 levels need to be monitored to check on the effectiveness of the various agreements to ban their use, and to be able to predict the future effects on the ozone depletion processes.

Question 22

Outcomes assessed: H3, H4, H5, H7

MARKING GUIDELINES

Criteria	Marks
• Demonstrates a depth of knowledge and understanding of the production of ethanol possibly being a carbon-neutral fuel using equations for photosynthesis, fermentation, combustion • Identifies other possible energy inputs that counter-act the carbon neutral argument • Provides a clear judgement based upon above criteria	4–5
• Provides a relevant chemical equation in an attempt to explain the production of combustion of ethanol • Identifies ONE other energy input that counter-acts the argument • Provides a judgement about carbon neutrality	2–3
• Identifies ONE other energy input that counteracts the argument OR • Provides a judgement OR • Provides ONE relevant equation about carbon neutrality	1

Sample answer:

Bioethanol is a renewable resource. The cycle of its manufacture via photosynthesis/fermentation and its combustion as a fuel should, in theory, contribute no net $CO_2(g)$ to atmosphere, as described by the following equations.

Photosynthesis: $6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$

Fermentation: $C_6H_{12}O_6(aq) \rightarrow 2C_2H_5OH(aq) + 2CO_2(g)$

Combustion(Complete): $2C_2H_5OH(l) + 6O_2(g) \rightarrow 4CO_2(g) + 6H_2O(l)$

However, there are other significant energy inputs in this cycle that would shed doubt on bioethanol being a carbon neutral fuel, (ie: energy required to produce fertiliser needed for cultivation of crops that are to be fermented and energy required for purifying fermented product).

Much of the energy used for this is generated via combustion of fossil fuels that adds to the $CO_2(g)$ emissions into the atmosphere, and thus the global warming phenomenon.

Bioethanol on the surface might appear to be carbon neutral, however, there is significant doubt about its carbon neutrality when other energy inputs are considered. Therefore this extract is scientifically incorrect.

Question 23

Outcomes assessed: H2, H3, H8

MARKING GUIDELINES

Criteria	Marks
• Includes equation describing Haber process, indicating that it is exothermic and reversible • Identifies typical temperature(s) and pressure(s) used in modern day Haber production plants • Identifies the compromise in temperature conditions • Explains the choice of temperature and pressure by referring to both reaction rate and Le Chatelier's Principle	4
• Includes equation showing it is exothermic OR identifies typical temp or pressures • Identifies compromise in temperature conditions • Explains (as above) using Le Chatelier's principle AND reaction rate	3
• Identifies compromise in temperature conditions OR high pressure conditions • Explains in part using Le Chatelier's principle OR reaction rate	2
• Describes Le Chatelier's Principle / Define Le Chatelier's Principle OR • Describe the Haber process OR • Gives correctly balanced equation with ΔH as exothermic	1

Sample answer:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92 \text{ kJ}$$

Typical temperature and pressure conditions used to optimise yield of NH_3 in the Haber process are 400 – 500°C and $(25 - 35) \times 10^3$ kPa respectively.

The high pressures used in the Haber process promote both a rapid reaction rate (by increasing number of successful reactant collisions) and high equilibrium yield. Increasing pressures, by Le Chatelier's principle, moves equilibrium to the right in order to decrease the number of gaseous particles from 4 to 2, and this increases $[NH_3]$.

High temperatures will increase the rate of reaction by increasing the number of molecules with appropriate E_A and increasing the number of successful collisions. However, increasing temperature by Le Chatelier's principle, will force equilibrium to the left, favouring formation of reactants because the reaction is exothermic. Thus a compromise in temperature is used to address these competing rate and equilibrium considerations.

Question 24 (a)

Outcomes assessed: H12

MARKING GUIDELINES

Criteria	Marks
• Identifies correct fuel	1

Sample answer:

Hydrogen

Question 24 (b)

Outcomes assessed: H12

MARKING GUIDELINES

Criteria	Marks
• Correctly calculates the energy released with correct units	2
• Correctly calculates the mass of 80 L of petrol in grams	1

Answers could include:

$$\begin{aligned}\text{Mass of 80 L petrol} &= \text{density} \times \text{volume (mL)}\\ &= 0.69\ \text{g/mL} \times 80 \times 1000\ \text{mL}\\ &= 55\,200\ \text{g}\end{aligned}$$

$$\text{Moles petrol} = \frac{55\,200}{114} = \text{Energy released from 80 L}$$

$$\begin{aligned}&= \text{moles} \times 5460\\ &= 484.2 \times 5460\\ &= 2\,643\,790\ \text{kJ}\end{aligned}$$

OR

Petrol releases 47.9 kJ/g

$$\begin{aligned}\text{Total energy from 80 L} &= 47.9 \times 55\,200\\ &= 2\,644\,080\ \text{kJ}\end{aligned}$$

Question 24 (c)

Outcomes assessed: H12

MARKING GUIDELINES

Criteria	Marks
• Correctly calculates volume using value (kJ) from part (b)	2
• Correctly calculates moles of H_2 OR • Correctly uses 24.79 with wrong moles	1

Answers could include:

$$\text{Moles hydrogen} = \frac{2\,643\,790}{285} = 9276.5 \qquad \text{OR} \qquad = \frac{2\,644\,080}{285} = 9277.5$$

$$\text{Vol } H_2 = 24.79 \times \text{moles} = 229\,963 \text{ L} \qquad \text{OR} \qquad = 229\,989 \text{ L}$$

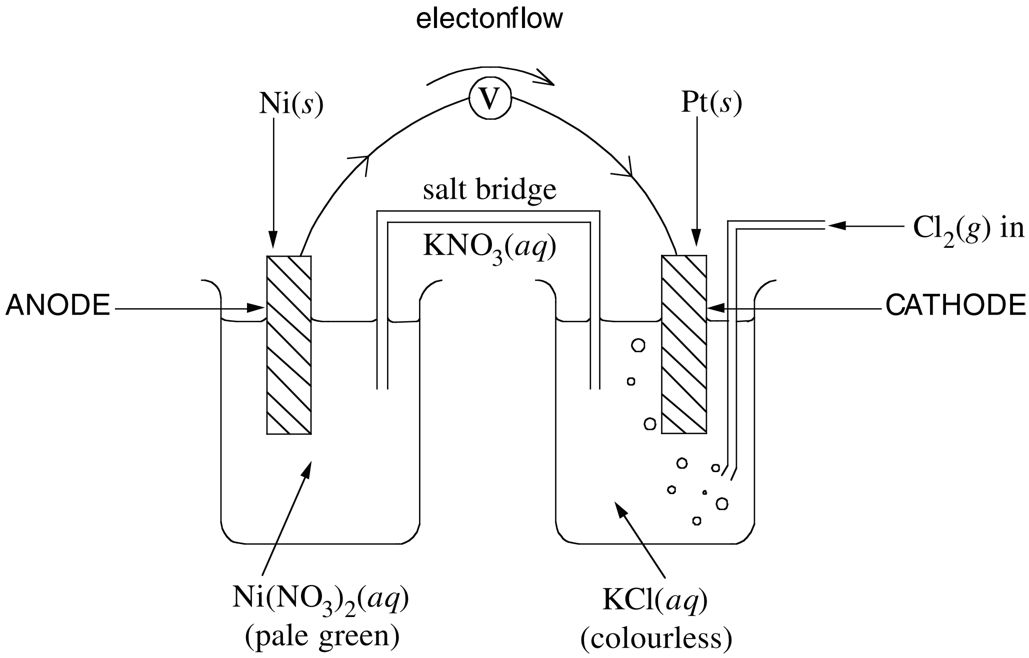
Question 25 (a)

Outcomes assessed: H7, H12

MARKING GUIDELINES

Criteria	Marks
• Correctly labels anode, cathode and the direction of election flow	1

Sample answer:



Question 25 (b)

Outcomes assessed: H10, H13

MARKING GUIDELINES

Criteria	Marks
• Writes a correctly balanced net ionic equation for the overall cell reaction	1

Answers could include:

$Ni(s) \rightarrow Ni^{2+}(aq) + 2e^-$

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

$Ni(s) + Cl_2(g) \rightarrow Ni^{2+}(aq) + 2Cl^-(aq)$ $\quad$ $Ni(s) + Cl_2(aq) \rightarrow Ni^{2+}(aq) + 2Cl^-(aq)$

Question 25 (c)

Outcomes assessed: H12

MARKING GUIDELINES

Criteria	Marks
• Calculates standard cell potential ($E^{\ominus}$) correctly	1

Answers could include:

$Ni(s) \rightarrow Ni^{2+}(aq) + 2e^-$

$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$

$E^{\ominus}(Ni)$	$= 0.24$		$E^{\ominus}(Ni)$	$= 0.24$
$E^{\ominus}(Cl_2(g))$	$= 1.36$	OR	$E^{\ominus}(Cl_2(aq))$	$= 1.40$
$E^{\ominus}(cell)$	$= 1.60$ V		$E^{\ominus}(cell)$	$= 1.64$ V

Question 25 (d)

Outcomes assessed: H7, H14

MARKING GUIDELINES

Criteria	Marks
• Identifies AND gives correct reason for colour change	2
• Identifies the correct colour change OR • Gives a valid explanation for an unidentified colour change	1

Sample answer:

As the reaction proceeds, the $[Ni^{2+}]$ at the anode increases

$Ni(s) \rightarrow Ni^{2+}(aq) + 2e^-$

Ni^{2+} ions are green and as the $[Ni^{2+}]$ increases, the green colour will intensify at the anode (darker green)

Question 26

Outcomes assessed: H8, H14

MARKING GUIDELINES

Criteria	Marks
• Correctly defines buffer systems • Shows how a buffer works by giving a relevant example within a natural system • Includes relevant equation with explanation OR equations	3–4
• Correctly defines buffer systems • Gives a relevant example	2
• Gives a natural example of a buffer system OR • Gives partial definition of buffer	1

Sample answer:

Buffers are solutions that resist changes in pH when small quantities of acid or base are added.

A buffer is made by mixing together a weak acid and its conjugate base, or a base with its conjugate acid in approximately equal proportions. A natural example is seen in the HCO_3^- buffering system that maintains blood pH.

$$H_2CO_3(aq) \rightleftharpoons HCO_3^-(aq) + H^+(aq)$$

When there are changes in acid/base level of the blood, the system is pushed either to the left on addition of an acidic substance or the right on the addition of a basic substance and the pH is maintained.

Answers could include:

$$HCO_3^-(aq) + H^+(aq) \rightarrow H_2CO_3(aq)$$

$$H_2CO_3(aq) + OH^-(aq) \rightarrow H_2O(l) + HCO_3^-(aq)$$

Question 27 (a)

Outcomes assessed: H6, H8

MARKING GUIDELINES

Criteria	Marks
• Correctly classifies each of the four salts	2
• Correctly classifies TWO or THREE of the FOUR salts	1

Sample answer:

Salt	*Classification of solutions*
Ammonium chloride	acidic
Sodium ethanoate	basic
Sodium chloride	neutral
Ammonium nitrate	acidic

Question 27 (b)

Outcomes assessed: H6, H8, H14

MARKING GUIDELINES

Criteria	Marks
• Correctly identifies ion (in solution) responsible for acidity or basicity • Writes equation relevant to chosen salt to show formation of either H_3O^+ or OH^-	2
• Correctly identifies ion responsible for acidity or basicity OR • Writes an equation to show how salt behaves as an acid or a base	1

Sample answer:

In solution a basic salt will form hydroxide ions.

$$CH_3COONa(aq) + H_2O(l) \rightarrow CH_3COOH(aq) + Na^+(aq) + OH^-(aq)$$

Answers could include:

Acidic salt: $NH_4NO_3(aq) + H_2O(l) \rightarrow NH_3(aq) + H_3O^+(aq) + NO_3^-(aq)$

Forms: H_3O^+ (or H^+)

Question 28 (a)

Outcomes assessed: H12, H13

MARKING GUIDELINES

Criteria	Marks
• Correctly calculates concentration	2
• Correctly calculates moles Na_2CO_3 OR • Correct calculation of concentration	1

Sample answer:

Mol $Na_2CO_3 = \dfrac{1.314}{105.99} = 0.01240$ Molar mass $Na_2CO_3 = 105.99$

Concentration Na_2CO_3 solution $= \dfrac{\text{mol}}{\text{volume}} = \dfrac{0.01240}{250 \times 10^{-3}} = 0.04959 \text{ mol L}^{-1}$

Question 28 (b)

Outcomes assessed: H8, H9, H13

MARKING GUIDELINES

Criteria	Marks
• Gives correctly balanced equation (states not essential)	1

Sample answer:

$Na_2CO_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)$

Question 28 (c)

Outcomes assessed: H12, H14

MARKING GUIDELINES

Criteria	Marks
• Calculates concentration for HCl correctly to 4 significant figures	3
• Calculates concentration of HCl correctly but incorrect significant figures OR • Calculates concentration of HCl without using mole ratio	2
• Calculates moles OR • Uses correct ratio of 2 : 1 for HC1 : Na_2CO_3	1

Sample answer:

$$\text{Moles } Na_2CO_3 \text{ used} = MV = 0.04959 \times 23.45 \times 10^{-3}$$

$$\text{In titration} = 0.001163$$

$$\text{Mol HCl required} = 2 \times \text{mols } Na_2CO_3$$

$$= 0.002326$$

$$\text{Concentration HCl} = \frac{\text{mol}}{\text{volume}}$$

$$= 0.002326$$

$$= 25.00 \times 10^{-3}$$

$$= 0.09303 \text{ mol L}^{-1}$$

Section II

Question 29 (a) (i)

Outcomes assessed: H3, H14

MARKING GUIDELINES

Criteria	Marks
• Correctly identifies contents of all three pipes	2
• Correctly identifies content of pipe 3 AND • Correctly identifies contents either pipe 1 or pipe 2 OR • Correctly identifies other two fluids	1

Sample answer:

Pipe 1: Hot compressed air or hot air
Pipe 2: Pressurised hot water
Pipe 3: Molten sulfur or sulfur slurry

Question 29 (a) (ii)

Outcomes assessed: H14

MARKING GUIDELINES

Criteria	Marks
• Relates extraction of sulfur to increased pressure and temperature	2
• Relates to either temperature or pressure OR relevant physical property of sulfur	1

Sample answer:

Sulfur has a relatively low melting point and is insoluble in water. The pressurised hot water melts the sulfur and increases the pressure in the chamber. The molten sulfur slurry is forced out of the middle pipe 3.

Question 29 (a) (iii)

Outcomes assessed: H4

MARKING GUIDELINES

Criteria	Marks
• Includes TWO environmental issues	2
• Includes ONE environmental issue	1

Answers could include:

The environment issues relating to this process include:

- Thermal pollution
- Water contamination
- Subsidence of the mine site

Question 29 (b) (i)

Outcomes assessed: H6, H7, H8, H12

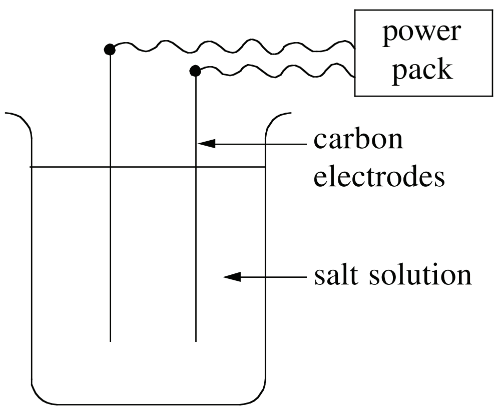
MARKING GUIDELINES

Criteria	Marks
• Provides features and characteristics of a valid first-hand investigation • Identifies equipment AND reagents used	3
• Outlines a valid first-hand investigation • Identifies equipment used	2
• Provides some steps of a valid first-hand investigation OR • Identifies equipment used OR • Identifies regent used	1

Answers could include:

In this investigation both dilute and more concentrated sodium chloride solutions were used. Universal indicator was added to the solution to help identify the products. Two carbon electrodes were placed in the solution (in the same beaker) and connected with leads to the power supply pack.

When the power supply was turned on, the solution changed colour and bubbles were formed. An odour was detected with the concentrated solution.



Question 29 (b) (ii)

Outcomes assessed: H8, H13

MARKING GUIDELINES

Criteria	Marks
• Correctly identifies the reaction at the anode and the cathode for the given conditions with equations	2
• Correctly identifies the reaction at the cathode with equation OR • Correctly identifies the reaction at the anode with equation OR • Correctly identifies the reaction at the anode and the cathode without equations	1

Answers could include:

Cathode reaction: $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$

Anode reaction: $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

OR

$H_2O_{(l)} \rightarrow \frac{1}{2} O_{2\,(g)} + 2H^+_{(eq)} + 2e^-$

Question 29 (b) (iii)

Outcomes assessed: H11, H14

MARKING GUIDELINES

Criteria	Marks
• States that sodium chloride must be in molten state (not a solution)	1

Sample answer:

Sodium metal is produced when molten NaCl is electrolysed, therefore, the solution of NaCl must be replaced with molten sodium chloride.

Question 29 (c) (i)

Outcomes assessed: H8, H10, H12, H14

MARKING GUIDELINES

Criteria	Marks
• Correctly calculates the value of Q and states that the system is not at equilibrium	3
• Uses equilibrium expression in some form but gets incorrect answer	2
• States the equilibrium expression in some form	1

Sample answer:

To determine if the system is at equilibrium it is necessary to calculate Q, the reaction quotient, and see if it is the same as K.

$$Q = \frac{[\text{Products}]}{[\text{Reactants}]}$$

$$Q = \frac{[CO][H_2]^3}{[CH_4][H_2O]}$$

$$Q = \frac{\left[\frac{0.75}{5}\right]\left[\frac{0.75}{5}\right]^3}{\left[\frac{2.00}{5}\right]\left[\frac{1.25}{5}\right]}$$

$$Q = \frac{\left[\frac{0.75}{5}\right]^4}{0.1}$$

$$Q = \frac{5.0625 \times 10^{-4}}{0.1}$$

$$Q = 5.0625 \times 10^{-3}$$

$$K = 0.26$$

And since $Q \neq K$.

$\therefore$ The system is not at equilibrium.

Question 29 (c) (ii)

Outcomes assessed: H8, H10, H14

MARKING GUIDELINES

Criteria	Marks
• Shows how THREE conditions can increase products OR • Shows how temperature AND pressure can increase products	3
• Shows how TWO conditions can increase products OR • Shows how temperature OR pressure can increase products	2
• Identifies ONE condition that will increase products	1

Answers could include:

- To increase the amount of products you could decrease the pressure: since there are two molecules on the LHS and four on the right this will cause the equilibrium to shift to the right.
- Increase temperature because it is endothermic
- Remove product as it is formed
- Add more reactants

Question 29 (d)

Outcomes assessed: H1, H3, H4, H9, H14

MARKING GUIDELINES

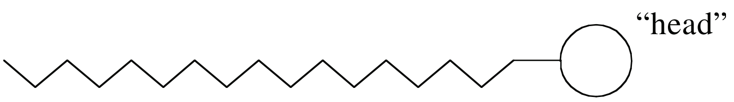
Criteria	Marks
• Demonstrates a thorough knowledge of the chemistry, uses and (historical) environmental impacts of anionic, cationic and non-ionic detergents • Shows how the THREE detergent types are different in terms of use and chemical composition • Provides a response that demonstrates coherence and logical progression of scientific principles and ideas	6–7
• Provides characteristics and features of anionic, cationic and non-ionic detergents • Clearly states how the THREE detergents differ in use and/or composition • Describes ONE impact that detergents have had on the environment	4–5
• Provides characteristics and features of TWO of the detergents • Describes ONE environmental issue caused by detergents	2–3
• Outlines detergents OR • Outlines an environmental issue related to detergents OR • Identifies a particular structure (draws a structure) and identifies correctly as anionic, cationic or non-ionic	1

Sample answer:

Synthetic detergents have been developed to replace soap. Synthetic detergents are synthesised from the products of petroleum refining, unlike soaps that are derived from natural oils.

The three classes of synthetic detergents differ in some respects and are similar in others

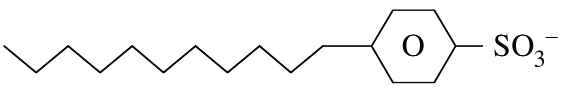
All the detergents have a general structure as shown below



hydrophobic hydrocarbon

The hydrocarbon tail is more or less the same in each detergent. The "head" group changes the nature of the detergent.

Anionic detergents have a negatively charged head group such as:



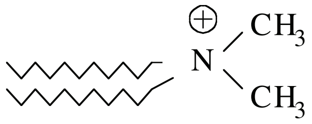
hydrophobic hydrocarbon alkyl sulfates

Question 29 (continued)

They foam strongly and are the most common form of synthetic detergent. They lather in hard water and are used in wide range of products such as laundry powders, shampoos, liquid soap and dish-washing powder because of the ability to remove grease and dirt.

<u>Cationic detergents</u> have a positively charged head group.

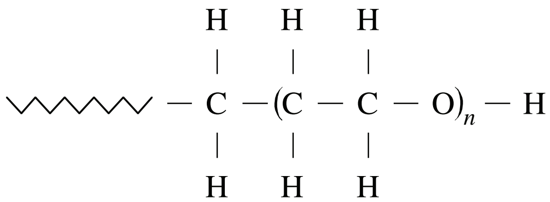
eg



quarternary ammoniun compounds

The cationic head binds strongly to negatively charged particles, meaning it attaches to surfaces "tail out". This makes them suitable for use as fabric softeners and hair conditioners. They are not used as "soaps" because they have a greasy feel. Other types are used as disinfectants and antiseptics because they disrupt bacterial membranes.

<u>Non-ionic detergents</u> have a non-charged head group.



polar ethoxylate group

The polar group improves the ability of non-polar and polar groups to adhere to each other.

They are low foaming and are often mixed with other detergents to reduce foaming such as in front loading washing machines and dishwashing powders.

The impact of these detergents on the environment has reduced over time. The initial impact was high because they were not biodegradable and persisted in the environment. This lead to natural water bodies becoming choked with foam. This problem was solved by reducing chain branching in the non-polar tail.

The use of phosphate as a builder improves performance in hard water and also leads to eutrophications and algal blooms because phosphate increases nutrient loads of water. Phosphate levels are being reduced in synthetic detergents and replaced with other substances which remove Ca and Mg ions and therefore this impact is reducing.

Cationic detergents can also decrease the efficiency of sewage treatment because of their antibacterial nature, but since their use is generally low in most cases this impact is minimal.

Question 30 (a) (i)

Outcomes assessed: H6, H7, H8 , H14

MARKING GUIDELINES

Criteria	Marks
• Identifies a metal suited to the application • Relates the chemistry of corrosion prevention to the metals • Includes relevant equations in the explanation	3
• TWO of the above	2
• Identifies a metal suitable for this application OR • Identifies the rod as a sacrificial anode	1

Sample answer:

Mg is a more active metal than iron, so is oxidised more readily $Mg(s) \rightarrow Mg^{2+}(aq) + 2e^-$. So it can provide electrons to reduce any Fe^{2+} therefore limiting corrosion of the pipeline $2e^- + Fe^{2+}(aq) \rightarrow Fe(s)$.

Answers could include:

Zn. It behaves as a sacrificial anode.

Question 30 (a) (ii)

Outcomes assessed: H6, H7, H8

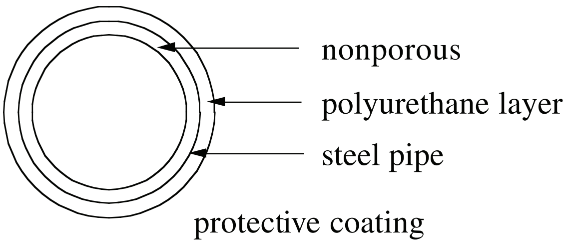
MARKING GUIDELINES

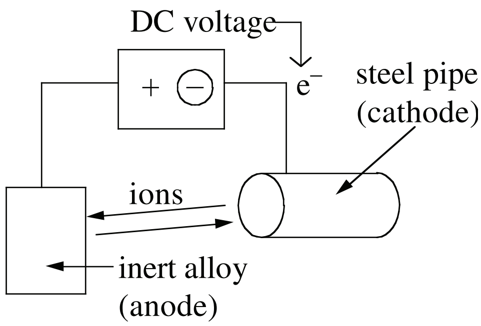
Criteria	Marks
• Identifies and describes TWO other methods of corrosion prevention • Shows how the methods are effective	3
• Identifies and describes TWO methods OR • Identifies and describes ONE method and shows how it is effective	2
• Identifies TWO methods OR • Describes ONE of the methods	1

Sample answer:

Polyurethane coating can be applied to internal and external surfaces of the pipe. It is effective as long as it is intact because it prevents the steel contacting agents of corrosion, soil, electrolytes, damp oxygen. A second protection method is applied voltage. Pipeline is made cathode (attach to –ve terminal of DC supply). Electrons fed to any $Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$ (Water reduced too) Inert electrode is buried nearby and contact maintained through soil moisture.

Answers could include:





Question 30 (b) (i)

Outcomes assessed: H6, H7, H8, H12

MARKING GUIDELINES

Criteria	Marks
• Provides features and characteristics of a valid first-hand investigation • Identifies equipment AND reagents used	3
• Outlines a valid first-hand investigation AND EITHER • Identifies equipment used OR • Identifies reagents used	2
• Provides some steps of a valid first-hand investigation OR • Identifies equipment used OR • Identifies reagents used	1

Sample answer:

Samples of 'iron wire' and nichrome (stainless steel) wire were placed into test tubes and half submerged in salt water. These were observed over a period of days and the amount of discolouration dark → red/brown particles and location on the wires were compared and noted.

Answers could include:

Types of iron: cast iron, wrought iron, mild steel

Question 30 (b) (ii)

Outcomes assessed: H6, H8, H13

MARKING GUIDELINES

Criteria	Marks
• Describes results of investigation • Writes equations relevant to corrosion of iron	2
• Writes an equation for corrosion of iron	1

Sample answer:

The stainless steel showed no evidence of corrosion, but there was an increasing amount of dark red/brown deposition first on the ends then along the body of the iron wire as the investigation proceeded.

Oxidation: $Fe(s) \rightarrow Fe^{2+} + 2e^-$

$$\frac{1}{2}O_2(g) + H_2O + 2e^- \rightarrow 2OH^-(aq)$$

OR

Reduction: $Fe(aq)^{2+} + 2OH(aq)^- \rightarrow Fe(OH)2(s)$

Question 30 (b) (iii)

Outcomes assessed: H3, H6, H8

MARKING GUIDELINES

Criteria	Marks
• Identifies named element(s) added to steel to increase resistance to corrosion	1

Sample answer:

Stainless steel typically has Cr and Ni added
~12 – 30% Cr added
and up to 8% Ni added

Answers could include:

High Ni:	18% Ni	4.0% Mo
Steel:	8% Co	0.8% Ti

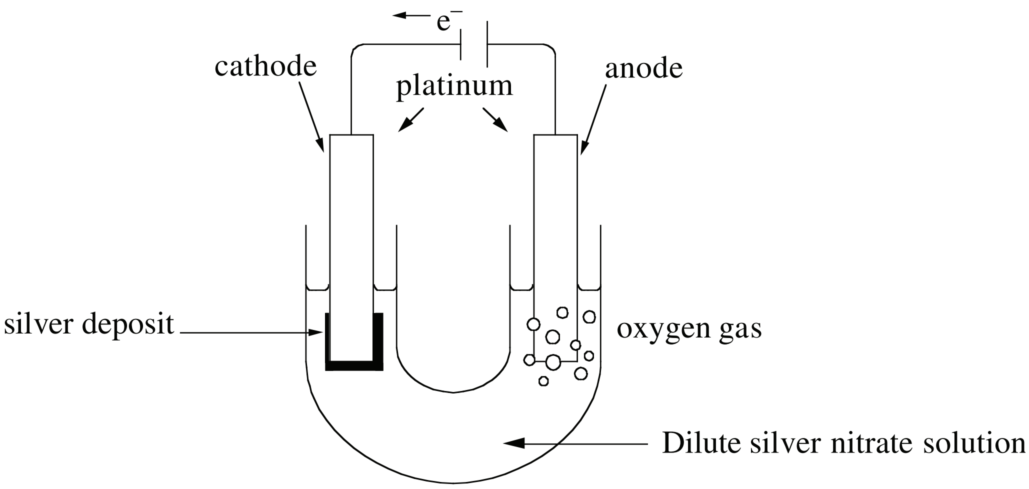
Question 30 (c) (i)

Outcomes assessed: H13

MARKING GUIDELINES

Criteria	Marks
• Draws correct cell in ONE phase with identifying labels, anode cathode, electron flow	2
• Draws correct cell in ONE phase without anode and cathode	1

Sample answer:



Question 30 (c) (ii)

Outcomes assessed: H8, H10, H13

MARKING GUIDELINES

Criteria	Marks
• Gives balanced equations at correct electrodes	2
• Gives ONE balanced equation at correct electrode OR • Gives TWO balanced equations but incorrect electrodes	1

Sample answer:

$Ag^+(aq) + e^- \rightarrow Ag(s)$ cathode

$2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$ anode

Question 30 (c) (iii)

Outcomes assessed: H8

MARKING GUIDELINES

Criteria	Marks
• Identifies FOUR factors	2
• Identifies TWO or THREE factors	1

Sample answer:

Four factors

- Concentration of silver nitrate solution
- Voltage
- Surface area of electrodes
- Separation of electrodes

Question 30 (d)

Outcomes assessed: H2, H3, H4, H5, H7, H8, H14

MARKING GUIDELINES

Criteria	Marks
• Demonstrates a thorough knowledge of the applications of chemistry, development of technology and current issues in the conservation and restoration of maritime archaeological projects • Shows how TWO identified Australian projects are different and/or similar • Provides a response that demonstrates coherence and logical progression of scientific principles and ideas	6–7
• Provides characteristics and features of TWO Australian projects • Clearly states how the chemistry is applied to the conservation of BOTH projects and shows how they are different and/or similar	4–5
• Outlines TWO Australian projects • Outlines the application of a chemical process included in conservation/restoration	2–3
• Names TWO Australian projects OR • Outlines ONE Australian project OR • Outlines the application of a chemical process in conservation/restoration OR • Names TWO chemical processes used in conversation	1

Answers could include:

The Vernon Anchors (1839) and Cook's Cannon–HMB Endeavour (1770)

Two large anchors and their timber stocks were conserved taking into consideration the nature of the materials as well as their condition. The timber stocks were chemically treated by zinc napthenate to discourage growth of micro organism causing rot. Removal in order to electrolytically conserve the iron anchors would have damaged the stocks so they were masked. The iron was blasted to remove earlier treatments and corrosion, and polished then coated with a zinc epoxy paint (both galvanic and barrier protection). The iron was in sufficiently good condition for this treatment to suffice. By contrast the much older cannon was found at depth, layered with concretions of coral. The stocks had probably long ago deteriorated. The treatment involved percussion (explosives and hammers) and the cannons were soaked in seawater and formalin (to kill micro organisms). Electrolysis in NaOH for weeks with regular solution changes/replacement as well as addition of chromate ions to form protective coating at surface (passivating). Drying and immersion in wax protects the cannons from exposure to air and water.

A diagram with relevant equations.

Question 31 (a) (i)

Outcomes assessed: H14

MARKING GUIDELINES

Criteria	Marks
• Correctly names both *X* and *Y* (words or formulae)	1

Answers could include:

X : oxygen, O_2
Y : water, H_2O

Question 31 (a) (ii)

Outcomes assessed: H14

MARKING GUIDELINES

Criteria	Marks
• Correctly names both the biological process AND the specific section outlined by the flowchart	2
• Correctly names EITHER the biological process OR the specific section outlined by the flowchart	1

Answers could include:

The biological process is aerobic cellular respiration or aerobic respiration.

The specific section outlined by the flowchart is oxidative phosphorylation or electron transport chain.

Question 31 (a) (iii)

Outcomes assessed: H7, H14

MARKING GUIDELINES

Criteria	Marks
• Identifies the role of the co-factors as electron and/or energy carriers • Uses appropriate equations to demonstrate this • Relates the hydrogen released by co-factors and electrons carried through cytochrome chain to the reduction of oxygen to form water	3
• Identifies the role of the co-factors AND EITHER • Relates their role to the formation of water via the reduction of oxygen OR • Uses ONE appropriate equation to demonstrate this	2
• Identifies the role of the co-factors OR • Relates their role to the formation of water OR • Provides relevant equation(s)	1

Sample answer:

Oxidative phosphorylation is the final process of aerobic cellular respiration. It involves the oxidation of high energy compounds $NADH + H^+$ and $FADH_2$.

$$NADH + H^+(aq) \rightarrow NAD^+ + 2H^+ + 2e^- + \text{energy}$$

$$FADH_2 \rightarrow FAD + 2H^+ + 2e^- + \text{energy}$$

The electrons released by the oxidation of these co-factors are transferred through a complex series of reactions involving cytochrome. The energy released during these processes ultimately ends up in the high-energy bonds of ATP. At the end of the cytochrome chain molecular oxygen is reduced to form water.

$$O_2(g) + 4e^- + 4H^+(aq) \rightarrow 2H_2O(l)$$

Question 31 (b) (i)

Outcomes assessed: H8, H12

MARKING GUIDELINES

Criteria	Marks
• Provides features and characteristics of a valid first-hand investigation • Identifies equipment AND reagents used	3
• Outlines a valid first-hand investigation AND EITHER • Identifies equipment used OR • Identifies reagents used	2
• Provides some steps of a valid first-and investigation OR • Identifies equipment used OR • Identifies reagents used	1

Sample answer:

Samples of liver extract containing the enzyme catalase, prepared and placed in 3 identical test tubes. One sample boiled in hot water bath, another cooled to 5°C in a refrigerator and the third incubated to 37°C.

Equal volumes of H_2O_2 (of appropriate concentration) were transferred by pipette into each of the test tubes.

The H_2O_2 decomposition to water and oxygen is accelerated by the catalase enzyme and macroscopically, a column of bubbles is produced. The height of this column of bubbles was measured in each of the three test tubes.

Question 31 (b) (ii)

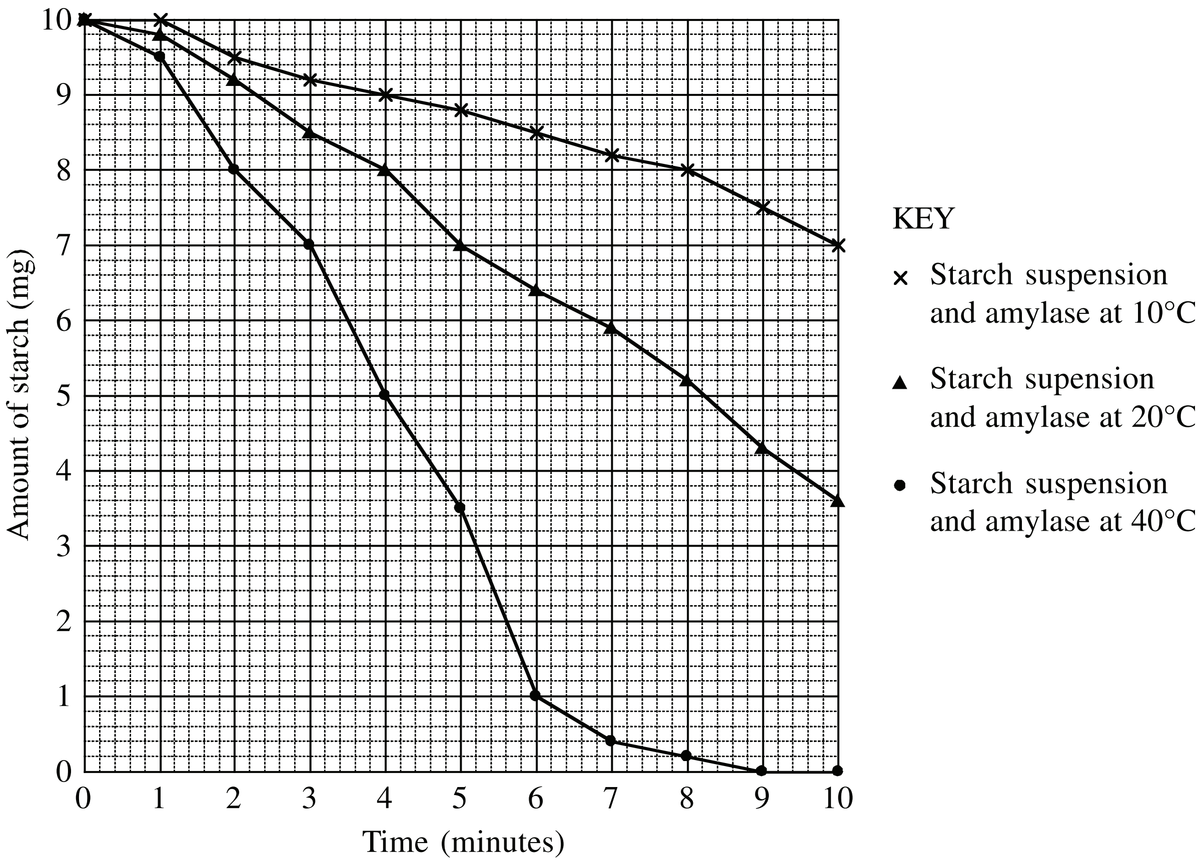
Outcomes assessed: H8, H9, H13, H14

MARKING GUIDELINES

Criteria	Marks
• Draws an appropriate graph with labelled axes • Sketches an appropriate number of trend lines for different temperature showing changes with temperature	2
• Draws an appropriate graph with labelled axes OR • Sketches an appropriate number of trend lines for different temperature showing changes with temperature	1

Answer could include:

Effect of temperature on enzyme (amylase) activity over 10 minutes



Question 31 (b) (iii)

Outcomes assessed: H9

MARKING GUIDELINES

Criteria	Marks
• Correctly names biochemical group	1

Sample answer:

Proteins

Question 31 (c) (i)

Outcomes assessed: H12

MARKING GUIDELINES

Criteria	Marks
• Names THREE nutrient groups	1

Sample answer:

Carbohydrates, proteins, fats

Question 31 (c) (ii)

Outcomes assessed: H12, H13

MARKING GUIDELINES

Criteria	Marks
• Correctly calculates total energy content of package • Compares total energy content of package to average daily requirement	2
• Correctly calculates total energy content of package OR • Compares total energy content of package to average daily requirement using incorrect energy	1

Sample answer:

Energy/100 g is 1420 kJ

Package size is 8×25 g = 200 g

Total energy content is 2×1420 kJ = 2840 kJ

To achieve average daily requirement no of packages = $\frac{8700}{2840}$

$\therefore$ 3 packages would give approximate average daily requirement = 3.063
or each packet is 1/3 of daily requirement

Question 31 (c) (iii)

Outcomes assessed: H7, H9, H14

MARKING GUIDELINES

Criteria	Marks
• Identifies carbohydrates as 80% of content of package and carbohydrates are broken down to glucose which is the major fuel for aerobic respiration • Identifies Type1 muscle as having a rich oxygen supply and undergoing aerobic respiration • Identifies link between contents of package and Type 1 muscles	3
• Identifies 80% of package is carbohydrate which is broken down to glucose • Identifies Type1 muscle undergoes aerobic respiration	2
• Identifies 80% of package is carbohydrate OR • Identifies Type 1 muscle undergoes aerobic respiration	1

Sample answer:

Type 1 muscle fibres are used in light endurance exercise. They have a rich blood supply and therefore an adequate oxygen supply for use in aerobic respiration. The content of this package is 80.8% carbohydrate which is broken down to glucose. This is the major fuel used in aerobic respiration. The contents of this package would therefore be suitable for meeting the metabolic requirements of Type1 muscle fibres.

Question 31 (d)

Outcomes assessed: H3, H7, H8, H9, H14

MARKING GUIDELINES

Criteria	Marks
• Demonstrates a thorough knowledge of applied chemistry and chemical concepts in relation to metabolic processes in different muscle and the fibres energy requirements of athletes • Shows how dietary requirements relate to the type of exercise performed (aerobic vs anaerobic) • Provides a response that demonstrates coherence and logical progression of scientific principles and ideas	6–7
• Distinguishes between aerobic and anaerobic exercise • Describes some aspects of dietary requirements of athletes • Relates dietary requirement to type of exercise • Describes type 1 and 2 muscle fibres	4–5
• Outlines aerobic and anaerobic exercise • Outlines dietary requirements of athletes • Identifies different muscle fibres	2–3
• Outlines aerobic and anaerobic exercise OR • Outlines dietary requirements of athletes OR • Outlines different muscle fibres	1

Sample answer:

Exercise is differentiated according to the way in which ATP is produced to meet the demands of the exercising muscle. Less strenuous and or extended exercise (such as long-distance jogging) is considered to be aerobic in nature, as it relies on aerobic respiration to meet energy needs. This type of exercise utilises Type 1 muscles cells that are designed to contract slowly and steadily. They have a rich blood supply which provides adequate amounts of oxygen that can be used to aerobically metabolise carbohydrate, fat and/or protein (at rest about 1/3 of the body's energy needs come from the metabolism of carbohydrates with about 2/3 being supplied by metabolism of fats). As aerobic exercise starts the metabolism of carbohydrates dominates fat metabolism, however, after a period (30 minutes) the body is again metabolising more fat than carbohydrate. Both carbohydrate and fat are important components in an athlete that uses predominately Type 1 muscle fibres.

Short term, high intensity athletic events (such as sprinting and weight lifting) utilise Type 2 muscle cells which are primarily anaerobic. Anaerobic respiration depends on the metabolism of carbohydrate in the form of available blood glucose and stored cellular glycogen. The anaerobic metabolism of this carbohydrate results in high levels of ATP (energy) over short periods of time but only for very short bursts of activity. Athletes involved in this type of activity must carbohydrate load which involves, eating large quantities of pasta, bread, fruit in the lead-up to their event.

Question 32 (a) (i)

Outcomes assessed: H6, H13

MARKING GUIDELINES

Criteria	Marks
• Gives correct electron configuration • Identifies correct block of periodic table	2
• Identifies correct block of periodic table OR • Gives correct electron configuration	1

Answers could include:

d–block

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^7$ or $[Ar]\ 4s^2\ 3d^7$

Question 32 (a) (ii)

Outcomes assessed: H6, H14

MARKING GUIDELINES

Criteria	Marks
• Relates absorbed wavelength of light to difference in energy of upper and lower energy • Relates differences in colour to the presence of different ligands • Relates observed colour to absorbed wavelength	3
• Provides TWO of THREE points from above	2
• Provides ONE of THREE points from above	1

Sample answer:

The difference in the colour of the complexes is because they are absorbing photons of different wavelengths (or energy). The energy of the absorbed photons is equal to the difference in energy between the upper and lower electron states. The $\left[CoCl_4\right]^{2-}$ complex has a smaller energy difference than $\left[Co\left(H_2O_6\right)\right]^{2+}$ and hence absorbs lower energy photons. Through the principle of complementary colours, the absorption of lower energy photons results in a blue colour. While the absorption of higher energy photons gives a red colour.

Question 32 (a) (iii)

Outcomes assessed H6

MARKING GUIDELINES

Criteria	Marks
• Gives correct reason	1

Sample answer:

Zinc solutions do not absorb visible light due zinc ions having a full d-subshell.

Question 32 (b) (i)

Outcomes assessed: H8, H12

MARKING GUIDELINES

Criteria	Marks
• Provides features and characteristics of a valid first-hand investigation • Identifies equipment AND reagents used	3
• Outlines a valid first-hand investigation AND EITHER • Identifies equipment used OR • Identifies reagents used	2
• Provides some steps of a valid first-and investigation OR • Identifies equipment used OR • Identifies reagents used	1

Sample answer:

A deep purple solution of potassium permanganate, $KMnO_4$, was added dropwise from a dropping pipette into a solution of iron(II) sulfate, $FeSO_4$, in a test tube. Upon mixing the purple colour of the $KMnO_4$ solution was lost, indicating reduction of the MnO_4^- ion, and the iron sulfate solution went green indicating that oxidation was occurring. The solutions were disposed of by pouring them into the specified waste container.

Question 32 (b) (ii)

Outcomes assessed: H8, H10, H13

MARKING GUIDELINES

Criteria	Marks
• Provides TWO correct half equations that explain observations	2
• Provides permanganate equation OR • Provides an observation of colour change	1

Answers could include:

$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$

$$\left.\begin{array}{l} Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + e^- \\ 2Br^-(aq) \rightarrow Br_2(aq) + 2e^- \end{array}\right\} \text{ } MnO_4^- \text{ purple colour decolourises to } Mn^{2+}$$

Question 32 (b) (iii)

Outcomes assessed: H6, H8, H12

MARKING GUIDELINES

Criteria	Marks
• Correctly names TWO compounds	1

Sample answer:

Potassium iodide and potassium bromide.

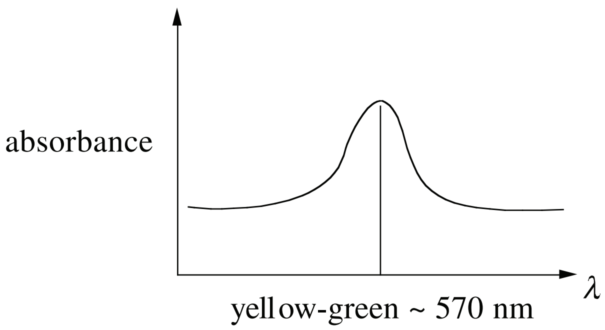
Question 32 (c) (i)

Outcomes assessed: H13

MARKING GUIDELINES

Criteria	Marks
• Produces a valid absorbance graph • Describes the principle of complementary colours	3
• Produces a valid absorbance graph • Identifies the principle of complementary colours	2
• Produces a valid absorbance graph OR • Identifies the principle of complementary colours	1

Sample answer:



A violet colour for the solution means that the complementary colour is being absorbed which is yellow-green at about 570 nm.

Question 32 (c) (ii)

Outcomes assessed: H10, H13

MARKING GUIDELINES

Criteria	Marks
• Gives correctly balanced overall equation	2
• Gives both correctly balanced half equations	1

Answers could include:

$VO_2^{+}(aq) + 4H^{+}(aq) + 3e^{-} \rightarrow V^{2+}(aq) + 2H_2O(l)$

$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^{-}$

$2VO_2^{+}(aq) + 8H^{+}(aq) + 3Zn(s) \rightarrow 2V^{2+}(aq) + 4H_2O(l) + 3Zn^{2+}(aq)$

Question 32 (c) (iii)

Outcomes assessed:H8

MARKING GUIDELINES

Criteria	Marks
• Correctly names type of reaction	1

Answers could include:

Oxidation reduction – redox reaction

Question 32 (d)

Outcomes assessed: H3, H4, H14

MARKING GUIDELINES

Criteria	Marks
• Demonstrates a thorough knowledge of the applied chemistry and use of technology in identification of pigments with respect to their historical context • States that the pigments were developed at different historical times and can be used to estimate age of art works • Provides characteristics and features of methods that chemists would use to identify pigments • Provides a response that demonstrates coherence and logical progression of scientific principles and ideas	6–7
• Provides characteristics and features of the historical context of pigments • Provides characteristics and features of the methods used to identify pigments	4–5
• Outlines TWO method used to identify pigments OR • Describes ONE method used to identify pigments • Outlines another method	2–3
• Outlines a method OR • Names a pigment	1

Answers could include:

Typical analysis methods include infrared transmission spectroscopy or infrared reflectography, ultraviolet-visible spectroscopy in reflectance mode. Laser microspectral analysis is a laser-based spectroscopic method. All rely on measuring the absorption or reflection of electromagnetic radiation.

For a 500 year old painting no synthetic pigments (eg cobalt(II) oxide, prussian blue, etc) would be present, and ancient pigments such as Naples yellow (lead(II) antimonate) may be present.

Question 33 (a) (i)

Outcomes assessed: H12

MARKING GUIDELINES

Criteria	Marks
• Names FOUR pieces of evidence	2
• Names TWO or THREE pieces of evidence	1

Sample answer:

- Blood
- Threads of cloth
- Oily patch
- Paint flakes on window glass

Collect samples of each of these

Blood, cloth to identify suspects; oil, paint to identify vehicle.

Answers could include:

Possible pieces of evidence:

- Blood
- Threads of cloth
- Fingerprints on shelves

Linked to suspect

- Head light glass
- Paint flakes on glass
- Oily patch
- Muddy tyre tracks for soil
- Muddy tyre for particles of tyre rubber

Linked to vehicle

Question 33 (a) (ii)

Outcomes assessed: H11

MARKING GUIDELINES

Criteria	Marks
• Identifies TWO appropriate instrumental techniques and relates the principle of these techniques to their application for each piece of evidence	4
• Identifies ONE appropriate instrumental technique and relates the principle of this technique to a piece of evidence • Identify another appropriate instrumental technique for a piece of evidence	3
• Identifies ONE appropriate instrumental technique and relates the principle of this technique and its application for the piece of evidence OR • Identifies TWO appropriate instrumental techniques for each piece of evidence	2
• Identifies ONE appropriate technique for a piece of evidence OR • Identifies TWO appropriate techniques and gives principle or application	1

Answers could include:

1 First item of evidence:

Analysis of oil patch sample by gas chromatograph. This chromatography relies on separation of mixture components by volatilising the mixture and passing it through a column to a detector carried by a carrier gas. The components pass through the column at different rates, so arrive at the detector separately. They are identified on the basis of retention time (maybe identified as compound using MS) and can be quantified on basis of peak height or area.

The sample chromatograph can be compared to standard oils and also to oil from a possible suspect vehicle if one is found.

2 Second item of evidence:

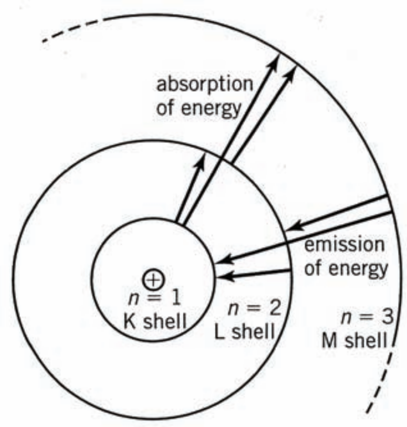
Muddy tracks – collect some of the mud and determine elemental metals composition by flame atomic absorption or emission spectroscopy. The results from the sample can be compared to standard soils or may be compared to soil collected from a suspect vehicle. Flame atomic absorption or emission spectroscopy. Sample solutions are volatilised in an air acetylene flame. In emission spectroscopy atoms of a particular element in the flame emit photons of a particular wavelength. These photons are selected and detected. The amount of light emitted is proportioned to the concentration of that element.

In absorption mode, light of a selected wavelength is shone through the flame. A portion of that light is absorbed by the element in the flame, while the remaining light is detected. The concentration of the element is proportional to the amount of absorption.

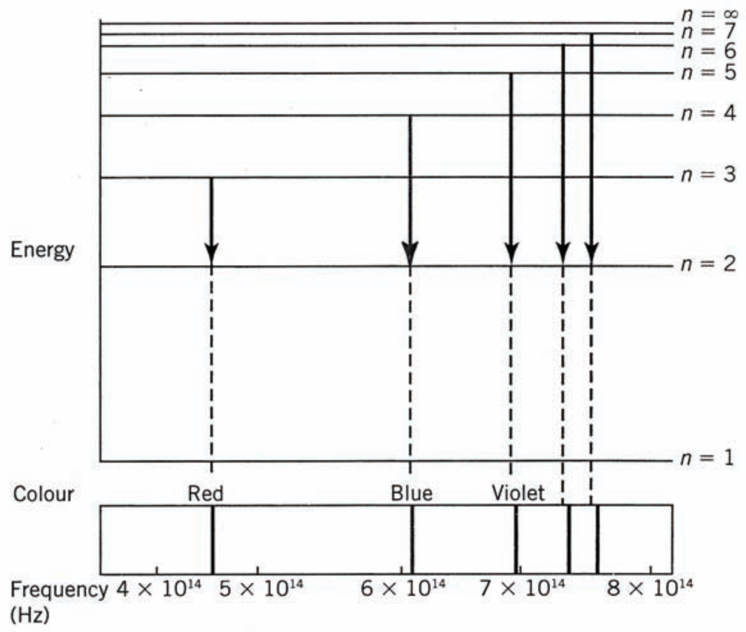
Question 33 (a) (ii) (continued)

Theory:

- Excitation of atoms allows electrons to move from ground state to a higher energy level. This excitation must be provided by an external source eg flame, electrical discharge
- Electrons can return to lower energy levels by emission of light, this light will be of a specific wavelength
- Multi electron atoms emit light at many different wavelengths, an emission spectrum
- Spectrum is element specific fingerprint



The three lowest energy orbits in the Bohr model of the hydrogen atom



Electron transitions corresponding to the visible region of the hydrogen spectrum

Examples: typically Na, Hg.

Analysis of mixtures: the line spectra of a mixture is compared to the line spectra of specific elements. The presence of an element is confirmed if the line spectra for this element is present in that of the sample. Thus species in a mixture can be identified and lead to identifying possible components of the mixture.

1. Excitation by inductively coupled plasma
2. Emitted energy is electromagnetic radiation some of which is in the visible range which we can see

Question 33 (a) (ii) (continued)

- Blood DNA fingerprint to identify suspects
  - based on electrophoresis: separation of DNA fragments relying on variable rates of migration to these fragments in an electric field. Detection by staining.

- Paint flakes – analysis by gas chromatography to give comparison to:
  - manufacturers' paints
  - suspect's vehicle

  G.C. analysis of mixture

  Also possible AAS analysis of inorganic component of paint – binders and fillers or inorganic pigments.

- Glass – analysis for metal elemental composition for comparison to manufacturer's standards or comparison to suspect vehicle. Analysis by AAS.

Question 33 (b) (i)

Outcomes assessed: H8, H12

MARKING GUIDELINES

Criteria	Marks
• Provides features and characteristics of a valid first-hand investigation • Identifies equipment AND reagents used	3
• Outlines a valid first-hand investigation AND EITHER • Identifies equipment used OR • Identifies reagents used	2
• Provides some steps of a valid first-hand investigation OR • Identifies equipment used OR • Identifies reagents used	1

Sample answer:

- 10% sugar solutions were made up for glucose, fructose, maltose, galactose and sucrose.
- 5 mL samples of these solutions were placed in clean test tubes.
- 1 mL Tollens Reagent was added to each.
- Each sample was gently heated in a boiling water bath on a Bunsen flame.
- The reaction was observed and recorded.
- Formation of a silver surface indicated a reducing sugar.

Answers could include:

- Sugar solutions were provided.
- Heating by hot plate a beaker of hot water instead of Bunsen flame.
- Fehling's solution results in brick red precipitate of Cu_2O as positive test for reducing sugars.
- Benedict's solution as Fehling's above.

Question 33 (b) (ii)

Outcomes assessed: H9

MARKING GUIDELINES

Criteria	Marks
• Gives reasons for the chemical differences between reducing and non-reducing sugars • Identify the reagent (Ag^+ or Cu^{2+}) as being reduced to give positive test	2
• Either of the above	1

Answers could include:

The result of the experiment was that of the five sugars tested, only sucrose gave a negative test. Only sucrose did not reduce Tollens' reagent giving no silver mirror.

Sugars are termed reducing if Ag^+ (Tollens' Reagent) or Cu^{2+} (Benedict's or Fehling's) are reduced. The sugar thus contains a carbonyl group in the ring open form, which can be oxidised. All of glucose, fructose, maltose and galactose can be oxidised. In contrast sucrose does not form an open chain structure with carbonyl present.

Question 33 (b) (iii)

Outcomes assessed: H9, H11

MARKING GUIDELINES

Criteria	Marks
• Correctly identifies an alternative method to the ONE described in part (b) (ii)	1

Sample answer:

HPLC

Question 33 (c) (i)

Outcomes assessed: H12, H14

MARKING GUIDELINES

Criteria	Marks
• Correctly names steroid	1

Sample answer:

Stanozolol

Question 33 (c) (ii)

Outcomes assessed: H14

MARKING GUIDELINES

Criteria	Marks
• Identifies compounds of low volatility will not be vaporised in GC, so HPLC needed • Identifies compounds which are thermally unstable will decompose in GC, so HPLC needed	2
• Gives a reason why HPLC is preferred method	1

Sample answer:

HPLC is usually performed at room temperature and can be used for a wide variety of substances. GC is usually performed at elevated temperatures and also has very wide applications.

The choice of method is limited by the thermal properties of the samples and compounds to be analysed. HPLC is the method of choice for substances that are difficult to volatilise, especially biological compounds such as sugars, fats, peptides and fatty acids. These compounds can be carried through a column in solution, but not easily in the gas phase. Substances need to vaporise below 250°C. HPLC is also the method of choice for substances that are thermally unstable.

Question 33 (c) (iii)

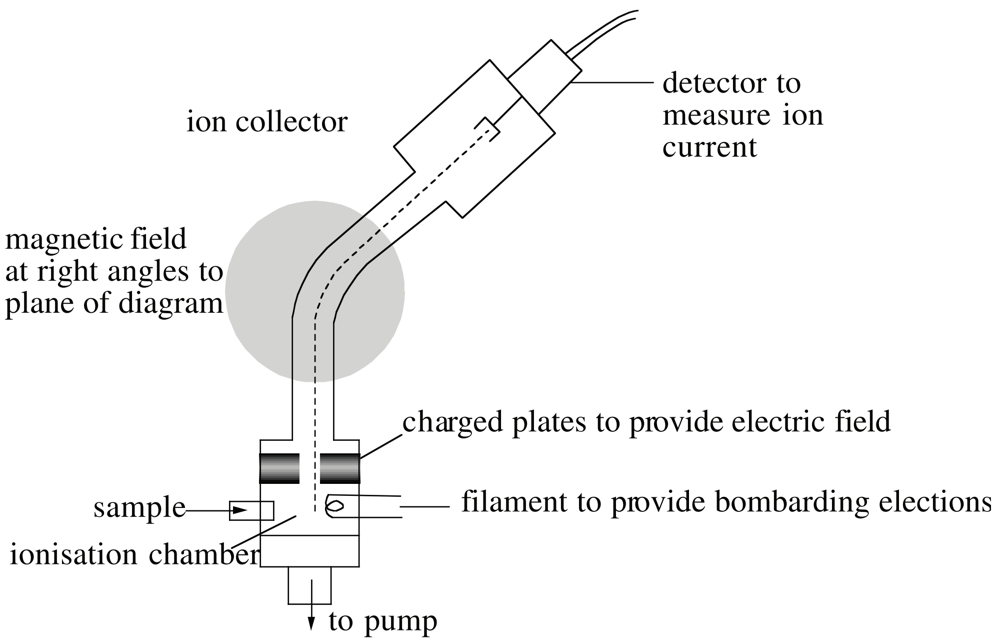
Outcomes assessed: H3, H13

MARKING GUIDELINES

Criteria	Marks
• Provides a well labelled diagram • States principle of operation	3
• ONE of the above OR • Outline of principle of operation AND provides an incomplete diagram	2
• Outlines principle OR • Provides an incomplete diagram	1

Answers could include:

See diagram attached. In the mass spectrometer a sample is vaporised and passed to an ionisation chamber where the particles are bombarded with high-energy electrons. The resulting negative charged ions are discarded, and the positive ions are then passed through an electric field where they are accelerated. The ions then pass through a magnetic field. The ions are forced into a curved path in the magnetic field, the radius of curvature is determined by the mass/charge ratio of each ion. Thus they are separated. The magnetic field strength is varied, so that ions of different charge/mass ration are separately directed to the detector and detected in turn. The spectrum includes fragments of large molecules that are fragmented by the initial bombardment by electrons. Fragmentation patterns provide information about the compound.



Question 33 (d)

Outcomes assessed: H3,H14

MARKING GUIDELINES

Criteria	Marks
• Demonstrates a thorough knowledge of the scientific principles and theory behind emission spectra • Describes the features that make emission spectra useful in determination of components in a mixture • Provides an appropriate example of suitable component typically Na, K, Ca, Cu, Hg • Provides a response that demonstrates coherence and logical progression of scientific principles and ideas	6–7
• Outlines the scientific principles and theory behind mission spectra • Describes some features that make emission spectra useful in determination of components in a mixture • Provides an appropriate example of suitable component typically Na, K, Ca, Cu, Hg	4–5
• Identifies a component of the theory • Outlines the way which emission spectra can be used for identification • Provides an example – typically Na, K, Ca, Cu, Hg	2–3
• Identifies a component of the theory OR • Provides an example of component OR • Provides an outline of use of emission spectra	1