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HSC Trial Examination

Chemistry 2001

This paper must be kept under strict security and may only be used on or after the morning of Tuesday 14 August, 2001, as specified in the NEAP Examination Timetable

General Instructions

Reading time 5 minutes

Working time 3 hours

Board-approved calculators may be used.

Write using blue or black pen.

Draw diagrams using pencil.

A Data Sheet and a Periodic Table are provided at the back of this paper.

Examination structure

Section I Pages 2–19 Total marks 75

This section has two parts, Part A and Part B

Part A Total marks (15)
Attempt Questions 1–15.
Allow about 30 minutes for this part.

Part B Total marks (60)
Attempt Questions 16–28.
Allow about 1 hour and 45 minutes for this part

Section II Pages 20–30 Total marks 25

Attempt ONE question from Questions 29–33.
Allow about 45 minutes for this section.

Section I

Total marks 75

Part A

Total marks 15
Attempt Questions 1–15.
Allow about 30 minutes for this part.

Use the multiple-choice answer sheet.
Select the alternative A, B, C, or D that best answers the question.

Use the multiple-choice answer sheet.
Select the alternative A, B, C, or D that best answers the question. Fill in the response oval completely.

Sample $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ✕ C ○ D ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and draw an arrow as follows:

correct ←

A ✕ B ✕ C ○ D ○

4. The teacher then made three statements.

   (i) The acid is a weak acid after it is diluted but a strong acid before dilution.

   (ii) The concentrated HCl needs more moles of NaOH for complete reaction than the dilute solution.

   (iii) Great care should be taken when diluting the concentrated acid.

   Which of the following is true?

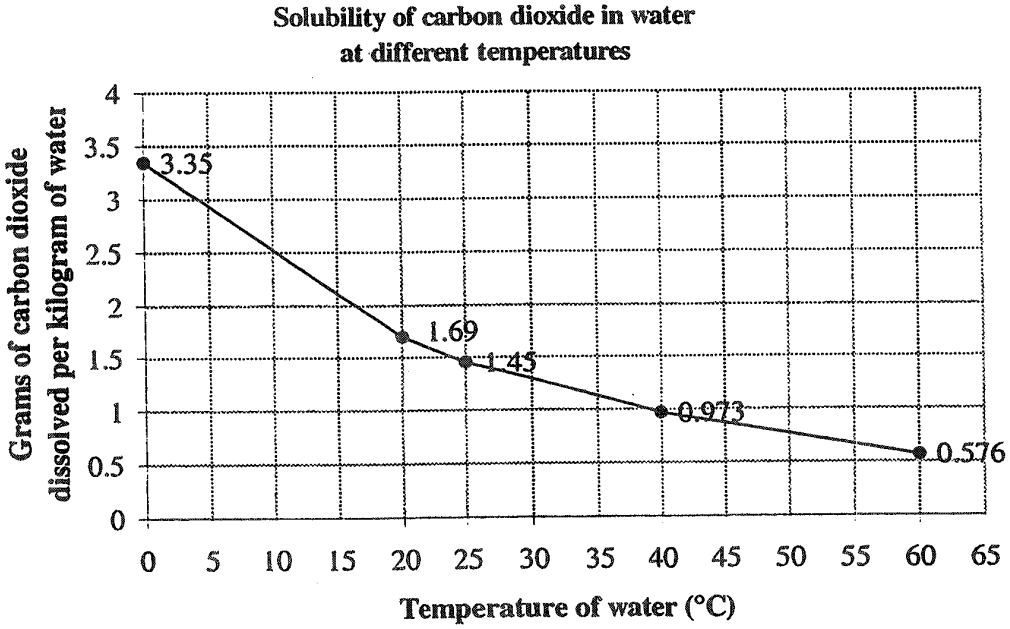
   (A) (i) and (ii) are both correct statements.

   (B) (i) and (iii) are both correct statements.

   (C) (iii) is a correct statement.

   (D) (i), (ii) and (iii) are correct statements.

5. The solubility of carbon dioxide gas in water varies at different temperatures as shown in the following graph.



   From this graph we can conclude that

   (A) the temperature of the water is dependent on the amount of carbon dioxide dissolved in it.

   (B) the dissolution of carbon dioxide is exothermic.

   (C) the ratio of carbon dioxide dissolved:mass of water can be increased by using more water.

   (D) the solubility of carbon dioxide in water is unaffected by Le Chatelier's principle.

6. Which of the following equations could represent the formation of a transuranic element in a nuclear reactor?

   (A) $^{238}_{92}U + {}^{4}_{2}He \rightarrow {}^{239}_{94}Pu + 3{}^{1}_{0}n$

   (B) $^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He$

   (C) $^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{3}_{1}H + {}^{1}_{1}H$

   (D) $^{1}_{0}n + {}^{238}_{92}U \rightarrow {}^{88}_{38}Sr + {}^{136}_{54}Xe + 12{}^{1}_{0}n$

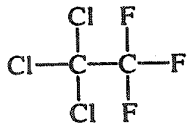
7. A student performed an experiment using 4 different metals known to her only as metals "W", "Y" and "Z" (not their real symbols). Each metal was placed into a solution which contained ic one of the other metals. The student tabulated the results of the experiment as follows:

	Solution of W ions	*Solution of X ions*	*Solution of Y ions*	*Solution of Z ions*
W placed into	no visible change	W dissolved; X produced	W dissolved; Y produced	W dissolved; Z produced
X placed into	no visible change	no visible change	no visible change	X dissolved; Z produced
Y placed into	no visible change	Y dissolved; X produced	no visible change	Y dissolved; Z produced
Z placed into	no visible change	no visible change	no visible change	no visible chan

From the table of results, which of the following correctly places the metals in order of incr relative activity?

(A) W Y X Z
(B) X W Y Z
(C) Z Y X W
(D) Z X Y W

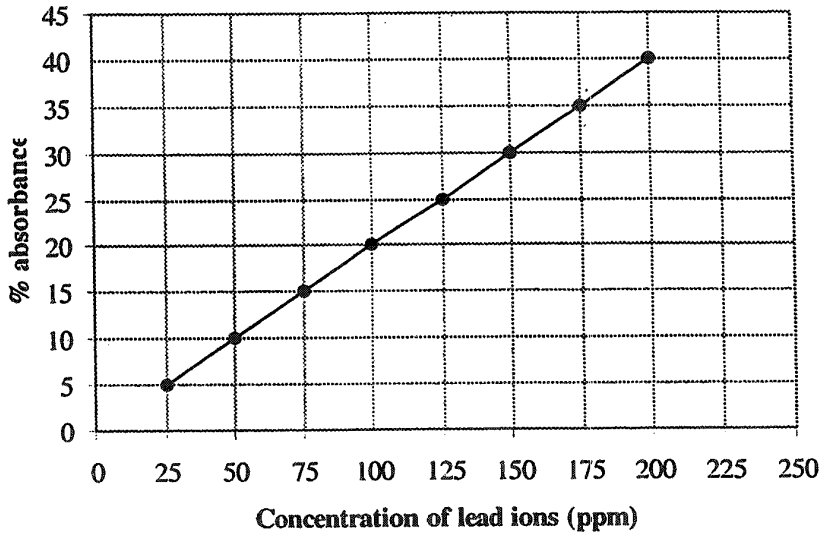
8. The molecular structure of the compound known as Freon-113 can be represented by the fol diagram.



An isomer of Freon-113 would be

(A) 1,2,3-trichloro-1,2,3-trifluoroethane
(B) 1,1,1-trichloro-2,2,2-trifluoroethane
(C) 1,1,2-trichloro-1,2,2-trifluorethane
(D) 1,2,2-trichloro-1,2,2-trifluorethane

13. The graph below shows the results of atomic absorption spectroscopy (AAS) of a number of stand lead ion, Pb^{2+}, solutions.



A sample of river water was analysed using AAS to determine its lead ion concentration. It was fo to have an absorbance of 33%. The concentration of lead ions in the water is

(A) 100 ppm
(B) 145 ppm
(C) 165 ppm
(D) 185 ppm

14. The composition of dry air by volume includes 0.0005% helium and 0.0001% krypton. These va can also be represented respectively as

(A) 0.0005 parts per million (ppm) and 0.0001 ppm
(B) 0.0005 g and 0.0001 g
(C) 5 parts per million (ppm) and 1 ppm
(D) 5 g and 1 g

15. The greatest change in oxidation state occurs when

(A) copper oxidises to copper(I)
(B) copper(I) oxidises to copper(II)
(C) copper(I) reduces to copper(II)
(D) copper(II) reduces to copper

Part B

Total marks 60
Attempt Questions 16–28.
Allow about 1 hour and 45 minutes for this part.

Answer Part B questions in the spaces provided.
Show all relevant working in questions that require calculations.

Marks

Question 16 (4 marks)

Water self-ionises slightly to produce hydronium and hydroxide ions. 4

Compare the Lowry-Bronsted and Lewis acid-base theories, using the above example to illustrate your answer.

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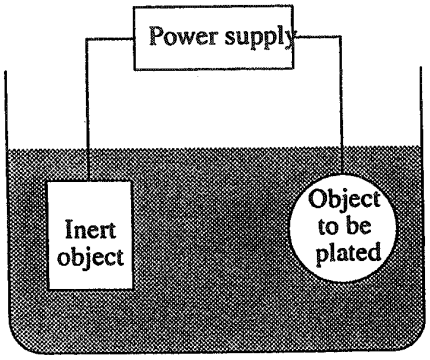
Question 17 (2 marks)

Electroplating is a process common in industry. An example of this process is shown in the diagram below.



In the case of chrome plating, an acidic dichromate solution is used as the electrolyte. The chromium is produced as shown in the following half equation:

$$Cr_2O_7^{2-}{}_{(aq)} + 14H^+{}_{(aq)} + 12e^- \rightarrow 2Cr_{(s)} + 7H_2O_{(l)}$$

(a) Is the item to be plated at the anode or at the cathode? Explain your reasoning. 1

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(b) Describe the benefits of electroplating. 1

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Marks

Question 18 (5 marks)

Spider silk is a biopolymer. It is made of organic acids linked to form silk fibres. A synthetic version of silk has been developed by using genetically modified goats to produce milk containing the same organic acids as in spider's silk. The acids are isolated and are used to produce the silk.

(a) Identify a different biopolymer that is used industrially and the enzyme or organism used to synthesise the material. 2

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(b) Clarify the need for the development of industrial biopolymers. Assess their impact on society and the environment. 3

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Question 19 (3 marks)

Fractional distillation of crude oil does not provide enough suitable hydrocarbons to meet the demand for petrol. Catalytic cracking is used to increase the yield. 3

Describe the process of catalytic cracking.

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Marks

Question 20 (2 marks)

A student is given two test tubes during a practical lesson. He is told that one test tube contains hexane while the other contains 1-hexene. The student is asked to use a chemical test which can identify the chemicals. The student decides to use bromine water in his test.

(a) The student adds some bromine water to each test tube and mixes each thoroughly. What are his observations for each test tube? 1

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(b) How does the student use these results to identify the chemicals? 1

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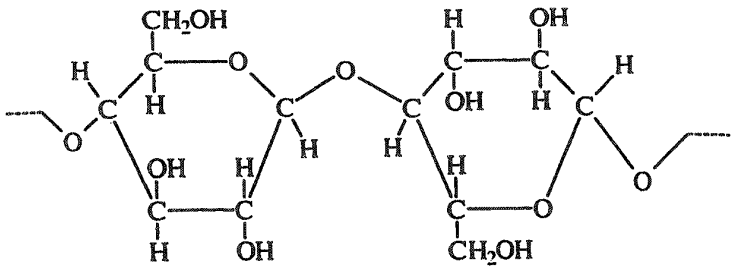
Question 21 (5 marks)

Cellulose is an example of a natural biopolymer produced by condensation. Molecules of glucose ($C_6H_{12}O_6$) join together to form this complex molecule. A section of its structure is shown in the following diagram.



(a) Cellulose is a major component of biomass. What does the term biomass mean? 1

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(b) The production of cellulose from glucose produces another product. What is the name of this second product? 1

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Marks

Question 21 (Continued)

(c) Discuss the potential of cellulose as a raw material in the production of petrochemicals. 3

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Question 22 (5 marks)

(a) Write a balanced equation for the complete combustion of ethanol. 1

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(b) Incomplete combustion of petrol (which can be considered to be mainly octane, C_8H_{18}) produces significant pollutants.

(i) Identify the pollutants. 1

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(ii) Explain why ethanol can be regarded as being less polluting than petrol. 1

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(c) Ethanol is widely used as a solvent. Discuss how it is effective in this use based on its molecular structure. 2

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Marks

Question 23 (4 marks)

A student was asked to analyse the concentration of nitrogen in a fertiliser. In this particular fertiliser the nitrogen was present in the form of ammonium sulfate, $(NH_4)_2SO_4$. She decided to precipitate the sulfate from solution using an excess solution of barium nitrate, $Ba(NO_3)_2$, and then use the mass of the precipitate formed to determine the concentration of the nitrogen.

$$Ba^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow BaSO_{4(s)}$$

She tabulated the results of her experiment as follows:

Mass of fertiliser used = 11.35 g
Mass of barium sulfate precipitated = 1.45 g

(a) Determine the number of moles of barium sulfate formed in the precipitation. 1

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(b) Hence determine the amount of nitrogen in the fertiliser sample. 1

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(c) Calculate the percentage nitrogen by mass in the fertiliser. 1

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(d) Explain why it is necessary to monitor the amount of nitrogen present in fertilisers. 1

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Marks

Question 24 (6 marks)

Scientific evidence suggests that nitrogen oxide emissions from supersonic aircraft which fly in the stratosphere can reduce the concentration of ozone. Similar conclusions have been drawn regarding chlorofluorocarbons (CFC) emission.

(a) Identify two possible sources of CFCs in the atmosphere. 2

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(b) Describe the function of ozone in the upper atmosphere and the benefits it provides. 2

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(c) Discuss the problems associated with the use of CFCs in respect to the concentration of ozone in the upper atmosphere. 2

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Marks

Question 25 (10 marks)

In the "Annual Environment and Public Health Report (2000)" released by Sydney Water, monitoring sites along the Hawkesbury-Nepean Rivers were rated as being "poor" or "very poor" in terms of their protection from eutrophication. It had been noted on the report that there were a number of algal blooms in areas of the river.

(a) Define the term *eutrophication* and identify two causes. 3

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(b) Discuss the relative importance of the tests used to determine if eutrophication is present in waterways. 3

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(c) Critically analyse the effects of eutrophication on living things in the waterways. 4

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Marks

Question 26 (3 marks)

When a mixture of 1 mol $N_{2(g)}$ and 3 mol $H_{2(g)}$ are brought to equilibrium over a catalyst at 500°C and 1013 kPa, the mixture reacts to form ammonia as shown in the following equation:

$$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)} \qquad \Delta H = -92 \text{ kJ}$$

The yield is small under these conditions; only about 2.5% of the reactants are converted.

(a) Explain how the following conditions can be changed to produce a greater yield in terms of Le Chatelier's principle: 2

- Temperature
- Pressure

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(b) In the industrial manufacture of ammonia, the use of high temperatures is still maintained. Explain why this is the case. 1

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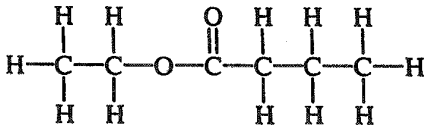
Question 27 (5 marks)

Marks

A compound "X" has a boiling point of 163°C. A compound "Y" has a boiling point of 78°C. When "X" and "Y" were reacted together, they formed a compound with the following structural formula.



(a) Draw and name X . Justify your choice. 2

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(b) Describe the process you would follow in a school laboratory to carry out this reaction. As part of your response use a well-labelled diagram to identify the equipment required. 3

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Marks

Question 28 (6 marks)

As a major practical task a student was set three tasks:

- Prepare a standard solution from a primary standard.
- Use this standard to determine the concentration of a hydrochloric acid solution
- Use the hydrochloric acid solution to determine the amount of citric acid in a sample of lime juice.

(a) Name a specific primary standard and outline the characteristics which make its use suitable. 2

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(b) The HCl solution was standardised and found to have a concentration of 0.608 mol L^{-1}. The student then determined the amount of citric acid in a sample of lime juice, using the method shown below. 4

A sodium hydroxide solution was standardised against the hydrochloric acid and found to have a concentration of 0.075 mol L^{-1}. A 25 mL sample of lime juice was diluted to 250 mL and 25 mL aliquots of the diluted sample were titrated with the sodium hydroxide to determine how much citric acid was present. The reaction was:

$$C_6H_8O_7 + 3NaOH \rightarrow C_6H_5O_7Na_3 + 3H_2O$$

Given that the average amount of NaOH used was 40.0 mL, calculate the concentration of citric acid in the original lime juice, as %(w/v).

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Section II

Total 25 Marks
Attempt ONE question from Questions 29–33.
Allow about 45 minutes for this section.
Answer the question in a writing booklet. Extra writing booklets are available.

Marks

Question 29 — Industrial Chemistry (25 marks)

(a) In the story of the Phantom of the Opera, the face of the lead character was horribly disfigured by sulfuric acid, which is why he wears a mask.

(i) This is an example of sulfuric acid acting as a dehydrating agent. Write a suitable equation illustrating this property of sulfuric acid. 1

(ii) Describe the safety precautions that you would take if you needed to dilute concentrated sulfuric acid. 2

(b) Most modern cleansers, such as shampoos and detergents, have the word biodegradable on their bottle. Many claim to be phosphate free. Explain why the manufacturers go to the trouble of making these claims. 2

(c) Sulfuric acid is capable of acting in a range of reactions. For each of the equations below, describe the appropriate chemical property of sulfuric acid.

(i) $Ba(NO_3)_{2(aq)} + H_2SO_{4(aq)} \rightarrow BaSO_{4(s)} + 2HNO_{3(aq)}$ 1

(ii) $Sn_{(s)} + 2H_2SO_{4(aq)} \rightarrow SnSO_{4(s)} + SO_{2(g)} + 2H_2O_{(l)}$ 1

(iii) $H_2SO_{4(aq)} + 2H_2O_{(l)} \rightarrow 2H_3O^+_{(aq)} + SO_4^{2-}{}_{(aq)}$ 1

(d) In the Haber process, a ratio of 3:1 of hydrogen and nitrogen are mixed and passed over an iron oxide catalyst at a pressure of 300 atmospheres and a temperature of about 450°C. The reaction temperature is usually referred to as a compromise. 4

$$3H_{2(g)} + N_{2(g)} \rightleftharpoons 2NH_{3(g)} \qquad \Delta H = -92 \text{ kJ}$$

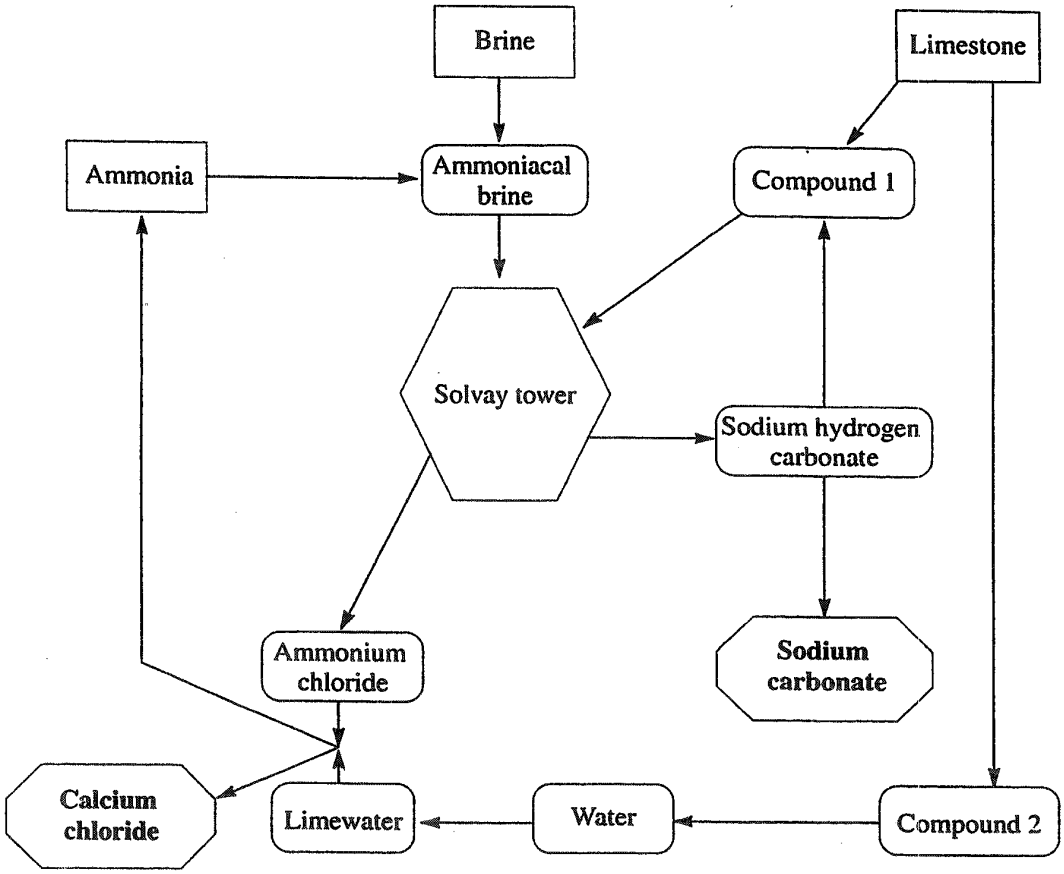
The ammonia produced is liquefied by the high pressure and is removed. Unreacted hydrogen and nitrogen are recycled.

Using your knowledge of equilibrium theory and of rates, explain why each of the reaction conditions of temperature, pressure and a catalyst are used and name any one other factor that may improve the yield of ammonia.

Question 29 (Continued)

Marks

(e) The Solvay process uses salt, limestone and ammonia to produce sodium carbonate. The process is represented in the diagram below.



(i) Write an equation to show how Compound 1 and Compound 2 are produced from limestone. 1

(ii) Write an equation showing how Compound 1 is also produced as a byproduct of the production of sodium carbonate. 1

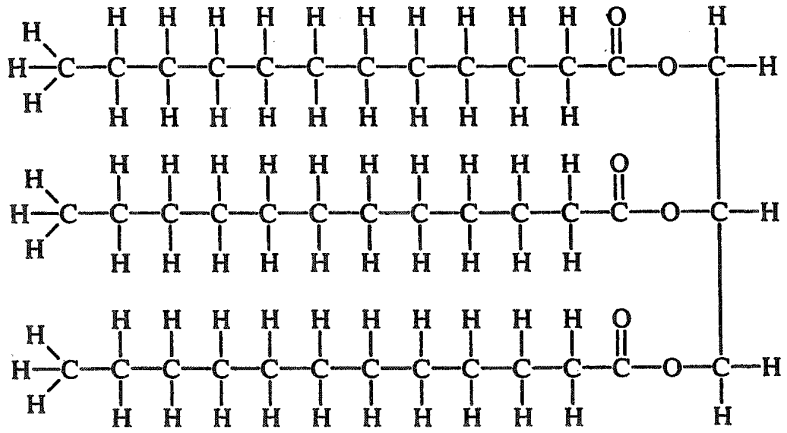
(iii) 1. Write an equation for the reaction occurring within the Solvay tower. 1

2. Calculate the minimum mass of ammoniacal brine containing 7% ammonia (w/w) necessary to produce 200 kg of sodium hydrogen carbonate. 3

Marks

Question 29 (Continued)

(f) Many natural substances contain long chain fatty acids often in the form of triglycerides. Coconut oil contains approximately 50% lauric acid $CH_3(CH_2)_{10}COOH$ as triglycerides.



(i) Explain in words how a soap may be produced by the saponification of a triglyceride. 2

(ii) Explain how the soap can clean grease from a surface. 2

(g) Three different electrolytic cells have been used in the commercial production of sodium hydroxide.

Describe the use of these cells with reference to the following points:

(i) Explain why energy is required to produce the sodium hydroxide. 1

(ii) Give a general overview of the cell design, commenting on any design features. 1

(iii) The environmental advantages and or disadvantages of one of the cells. 1

Question 30 — Shipwrecks and Salvage (25 marks) Marks

(a) A student was asked to make a prediction about the corrosion of shipwrecks found at different ocean depths. She believed that corrosion would be considerably greater in shallow water. She based her reasoning on the following assumptions:

- the rate of reaction is proportional to temperature
- concentration of dissolved oxygen decreases with added pressure

(i) Explain how the student's first assumption can be related to the depth of the water. 1

(ii) With reference to Le Chatelier's principle and the use of an equation, explain how the student's assumption about dissolved oxygen concentration is incorrect. 2

(iii) Dissolved oxygen levels achieve minimum values between depths of around 500 to 1000 m. However the corrosion of shipwrecks still continues by the action of anaerobic bacteria.

1. Give one reason why oxygen depletion can occur at such great depths. 1

2. Define the term "anaerobic". 1

3. Explain how anaerobic bacteria can cause this corrosion to accelerate at these great depths. 1

(b) The following table compares the composition and properties of iron and steel.

Substance	*Composition*	*Properties*
Pure iron	100% Fe	Malleable, corrodes slowly
Cast iron	4% C, 1% Mn, 1% Si, 94% Fe	Hard, brittle, corrodes easily
Structural steel	0.5% C, 99.5% Fe	Hard, malleable, corrodes easily
Stainless steel	15% Cr, 10% Ni, 75% Fe	Hard, resistant to corrosion

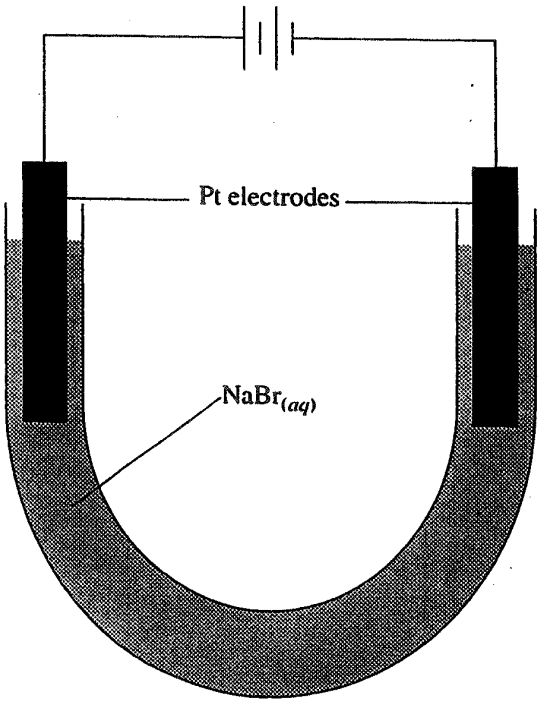
The corrosion of steel is dependent on its composition.

(i) You have performed a first hand investigation in which you compared the rate of corrosion of pure iron and an identified form of steel. Describe how you performed this experiment. Identify the factors that needed to be considered during this investigation to ensure that the result produced a fair comparison in the rate of corrosion between the two substances. 2

(ii) Account for the difference in corrosion of active and passivating metals. 2

Question 30 (Continued) Marks

(c) An experiment is set up using the following equipment.



The electrodes were connected to an external power source. Once the current had flowed for a few minutes, small bubbles formed in the solution near one electrode. Around the other electrode, a brown colour appeared in the solution.

(i) Write a half equation which represents the formation of the brown substance in the solution. 1

(ii) Is the formation of the brown substance occurring at the anode or the cathode? Explain your reasoning. 2

(iii) Write a half equation which represents the formation of the bubbles in the solution 1

(d) Draw a fully labelled diagram showing how you would determine the standard potential of a cell made from $Sn_{(s)}|Sn^{2+}_{(aq)}$ and $Pb_{(s)}|Pb^{2+}_{(aq)}$. On your diagram include the direction of movement of all charged particles as well as half equations at the specified electrodes. 6

(e) Various methods can be used to protect the hulls of ships from corrosion. Outline two such methods and how they work to prevent corrosion. 4

(f) A common problem that occurs in shipwrecked artefacts is that they become saturated with chloride ions due to their long period in sea water. The removal of an artefact from sea water can eventually ruin it. 1

Describe the changes that occur to a wooden, leather or textile artefact if it is removed from salt-saturated water and allowed to dry.

Question 31 — Biochemistry of Movement (25 marks)

Marks

(a) Glycolysis is the first stage of respiration.

(i) Identify the site of glycolysis. 1

(ii) Name the end products of glycolysis produced from 1 molecule of glucose. 1

(iii) Analyse the role of fats in the supply of fuels for exercising athletes. 2

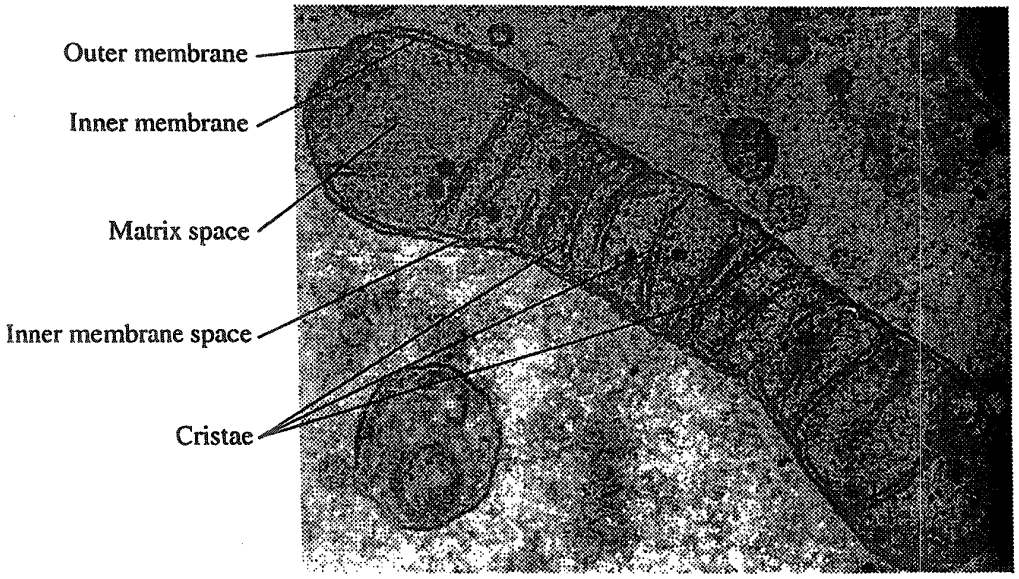
(b) The production of energy in the TCA (Tricarboxylic Acid) Cycle can be considered as an oxidation-reduction process.

(i) Identify the substance oxidised and the product of oxidation. 1

(ii) Identify the substances which are reduced and the products of reduction. 1

(iii) The reduced products of the TCA Cycle are then oxidised to produce ATP. Summarise the reactions involved in oxidative phosphorylation. 4

(iv) Use the electron micrograph below to describe where the TCA Cycle and oxidative phosphorylation occur. 2



(c) Enzymes catalyse the reactions of the TCA cycle other reactions in the body.

(i) Name and draw the general structure of the chemical unit that makes up enzymes. Identify the major functional groups of the molecule. 2

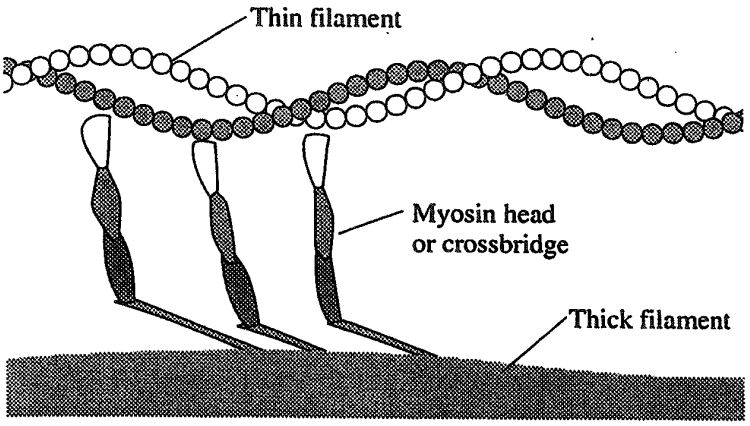
(ii) Account for the formation of substrate specific binding sites of enzymes in terms of the forces or bonds involved. 3

(d) Athletes achieve high heart rates and sweat when they exercise. Analyse the significance of both of these physiological activities to the exercising athlete. 2

Marks

Question 31 (Continued)

(e) The diagram below is a model of muscle contraction.



(i) Analyse the diagram and outline the processes involved in muscle contraction. 2

(ii) Sprinting athletes, such as 100 m runners, maintain their top speed for short periods. Marathon runners can maintain relatively high speeds over long periods. What differences would you expect in the muscle structure and anatomy of marathon runners that could account for their speed and endurance? 2

(iii) Explain how the sprinting athlete solves the problems of supply and use of fuels during exercise. Critically evaluate any disadvantages to the athlete. 2

Question 32 — Chemistry of Art (25 marks)

Marks

(a) (i) Explain the positions of nickel and aluminium on the periodic table in terms of their electron structures. 2

(ii) Nickel(II) salts are coloured solids which form coloured solutions but Al^{3+} salts are white solids which give colourless solutions. Explain why this occurs. 3

(b) Chelating agents are used to form large complex ions which carry out specific functions. Name a chelating agent, briefly describe what chelating is and give a specific use of chelating agents. 5

(c) Describe the two main components of a paint. Compare how these have changed over time, using two different examples, one of which must relate to Aboriginal art. 5

(d) A major problem faced by collectors of art is that the paintings they buy might be forgeries. Discuss how two of the following methods are used to determine if artworks are genuine, giving appropriate examples. 6

– reflectance spectra

– UV spectra

– atomic force microscopy

(e) (i) Identify the oxidising agent in the following equation, giving reasons. 2

$$2MnO_{2(s)} + O_{2(g)} + 4KOH_{(s)} \rightarrow 2K_2MnO_{4(s)} + 2H_2O_{(g)}$$

(ii) The dichromate ion, $Cr_2O_7^{2-}$, is classified as a strong oxidant. Why is $Cr_2O_7^{2-}$ a stronger oxidant than Fe^{2+}? 2

Marks

Question 33 — Forensic Chemistry (25 marks)

(a) A sample obtained at the scene of a crime is found to contain a compound, Compound R, with the formula $C_7H_{14}O_6$. Compound R is a non-reducing sugar. It is hydrolysed by aqueous HCl to a new compound, Compound T, with the formula $C_6H_{12}O_6$. Compound T is a reducing sugar. A new compound, Compound U is produced.

(i) Write a balanced chemical equation showing the hydrolysis of Compound R — 2

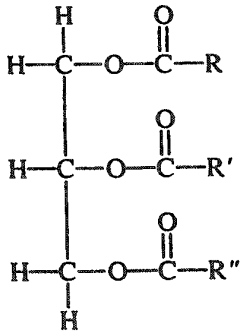
(ii) Describe a test that reveals the presence of a reducing sugar. — 2

(iii) Draw possible structural formulae for Compounds R and T. — 2

(iv) Name Compound T. — 1

(v) What conclusion could you draw about the origin of the initial sample containing Compound R? — 1

(b) The general formula for a fat, or glyceride, is shown below.



(R, R′, R″ are fatty acid residues)

Trimyristin is a white crystalline fat, or triglyceride, that can be obtained from nutmeg. In order to confirm the presence of trimyristin, a forensic chemist performed a chemical test. It involved hydrolysis of the fat sample with concentrated sodium hydroxide and analysis of the products. The sodium salt of only one fatty acid, tetradecanoic acid (common name: myristic acid), is formed.

(i) Write the chemical formula for the fatty acid product of the hydrolysis of trimyristin. — 1

(ii) Name the other substance formed from the hydrolysis of a fat, or glyceride, such as trimyristin? — 1

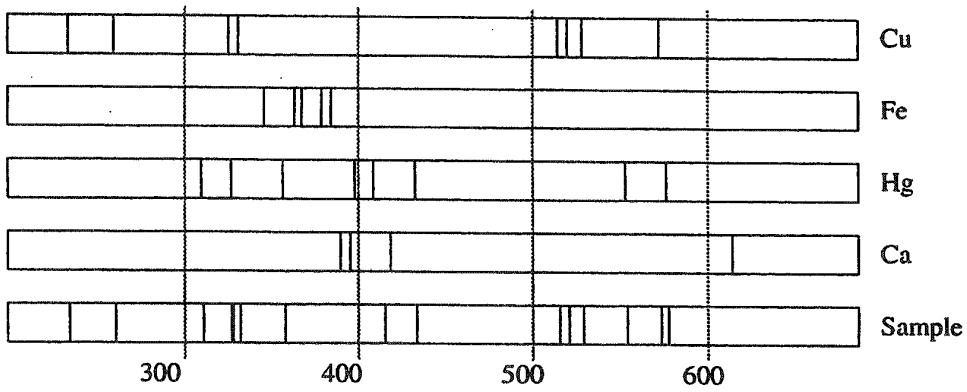
(iii) Describe the diagnostic test to confirm the presence of the substance named in (ii). — 2

(iv) What is likely to be the main difference between trimyristin and a fat obtained from an animal? — 1

Question 33 (Continued) Marks

(c) The possible origins, along with the major mineral compositions, of a soil sample found with an illegal shipment of endangered lizards are outlined below. In order to confirm the origin of the sample, a forensic chemist performed atomic emission analysis. The amount of sample available for analysis was very small.

Possible origin	*Minerals present*	*Chemical composition of mineral*
Site A	haematite malachite	Fe_2O_3 $CuCO_3.Cu(OH)_2$
Site B	cinnabar azurite	HgS $CuCO_3.Cu(OH)_2$
Site C	calcite cuprite	$CaCO_3$ Cu_2O



(i) Name ONE other method of analysing small samples. 1

(ii) Describe a situation, giving an example, where the destructive testing might be a problem in forensic analysis. 1

(iii) Outline the conditions necessary for elements to emit light. 2

(iv) Explain why each element has a signature line emission spectrum. 1

(v) Use the emission spectra obtained from the soil sample and the reference spectra to identify the origin of the sample. 1

(d) Blood stains were found on the clothes of a murder suspect. Blood contains globular proteins. Proteins can be described as long chains of amino acids. An identification of the amino acid composition of the proteins was performed. A DNA "fingerprint" was obtained.

(i) Describe a chemical test used to confirm the presence of protein material. 1

(ii) Write the general formula for an amino acid. 1

(iii) Name the bond that forms between amino acids to produce protein molecules. 1

(iv) List the steps a forensic chemist would take to determine the amino acid composition of a protein. 1

(v) Discuss the use of DNA "fingerprints" and DNA databases in forensic investigations. 2

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HSC Trial Examination 2001

Chemistry

Solutions and suggested marking scheme

Section I

Part A

Answer and explanation	Outcomes assessed
Question 1 D The red colour only indicates that the pH is higher than the range limit of 4.4; it does not identify exactly the pH value.	H14
Question 2 B The monomer needs to be an alkene with a fluorine on each carbon atom. One carbon atom also has a hydrogen atom, the other C atom also has a Cl atom.	H9, H6
Question 3 A Other answers appear if mistakes are made in not allowing for dilution, not converting mL to litres, not using the pH equation correctly.	H10
Question 4 C HCl is always a strong acid. In risk assessments it will have become apparent to students that concentrated acids should always be added carefully to water.	H11
Question 5 B Carbon dioxide increases in solubility at lower temperatures.	H2
Question 6 A Transuranic elements have an atomic number greater than 92. The element Pu is the only product with such an atomic number.	H6
Question 7 D Metal W displaces all the other ions ∴ it is the most reactive. The ions of metal Z are displaced by all the other metals ∴ it is the least reactive. Metal Y displaces X ions so Y is more reactive than X.	H14
Question 8 C This is the only compound name that has 3 chlorine atoms and 3 fluorine atoms joined to an ethane molecule producing a different structural formula to that shown in the diagram.	H6
Question 9 C Zinc is oxidised; mercury(II) is reduced. The electrolyte needs to be ionic, therefore it is the potassium hydroxide paste.	H6, H7
Question 10 D This equation represents an acid/base reaction. It also correctly identifies that the neutralisation process is exothermic.	H7
Question 11 D Each of the bonds in NCl_3 is a single covalent bond.	H6
Question 12 B Since no precipitation occurred, chloride could not be present. Carbonate can only be confirmed if the addition of acid produced effervescence; the gas evolved would then have to change lime water to a milky appearance.	H14
Question 13 C Since absorbance is proportional to [ion], we have a ratio of 1:5 from the gradient of the curve. At an absorbance off 33%, the concentration would be calculated as being $33 \times 5 = 165$.	H10

Part A (Continued)

Answer and explanation	Outcomes assessed
Question 14 C The percentage by volume can be converted into ppm by finding the corresponding percentage from a million particles. $\therefore$ 0.0005% × 1 000 000 = 5 ppm $\therefore$ 0.0001% × 1 000 000 = 1 ppm	H13
Question 15 D In this case, the oxidation number changes by a value of 2; in the other cases the oxidation number only changes by a value of 1.	H6

Part B

Sample answer	Syllabus outcomes and marking guide
Question 16	H2
The Lowry Bronsted theory of acids and bases defines an acid as a proton donor. The Lewis theory defines an acid as being able to form a covalent bond using a lone pair of electrons from another substance (an acceptor of an electron pair). In the example given, the equation for the ionisation of water is $2H_2O \rightleftharpoons H_3O^+ + OH^-$ According to the Lowry Bronsted theory, one water molecule donates a proton to the other molecule. The donating molecule is the acid and the molecule which accepts the proton is the base. The Lewis theory would explain the formation of H_3O^+ by the donation of the pair of electrons by one water molecule to the H^+ ion released from the other molecule to form a coordinate covalent bond and the H_3O^+ ion. The water molecule is the base and the proton is the acid. In both cases the water molecule accepting the proton is the base. The proton is an acid in terms of the Lewis theory but by the Lowry Bronsted definition, the water molecule is the acid.	• Demonstrates in depth understanding of the two theories and uses equations or diagrams for the information given to illustrate the Lowry Bronsted theory of acids as proton donors and the Lewis theory of acids as electron acceptors. . . . . 3–4 • Demonstrates a sound knowledge of the two theories and is able to apply them to one of the equation for the ionisation of water . . 2 • Recalls knowledge of the two theories 0–1
Question 17	H10
(a) The object to be plated is the cathode. The cathode is the site of the reduction process. The cations (Cr ions) are attracted to the cathode which is negative and so are deposited at that electrode. Electrons are given up at the cathode.	• Correct statement of the object as the cathode and explanation demonstrating knowledge of cathode as site of reduction 1
(b) Electroplating is used for protection against corrosion and to give improved appearance.	• Explanation demonstrating knowledge of the uses of electroplating 1
Question 18	H4
(a) For example : Poly-3-hydroxybutyrate made by the bacterium *A. Eutrophus*.	• Correctly named bioploymer . . . . . 1 • Correctly named organism or enzyme . . . 1
(b) Biopolymer research is developing alternatives to fossil fuels as raw materials for polymers. Genetically engineered enzymes or colonies of bacteria manufacturing biopolymers using biomass are all renewable resources. Fossil fuel resources will be conserved and the pollution associated with drilling and mining will be reduced. Biopolymers are also biodegradable. This will reduce visual environmental pollution and reduce and the need to acquire space for landfill disposal of traditional plastics that may take hundreds of years to break down. It is possible that "designer" polymers will be able to be produced for specific purposes with particular properties using biopolymer techniques.	• Demonstrates an extensive understanding of the reasons for developing biopolymers and the effect on the environment that will result from their widespread introduction . . . . . 3 • Demonstrates a sound knowledge of the reasons why biopolymer research will benefit society and the environment . . . . 2 • Recalls that biopolymers provide an alternative to using plastics made from fossil fuels 0–1
Question 19	H8, H9
The process of catalytic cracking is the breaking of large molecules to produce desirable smaller molecules using an inorganic catalyst (a zeolite or an aluminium silicate) to increase the surface area for the reaction and lower the energy required for the reaction to proceed.	• Correct, detailed description of the process of catalytic cracking. . . . . 3 • Description which includes formation of smaller molecules and requirement of catalyst, with mention of increased surface area or lower activation energy . . . . . 2 • Description which includes formation of smaller molecules and use of a catalyst . . 1

Part B (Continued)

Sample answer	Syllabus outcomes and marking guide
Question 20	H 9
(a) One test tube will decolourise the bromine water rapidly, forming two layers. The other test tube will decolourise slowly.	• Description demonstrating understanding of the difference between reactions of alkanes and alkenes with bromine water 1–2
(b) The test tube that decolourises rapidly contains hexene and the other test tube contains hexane. Hexene has a C=C bond which reacts with the Br_2.	• Correctly identifies the test tube that decolourises rapidly as containing hexene and the other test tube containing hexane 1
Question 21	H 4
(a) Biomass is the material produced by living organisms.	• Correct definition of biomass..... 1
(b) Water	• Correct identification of the second product as water..... 1
(c) Cellulose is the main component of biomass. There is no efficient way of converting cellulose to glucose to produce say ethanol from fermentation that could then be dehydrated to ethene to replace petrochemical sources. However, cellulose is used to make fabrics such as rayon or viscose for clothing and substances such as celluloid for filmmaking. Although cellulose has been widely used to make these products it is still not possible to use cellulose to replace polymers or substances produced from petroleum despite the potential.	• Discussion of the potential of cellulose as a raw material giving reasons for and against its use in the production of petrochemicals and giving named examples..... 3 • Discussion of the potential of cellulose as a raw material giving reasons for and against its use in the production of petrochemicals..... 2 • Recalls that cellulose has the potential to replace petroleum or gives an example of the use of cellulose in products 1
Question 22	H8, H9
(a) $CH_3CH_2OH_{(l)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(l)}$	• Correctly balanced equation 1
(b) (i) $CO_{(g)}$, $CO_{2(g)}$ because it contributes to greenhouse gases, $C_{(s)}$ and other particulates, oxides of nitrogen, unburnt hydrocarbons including benzene and toluene and possibly lead	• Identification of pollutants demonstrating an in depth knowledge 1
(ii) Ethanol can be regarded as less polluting because there are no unburnt hydrocarbons present to contribute to photochemical smog. Both petrol and ethanol produce $CO_{2(g)}$ which contributes to global warming. (If the temperature of the ethanol combustion engine was lower than the petrol engine, then $NO_{2(g)}$ would not be produced at all as $O_{2(g)}$ combines with the $N_{2(g)}$ in the atmosphere at high temperatures. This would reduce the buildup of ozone in the atmosphere at ground level.)	• Explanation of the reasons why ethanol can be less polluting than petrol demonstrating sound knowledge of the chemical reactions involved 1
(c) The bonds between the C and O and O and H atoms in the molecule are polar, creating a polar molecule that can dissolve polar substances. It can also form H bonds with other substances containing C, O or F which makes it an ideal solvent for substances such as glucose, amino acids and organic acids.	• Description of ethanol is a polar molecule demonstrating understanding of the nature of hydrogen bonding ..... 2 • Recall of ethanol as a polar molecule that can dissolve polar substances 1

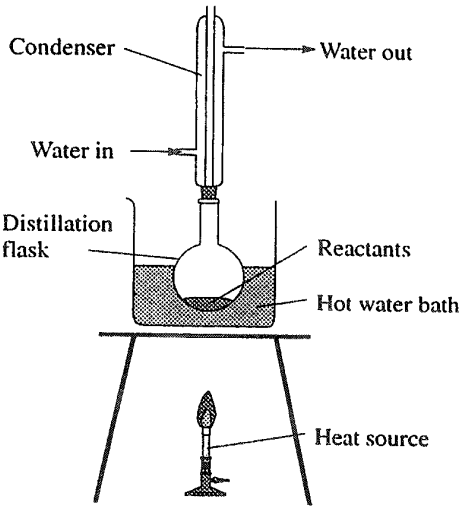
Part B (Continued)

Sample answer	Syllabus outcomes and marking guide
Question 23	H4, H10
(a) $(NH_4)_2SO_{4(aq)} + Ba(NO_3)_{2(aq)} \rightarrow BaSO_{4(s)} + NH_4NO_{3(aq)}$ $n(BaSO_4) = \frac{\text{mass}}{\text{molar mass}}$ $= \frac{1.45}{233.9}$ $= 6.2 \times 10^{-3}$ mol	• Identification of 6.2×10^{-3} mol of barium sulfate formed 1
(b) By molar ratio, $BaSO_4$:N is 1:2. $n(N) = 0.0124$ mol $m(N) = n \times M$ $= 0.0124 \times 14.01$ $= 0.174$ g	• Identifcation of 0.174 g of nitrogen in the fertiliser sample 1
(c) % by mass N in fertiliser $= \frac{0.174}{11.35} \times 100$ $= 1.53$ %	• Identification of 1.53% nitrogen in the fertilizer. 1
(d) • Nitrogen in fertiliser is usually present as ammonium salt. The overuse of ammonium-containing fertiliser leads to ammonium poisoning of the plants and increase of the acid content of the soil above that suitable for plant growth. • Fertiliser unnecessarily high in N, if overused, contributes to run off into waterways and produces algal blooms.	• An explanation giving a reason why the content of N in fertiliser is monitored demonstrating understanding of its potential impact..... 1
Question 24	H4, H9
(a) From insulation, refrigeration and air conditioning fluids or cleaning electronic circuit boards.	• Identification of two sources of CFCs... 2
(b) Ozone in the stratosphere absorbs most of the UV-B or short wavelength (320–280 nm) radiation that damages living tissue. This reduces the harm caused by sunburn, skin cancer, cataracts on the lens of the eye and diminished immune response. Ozone also absorbs that proportion of the damaging UV-C radiation (wavelengths shorter than 280 nm) not absorbed by oxygen. While providing this protection from harmful radiation, ozone allows the transmission of UV-A, which provides the energy for photosynthesis and forms Vitamin D in humans.	• Description of the benefits of ozone demonstrating well developed knowledge of the types of radiation absorbed and transmitted by ozone and the benefits of absorption or transmission..... 2 • Description of the benefits of ozone demonstrating sound knowledge of the benefits of absorbing UV radiation 1
(c) CFCs react in the stratosphere according to the following equations: $CCl_3F + \text{uv light} \rightarrow Cl + CCl_2F$ $CCl_2F + \text{uv light} \rightarrow Cl + CClF_2$ These chlorine atoms react with ozone to produce oxygen and the free radical ClO. $Cl + O_3 \rightarrow ClO + O_2$ Any free O atoms in the atmosphere as the result of the breakdown of ozone are then used to create more Cl atoms. $ClO + O \rightarrow O_2 + Cl$ The Cl continues to be produced in these reactions and can continue to reduce the concentration of ozone. There is a chain reaction set up continually destroying the ozone in the stratosphere.	• An account of the ozone-destroying reaction of CFCs demonstrating a high level of knowledge about the initial reactions of the CFCs with uv light to produce Cl atoms and the nature of the chain reactions which follow ..... 2 • An account of the ozone destroying reactions of CFCs demonstrating understanding of the nature of the initial reaction with uv light and a following chain reaction..... 1

Part B (Continued)

Sample answer	Syllabus outcomes and marking guide
Question 25	H2, H8
(a) Eutrophication is the process by which bodies of water become enriched with dissolved nutrients. The sources of these nutrients are usually run off from agricultural land where fertilisers have been used and discharge of raw or partly treated sewerage.	• Correct definition of eutrophication and complete identification of two sources of nitrates and/or phosphates . . . . . 3 • Correct definition of eutrophication and identification of one source of nutrient enrichment OR • identification of two sources of nitrates and/or phosphates . . . . . 2 • Correct definition of eutrophication. 1
(b) Nitrogen and phosphate are the limiting nutrients for plant growth. Therefore the value of these nutrients from all sources gives the best indication of the level of eutrophication. 1. Kjeldahl method for nitrogen in organic material. 2. Nitrates present are determined by colorimetric methods because other methods are not sensitive enough. 3. Phosphorous: A coloured solution of molybdenum blue is produced when ascorbic acid is added and the absorbance compared to standard solutions. The N:P ratio can be calculated as visible eutrophication occurs at a ratio of 10:1. However it is the level of total nitrogen above 0.1–1 ppm and 0 .001–0.1 ppm for phosphorous that indicates possible eutrophication.	• Discussion of the methods used which notes the importance of assaying the total nitrogen and phosphorous of a water sample to determine value of the N:P ratio . . . . . 3 • Discussion which gives a basic description of one or two tests and includes a comparison of some relevant features . . . 2 • A response which refers to one of the tests for eutrophication 1
(c) Phosphate and nitrate levels in water usually limit plant growth and an ecological balance is reached. When the levels of P and N are high growth of algae and/or cyanobacteria continues unchecked and algal blooms form which prevent sunlight penetrating the water and stop atmospheric oxygen mixing with the water, reducing the dissolved oxygen (DO) available for other living things. At night the algae use the dissolved oxygen in the water for respiration, which further depletes the dissolved oxygen content. The biochemical oxygen demand (BOD) is the quantity of oxygen required to respire organic waste in a body of water. The algal bloom reduces the oxygen available to other living things to the point where the BOD is greater than the DO and living things die. When the nutrient in excess supply is used by the algae, the algae themselves die and consume all available oxygen in the water until they eventually decay anaerobically producing a solid mass of substance which results in the death of all living things in the waterway.	• An analysis of the effects of eutrophication demonstrating a high level of knowledge and understanding of the sequence of events that leads to the death of living things in waterways. The answer will include reference to dissolved oxygen and/or biochemical oxygen demand. . . . . 4 • An analysis of the effects of eutrophication demonstrating knowledge and understanding of the sequence of events that leads to the death of living things in waterways. The answer may include reference to dissolved oxygen or biochemical oxygen demand. . . . . 2–3 • Recall of the effects of eutrophication on waterways. 1

Part B (Continued)

Sample answer	Syllabus outcomes and marking guide
Question 26	H8
(a) A decrease in the temperature will drive the reaction in the direction that produces more heat, which is to the right, increasing the amount of ammonia. An increase in pressure will drive the reaction in the direction that reduces pressure, which is the side with fewer molecules of gas (according to the chemical equation), so it will shift to the right, increasing the amount of ammonia.	• Demonstrates understanding of the effect of changes on an equilibrium system according to Le Chatelier's principle 2
(b) The increase in rate due to higher temperatures is much more significant than the decrease in yield.	• Correctly identifies the reason 1
Question 27	H7, H8, H11
(a) X is butanoic acid, $CH_3CH_2CH_2COOH$. Its boiling point is much higher than the other possible reactant, ethanol. Butanoic acid has a higher molecular mass, hence greater dispersion forces than ethanol, and it also has two sites available for hydrogen bonding, whereas ethanol only has one.	• One mark for identification and drawing of butanoic acid • One mark for justification identifying its greater dispersion forces or larger number of sites for hydrogen bonding 2
(b)  The process is refluxing and it is used to increase the reaction rate. This is done by mixing the reactants together with a small amount of concentrated sulfuric acid (or phosphoric acid) and heated appropriately (water bath/oil bath/heating mantle - NOT direct heat). A water jacketed condenser or air condenser cools the product and reactant vapours so that they fall back into the reaction vessel.	• Two marks for correctly drawing and labelling the equipment • One mark for describing the process of refluxing 3
Question 28	H10, H14
(a) A primary standard needs to be of high purity and sufficiently stable so that it does not deliquesce as it is being weighed. An example of such a chemical would be anhydrous sodium carbonate.	• Correct identification of a primary standard and discussion of its relevant properties . 2 • An example of a primary standard or a property..... 1

Part B (Continued)

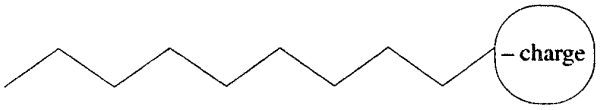
	Sample answer	Syllabus outcomes and marking guide
(b)	$n(\text{citric acid}) = \frac{n(\text{NaOH})}{3}$ $= \frac{0.040 \times 0.075}{3}$ $m(\text{citric acid}) = n(\text{citric acid}) \times M$ $= \frac{0.040 \times 0.075}{3} \times 192$ $= 0.192 \text{ g}$ Undiluted sample contains $0.192 \times \frac{250}{25} = 1.92 \text{ g}$ % w/v of citric acid is $\frac{1.92}{25} = 7.68\%$	• One mark for n(citric acid) in dilute sample • One mark for m(citric acid) in dilute sample • One mark for converting to undiluted sample • One mark for correct %w/v 4

Section II

Question 29 Industrial Chemistry

		Sample answer	Syllabus outcomes and marking guide
(a)	(i)	Sulfuric acid has a strong affinity for water. It will quickly dehydrate many organic molecules. $C_{12}H_{22}O_{6(s)} \xrightarrow{\text{Conc. } H_2SO_4} 12C + 11H_2O_{(g)}$	H7, H9 • A correct equation 1
	(ii)	Wear appropriate eyewear, lab-coat and gloves. Add acid in small amounts to a large volume of water.	• One mark for safe technique • One mark for identifying safety equipment. 2
(b)		Biodegradable detergents are capable of being broken down by bacteria and other decomposers. This means they do not remain in the environment for long periods. Phosphate is a problem in the environment because it acts as a nutrient to promote the growth of algae to a point where it overwhelms the ecological balance eventually causing oxygen depletion and the death of aquatic life.	H13, H15 • Clearly explains what is meant by "biodegradable" and the environmental advantages of biodegradable and phosphate-free cleansers ..... 2 • Describes biodegradability OR • Mentions a relevant environmental advantage of biodegradable or phosphate-free cleansers 1
(c)	(i)	Acting as a means of precipitating an insoluble sulfate salt.	H8 • Correct answer 1
	(ii)	Acting as an oxidising agent.	• Correct answer 1
	(iii)	Acting as an acid.	• Correct answer 1
(d)		Moderate temperature to enable a reasonable rate of reaction coupled with an acceptable yield (reaction is exothermic and therefore favoured by lower temperatures). The high pressure favours the formation of product as four mole of reactants are reduced to two mole of product. Pressure would also increase rate. The catalyst increases the rate at which equilibrium is obtained. (Does not affect the extent of reaction). • The removal of ammonia would favour formation of product. • A slight excess of a reactant would favour production of the product.	H3, H8 • One mark for correctly explaining temperature • One mark for correctly explaining pressure • One mark for correctly explaining catalyst • One mark for correctly identifying the effect of the amount of reactant or products present 4
(e)	(i)	Compound 1 is carbon dioxide. Compound 2 is calcium oxide (lime). $CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$	H9, H13 • Correct equation 1
	(ii)	$2NaHCO_{3(s)} \rightarrow Na_2CO_{3(s)} + H_2O_{(g)} + CO_{2(g)}$	• Correct equation 1
	(iii)	1) $NH_{3(aq)} + CO_{2(g)} + H_2O_{(l)} + NaCl_{(aq)} \rightleftharpoons NH_4Cl_{(aq)} + NaHCO_{3(s)}$	• Correct equation 1
		2) $n(NH_3) = n(NaHCO_3)$ $n(NaHCO_3) = \frac{200 \times 10^3}{84}$ $m(NH_3) = \frac{200 \times 10^3}{84} \times 17$ $m(\text{ammoniacal brine}) = \frac{200 \times 10^3}{84} \times 17 \times \frac{100}{7}$ minimum mass $= 578.2$ kg	• One mark for correct expression or value for $n(NaHCO_3)$ • One mark for correct expression or value for $m(NH_3)$ • One mark for correct value for minimum mass of ammoniacal brine 3

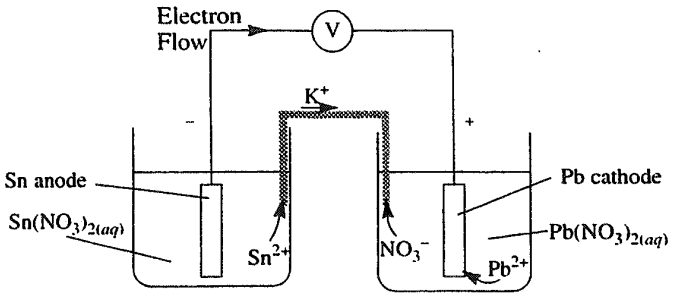
Question 29 Industrial Chemistry (Continued)

		Sample answer	Syllabus outcomes and marking guide
(f)	(i)	Triglycerides are reacted with concentrated sodium hydroxide and heated with steam. This hydrolyses the triglyceride producing a sodium salt of the long chain fatty acid (the soap) and glycerol.	H7, H13, H16 • Correctly explains the use of concentrated sodium hydroxide and steam in the hydrolysis of triglycerides and which correctly identifies the soap as the sodium salt of a fatty acid. . . . . 2 • Mentions hydrolysis and the use of sodium hydroxide OR • Mentions hydrolysis and correctly identifies the soap as a sodium salt of a fatty acid. . 1
	(ii)	The soap contains a long carbon chain that is hydrophobic attached to a hydrophilic carboxyl group carrying a negative charge.  The charged head of the molecule is attracted to water molecules while the 'tail' buries itself in the grease. Agitation of the washing water begins to pull the grease away from the surface. Many molecules attach themselves in this manner making the outside of the grease appear to be covered in a hydrophilic layer that is stable in water.	• Describes soap structure and action of cleaning . . . . . 2 • Mentions hydrophobic non-polar 'tail' and hydrophilic polar head OR • A resonable attempt at an explanation of removal of grease 1
(g)	(i)	Sodium hydroxide is produced by electrolysis of brine. The process uses energy to produce less stable products than the reactants i.e. chlorine, hydroxide and hydrogen.	H3, H7, H13 • Correctly states that the products of the electrolysis are higher energy/less stable. 1
	(ii)	The cells are designed with a cathode and an anode in separate areas so that the reactive products are kept separated.	• Correctly mentions the separation of cathode and anode 1
	(iii)	Mercury cell: possible release of mercury into the environment. Diaphragm cell: Possible danger due to asbestos. Sodium hydroxide produced contains a reasonably high percentage of NaCl (~2%) Membrane cell: Produces high purity NaOH	• Any one advantage or disadvantage of a correctly named cell. 1

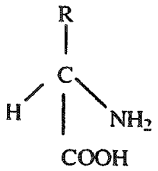
Question 30 Shipwrecks and Salvage

		Sample answer	Syllabus outcomes and marking guide
(a)	(i)	At great depths the temperature of water would be very low, resulting in a very slow rate of reaction for the corrosion process.	H8 • Correctly relates rate of reaction with depth of water 1
	(ii)	For the equation $O_{2(g)} \rightleftharpoons O_{2(aq)}$ According to Le Chatelier's Principle, an increase in pressure would shift the equilibrium to the right, therefore increasing the concentration of dissolved oxygen in the water.	• One mark for correctly applying Le Chatelier's principle • One mark for correctly writing equation . 2
	(iii)	1) Depletion at such great depths can be the result of aerobic organisms closer to the surface using up the oxygen and so no oxygen is left to diffuse to deeper water.	• A correctly stated reason 1
		2) Anaerobic means without the need of oxygen.	• Correct definition..... 1
		3) The reduction of sulfur by anaerobic bacteria allows the oxidation of iron to take place.	• Correctly referring to the role of sulfur in the oxidation of iron..... 1
(b)	(i)	A sample of pure iron and a sample of steel are placed into water (or salt water solution). The samples are left in the water for a specified period and then compared for their relative amounts of corrosion. To make the investigation a fair comparison, the temperature of water, concentration of ions in the water and amount of air available to each sample would need to be the same.	H8 • One mark for identifying steps of the experiment • One mark for identifying the need for maintaining constant water temperature, concentration of ions and amount of air available for each sample..... 2
	(ii)	Passivating metals form an unreactive surface coating with substances such as oxygen, sulfur and/or air. These layers prevent further corrosion because they are impermeable thus preventing the metal beneath the coating to be exposed to further reaction. Active metals produce a surface coating which is permeable. This allows reactants such as oxygen and water to move through the layer and thus cause further corrosion of the metal.	• Correctly identifying the presence of impermeable oxide or sulfide layers in passivating metals and permeable layers in non-passivating metals..... 2 • Correctly states that an impermeable oxide/sulfide layer may be formed in passivating metals 1
(c)	(i)	$2Br^-_{(aq)} \rightarrow Br_2 + 2e^-$	H8 • Correct equation 1
	(ii)	The formation of bromine, the source of the brown colour, occurs at the anode. This is known because it is the result of oxidation.	• One mark for correctly identifying anode • One mark for a correct reason 2
	(iii)	$H_2O + e^- \rightarrow \frac{1}{2} H_2 + OH^-$	• Correct equation 1

Question 30 Shipwrecks and Salvage (Continued)

Sample answer	Syllabus outcomes and marking guide
(d)  $Sn_{(s)} \rightarrow Sn^{2+} + 2e^-$ $\quad Pb^{2+} + 2e^- \rightarrow Pb_{(s)}$ Standard Potential = $E^\circ = 0.14 + (-0.13) = 0.01$ V	H8 • One mark for correctly labelled electrodes and solutions • One mark for correctly identified contents of salt bridge • One mark for correct direction of electron flow • One mark for correct direction of ion flow • One mark for correct half equations • One mark for correctly calculated potential 6
(e) Examples: • Modern rust-preventing paints create an impermeable layer that prevents oxygen and water passing through to the iron below. Additives in the paint react with surface atoms in the steel to produce a layer of very insoluble salt which prevents the migration of ions and therefore stops electron transfer reactions taking place. • Surface alloys are the result of gaseous metal ions (plasma) of chromium and nickel being directed onto the surface of steel. The ions become embedded as atoms and create a passivating layer on the surface of the steel. • Sacrificial anodes can be used to provide protection to steel hulls. A metal is in contact with the steel hull. This sacrificial anode is allowed to corrode (oxidise) thus allowing electrons to travel to the steel hull which acts as the cathode. Since the hull receives electrons, it is unable to oxidise. This method can be performed in two different ways 1. Using a more active metal as the sacrificial anode and therefore creating a galvanic cell. 2. Using a power supply to force electrons onto the hull, thus creating an electrolytic cell.	H8 • Two correctly named methods with explanations of how each prevents corrosion . . . . . 3–4 • One correctly named method with explanation. . . . . 2 • One correctly named method with relevant properties mentioned OR • Two correctly named methods. 1
(f) As the artefact starts to dry, the ions in the solution start to solidify. The formation of the ionic crystals throughout the porous material can result in that materials shape being distorted, its body cracking or the components in the material chemically reacting with the salt.	• A correctly identified change. 1

Question 31 Biochemistry of Human Movement

		Sample answer	Syllabus outcomes and marking guide
(a)	(i)	The cytosol or cytoplasm	H7, H9, H10 • Correct answer 1
	(ii)	2 ATP, 2 Pyruvate and 2 NADH	• Two or more correctly identified products 1
	(iii)	The oxidation of fats provides many more Acetyl Co A molecules for the TCA Cycle to produce more ATP per gram than carbohydrates in all tissues except the brain. The electron carriers NADH and $FADH_2$ are also produced each time 2 C atoms for Acetyl Co A are removed from the fatty acid, providing more energy via oxidative phosphorylation.	• Clearly explains the role of fats as a fuel supply . . . . . 2 • Mentions that fats provide more energy in the form of ATP than carbohydrates 1
(b)	(i)	Acetyl Co A is the substrate oxidised to form CO_2.	H7,H9, H10, H13 • Correctly identified substances 1
	(ii)	NAD^+ and FADH are reduced to NADH and $FADH_2$	• A correctly identified pair 1
	(iii)	NADH and $FADH_2$ transfer electrons gained from the oxidation of Acetyl Co A to the electron transport chain. As the electrons are transferred to the acceptor molecules energy is released which is used to drive H^+ ions across the membrane, generating an H^+ ion gradient. This gradient provides the energy for the production of ATP from ADP and Pi. The electrons are eventually transferred to O_2 that combines with H^+ to produce water.	• Demonstrates extensive knowledge of oxidative phosphorylation . . . . . 4 • Shows sound knowledge of the process. . 3 • Demonstrates knowledge of some of the parts of oxidative phosphorylation. . . . . 2 • Mentions only one correct aspect of oxidative phosphorylation 1
	(iv)	The enzymes that catalyse the oxidative phosphorylation reactions are found in the inner membrane of the mitochondrion that is extensively folded into the cristae. The H^+ ions are pumped into the intermembrane space during the reactions and O_2 diffuses in to combine with the H^+ to form water. This arrangement confines the reactants to the membrane and the space between it and the mitochondrion wall. The soluble enzymes that catalyse the TCA Cycle and the oxidation of fatty acids are found in the matrix.	• Clearly explains the use of spaces and membranes in the mitochondrion . . . . . 2 • Correctly identifies some sites within the mitochondrion and their roles in one of the given processes . 1
(c)	(i)	The structural units of enzymes are amino acids. Each acid contains an amine group (NH_2), a carboxylic acid group (COOH) and one other functional group (R).  	H2, H13 • Correctly identifies and draws an amino acid and correctly identifies two of the functional groups . . . . . 2 • Correctly identifies and draws amino acid OR • Correctly identifies at least two functional groups 1

Question 31 Biochemistry of Human Movement (Continued)

		Sample answer	Syllabus outcomes and marking guide
	(ii)	The primary structure of an enzyme is the amino acid sequence. The secondary structure involves the formation of either an α helix or β pleated sheets. The CO group of one amino acid is hydrogen bonded to the NH group of the amino acid three or four ahead of it in the chain when polypeptide chains fold into an α helix. β pleated sheets are made up of two polypeptide chains stretched parallel to one another and joined by hydrogen bonds between CO and NH of amino acids from different polypeptide chains. Tertiary structure refers to the spatial arrangement of amino acids that are far apart in the linear sequence. In the aqueous environment of the cell strong hydrophobic forces drive protein folding. The non–polar side chains move to be away from water. The interior of the folded protein consists of the non polar side chains of amino acids. Dispersion forces (van der Waal's forces) between these non-polar ends contribute to the stability of the protein and the compact nature of the inside of the structure. The polar or charged side chains are all on the surface of the structure. The electrostatic forces between the charged groups and water ensure they move to the surface of the macromolecule.	• Demonstrates an extensive knowledge and understanding of the shape of protein molecules, discussing both the forces and the bonds. ..... 3 • Demonstrates a sound knowledge and understanding of the shape of protein molecules but does not mention all the forces and bonds ..... 2 • Mentions only one or two forces or bonds 1
(d)	(i)	High heart rate is required to supply exercising muscles with O_2. The increased blood flow also removes metabolites, in particular CO_2 and lactic acid. This prevents the pH changes that denature enzymes. Sweating cools the athlete by evaporation to maintain a constant body temperature and prevent the denaturation of enzymes.	H8, H13 • Analyses the significance of both physiological activities showing a high level of understanding. ..... 2 • Analyses the significance of only one physiological activity to a sound level OR • Analyses both physiological activities at a basic level. 1
(e)	(i)	The binding of ATP to the myosin head dissociates it from the actin filament. This causes a change in the shape of the head that moves it to a new position on the actin with the release of Pi. ADP is then released and myosin head returns to its original position causing actin filament sliding.	H2, H5, H13 • Clearly describes muscle contraction showing understanding of the main features. ..... 2 • Outlines only one or two of the features of filament sliding 1
	(ii)	Marathon runners would have more Type 1 muscle than sprinting athletes. Type 1 muscles contract relatively slowly, have fewer contractile filaments and have many mitochondria for aerobic respiration. Type 1 muscles are well supplied with blood to deliver oxygen so marathon runners can run for long periods of time using aerobic respiration.	• Correctly identifies differences in quantities of type 1 muscles and links structure to function ..... 2 • Correctly identifies differences in quantities of type 1 muscles 1

Question 31	Biochemistry of Human Movement (Continued)	
	Sample answer	**Syllabus outcomes and marking guide**
(iii)	During sprinting exercise the blood supply cannot keep up the supply of oxygen and so type 2 muscles use anaerobic respiration to provide energy. The breakdown of glycogen during glycolysis produces only 2 ATP per molecule of glucose and 2 NADH. The NADH must be regenerated to maintain glycolysis and so pyruvate is converted to lactate returning NADH to NAD^+ for use in glycolysis. The lactate is converted back to glucose in the liver in the process known as gluconeogenesis. The build up of acid in the muscles significantly changes the pH causing denaturation of the enzymes of glycolysis, pain and tiredness for the athlete.	• Explains clearly that anaerobic respiration provides the energy needs of sprinting athletes and demonstrates a clear understanding of the problems of blood supply, low output of ATP compared to aerobic respiration and the buildup of lactate associated with sprinting . . . . . 2 • Explains that anaerobic respiration provides the energy needs of sprinting athletes and that lactate builds up in muscles and causes muscular pain. 1

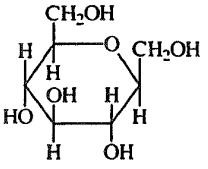
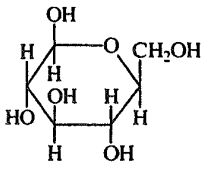
Question 32 Chemistry of Art

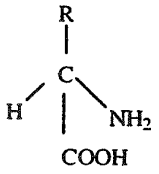
		Sample answer	Syllabus outcomes and marking guide
(a)	(i)	Al has the configuration $1s^2 2s^2 2p^6 3s^2 3p^1$ so it is in period 3, group III as it has 3 outer shell electrons. Ni has the configuration $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$ so it is in period 4, transition group VIII.	H2, H6 • Two correct explanations . . . . . 2 • One correct explanation 1
	(ii)	Electrons in aluminium need to absorb large amounts of energy to jump to a higher energy level and this amount of energy does not correspond to wavelengths in the visible spectrum. Electron transitions in Ni(II) salts require much smaller amounts of energy and these occur in the visible range, resulting in reflected or transmitted light which is coloured.	H2, H6 • Clearly explains the relationship between energy levels of electron transitions and wavelength (or frequency) of light as they apply to aluminium and nickel salts, and of how wavelengths in the visible band result in transmission and reflection of coloured light . . . . . 3 • Demonstrates some understanding of the relationship between energy of electron transitions and wavelength (frequency) of light . . . . . 2 • Mentions energy levels and wavelength or frequency, or mentions a relevant difference in the properties of the two salts 1
(b)		Examples of chelates include ethylenediaminetetraacetic acid (EDTA), diaminoethane, heme. Chelates are ligands which have two or more lone pairs of electrons that can be donated to form coordinate bonds with a central cation. The lone pairs are attracted to the positive charge and form a 'cage-like' structure around the cation. A specific use is in heme, to bind oxygen, or in pharmaceuticals.	H6, H13 • Demonstrates a detailed knowledge of the structure of chelates and gives an example and a use . . . . . 4–5 • Mentions some relevant property of chelates, an example and a use . . . . . 3 • States an example and mentions a relevant property or a use . . . . . 2 • States an example or a relevant property . 1
(c)		The vehicle is the liquid part of the paint which polymerises in some way. The pigment is a solid which is suspended in the vehicle, which is opaque, scatters light and colours the film formed as the vehicle dries out. Over time changes have occurred in the pigments used, as more were discovered as technology improved, and the vehicle, which changed as more suitable materials were discovered. Early Aboriginal art was produced by spray-painting ochres (iron oxide made into a paste with water and possibly animal fat) using the hands as stencils, after which the image dried out. Gesso, where glue or gelatine is bound to chalk, gypsum or plaster, was very different, as a polymer formed to protect the image. Lead based pigments such as orpiment have fallen out of favour due to their toxic nature. Titanium dioxide has replaced white lead as it is safer.	H4, H13, H14 • Demonstrates a clear understanding of the components of paint, correctly describes how these components have changed over time with two relevant examples . . . . . 4–5 • Demonstrates some understanding of the components of paint or how these have changed over time, and includes at least one relevant example . . . . . 2–3 • Mentions some relevant properties of the components of paint or states relevant examples 1

Question 32 Chemistry of Art (Continued)

		Sample answer	Syllabus outcomes and marking guide
(d)	Two of:		H1, H4, H6, H11, H12, H13
	•	Reflectance spectroscopy relies on pigments and the vehicles they are in absorbing particular frequencies of light and reflecting the remaining light. Artworks from different periods contain pigments and backings/films specific to that time. If different or replacement materials are used they will show up because their spectra are different.	• Clearly describes the method, with an explanation of what it measures and of how comparison with known samples takes place ..... 3 • Describes the method and mentions the type of comparison that is done ..... 2 • Gives a reasonable attempt at describing the method 1
	•	UV light can be shone onto paintings and some pigments fluoresce (if they contain ZnS or CdS) or phosphoresce (if they contain ZnS, CuS or SrS). Fluorescence occurs when UV light is shone onto the painting and visible light is emitted. Phosphorscence occurs when UV light is shone onto the painting and the painting glows in the dark. If either of these occurs when not expected to then the painting is not genuine.	• A second method, marked according to the criteria given above 0–3
	•	Atomic force microscopy relies on a cantilevered crystal passing over the surface of a painting (or part of it) within nanometres of its surface and being deflected as atomic forces act upon it. This is interpreted as a 3-dimensional image specific to certain materials. If the painting uses materials different from the original, they can be identified by comparing them to materials that were used when the original was completed.	
(e)	(i)	MnO_2 is oxidised from Mn^{+IV} to Mn^{+VI} and O_2 has been reduced from zero to –II, hence oxygen gas is the oxidising agent.	H6, H13 • Correctly identifies oxidising agent and gives relevant reason ..... 2 • Correctly identifies oxidising agent 1
	(ii)	The chromium in $Cr_2O_7^{2-}$ is in a higher oxidation state (+VI) than iron in Fe^{2+} (+ II), and therefore can attract electrons more strongly.	H6, H13 • Clear explanation based on comparison of oxidation states and ability to attract electrons ..... 2 • Mentions higher oxidation number or greater electron attracting ability of chromium in $Cr_2O_7^{2-}$ 1

Question 33 Forensic Chemistry

		Sample answer	Syllabus outcomes and marking guide
(a)	(i)	$C_7H_{14}O_6 + H_2O \rightarrow C_6H_{12}O_6 + CH_4O$	H9, H13, H14 • One mark for correctly recognising that water is involved in hydrolysis • One mark for identifying methanol as a product 1
	(ii)	A solution of the sugar is prepared. Use an oxidising reagent such as Fehlings solution, Tollens reagent or Benedicts solution. Warming is necessary. Tollens reagent produces metallic silver; Benedicts and Fehlings produce red–brown copper oxide.	• Correctly lists the relevant steps and properties of the test. ..... 2 • Correctly lists at least two relevant steps or properties of the test 1
	(iii)	 Compound R  Compound T	• One mark for illustrating pyranose ring structure • One mark for correctly placed side chains 2
	(iv)	Glucose	• Correctly names compound 1
	(v)	The original sample came from plant or animal material as a source of carbohydrate.	• Correctly identifying the source as carbohydrate material from a plant or animal 1
(b)	(i)	$CH_3(CH_2)_{12}CO_2H$ (myristic acid)	H9, H11, H14 • Correct formula 1
	(ii)	glycerol–1,2,3–propanetriol	• Correctly named compound 1
	(iii)	Decolourises dilute aqueous potassium permanganate (purple). The amount of permanganate needed identifies the number of –OH groups present. A triol requires 0.03 moles of permanganate per gram of sample.	• Correctly lists the relevant properties of the test ..... 2 • Correctly lists at least two relevant properties of the test. 1
	(iv)	The fat from an animal will contain a greater proportion of saturated fatty acids.	• Correctly identifying greater proportion of saturated fatty acids 1
(c)	(i)	One of: • mass spectroscopy • electron spectroscopy • atomic–force microscopy • scanning tunnelling microscopy	H1, H11, H4, H6 • Naming one method. 1
	(ii)	Destructive testing would be a problem where the sample origin is of great economic, historical or cultural significance. Examples include artwork, artefacts, valuable jewellery.	• A correctly identified situation 1
	(iii)	The element must first be ionised (acid), then vapourised (gaseous sample). This sample absorbs energy which excite electrons. As the electrons return to their ground state, energy in the form of light is emitted.	• Correct identification of all relevant conditions. ..... 2 • Correctly identifying at least two relevant conditions. 1
	(iv)	The emission spectrum is dependent on the amount of energy absorbed in excitation. The energy required to excite electrons is dependent on the electron configuration and energy levels in the element. Since this is unique for each element, each element has a different emission spectrum.	• Correctly identifying that the energy of excitation depends on each element's electron configuration 1

Question 33		Forensic Chemistry (Continued) Sample answer	Syllabus outcomes and marking guide
	(v)	Site B	• Correct site 1
(d)	(i)	Ninhydrin, heat changes from colourless to purple solution OR Biuret test, sodium hydroxide and copper sulfate forms a purple solution.	H9, H11, H16, H4 • Correct answer 1
	(ii)		• Correctly drawn structure 1
	(iii)	Peptide bond	• Correct answer 1
	(iv)	Hydrolysis; separation by electrophoresis or chromatography; visualisation/staining; identification from standards.	• Correctly listing steps 1
	(v)	As only 1 in 10 billion people will have the same DNA fingerprint, this is a highly accurate way of identifying individuals. Samples of DNA must be collected and available to investigators for fingerprinting to be useful. Scientific discoveries usually happen independently from specific uses and so the idea of fingerprinting and keeping the information in a database has emerged from the technology. It is extremely useful for forensic investigation but is often seen as encroaching on individual civil liberties. Who has access and how the information is used is of concern and interest to the whole community.	• One mark for identifying the usefulness of DNA fingerprinting • One mark for identifying the controversy of databases 2

HSC Trial Examination 2001

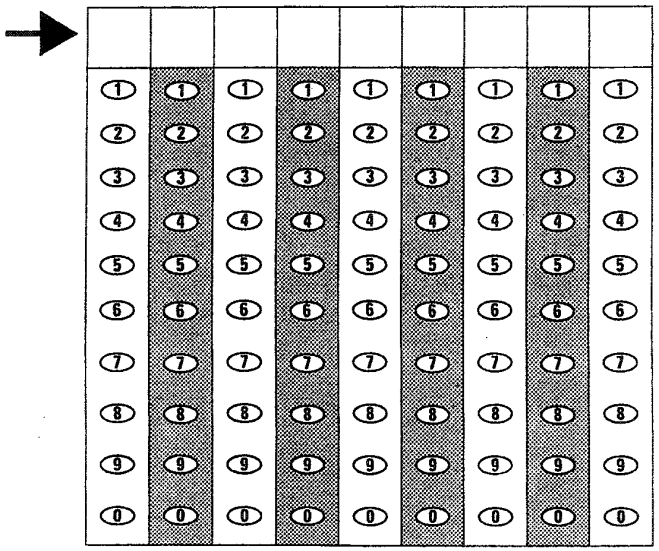
Chemistry

DIRECTIONS:
Write your name in the space provided.
Write your student number in the slots provided below as indicated by the large arrow. Then, in the columns of digits below each box, fill in the oval which has the same number as you have written in the box. Fill in one oval only in each column.

Read each question and its suggested answers. Select the alternative A, B, C, or D that best answers the question. Fill in the response oval completely, using blue or black pen. Mark only one oval per question. If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer. If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and draw an arrow as shown on page 2 of your examination paper.

NAME: _____

STUDENT NUMBER:



PART A
ANSWER SHEET

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

STUDENTS SHOULD NOW CONTINUE WITH PART B

Students are reminded that this is a trial examination only and cannot in any way guarantee the content or the format of the 2001 Chemistry Higher School Certificate examination.