PERIODIC TABLE

KEY

Atomic number
Atomic mass
79 Au 197.0 Gold — Symbol of element; Name of element

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorous	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 72.61 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [98.91] Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanides	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.9 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po [210.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223.0] Francium	88 Ra [226.0] Radium	89–103 Actinides	104 Rf [261.1] Rutherfordium	105 Db [262.1] Dubnium	106 Sg [263.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [265.1] Hassium	109 Mt [268] Meitnerium	110 Uun — Ununnilium	111 Uuu — Unununium	112 Uub — Ununbium	113	114 Uuq — Ununquadium	115	116 Uuh — Ununhexium	117	118 Uuo — Ununoctium

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [146.9] Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.0 Ytterbium	71 Lu 175.0 Lutetium
89 Ac [227.0] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237.0] Neptunium	94 Pu [239.1] Plutonium	95 Am [241.1] Americium	96 Cm [244.1] Curium	97 Bk [249.1] Berkelium	98 Cf [252.1] Californium	99 Es [252.1] Einsteinium	100 Fm [257.1] Fermium	101 Md [258.1] Mendelevium	102 No [259.1] Nobelium	103 Lr [262.1] Lawrencium

Where the atomic masses are not known, the relative atomic mass of the most common radioactive isotope is shown in brackets.
The atomic masses of Np and Tc are given for the isotopes ^{237}Np and ^{99}Tc.

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HSC Trial Examination

Chemistry

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 ○

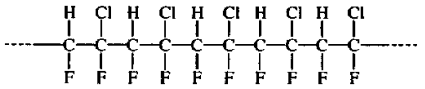
If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and draw an arrow as follows:

correct

A ✕ B ✕ C ○ D ○

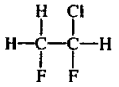
1. A common indicator used to determine the pH of solutions is methyl orange. This indicator is red at lower pH and orange at higher pH. It changes colour within a pH range of 3.1–4.4.
   An unknown colourless solution has a few drops of methyl orange added to it. The colour of the indicator becomes orange. This means that the unknown solution
   (A) must be a base.
   (B) must be an acid.
   (C) must be neutral.
   (D) still needs to be tested with further indicators to determine its pH.

2. The following diagram represents a polymer produced by the process of addition polymerisation.



   The monomer used to make this polymer is

   (A)



   (B)

   (C)

   (D)

Questions 3–4 relate to the following information.

To demonstrate the concept of dilution a teacher carefully mixed 100 mL of concentrated HCl with water until the total volume was 3 litres.

3. The pH of the solution was found to be 0.27. The concentration of H^+ ions in this solution is
   (A) 0.54 mol L^{-1}
   (B) 160 mol L^{-1}
   (C) 5.3 mol L^{-1}
   (D) 0.27 mol L^{-1}

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?

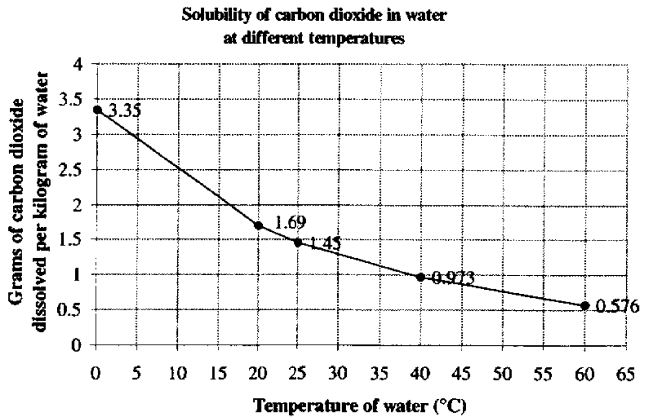
   (A) (i) and (ii) are both correct statements.

   (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", "X", "Y" and "Z" (not their real symbols). Each metal was placed into a solution which contained ions of 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 change

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

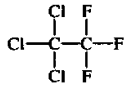
   (A) W Y X Z

   (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 following diagram.



   An isomer of Freon-113 would be

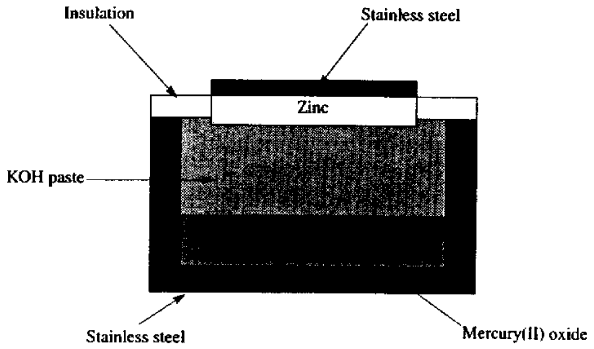
   (A) 1,2,3-trichloro-1,2,3-trifluoroethane

   (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

9. The diagram below shows a mercury cell, which can be used to power hearing aids.



The half equations for the reaction process are given as follows:

$$Zn_{(s)} + 2OH^-_{(aq)} \rightarrow ZnO_{(s)} + H_2O_{(l)} + 2e^-$$

$$HgO_{(s)} + H_2O_{(l)} + 2e^- \rightarrow Hg_{(l)} + 2OH^-_{(aq)}$$

Which of the following correctly summarises the parts of the cell?

	Anode reactant	*Cathode reactant*	*Electrolyte*
(A)	mercury(II) oxide	zinc	potassium hydroxide
(B)	stainless steel	zinc	water
(C)	zinc	mercury(II) oxide	potassium hydroxide
(D)	zinc	mercury(II) oxide	water

10. Which of the following correctly represents a neutralisation process?

(A) $HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$ $\quad \Delta H = +60 \text{ kJ mol}^{-1}$

(B) $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$ $\quad \Delta H = -92 \text{ kJ mol}^{-1}$

(C) $C_3H_{8(l)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(l)}$ $\quad \Delta H = -2220 \text{ kJ mol}^{-1}$

(D) $HNO_{3(aq)} + KOH_{(aq)} \rightarrow KNO_{3(aq)} + H_2O_{(l)}$ $\quad \Delta H = -61 \text{ kJ mol}^{-1}$

11. Which of the following Lewis electron dot structures does not include a coordinate covalent bond?

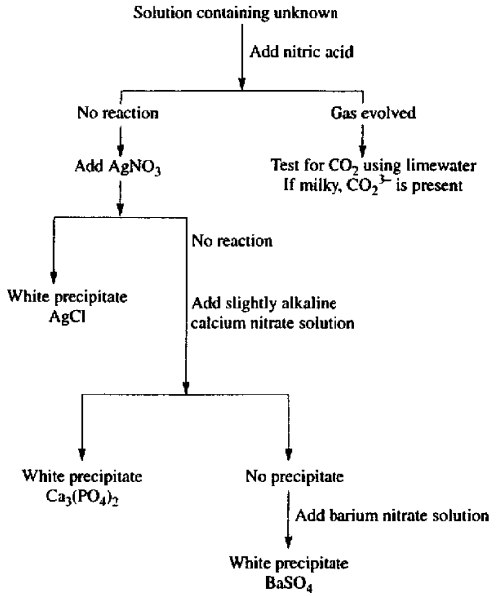
(A)

(B)

(C)

(D)

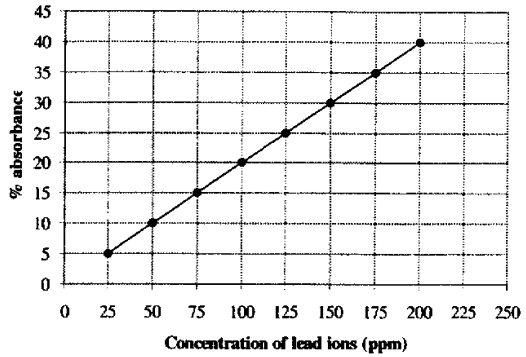
12. A student decided to use the following flow chart to identify the anion present in an unknown solution.



The student added only silver nitrate to the unknown solution. No precipitate formed.
The student concluded that the solution could NOT contain

(A) carbonate
(B) chloride
(C) phosphate
(D) sulfate

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



A sample of river water was analysed using AAS to determine its lead ion concentration. It was found 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 values 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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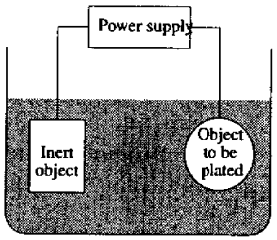
Question 17 (2 marks)

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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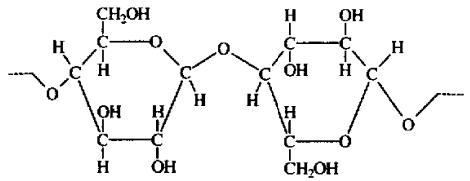
Question 21 (5 marks)

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**

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

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

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**

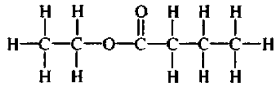
- Temperature
- Pressure

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

Marks

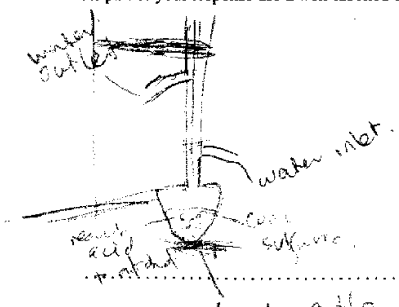
Question 27 (5 marks)

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

(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



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

* solid → need to weigh out

(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).

1 mol. 0.075

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.

Question 29 — Industrial Chemistry (25 marks)

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**

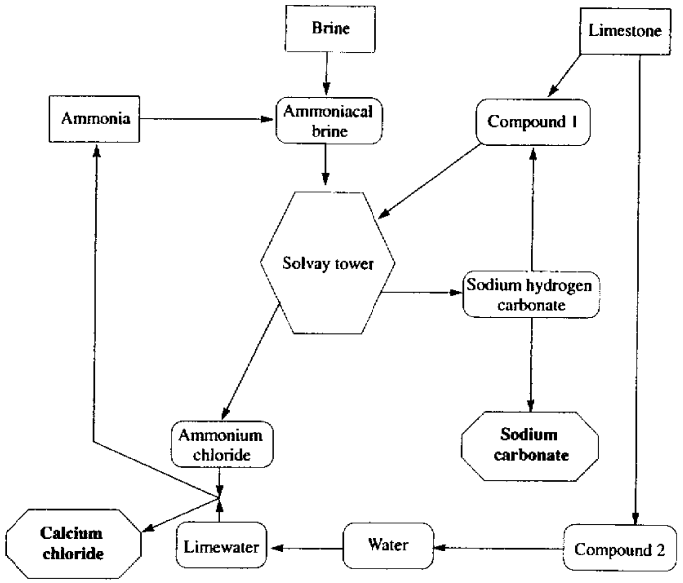
$$3H_{2(g)} + N_{2(g)} \rightleftharpoons 2NH_{3(g)} \qquad \Delta H = -92 \text{ kJ}$$

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

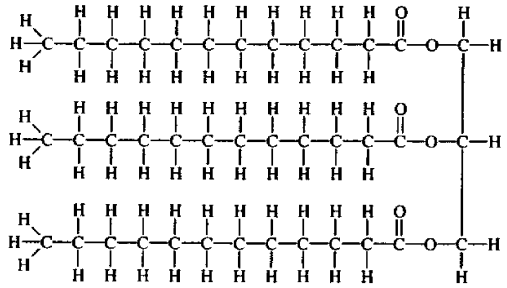
(ii) Write an equation showing how Compound 1 is also produced as a byproduct of the production of sodium carbonate. 1

(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

Question 29 (Continued) Marks

(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.

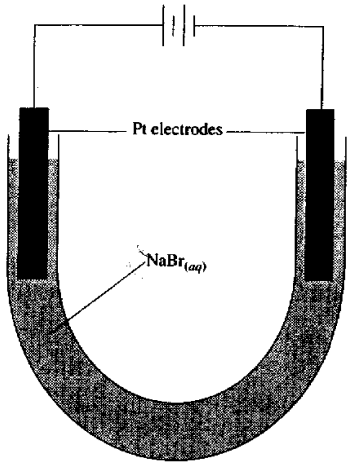
(i) You have performed a first hand investigation in which you compared the rate of corrosion of pure iron and an identified form of steel. Describe how you performed this experiment. Identify the factors that needed to be considered during this investigation to ensure that the result produced a fair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

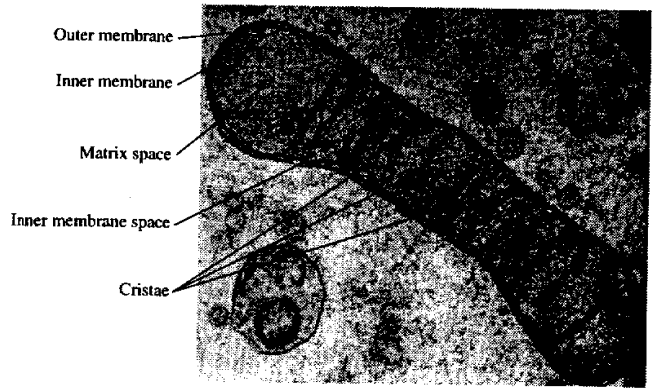
(b) The production of energy in the TCA (Tricarboxylic Acid) Cycle can be considered as an oxidation-reduction process.

(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.

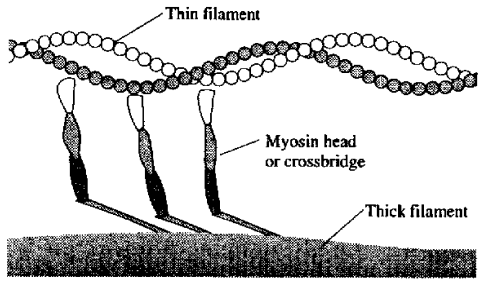
(i) Name and draw the general structure of the chemical unit that makes up enzymes. Identify the major functional groups of the molecule. 2

(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

Question 31 (Continued) Marks

(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

Marks

Question 32 — Chemistry of Art (25 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**

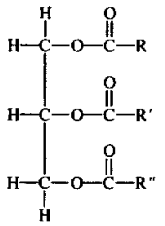
(ii) Describe a test that reveals the presence of a reducing sugar. **2**

(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**

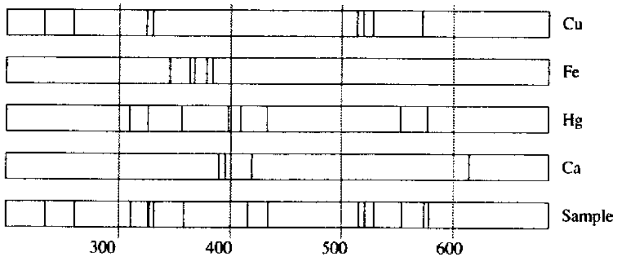
(iv) What is likely to be the main difference between trimyristin and a fat obtained from an animal? **1**

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

Chemistry Data Sheet

Values of several constants

Avogadro's constant, N_A	6.022×10^{23} mol^{-1}
Volume of 1 mole of ideal gas at 101.3 kPa (1.00 atm)	
at 273 K (0°C)	22.41 L
at 298 K (25°C)	24.47 L
Ionisation constant for water	
at 298 K (25°C), K_w	1.0×10^{-14} mol^2 L^{-2}
Specific heat capacity of water	4.18 J K^{-1} g^{-1}

Useful formulae

$pH = -\log_{10}[H^+]$ $\quad\quad$ $\Delta H = mC\Delta T$

Standard potentials

$K^+ + e^- \rightleftharpoons K_{(s)}$	–2.92 V
$Ba^{2+} + 2e^- \rightleftharpoons Ba_{(s)}$	–2.90 V
$Ca^{2+} + 2e^- \rightleftharpoons Ca_{(s)}$	–2.87 V
$Na^+ + e^- \rightleftharpoons Na_{(s)}$	–2.71 V
$Mg^{2+} + 2e^- \rightleftharpoons Mg_{(s)}$	–2.36 V
$Al^{3+} + 3e^- \rightleftharpoons Al_{(s)}$	–1.66 V
$Mn^{2+} + 2e^- \rightleftharpoons Mn_{(s)}$	–1.18 V
$H_2O_{(l)} + e^- \rightleftharpoons \frac{1}{2}H_{2(g)} + OH^-$	–0.83 V
$Zn^{2+} + 2e^- \rightleftharpoons Zn_{(s)}$	–0.76 V
$Fe^{2+} + 2e^- \rightleftharpoons Fe_{(s)}$	–0.41 V
$Ni^{2+} + 2e^- \rightleftharpoons Ni_{(s)}$	–0.23 V
$Sn^{2+} + 2e^- \rightleftharpoons Sn_{(s)}$	–0.14 V
$Pb^{2+} + 2e^- \rightleftharpoons Pb_{(s)}$	–0.13 V
$H^+ + e^- \rightleftharpoons \frac{1}{2}H_{2(g)}$	0.00 V
$SO_4^{2-} + 4H^+ + 2e^- \rightleftharpoons H_2SO_3 + H_2O$	0.17 V
$Cu^{2+} + 2e^- \rightleftharpoons Cu_{(s)}$	0.35 V
$\frac{1}{2}O_{2(g)} + H_2O_{(l)} + 2e^- \rightleftharpoons 2OH^-$	0.40 V
$Cu^+ + e^- \rightleftharpoons Cu_{(s)}$	0.52 V
$\frac{1}{2}I_{2(s)} + e^- \rightleftharpoons I^-$	0.54 V
$\frac{1}{2}I_{2(aq)} + e^- \rightleftharpoons I^-$	0.62 V
$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$	0.77 V
$Ag^+ + e^- \rightleftharpoons Ag_{(s)}$	0.80 V
$\frac{1}{2}Br_{2(l)} + e^- \rightleftharpoons Br^-$	1.07 V
$\frac{1}{2}Br_{2(aq)} + e^- \rightleftharpoons Br^-$	1.09 V
$O_{2(g)} + 4H^+ + 4e^- \rightleftharpoons 2H_2O_{(l)}$	1.23 V
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O_{(l)}$	1.23 V
$\frac{1}{2}Cl_{2(g)} + e^- \rightleftharpoons Cl^-$	1.36 V
$\frac{1}{2}Cl_{2(aq)} + e^- \rightleftharpoons Cl^-$	1.40 V
$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O_{(l)}$	1.51 V
$\frac{1}{2}F_{2(g)} + e^- \rightleftharpoons F^-$	2.87 V