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HSC Trial Examination 2003

Chemistry

This paper must be kept under strict security and may only be used on or after the afternoon of Friday 8 August, 2003, as specified in the NEAP Examination Timetable

General Instructions

Reading time 5 minutes

Working time 3 hours

Write using blue or black pen.

Draw diagrams using pencil.

Board-approved calculators may be used.

A data sheet and a Periodic Table are provided at the back of this paper.

Total marks 100

Section I Pages 2–18

Total marks 75

This section has two parts, Part A and Part B

Part A — 15 marks

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

Part B — 60 marks

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

Section II Pages 19–25

Total marks 25

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

Students are reminded that this is a trial examination only and cannot in any way guarantee the content or the format of the 2003 Chemistry Higher School Certificate examination.

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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.

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. Which of the following equations correctly represents the molar heat of combustion of a compound?

(A) $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$

(B) $2C_2H_{6(g)} + 7O_{2(g)} \rightarrow 4CO_{2(g)} + 6H_2O_{(l)}$

(C) $C_6H_{12}O_{6(aq)} + O_{2(g)} \rightarrow 2CO_{2(g)} + 2C_2H_5OH_{(aq)}$

(D) $C_3H_{8(g)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(l)}$

2. The formation of ethyl methanoate, ammonia and ethylene from ethanol all require catalysts.

Which of the following correctly lists the catalysts for these reactions in order?

(A) Concentrated sulfuric acid, finely divided iron, yeast enzymes.

(B) Dilute sulfuric acid, methane, concentrated sulfuric acid.

(C) Concentrated sulfuric acid, high pressure, yeast enzymes.

(D) Concentrated sulfuric acid, finely divided iron, concentrated sulfuric acid.

3. The reaction between silver ions and manganese (II) ions may be represented as follows.

$$2Ag^+_{(aq)} + Mn^{2+}_{(aq)} \rightarrow 2Ag_{(s)} + Mn^{4+}_{(aq)}$$

This equation shows us that

(A) Mn^{2+} acts as a reducing agent.

(B) Mn^{2+} gets reduced.

(C) Ag^+ donates electrons.

(D) Ag^+ gains two electrons.

4. Which of the following equations represents β-decay?

(A) ${}^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$

(B) ${}^{238}_{92}U \rightarrow {}^{232}_{90}Th + {}^{4}_{2}He$

(C) ${}^{35}_{17}Cl + {}^{0}_{-1}e \rightarrow {}^{35}_{16}S$

(D) ${}^{238}_{92}U + {}^{1}_{0}n \rightarrow {}^{94}_{35}Br + {}^{152}_{54}Xe + 3{}^{1}_{0}n$

5. A solution of pH 3 has the necessary changes made to it so that it is now a pH of 5.

What change has been made to the concentration of H^+?

(A) It has become more concentrated by a factor of 2.

(B) It has become more concentrated by a factor of 100.

(C) It has become less concentrated by a factor of 2.

(D) It has become less concentrated by a factor of 100.

6. Citric acid (2-hydroxypropane-1,2,3-tricarboxylic acid) is a weaker acid than sulfuric acid, even though citric acid is triprotic.

Which of the following best explains the above statement?

(A) Citric acid ionises more completely than sulfuric acid.

(B) Sulfuric acid will react completely with a base, but citric acid will only react partially with a base.

(C) Sulfuric acid is diprotic and therefore ionises more easily.

(D) Citric acid ionises less completely than sulfuric acid.

7. Consider the reactions shown below.

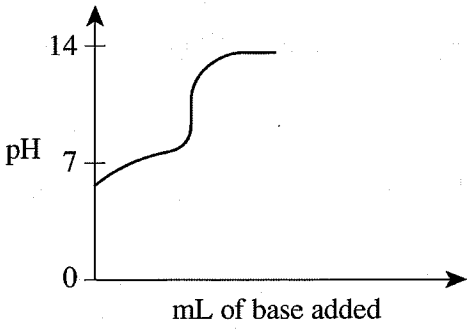
I $H_2SO_3 + H_2O \rightarrow H_3O^+ + HSO_3^-$

II $Fe^{3+} + SCN^- \rightarrow FeSCN^{2+}$

Which of the following statements is correct?

(A) I and II are both acid-base reactions.
(B) H_2SO_3 / HSO_3^- and Fe^{3+} / $FeSCN^{2+}$ are conjugate pairs.
(C) Reaction I involves the formation of a co-ordinate covalent bond.
(D) Reaction I shows HSO_3^- acting as an acid.

8. A student performed a titration and presented her results in the following graph.



What does the pH of the equivalence point suggest?

(A) The solution was neutral at that point.
(B) There are more OH^- ions than H^+ ions.
(C) There are free OH^- present in the original solution.
(D) The acid/base mixture was never neutral.

9. According to Lavoisier's ideas about acids, which of the following compounds would be acidic in water?

(A) NO_2
(B) NH_3
(C) HCl
(D) HBr

10. The production of ammonia needs raw materials. Which substance or process is the major source of hydrogen?

(A) Hydrogen carbonate ions
(B) Distillation of liquefied air
(C) Natural gas
(D) Catalytic cracking

11. A solution containing a dissolved salt is tested as follows.

> Dilute HCl is added and the white precipitate formed is filtered off.
> $Na_2SO_{4(aq)}$ is added to the filtrate but nothing happens.
> Addition of dilute NaOH results in the formation of a brown precipitate.

Which cations are present in the solution?

(A) Ba^{2+} and Ca^{2+}
(B) Ca^{2+} and Fe^{2+}
(C) Fe^{2+} and Cu^{2+}
(D) Pb^{2+} and Fe^{3+}

12. Read the following statements.

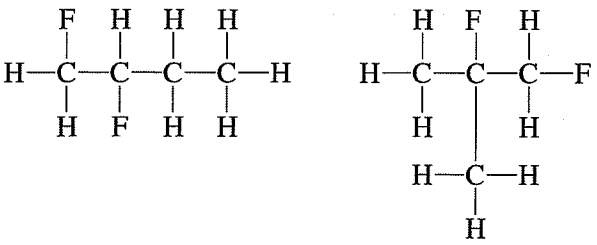
I Water vapour and carbon dioxide are both greenhouse gases.
II To reduce ozone depletion chlorofluorocarbons have been replaced by halons such as 1,2-dibromoethane.
III Ozone is a pollutant in the stratosphere but acts as a UV absorber in the troposphere.

Which of the statements I, II and III are true?

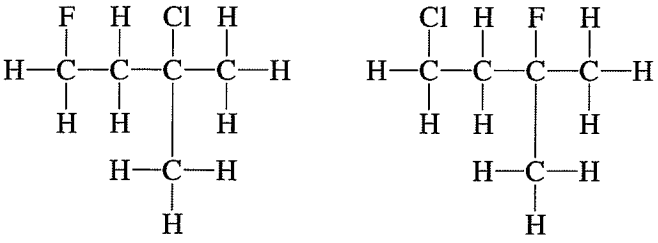
(A) I only
(B) I and II only
(C) I, II and III
(D) II only

13. Which of the following pairs are NOT isomers?

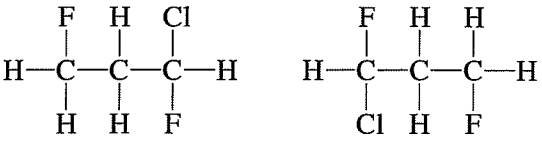
(A)



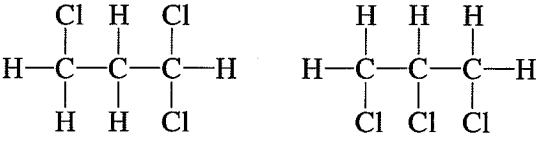
(B)



(C)



(D)



14. Why are microscopic membrane filters useful?

(A) They are unable to remove colloidal particles.

(B) Organisms such as *Giardia* and *Cryptosporidium* will not pass through them if the pores are small enough.

(C) Osmosis can be used to produce drinking quality water.

(D) They are cheaper than chemical treatments.

15. Students at a coastal school were given some water samples to analyse. Their results are shown in the table below.

Test	*Turbidity*	*Nitrate concentration*	*Dissolved oxygen*
Sample 1	very low	low	9 ppm
Sample 2	very low	low	4 ppm
Sample 3	medium	high	1 ppm
Sample 4	high	low	3 ppm

Which of the following shows the most likely source for the given samples?

	Source	
	Flowing river	*Downstream from a diary farm*
(A)	Sample 1	Sample 4
(B)	Sample 1	Sample 3
(C)	Sample 2	Sample 3
(D)	Sample 2	Sample 4

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 (3 marks)

Give the systematic name of vinyl chloride. Describe TWO uses of a polymer made from it in terms of its properties. **3**

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Marks

Question 17 (4 marks)

Describe the structure of cellulose and its potential as a raw material. **4**

Marks

Question 18 (6 marks)

(a) Draw a galvanic cell comprised of $Zn_{(s)}$, 1 mol L^{-1} $Zn(NO_3)_{2(aq)}$, $Ag_{(s)}$ and 1 mol L^{-1} $AgNO_{3(aq)}$ and an ammonium nitrate salt bridge. Make sure that the anode is on the left and that you clearly label the direction of electron flow. **2**

(b) Write the ionic equations and the overall reaction for this cell, including the cell voltage. **2**

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(c) Using Le Chatelier's principle, explain what will happen to the cell voltage if the concentration of zinc ions is increased. **2**

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Marks

Question 19 (7 marks)

Ethanol has potential as an alternative fuel. Assess this potential, including in your answer a brief description of two ways in which it can be produced, with relevant equations, and a discussion of the advantages and disadvantages of its use. 7

Marks

Question 20 (3 marks)

A student dissolved some $NaHCO_3$ in a small amount of water. She knew that $HCO_3^-{}_{(aq)}$ could react in each of the following ways.

I $HCO_3^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons H_2CO_{3(aq)} + OH^-{}_{(aq)}$

OR

II $HCO_3^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons CO_3^{2-}{}_{(aq)} + H_3O^+{}_{(aq)}$

(a) Name the type of behaviour being shown by $HCO_3^{-1}{}_{(aq)}$. **1**

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(b) Describe a simple test you could perform to determine whether reaction I or II is more likely to occur. Give the expected result for your test. **2**

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Question 21 (4 marks)

Vinegar is an aqueous solution of acetic (ethanoic) acid, a weak acid.

(a) Apart from its taste, explain why acids such as vinegar are often used as food additives. **2**

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(b) Explain why such a solution would have a higher pH than a hydrochloric acid solution of the same concentration. **2**

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Marks

Question 22 (6 marks)

Assess the evidence which indicates that the atmospheric concentration of oxides of sulfur and nitrogen have been increasing. **6**

Marks

Question 23 (5 marks)

In your studies, you have investigated the production of esters, an endothermic process, and the Haber process, an exothermic process. **5**

Compare the application of reaction rate and equilibrium principles in the production of esters and the Haber process.

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Question 24 (1 mark)

Internal combustion engines use petrol or diesel as fuels. State why computers in modern cars monitor the levels of carbon monoxide and nitrogen oxides produced. **1**

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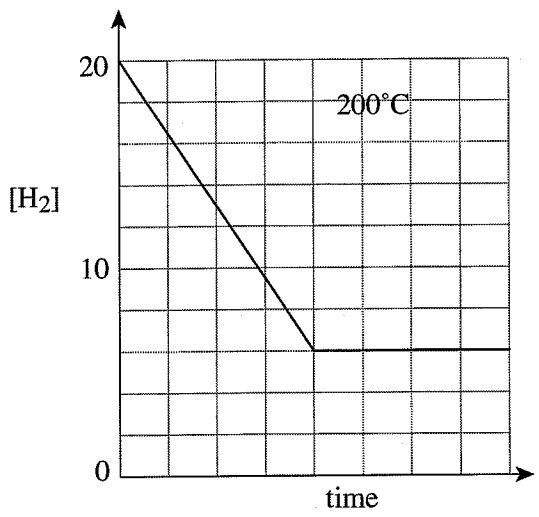
Marks

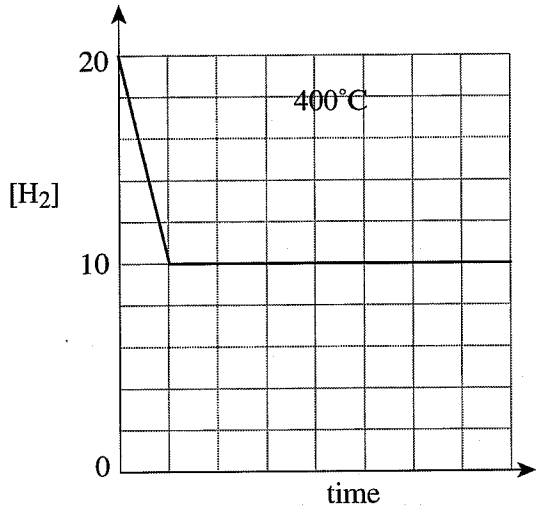
Question 25 (7 marks)

The formation of ammonia from its constituent elements can be summarised using the following equation.

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

This reaction was performed at two different temperatures. The change in the concentration of the hydrogen gas during reaction was monitored. The results were presented as follows.





Using these graphs, answer the following questions.

(a) At which temperature was equilibrium achieved fastest? Explain your reasoning. **2**

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(b) How can it be deduced that the formation of ammonia is exothermic? **2**

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(c) When this reaction is performed industrially, a catalyst is used. **1**

Identify the catalyst.

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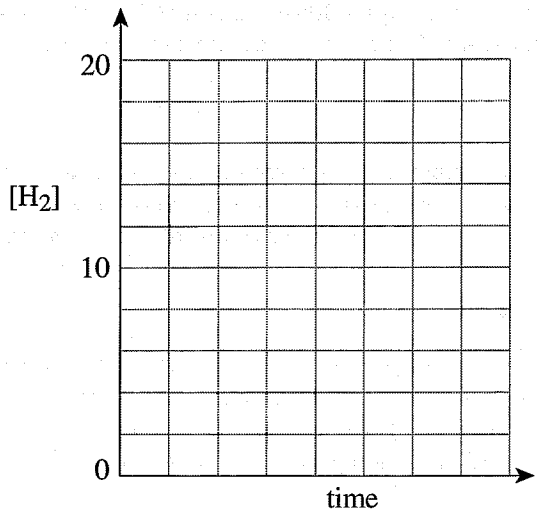
Marks

(d) On the graph below, draw the curve to show how the concentration of hydrogen gas would vary during the reaction if a catalyst was used at 200°C. **2**



Marks

Question 26 (7 marks)

As part of the course you designed and carried out a first hand investigation to determine the percentage of sulfate ion in a lawn fertiliser. Read the following two methods. In each case, barium sulfate is produced.

STUDENT A

"I dissolved a 10 g sample of ammonium sulfate in a total volume of 100 mL of solution, added 10 mL of dilute hydrochloric acid and an excess of 0.1 M barium chloride solution. The white precipitate formed was collected and 5.4 g of precipitate was present. I noticed that some solid passed through the filter paper."

STUDENT B

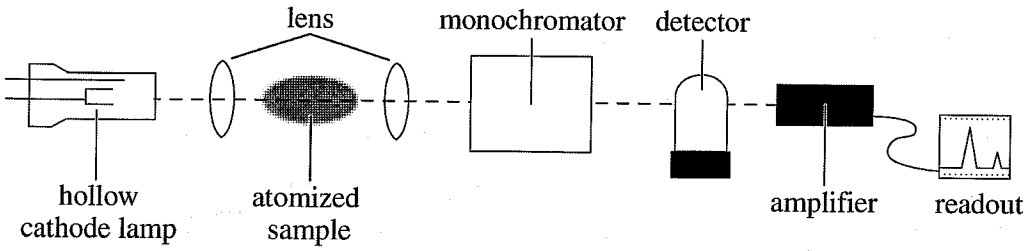
"I dissolved a 2 g sample of Epsom salts ($MgSO_4$) which I had bought from the garden shop, to make up 30 mL of solution. Some dilute acid was added as were a few drops of Alizarin Red indicator. Barium chloride solution (0.2 mol L^{-1}) was added from a burette until the indicator changed from a pale yellow to a pale red, indicating the end point. The volume added was 44 mL."

Evaluate each of the methods used in terms of procedure and validity of results. Determine the percentage of sulfate in the Epsom salts. **7**

Marks

Question 27 (3 marks)

Atomic absorption spectroscopy (AAS) is a method used to determine the concentration of a metal ion down to levels of ppm or ppb. Samples of accurately known concentration are vaporised and allowed to absorb radiation of a specific frequency. The amount of radiation absorbed is a measure of how much of the ion is present.

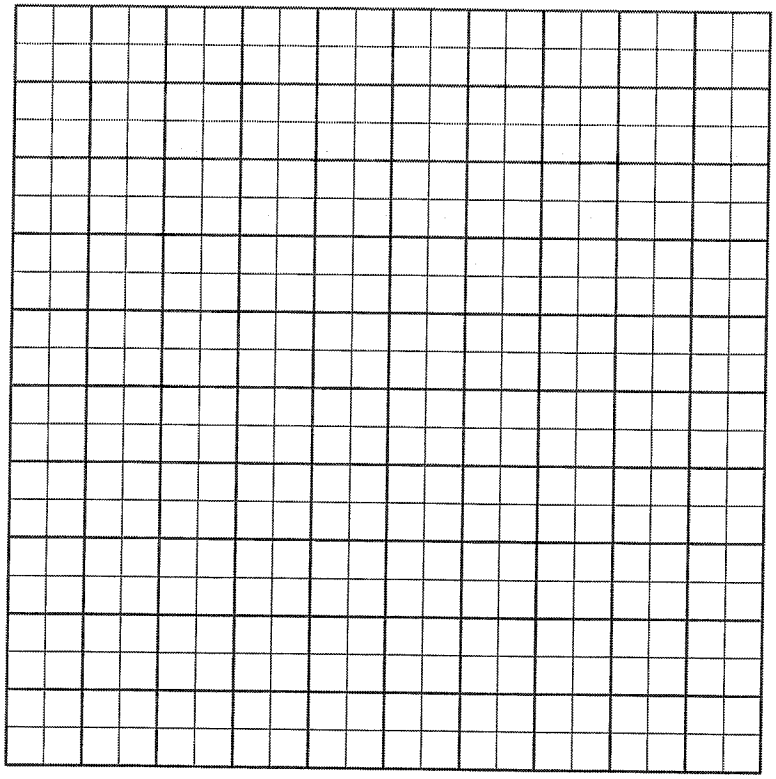


The following AAS data was obtained for cadmium:

Concentration of cadmium (ppm)	2.1	3.9	6.0	7.9	9.8
Absorbance	0.16	0.32	0.49	0.64	0.80

A sample of soil containing cadmium was dissolved and diluted by a factor of 100. Its absorbency was measured and found to be 0.53. **3**

Graph the calibration data given in the table and use your graph to calculate the concentration of cadmium in the soil sample.



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Marks

Question 28 (4 marks)

In May 2003, heavy rains swept through the Sydney region. Describe a possible effect on each of the following factors that determine water quality of local waterways.

(a) Turbidity **1**

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(b) Total dissolved solids **1**

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(c) Nitrogen to phosphorus ratio **1**

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(d) pH **1**

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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) (i) Define *oleum*. **1**

(ii) Identify the safety precautions needed when concentrated sulfuric acid is diluted in the laboratory and explain why these precautions are necessary. **3**

(b) (i) Describe, with the use of chemical equations, the products of electrolysis of dilute sodium chloride solution and concentrated sodium chloride. **2**

(ii) Explain why the predicted products are obtained. **2**

(c) During your practical work you performed a first hand investigation to model a chemical step involved in the Solvay process.

(i) Outline the procedure you used. **2**

(ii) Discuss the significance of the chemical step within the Solvay process. **2**

(d) Sulfuric acid is a chemical of major importance to industrialised nations.

The production of sulfuric acid is a step-wise procedure. One of these steps is described by the equilibrium reaction

$$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)} + \text{heat}$$

(i) Write the expression for the equilibrium constant for the reaction as written above. **1**

(ii) In one preparation, the following concentrations of gases were recorded at equilibrium. **2**

$[SO_2] = 0.4 \text{ mol L}^{-1}$
$[O_2] = 1.0 \text{ mol L}^{-1}$
$[SO_3] = 5.0 \text{ mol L}^{-1}$

Calculate the value of the equilibrium constant, K.

(iii) Explain what would happen to the value of K and the position of equilibrium if **4**

- the temperature at which the reaction was conducted was increased while keeping other conditions constant.
- the pressure on the reaction system was increased while keeping other conditions constant.

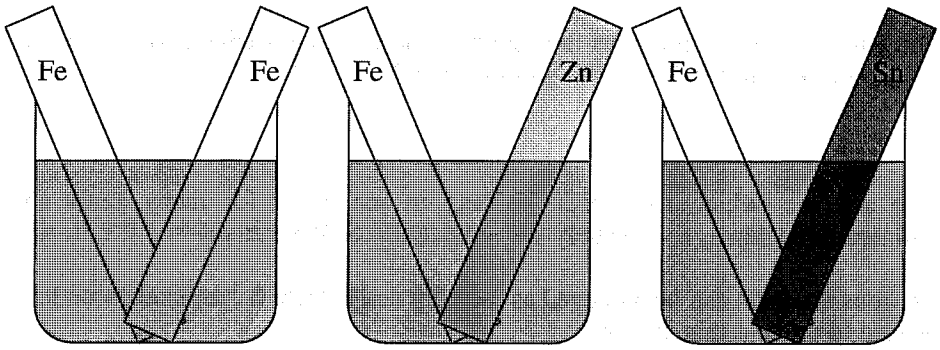
(e) Evaluate the impact of soaps and detergents on the environment. **6**

Marks

Question 30 — Shipwrecks, Corrosion and Conservation (25 marks)

(a) Account for the differences in the corrosion of active and passivating metals. **2**

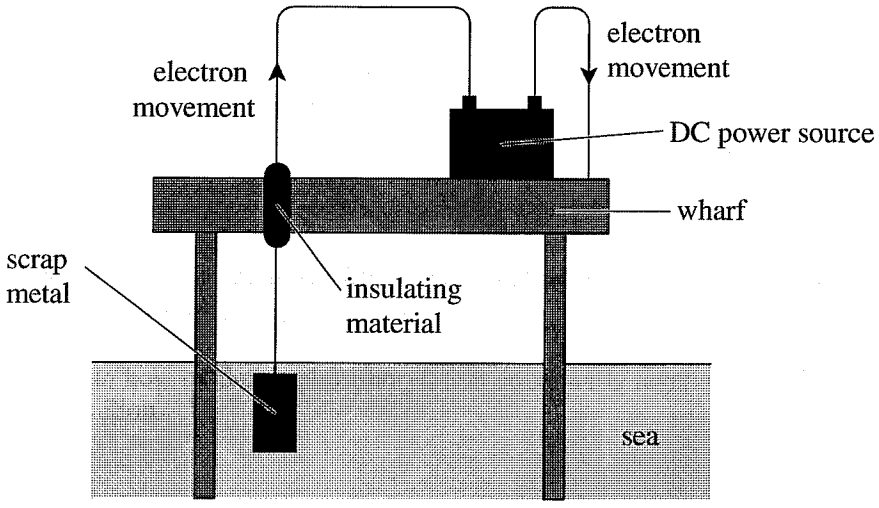
(b) Three beakers containing 200 mL of deionised water at 20°C had pieces of metal placed in them as shown in the following diagrams.



(i) Compare the rate of rust formation in each of the above experiments. Use equations to explain your answer. **3**

(ii) The above experiment was repeated using 0.5 mol L^{-1} NaCl rather than water. Predict what change, if any, would occur to the rate of corrosion. Explain why. **2**

(c) Techniques have been developed to protect steel structures while they float in the ocean. One such method is shown in the following diagram.



(i) Name the process shown in the above diagram. **1**

(ii) Describe how this process works to protect the steel wharf from corrosion. **3**

(iii) Identify and discuss one other way that can be used to protect the metal hull of a ship from corrosion in sea water. **2**

Question 30 continues on page 22

Marks

Question 30 (Continued)

(d) Shipwrecks at great depths were expected to show little corrosion of iron. Once recovered, this was found not to be the case. The iron showed extensive corrosion. It is now believed that the action of sulfate-producing bacteria are responsible for this corrosion.

(i) Outline TWO reasons why it was anticipated that corrosion of iron at great depths in the ocean would be minimal. **2**

(ii) Describe with the use of equations the action of these bacteria which contributes to the corrosion of the iron. **4**

(e) Porous organic artefacts which have been soaking in sea water for many years are particularly vulnerable to damage when they are removed from the water.

Explain how porous artefacts can be damaged as they dry and discuss a chemical procedure which can be used to prevent this damage. **6**

End of Question 30

Marks

Question 31 — The Biochemistry of Movement (25 marks)

(a) (i) Humans store carbohydrates as glycogen granules in our muscles and liver. Identify the monomer that makes up the polymer glycogen. **1**

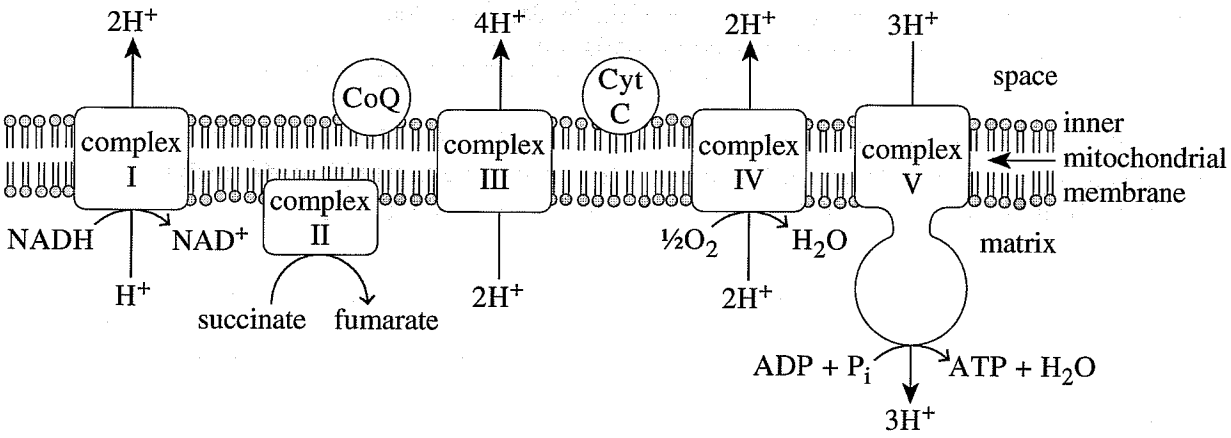
(ii) Describe the process of bond formation between these monomers to produce glycogen. **3**

(b) Discuss the role of the oxidation of fatty acids in the inhibition of the pyruvate conversion to acetyl CoA. **4**

(c) (i) Identify the cause of contraction movement in muscles. **1**

(ii) Explain the role of ATP in this process. **4**

(d) During your studies of this module you processed information from a simplified flow chart of biochemical pathways to analyse the steps in oxidative phosphorylation. The diagram below represents the reactions of oxidative phosphorylation.



(i) Explain the role of $NADH/FADH_2$ oxidation as a part of the oxidation-reduction process leading to ATP production. **2**

(ii) Explain how oxidative phosphorylation continually regenerates ATP used in muscle contraction. **4**

(e) Carbohydrate loading is a strategy sometimes used by athletes to increase their stores of energy. Six days before competition, the athlete reduces carbohydrate intake and increases exercise to deplete the body stores, and then eats high levels of carbohydrates for the next three days to restore and enhance energy stores. **6**

Evaluate the use of this strategy for the two extremes of exercise.

Marks

Question 32 — The Chemistry of Art (25 marks)

(a) Name TWO pigments and outline how each is prepared and used. **4**

(b) In your study you have investigated species such as $[Co(NH_3)_6]^{3+}$.

(i) Define what is meant by the term ligand. **1**

(ii) Explain the bonding between the metal and the NH_3 in $[Co(NH_3)_6]^{3+}$. **2**

(c) Explain how information about the electron structure of atoms is obtained by studying the atomic emission spectrum of hydrogen. **5**

(d) As part of this option you performed a first hand investigation to observe colour changes of a transition metal in its various oxidation states.

(i) Name the metal you investigated and state the colour changes observed for each oxidation state. **2**

(ii) Outline one method used to change one of the oxidation numbers. Explain this change in terms of electron configurations. **5**

(e) Giving appropriate examples, explain the use of infrared and ultraviolet light in the analysis and identification of pigments such as zinc oxide and those containing copper. **6**

Marks

Question 33 — Forensic Chemistry (25 marks)

(a) (i) Identify the empirical formula for carbohydrates. **1**

(ii) Describe the chemical difference between reducing and non-reducing sugars with reference to distinguishing tests. **3**

(b) Discuss the importance of accuracy in forensic chemistry with reference to both the precautions required to prevent contamination of samples and the ethical issues which may arise during an investigation. **4**

(c) (i) Identify the structure and composition of DNA. **2**

(ii) Describe the use of electrophoresis to analyse DNA and explain how this analysis allows identification of individuals. **3**

(d) During your practical work you have performed a first hand investigation to separate a mixture of organic materials.

(i) Name the process used to perform the separation. **1**

(ii) Outline the procedure used in this investigation. **2**

(iii) Identify the characteristics of the mixture which allow it to be separated by this process and explain how this technique could assist a forensic chemist. **3**

(e) Discuss the ways in which analytical techniques such as gas-liquid chromatography and high performance liquid chromatography provide evidence about forensic samples and assess their value in small sample analysis. **6**

End of paper

Chemistry Data Sheet

Avogadro's constant, N_A ..... 6.022×10^{23} mol^{-1}

Volume of 1 mole of ideal gas at 100 kPa and

at 0°C (273 K) ..... 22.71 L

at 25°C (298 K) ..... 24.79 L

Ionisation constant for water at 25°C (298 K), K_w 1.0×10^{-14}

Specific heat capacity of water ..... 4.18×10^3 J kg^{-1} K^{-1}

Some useful formulae

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

Some standard potentials

$K^+ + e^- \rightleftharpoons K_{(s)}$	–2.94 V
$Ba^{2+} + 2e^- \rightleftharpoons Ba_{(s)}$	–2.91 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
$Al^{3+} + 3e^- \rightleftharpoons Al_{(s)}$	–1.68 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
$Fe^{2+} + 2e^- \rightleftharpoons Fe_{(s)}$	–0.44 V
$Ni^{2+} + 2e^- \rightleftharpoons Ni_{(s)}$	–0.24 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
$SO_4^{2-} + 4H^+ + 2e^- \rightleftharpoons SO_{2(aq)} + 2H_2O$	0.16 V
$Cu^{2+} + 2e^- \rightleftharpoons Cu_{(s)}$	0.34 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
$\frac{1}{2}Br_{2(l)} + e^- \rightleftharpoons Br^-$	1.08 V
$\frac{1}{2}Br_{2(aq)} + e^- \rightleftharpoons Br^-$	1.10 V
$\frac{1}{2}O_{2(g)} + 2H^+ + 2e^- \rightleftharpoons H_2O_{(l)}$	1.23 V
$\frac{1}{2}Cl_{2(g)} + e^- \rightleftharpoons Cl^-$	1.36 V
$\frac{1}{2}Cr_2O_7^{2-} + 7H^+ + 36e^- \rightleftharpoons Cr^{3+} + \frac{7}{2}H_2O_{(l)}$	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
$\frac{1}{2}F_{2(g)} + e^- \rightleftharpoons F^-$	2.89 V

Periodic Table of the Elements

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 — Ununnium	112 Uub — Unubium	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.