2002
Higher School Certificate
Trial Examination

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Board approved calculators may be used
- Write using black or blue pen
- Draw diagrams using pencil
- A Data Sheet and Periodic Table are provided at the back of this paper
- Write your student number and/or name at the top of every page

Total marks - 100
Section I
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 – 29
Allow about 1 hour 45 minutes for this part
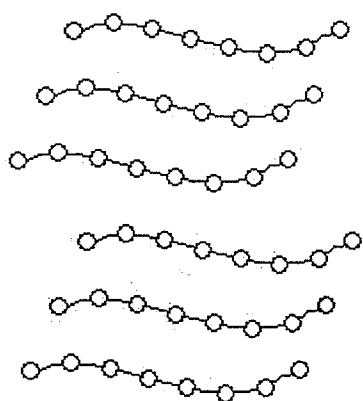
Section II
Total marks (25)
Attempt ONE question from Questions 30-34
Allow about 45 minutes for this section

This paper MUST NOT be removed from the examination room

STUDENT NUMBER/NAME: ... ...

1. Each line in the diagram below represents a strand in the polymer chain polyethylene.
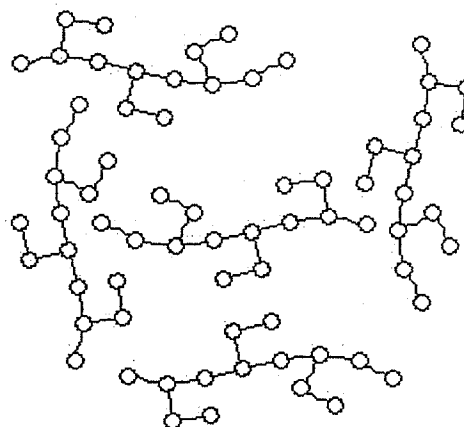
Polymer A   **Polymer B**

Compared with Polymer B, Polymer A would:

(A) be more rigid and dense
(B) more easily dissolve in a non-polar substance such as kerosene
(C) react rapidly with bromine water
(D) take much longer to break down in sunlight

2. Bromine water can be used to distinguish between:

(A) ethane and propane
(B) propane and propene
(C) ethene and propene
(D) ethane and ethanol

3. Which of the following metals could reduce iron(II) ions in aqueous solution?

(A) zinc
(B) tin
(C) copper
(D) silver

4. Consider the reaction described by the equation below:

$$C_2H_5OH \rightarrow C_2H_4 + H_2O$$
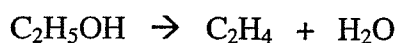
This reaction is an example of:

(A) polymerisation
(B) hydration
(C) dehydration
(D) addition

5. The table below gives some properties of radioactive isotopes

Name	Radiation emitted	Half Life
Americium-241	α	432 years
Carbon-14	β	5.7×10^3 years
Magnesium-27	β	9.5 minutes
Sodium-24	β, γ	15 hours

The isotope that is most suitable for detecting leaks in water pipes would be.

(A) Americium-241
(B) Carbon-14
(C) Magnesium-27
(D) Sodium-24

Questions 6 and 7 refer to the table below which shows the colour ranges of three acid–base indicators.

Indicator	Very acidic						Neutral						Very basic		
pH	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Bromothymol blue	yellow						$\rightarrow$6.0		7.6$\leftarrow$				blue		
Methyl orange	red		$\rightarrow$3.1		4.5$\leftarrow$			yellow							
Phenolphthalein	colourless								$\rightarrow$8.3		10.0$\leftarrow$		red		

6. A solution is yellow in bromothymol and methyl orange, and colourless in phenolphthalein. What is the pH range of the solution?

(A) 7.5 to 8.5
(B) 6.0 to 7.5
(C) 4.5 to 6.0
(D) 8.5 to 10.0

7. 0.1 mol L^{-1} citric acid ($C_6H_8O_7$) solution is neutralised with a solution of 0.1 mol L^{-1} sodium hydroxide (NaOH). The best indicator for this titration would be:

(A) methyl orange
(B) phenolphthalein
(C) a mixture of methyl orange and bromothymol blue.
(D) bromothymol blue

8. Three pieces of apparatus used in titrations are a conical flask, a burette and a pipette. Which of these pieces of apparatus should be rinsed with distilled water immediately prior to use in a titration?

(A) all three
(B) conical flask only
(C) burette only
(D) pipette only

9. The pH of four acids and their concentrations are shown in the table below.

Acid	Conc. (mol L^{-1})	pH
A	0.1	1.0
B	0.05	1.0
C	0.01	2.0
D	0.1	2.0

Which acid in the table is the weakest?

(A) A
(B) B
(C) C
(D) D

10. The pH of a solution of magnesium hydroxide of concentration 4.5×10^{-3} mol L^{-1} is closest to:

(A) 11.9
(B) 11.6
(C) 2.1
(D) 2.4

11. What is the correct systematic name for the following compound?

$$\begin{array}{ccc} F & Cl & \\ | & | & \\ H-C-C-Cl \\ | & | & \\ F & Cl & \end{array}$$
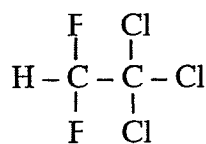
(A) 1,1,2,2,2 – difluorotrichloroethane
(B) ethane – 1,1 – difluoride – 2,2,2 – trichloride
(C) 1,1,1 – trichloro – 2,2 – difluoroethane
(D) trichlorodifluoroethane

12. A student analysed a sample of water from an underground spring which was suspected to be contaminated with certain metallic ions.

The student added dilute hydrochloric acid to the solution and noted no changes. She then added dilute ammonia to a second sample and also noted no change. She then performed a flame test and noted a faint but distinct red colour.

The ion in the water is most probably:

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

13. The diagram below represents the stages in the treatment of sewage.

Primary treatment   **Secondary treatment**
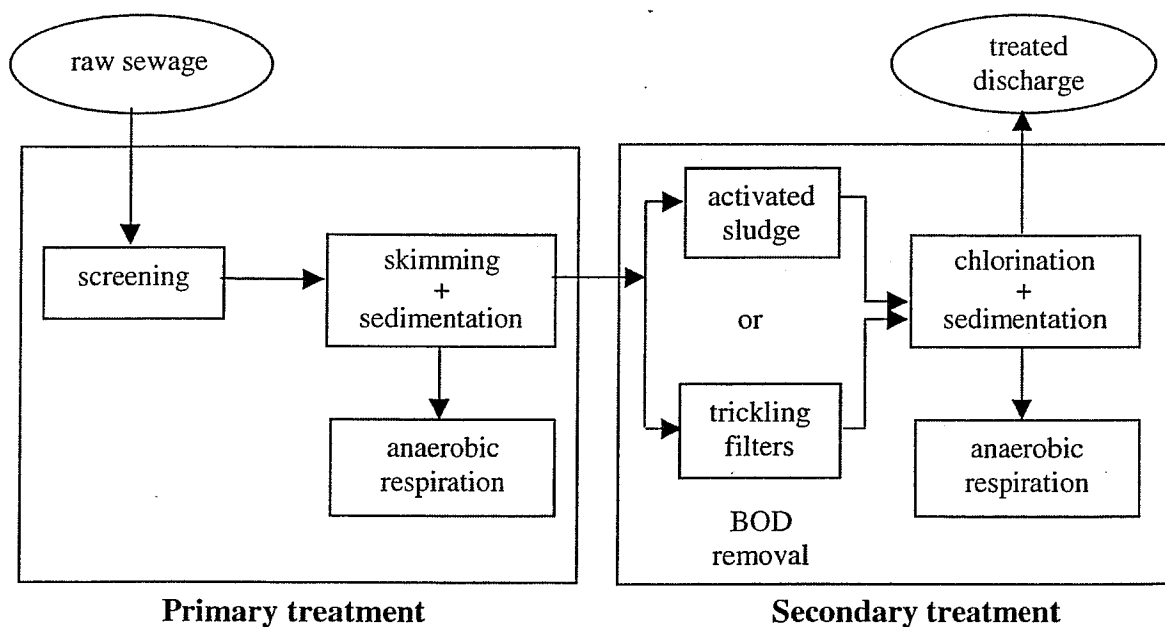
Secondary treatment chlorination would be used to:

(A) adjust the pH
(B) improve the BOD levels
(C) kill pathogens
(D) activate enzymes necessary for sewage digestion

14. The technique best suited to detecting low concentrations of metal ions in solutions would be:

    (A) fractional distillation
    (B) gas-liquid chromatography (GLC)
    (C) atomic absorption spectroscopy (AAS)
    (D) nuclear magnetic resonance spectroscopy (NMR)

15. The following table shows the potential release of acid into waterways from some minerals as a result of mining.

Potential acid release from some alunite group minerals		
Mineral	Formula	moles H^+/mole
Plumbojarosite	$PbFe_6(SO_4)_4(OH)_{12}$	6
Benverite	$Pb(Cu,Fe,Al)_3(SO_4)_2(OH)_6$	0 – 5
Natrojarosite	$NaFe_3(SO_4)_2(OH)_6$	3
Alunite	$KAl_3(SO_4)_2(OH)_6$	0

The most noticeable effect of run off from a mine waste heap with a high concentration of plumbojarosite into a nearby stream would be:

    (A) a rapid rise in BOD levels
    (B) pH levels would drop
    (C) dissolved oxygen levels would drop
    (D) eutrophication would begin

Section I - continued

Part B
Total marks (60)
Attempt questions 16 – 29
Allow about 1 hour 45 minutes for this part

Answer the questions in the spaces provided

Show all relevant working in questions involving calculations.

Marks

Question 16   (6 marks)

Many cosmetic and pharmaceutical preparations require the use of a solvent such as ethanol, which can be produced by the fermentation of sugars.

(a)   Relate the use of ethanol as a solvent to the nature of the ethanol molecule.   **2**

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(b)   Describe the conditions required to produce ethanol by the fermentation of glucose.   **2**

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(c)   Explain how mass changes can be used to monitor the fermentation reaction. A suitable equation should be included in your answer.   **2**

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Marks

Question 17 (2 marks)

The table below compares some properties of ethanol and diesel for use as fuels in motor vehicles. Assess ONE advantage and ONE disadvantage for ethanol as a fuel.

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Property	Ethanol	Diesel (approximate values)
Flashpoint	13°C	60-70°C
Ignition temperature	365°C	315°C
Enthalpy of combustion	30 MJ kg^{-1}	45 MJ kg^{-1}
Solubility in water	soluble	insoluble

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Question 18 (5 marks)

The equations below show the half reactions involved in the operation of a vanadium redox cell.

$$V^{3+} + e^- \Leftrightarrow V^{2+} \quad E^0 = -0.26 \text{ V}$$

$$VO_2^+ + 2H^+ + e^- \Leftrightarrow VO^{2+} + H_2O \quad E^0 = 1.00 \text{ V}$$
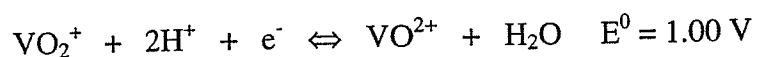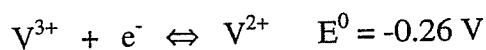
The reaction direction depends on whether the cell is charging or discharging.

(a) Identify the anode reaction when the cell is operating as a galvanic cell.

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(b) Write the overall cell reaction when the cell is operating as a galvanic cell.

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(c) Calculate the theoretical cell voltage that this cell could deliver under standard conditions.

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Question 18 continues on next page

Question 18 (continued)   **Marks**

(d) Describe ONE advantage of the vanadium redox cell in terms of its impact on society
     or the environment.   **2**

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Question 19 (3 marks)

Poly(chloroethene) is an addition polymer often referred to as poly(vinyl chloride) or PVC.

Describe how an addition polymer is formed using poly(chloroethene) as an example.   **3**

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Question 20 (4 marks)   **Marks**

"Radioactive carbon dating" is the name of a process used to date historical artifacts and specimens by determining the amount of the carbon-14 radioisotope present in the sample.

(a) Write an equation to represent the beta decay of carbon-14.   1

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(b) Identify an instrument that could be used to detect the radiation emitted from a
     radioisotope such as carbon-14.   1

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(c) Other radioisotopes are used in medicine for both diagnostic purposes and treatment.
     Give an example of a radioisotope used and analyse benefits associated with the use of
     this radioisotope.   2

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Question 21 (2 marks)

When 1.5 L of HCl gas and 1.8 L of NH_3 gas are mixed, a white solid of NH_4Cl is formed.
Calculate the mass of NH_4Cl formed if the gas volumes were measured at 25°C and
101.3 kPa.   2

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Question 22 (3 marks)   **Marks**

Choose an example of an amphiprotic substance and write equations to help explain its
behaviour in acidic and basic solutions.   **3**

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Question 23 (8 marks)   **Marks**

(a)   To perform an esterification reaction in the laboratory a student was provided with
      methanol and propanoic acid, which she heated together under reflux with a catalyst.

      (i)   Name the ester which could be synthesised.   **1**

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      (ii)   Draw a structural formula for this ester.   **1**

      (iii) Name a suitable catalyst for this reaction.   **1**

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      (iv)   Justify the use of heating under reflux for this experiment.   **2**

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Question 23 continues on next page

Question 23 (continued)   **Marks**

(b)   The ester formed in the above reaction has a molar mass of 88 g and boils at 78°C.
       Two other substances with the same molar mass are:
              1-pentanol   BP 138°C
              butanoic acid   BP 163°C

       Explain the difference in boiling points between these three substances.   **3**

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Question 24 (4 marks)

An equilibrium exists between gaseous and dissolved carbon dioxide in water as shown by
the following equation:

$$CO_{2(g)} \Leftrightarrow CO_{2(aq)}$$

With reference to Le Chatelier's principle explain the following:

(a)   fizzing occurs when a bottle of a carbonated drink is opened.   **2**

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(b)   It is observed that the fizzing is less if the bottle is kept under refrigeration rather than
       at room temperature. Deduce whether the dissolving process is exothermic or
       endothermic; explaining your reasoning.   **2**

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Question 25 (4 marks)

Marks

In a titration it is found that 20.0 mL of 0.200 mol L^{-1} sulfuric acid is required to neutralise 25.0 mL of a potassium hydroxide solution.

(a)   Write a balanced equation for the neutralisation.

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(b)   Calculate the concentration of the potassium hydroxide in mol L^{-1}.

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(c)   Calculate the mass of the potassium hydroxide in 5 litres of the above solution.

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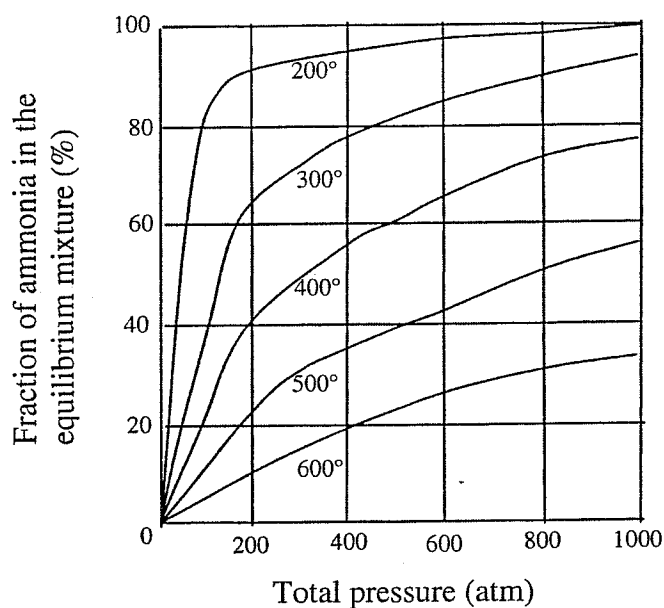**Question 26** (5 marks)   **Marks**

The graphs below show the fraction of ammonia present at equilibrium when nitrogen and hydrogen are reacted in a pressure vessel.

(a)   Write a balanced equation for this reaction.   **1**

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(b)   Referring to Le Chatelier's principle:

   (i)   explain why the gas mixture is compressed during the industrial manufacture of
         ammonia.   **1**

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   (ii) Explain why only temperatures of 400-500°C are used in the manufacture of
         ammonia although a higher temperature would accelerate the reaction.   **1**

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Question 26 continues on the next page

Question 26 (continued)

(c) Identify one reason for close monitoring of the gas stream entering the reaction vessel in the industrial synthesis of ammonia.   **1**

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(d) Identify ONE industrial use of ammonia.   **1**

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Question 27 (3 marks)

The data below gives the percentage composition of air by volume at sea level for a town on the far north coast of NSW.

Constituent	Symbol	Volume % in air	Molar mass
Nitrogen	N_2	78.084	28.01
Oxygen	O_2	20.9476	32.00
Argon	Ar	0.934	39.95
Carbon dioxide	CO_2	0.037	44.01
Neon	Ne	0.001818	20.18
Helium	He	0.000524	4.00
Methane	CH_4	0.00017	16.04

(a) Calculate the moles of oxygen present in 20 litres of this air at 25°C and 101.3 kPa.   **1**

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(b) Calculate the mass of argon which could be extracted from 200 litres of this air.   **2**

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Question 28 (7 marks)   **Marks**

A student analysed a 2.85 gram sample of washing powder for its phosphorus content. The phosphorus was precipitated as $Mg_2P_2O_7$ and then filtered. The mass of the precipitate was 0.125 gram.

(a) To assure accuracy describe TWO procedures that the student needed to undertake after filtration and before determining the mass of the precipitate.   **2**

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(b) Determine the percentage, by mass, of phosphorus in the washing powder.   **2**

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(c) Phosphorus in detergents in the form of phosphates acts as low cost builders, but together with nitrates cause pollution in waterways through the process of eutrophication.

Outline and describe the effects of eutrophication in natural waterways.   **3**
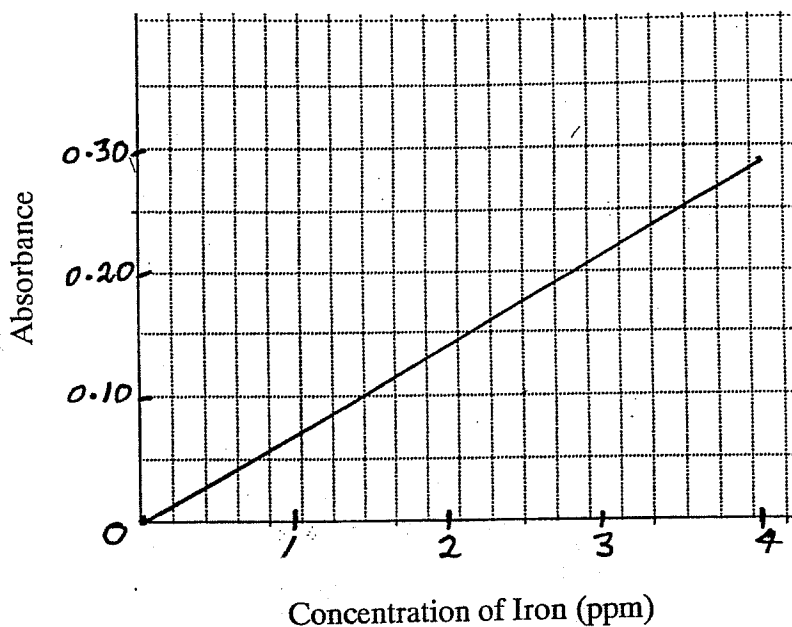
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Question 29 (4 marks)

A food company developed a new breakfast chocolate drink containing iron which is essential to human health.

The graph below shows the absorbance of a number of standard solutions containing iron using an Atomic Absorption Spectrometer.

Concentration of Iron (ppm)

A 10.0 mL sample of the chocolate drink was diluted to 50.0 mL and placed into the spectrometer. It was found to have an absorbance of 0.190.

(a) What is the concentration of iron, in ppm, in the undiluted chocolate drink? **1**

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(b) What mass of iron would you consume by drinking a 260 mL (260 g) glass of the chocolate drink? **1**

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(c) The recommended daily allowance of iron for people over 12 years of age is 18 mg. What percent of your daily needs does a 260 mL glass of the chocolate drink provide? **1**

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(d) Why was the chocolate drink diluted before its absorbance determined? **1**

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Question 31 – Shipwrecks and Salvage (25 marks)   **Marks**

(a)   (i)   The following pieces of information represent data obtained from an
            electrochemist's notebook

$$Sn_{(s)} \mid Sn^{2+}_{(aq)} \mid\mid Mn^{2+}_{(aq)} \mid Mn_{(s)}$$

            Predict which metal will corrode by using a list of standard potentials.   **1**

      (ii) Process information to supply the net ionic equation for the above
            electrochemical cell and predict the expected voltage of the cell under
            standard conditions.   **2**

(b)   (i)   In the electrochemical cell shown:
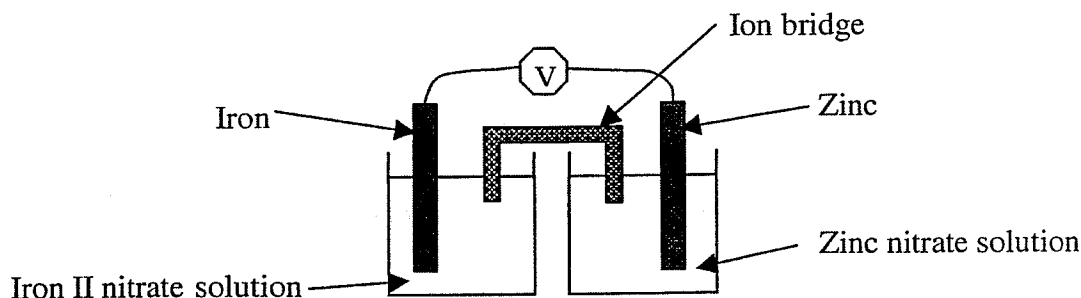
            Identify the ANODE in this device. Justify your choice.   **2**

      (ii) Examine the oxidation-reduction device shown below :
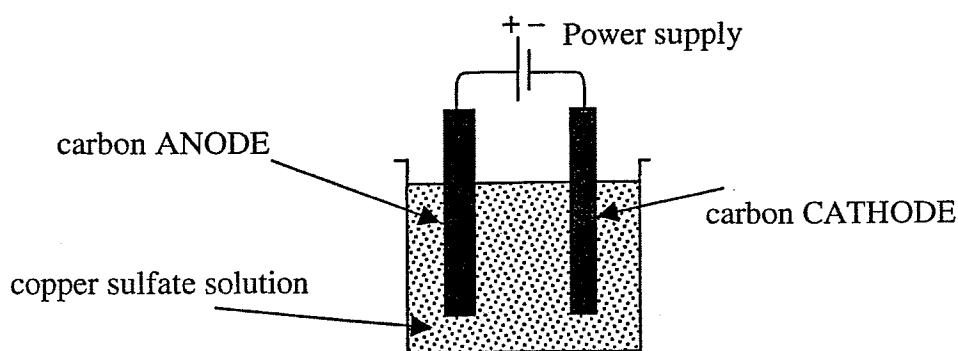
            This device, an electrolytic cell will be similar to one that you prepared in a first
            hand investigation that you conducted.

            Outline TWO observations, one at the ANODE and one at the CATHODE, that
            you would see as electrolysis occurred over a period of time.   **2**

Question 31 – Shipwrecks and Salvage continued on the next page

Question 31 – Shipwrecks and Salvage (continued)   **Marks**

(c)   A marine archaeologist has recently discovered a 600 year old wreck at the bottom of a Norwegian fjord (an ocean filled glacial valley). Describe all of the relevant issues in the preparing and preserving of pieces of wood from the wreck so that they can be displayed in a local museum.

5

(d)   (i)   Identify a passivating metal.

1

(ii)   Outline an experiment that you have undertaken to compare the corrosion rates of metals in different acidic & neutral conditions.

2

(iii)   The research done by deep-sea explorers such as Bob Ballard on deep ocean wrecks such as the RMS Titanic suggests that earlier predictions of slow corrosion rates at great depths were apparently incorrect.
In light of your studies discuss this dilemma.

3

(e)   Imagine that you are the Manager of Operations for the Silver Star Line with a fleet of five steel ships trading between Sydney and London carrying container cargo.

Outline the range of corrosion protection measures available to you. Make a comparison of their effectiveness to protect the steel of the ships hulls. Justify your recommendation to the owners of the Silver Star Line as to the best type of protection to prevent the corrosion of their ships.

7

End of Question 31