



**2003**  
**FORM VI**  
**TRIAL HSC EXAMINATION**

# Chemistry

## General Instructions

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

## Total marks - 100

### Section I Pages 2 - 24

#### 75 marks

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 25 - 29

#### 25 marks

- Attempt ONE Question from Questions 29 - 32
- Allow about 45 minutes for this Section

**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. Fill 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 drawing an arrow as follows.

- A       B       C       D
- correct* ↙

- 1 Which of the following instruments is used to detect radioactivity?
- (A) Reflux apparatus
  - (B) UV – visible spectrometer
  - (C) Microscopic membrane filter
  - (D) Geiger counter
- 2 Plastic film for wrapping sandwiches is made from which of the following polymers?
- (A) Low density polyethylene
  - (B) High density polyethylene
  - (C) Polystyrene
  - (D) Poly(vinyl chloride)
- 3 How can atomic absorption spectroscopy be used in the detection of pollutants?
- (A) To find organic contaminants in a water supply.
  - (B) To analyse concentrations of non-metals in solution.
  - (C) To find the pH of a water supply.
  - (D) To analyse concentrations of metals in solution.
- 4 Which of the following indicators would be best for the titration of a weak acid with a strong base?
- (A) Litmus
  - (B) Phenolphthalein
  - (C) Methyl orange
  - (D) Bromothymol blue
- 5 Which of the following is an industrial source of ethylene?
- (A) The cracking of alkanes.
  - (B) The cracking of alkanols.
  - (C) The cracking of styrene.
  - (D) The cracking of polyethylene.
- 6 Which of the following chemical tests could distinguish between 1-hexene and hexane?
- (A) Addition of  $\text{CO}_3^{2-}(\text{aq})$
  - (B) Addition of  $\text{SO}_4^{2-}(\text{aq})$
  - (C) Addition of  $\text{Br}_2(\text{aq})$
  - (D) Addition of  $\text{Ag}^+(\text{aq})$

- 7 Which of the following types of radioactive decay produces an element with a larger atomic number?
- (A)  $\alpha$  and  $\beta$  decay
  - (B) gamma ray emission
  - (C)  $\alpha$  decay only
  - (D)  $\beta$  decay only
- 8 Which of the following methods could you use in the laboratory to find the percentage of aspirin (acetylsalicylic acid) in a tablet?
- (A) distillation
  - (B) titration
  - (C) gravimetric analysis
  - (D) evaporation
- 9 In which species does manganese have an oxidation number of VII?
- (A)  $\text{MnO}_4^-$
  - (B)  $\text{MnO}_2$
  - (C)  $\text{Mn(OH)}_2$
  - (D)  $\text{MnO(OH)}_3$
- 10 In a 0.25 M solution of  $\text{H}_2\text{SO}_4$  the pH would be closest to which of the following?
- (A) 0.8
  - (B) 0.3
  - (C) 2.5
  - (D) 1.0
- 11 Which of the following statements is true of a saturated solution of sodium carbonate?
- (A) Addition of  $\text{HCl(aq)}$  would produce a precipitate.
  - (B) Addition of  $\text{NaCl(aq)}$  would produce a precipitate.
  - (C) Addition of  $\text{CaCl}_2\text{(aq)}$  would not produce a precipitate.
  - (D) Addition of  $\text{HCl(aq)}$  would produce a gas.

- 12 The formulas of four compounds are given below.



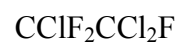
W



X



Y



Z

Which of these compounds are CFC's?

- (A) W and X  
(B) X and Y  
(C) Y and Z  
(D) W and Z
- 13 Which one of the following equations shows water acting as an amphiprotic species?
- (A)  $\text{H}_2\text{O}(\text{l}) + \text{H}^+(\text{aq}) \rightarrow \text{H}_3\text{O}^+(\text{aq})$   
(B)  $2\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_3\text{O}^+(\text{aq}) + \text{OH}^-(\text{aq})$   
(C)  $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_3\text{O}^+(\text{aq}) + \text{OH}^-(\text{aq})$   
(D)  $2\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}^+(\text{aq}) + \text{OH}^-(\text{aq})$
- 14 Which of the following chemists based his ideas of acids and bases on the fact that HCl and HCN for example were found not to contain oxygen?
- (A) Davy  
(B) Arrhenius  
(C) Lavoisier  
(D) Lowry
- 15 Which of the following statements is true of an equilibrium system?
- (A) Changes to the system are minimised by a shift in the equilibrium position.  
(B) There is constant change so properties such as colour or concentration continuously change.  
(C) Changes to the system are completely reversed by a shift in the equilibrium position.  
(D) There is constant change so rates of the forward and reverse reactions are never equal.

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Candidate Number

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Candidate Number

**Part B**

**Total marks (60)**

**Attempt Questions 16 - 28**

**Allow about 1 hour and 45 minutes for this Part**

Answer the questions in the spaces provided

Show all relevant working in questions involving calculations

**Marks**

**Question 16 (2 marks)**

Isotopes may be stable or unstable depending upon the number of protons present, and the neutron to proton ratio.

**2**

Use equations to illustrate two modes of radioactive decay.

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Candidate Number

**Marks****Question 17** (2 marks)

The carbon compound  $C_5H_{11}Cl$  can exist as eight isomers. Draw and give the systematic name of two of these isomers.

**2**



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Candidate Number

**Marks**

**Question 18** (3 marks)

Account for the many uses of ethanol as a solvent.

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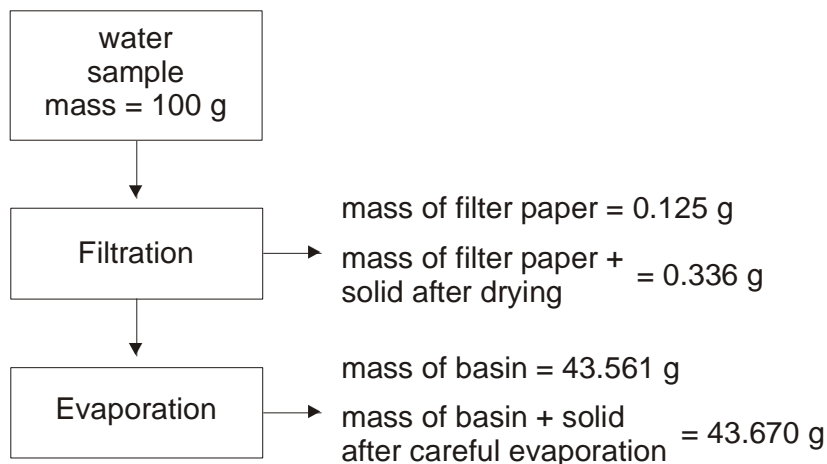
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Candidate Number

**Marks**

**Question 19** (3 marks)

A water sample from a local creek was analysed and the following data collected.



- (a) Find the percentage (w/w) of undissolved and dissolved solids in the above sample. **2**

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- (b) Describe a test that could be carried out on the water sample to find the level of dissolved oxygen. **1**

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Candidate Number

**Marks**

**Question 20** (4 marks)

- (a) Write the equation for the formation of ammonia in the Haber process. **1**  
Indicate whether the reaction is exothermic or endothermic.

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- (b) The following conditions may be used in the Haber process: **3**
- high pressure (35 MPa)
  - intermediate temperature (525°C)
  - a catalyst of Fe / Fe<sub>3</sub>O<sub>4</sub>

Explain the choice of the three conditions described above in the manufacture of ammonia.

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Candidate Number

**Marks**

**Question 21** (5 marks)

When a piece of zinc is added to an aqueous solution of copper(II) nitrate, the blue colour of the solution fades, the zinc disappears, and a brown solid forms.

- (a) Explain these observations in terms of oxidation and reduction, using half equations to illustrate your answer. **3**

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- (b) Calculate the voltage produced if a galvanic cell was produced using zinc, copper and an appropriate electrolyte solution. **2**

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Candidate Number

**Marks**

**Question 22** (5 marks)

Compare addition polymerisation and condensation polymerisation, using a specific example of each to illustrate your answer.

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Candidate Number

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**Question 23** (5 marks)

Human activity impacts on waterways. Discuss this statement with reference to nitrate and phosphate levels in natural bodies of water.

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Candidate Number

**Marks**

**Question 24** (5 marks)

Consider a cold, unopened bottle of soft drink, which has just been removed from the refrigerator. Explain the changes in the amount of dissolved carbon dioxide when the bottle is opened and as it warms up.

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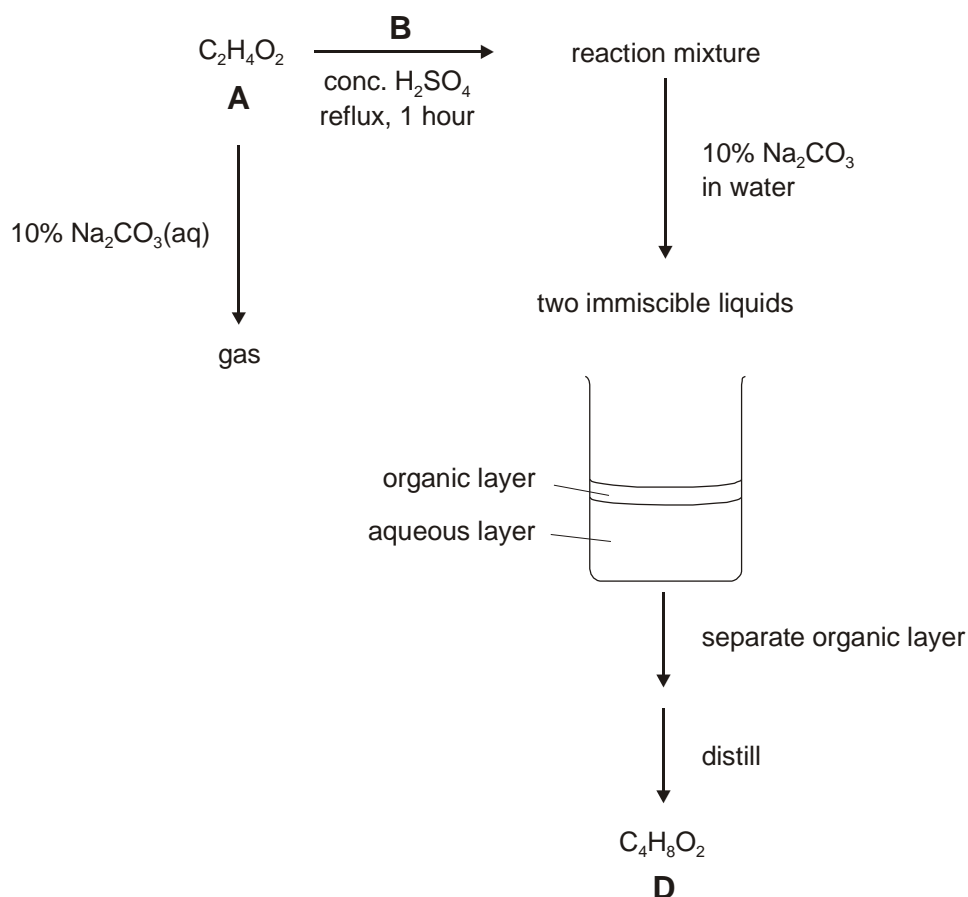
**Marks****Question 25** (9 marks)

The compound **A** ( $C_2H_4O_2$ ) reacts with 10% sodium carbonate solution liberating a gas that turns lime water milky.

When **A** is heated under reflux with another organic compound **B** in the presence of a little concentrated sulphuric acid, a new substance **D** ( $C_4H_8O_2$ ) can be obtained.

When the reaction is finished, the cooled reaction mixture is poured into a beaker containing an excess of 10% aqueous sodium carbonate solution. Two layers form. The organic layer is separated from the aqueous layer and then distilled to yield pure **D**.

The process is outlined below:



**Question 25 continues on page 19**

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Class

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Candidate Number

**Marks**

Question 25 (continued)

- (a) Draw and label a diagram of the apparatus used to heat the reaction mixture under reflux. **3**

- (b) Explain why reflux is used in this reaction. **2**

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- (c) The yield of D was found to be 50%. Explain this result. **1**

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**Question 25 continues on page 20**

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Candidate Number

**Marks**

Question 25 (continued)

- (d) Calculate the volume (at 25°C and 100 kPa) of CO<sub>2</sub>(g) produced when 2.54 g of A reacts completely with excess Na<sub>2</sub>CO<sub>3</sub>(aq).

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Candidate Number

**Marks**

**Question 26** (5 marks)

Oxygen and its allotrope, ozone are both found in the Earth's atmosphere.

- (a) Compare the structure and bonding of these two allotropes and use diagrams to illustrate your answer. **3**

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- (b) Explain how ozone occurs in the stratosphere. **1**

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- (c) A high altitude balloon measured the concentration of ozone as 1.23 mL per 100 litres of air. **1**

Express this concentration of ozone in ppm.

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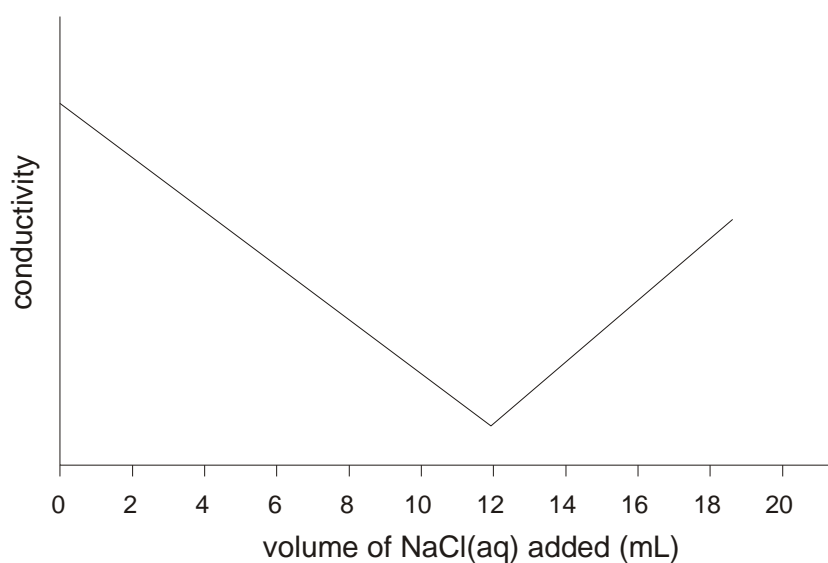
Class

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Candidate Number

**Marks****Question 27** (5 marks)

25.00 mL of 0.025 M silver nitrate solution was titrated with sodium chloride solution of unknown concentration. A conductivity probe connected to a data logger was used to monitor the reaction. The results are shown below.



- (a) Write a balanced chemical equation for the reaction taking place. **1**

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- (b) What volume of sodium chloride solution was required for complete reaction? **1**

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**Question 27 continues on page 23**

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Class

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Candidate Number

**Marks**

Question 27 (continued)

(c) Calculate the concentration of the NaCl(aq).

**2**

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(d) Why does the conductivity not drop to zero?

**1**

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Candidate Number

**Marks**

**Question 28** (7 marks)

Assess the impact of advances in polymerisation reactions on society and the environment.

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## Section II

**Total marks (25)**

**Attempt ONE question from Questions 29 - 32**

**Allow about 45 minutes for this Section**

Answer the question in a writing booklet. Extra writing booklets are available.  
Show all relevant working in questions involving calculations.

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	<b>Pages</b>
<b>Question 29</b>	<b>Industrial Chemistry ..... 27</b>
<b>Question 30</b>	<b>Shipwrecks and Salvage</b>
<b>Question 31</b>	<b>Biochemistry of Movement</b>
<b>Question 32</b>	<b>Chemistry of Art ..... 28-29</b>

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**Marks****Question 29 - Industrial Chemistry (25 marks)**

- (a) An important role of the chemical industry is to provide alternatives to natural products.
- (i) State one dwindling natural resource which is not a fossil fuel. **1**
- (ii) Outline two uses of the natural product identified in (i) and name a replacement material used instead. **3**

- (b) The following equation represents the decomposition of hydrogen iodide. **4**



0.002 mol of hydrogen iodide was heated at 764 K in a 1000 cm<sup>3</sup> bulb. When an equilibrium was established the amount of iodine present was determined. 0.00028 moles of iodine were present.

Calculate K for the reaction at 764 K.

- (c) Sulfuric acid is an important industrial chemical.
- (i) Outline one industrial use of sulphuric acid, illustrating your answer with a chemical equation. **2**
- (ii) Describe the process used to extract sulfur from mineral deposits, and identify a property of sulfur which allows this. **3**
- (d) (i) Outline and explain the safe dilution of concentrated sulphuric acid. **2**
- (ii) Describe an experiment you have done to investigate the reaction of sulphuric acid as a dehydrating or oxidising agent. **4**

- (e) Discuss the following statement. **6**

*The conversion of molten sulphuric acid (the Contact Process) is a multi-step process. The conditions used for the conversion of SO<sub>2</sub> to SO<sub>3</sub> are a compromise between reaction rate and equilibrium yield.*

**End of Question 29**

**Marks****Question 32 - Chemistry of Art (25 marks)**

- (a) (i) Name and give the chemical composition and colour of a pigment used by Australian Aboriginal people. **1**
- (ii) Illustrate the relationship between the discovery of new mineral deposits and an increase in the range of available pigments by describing an historical example. **3**
- (b) Discuss the use of two pigments by early Egyptian or Roman people. **4**
- (c)  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Ba}^{2+}$ ,  $\text{Sr}^{2+}$  and  $\text{Cu}^{2+}$  can be identified by their flame colour.

A colourless solution contained two of the above ions. When a solution of potassium carbonate was added to the unknown solution a dense white precipitation formed. When precipitation was complete, the solid was filtered off and washed.

The filtrate gave a yellow flame colour.

The solid residue was 'dissolved' in hydrochloric acid and the solution flame tested – giving a green colour.

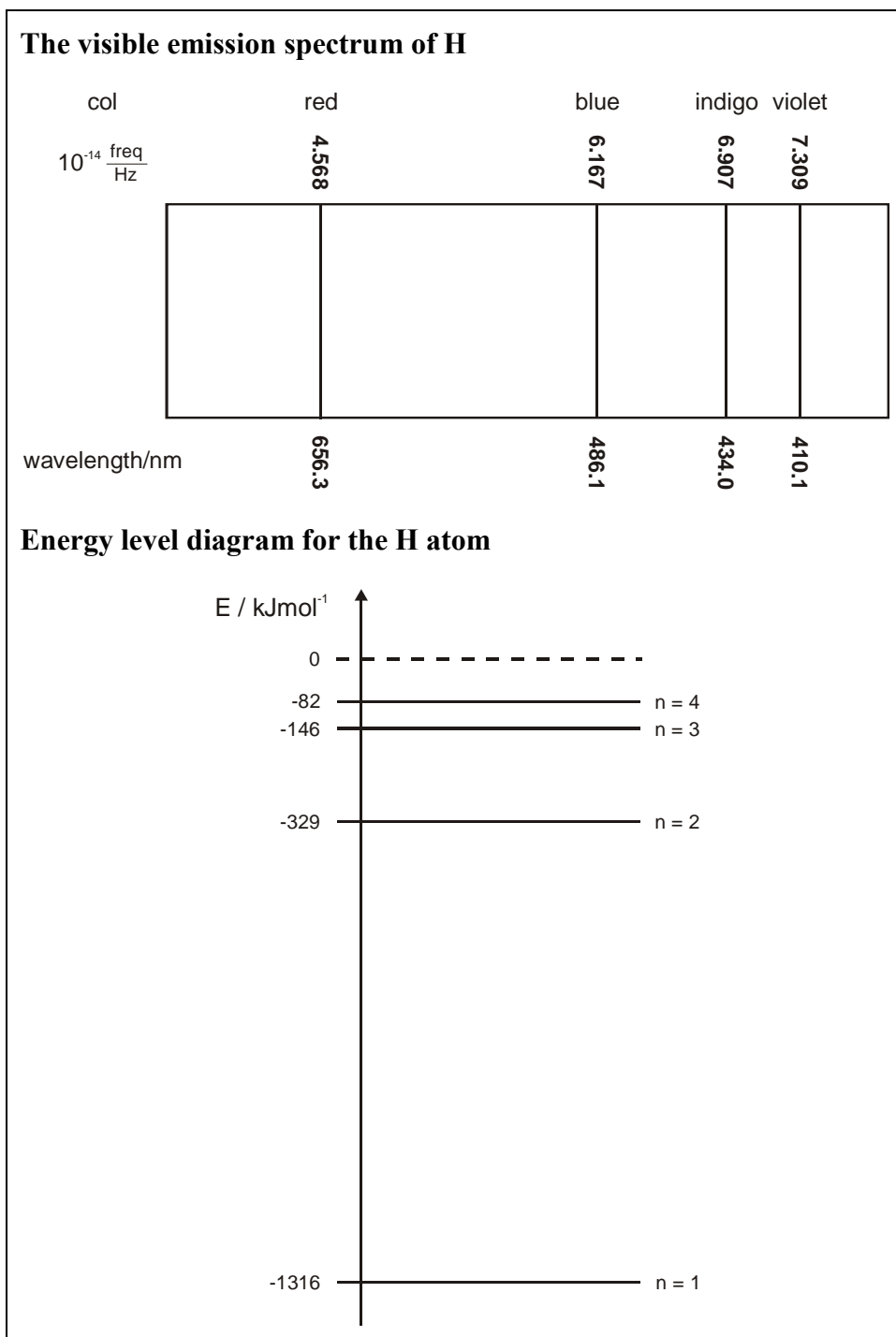
- (i) What cations were present in the original solution? **2**
- (ii) Describe how a flame test is carried out. **3**

**Question 32 continues on page 29**

Marks

Question 32 (continued)

- (d) (i) Explain how the Pauli exclusion principle and Hund's rule can be used to predict the arrangement of electrons in atoms. 2
- (ii) Use the information in the diagrams below to describe the development of the Bohr model of the atom from the hydrogen spectrum. 4



- (e) Describe the use of laser microspectral analysis in art. 6

End of Question 32

## SYDNEY GRAMMAR SCHOOL

**2003**  
**FORM VI**  
**TRIAL HSC EXAMINATION****Chemistry**  
**CRIB****General Instructions**

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

**Total marks - 100****Section I** Pages 2 - 24**75 marks**

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 25 - 29**25 marks**

- Attempt ONE Question from Questions 29 - 32
- Allow about 45 minutes for this Section

**Part A****Total marks (15)****Attempt Questions 1 - 15****Allow about 30 minutes for this Part**

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

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 Class
**Part B**

Total marks (60)

Attempt Questions 16 - 28

Allow about 1 hour and 45 minutes for this Part

Answer the questions in the spaces provided

Show all relevant working in questions involving calculations

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Candidate Number

Marks

**Question 16 (2 marks)**

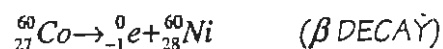
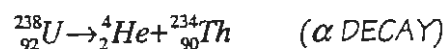
Isotopes may be stable or unstable depending upon the number of protons present, and the neutron to proton ratio.

2

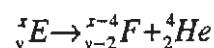
Use equations to illustrate two modes of radioactive decay.

2 MARKS FOR:

TWO CORRECT REAL EXAMPLES



OR TWO GENERALISED EXAMPLES



1 MARK FOR:

ONE CORRECT REAL EXAMPLE

OR TWO INCORRECT EXAMPLES BUT CORRECT DECAY MODES

(E.G.  $\alpha$  DECAY OF  ${}_{6}^{12}\text{C}$ )



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Class

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Candidate Number

Marks

**Question 17** (2 marks)

The carbon compound  $C_5H_{11}Cl$  can exist as eight isomers. Draw and give the systematic name of two of these isomers.

2

N.B. NAMES ARE ALL ONE WORD

NUMBERS ARE LINKED TO LETTERS BY HYPHENS

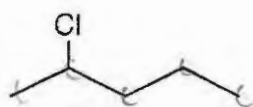
2 MARKS FOR TWO CORRECT STRUCTURAL FORMULAS, CORRECTLY NAMED

1 MARK FOR TWO CORRECT STRUCTURAL FORMULAS

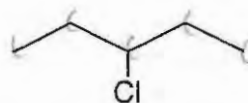
OR ONE CORRECTLY NAMED STRUCTURAL FORMULA



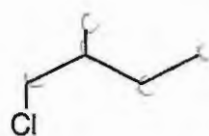
1-chloropentane



2-chloropentane



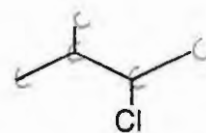
3-chloropentane



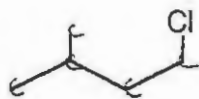
1-chloro-2-methylbutane



2-chloro-2-methylbutane



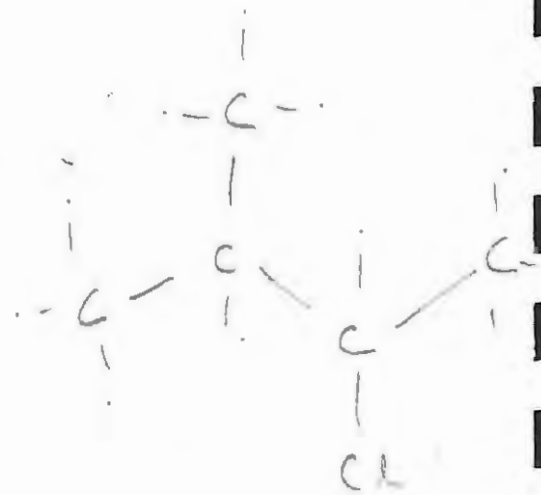
2-chloro-3-methylbutane



1-chloro-3-methylbutane



1-chloro-2,2-dimethylpropane



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Candidate Number

Marks

**Question 18** (3 marks)

Account for the many uses of ethanol as a solvent.

3

- 1     DISSOLVES BOTH POLAR AND NON-POLAR SUBSTANCES
  
- 2     DISSOLVES BOTH POLAR AND NON-POLAR SUBSTANCES & EXAMPLES  
      OR + VAGUE STATEMENT ABOUT STRUCTURE OF ETHANOL  
      OR + COMMENT ON EXPENSE / TOXICITY
  
- 3     EXPLICIT AND DETAILED  
      POLAR AND NON-POLAR SUBSTANCES  
      EXAMPLES  
      RELATED TO STRUCTURE OF ETHANOL

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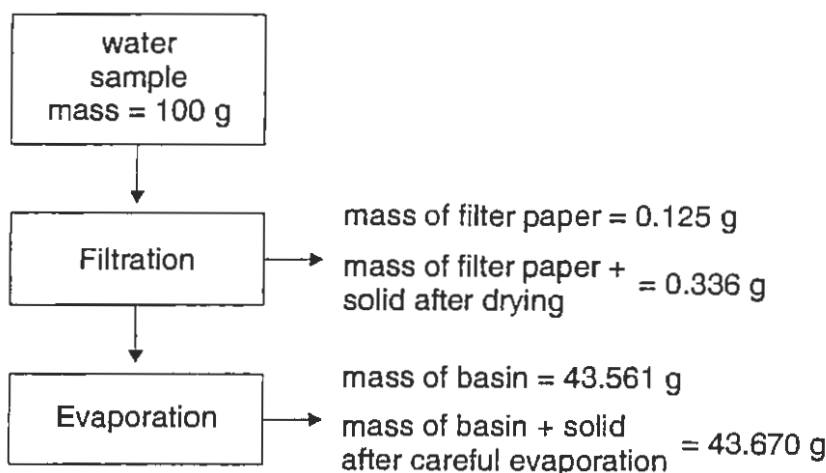
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 Candidate Number

Marks

**Question 19** (3 marks)

A water sample from a local creek was analysed and the following data collected.



- (a) Find the percentage (w/w) of undissolved and dissolved solids in the above sample. 2

*UNDISSOLVED = 0.211%*

*DISSOLVED = 0.109%*

- (b) Describe a test that could be carried out on the water sample to find the level of dissolved oxygen. 1

*THE WINKLER TITRATION*

*A DISSOLVED OXYGEN METER*

*N.B. THE BOOK IS WRONG ABOUT THIS: IT IS AN ELECTROCHEMICAL CELL  
THE POTENTIAL OF WHICH DEPENDS ON THE CONCENTRATION OF  $O_2(aq)$   
NOT AN ELECTROLYTIC CELL*

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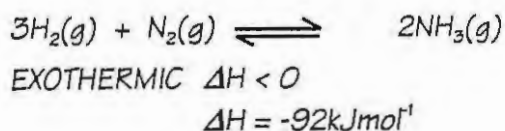
 Candidate Number

Marks

## Question 20 (4 marks)

- (a) Write the equation for the formation of ammonia in the Haber process. Indicate whether the reaction is exothermic or endothermic.

1



- (b) The following conditions may be used in the Haber process:

3

- high pressure (35 MPa)
- intermediate temperature (525°C)
- a catalyst of Fe / Fe<sub>3</sub>O<sub>4</sub>

Explain the choice of the three conditions described above in the manufacture of ammonia.

- 1 SIMPLE STATEMENT E.G. BECAUSE BOTH YIELD OF NH<sub>3</sub> AND RATE OF REACTION INCREASE
- 2 PRESSURE AND TEMPERATURE FAVOURS YIELD OF NH<sub>3</sub> AND CATALYST INCREASES RATE – NO EXPLANATION (OR INCORRECT EXPLANATION)
- 3 PRESSURE / TOTAL NUMBER OF MOLECULES  
  
 TEMPERATURE / EXOTHERMIC / EFFECT OF EQUILIBRIUM YIELD OR GOOD DISCUSSION OF TRADE OFF BETWEEN RATE AND EQUILIBRIUM YIELD  
  
 CATALYST / INCREASE RATE WITHOUT AFFECTING EQUILIBRIUM YIELD ALLOWS ECONOMIC RATE AT LOWER TEMPERATURE OR MECHANISM OF CATALYST ACTION AND AFFECT ON RATE

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 Candidate Number

Marks

**Question 21** (5 marks)

When a piece of zinc is added to an aqueous solution of copper(II) nitrate, the blue colour of the solution fades, the zinc disappears, and a brown solid forms.

- (a) Explain these observations in terms of oxidation and reduction, using half equations to illustrate your answer. 3

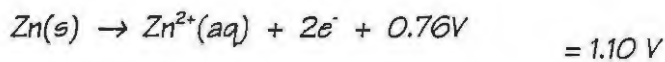
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$  → BLUE COLOUR OF SOLUTION FADES AND BROWN  $Cu$  PRECIPITATES AS COPPER(II) IONS REDUCED TO  $Cu$  METAL.

ZINC METAL DISSOLVES (DISAPPEARS) – AS ZINC IS OXIDISED  $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$

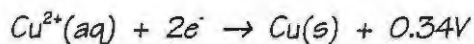
ALL THREE OBSERVATIONS MUST BE EXPLAINED

HALF EQUATIONS NEED STATES – OTHER THAN (aq) MUST INDICATE OXIDATION OF  $Zn$  AND REDUCTION OF  $Cu^{2+}$  IONS

- (b) Calculate the voltage produced if a galvanic cell was produced using zinc, copper and an appropriate electrolyte solution. 2



= 1.10 V



ANY REASONABLE WORKING → 1 MARK

ANSWER ALONE → 1 MARK

N.B. THERE WAS CONFUSION BETWEEN  $Cu^+$  AND  $Cu^{2+}$

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 Class

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 Candidate Number
**Marks****Question 22** (5 marks)

Compare addition polymerisation and condensation polymerisation, using a specific example of each to illustrate your answer.

**5**

SOURCE OF MONOMERS	ADDITION POLYMERISATION USUALLY PETROCHEMICAL	CONDENSATION POLYMERISATION BIOLOGICAL OR PETROCHEMICAL
STRUCTURE (NATURE OF MONOMERS)	DOUBLE OR TRIPLE BONDS (UNSATURATE)	REACTIVE GROUPS E.G. $\text{NH}_2$ , $-\text{COOH}$ ETC
PRODUCTS OF POLYMERISATION	POLYMER ONLY	POLYMER + SMALL MOLECULE (E.G. $\text{H}_2$ )
EXAMPLE	POLYETHENE	CELLULOSE, NYLON ETC
BIODEGRADABLE	USUALLY NOT	OFTEN
EQUATION FOR REACTION	HAS TO BE ACCURATE	FOR RING STRUCTURE OF GLUCOSE ETC BASIC IDEA MUST BE CORRECT

4 DIFFERENT COMPARISONS AND EXAMPLES OF EACH TYPE OF POLYMERISATION  
→ 5 MARKS

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 Class

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Candidate Number

Marks

**Question 23** (5 marks)

Human activity impacts on waterways. Discuss this statement with reference to nitrate and phosphate levels in natural bodies of water.

5

MARKS	SOURCES	EFFECTS
1	AGRICULTURAL ACTIVITY → FERTILISER RUNOFF OR SEWAGE DISCHARGE AND LEADS TO INCREASED N, P LEVELS	ALGAL BLOOMS + 1 CONSEQUENCE
2	BOTH ABOVE LEADING TO INCREASES IN N, P LEVELS	ALGAL BLOOMS WHICH REDUCES LIGHT PENETRATION AND INCREASES OXYGEN DEMAND
2 (EXCELLENT RESPONSE)	BOTH ABOVE + SUPERPHOSPHATE, AMMONIUM NITRATE + LEVELS EXCEED 0.1-1 PPM FOR N & 0.01-0.1 PPM FOR P	ABOVE + THREE CONSEQUENCES AND EXAMPLE E.G. MURRAY-DARLING
CONSEQUENCES:	REDUCED LIGHT PENETRATION INCREASED O <sub>2</sub> DEMAND ANOXIC CONDITIONS AT NIGHT INNER BARRIER REEF DAMAGE	DEATH OF LOWER PLANT LIFE DEATH OF OTHER ORGANISMS RELEASE OF TOXINS REDUCED AESTHETICS / RECREATIONAL USE

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 Class

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 Candidate Number
**Marks****Question 24** (5 marks)

Consider a cold, unopened bottle of soft drink, which has just been removed from the refrigerator. Explain the changes in the amount of dissolved carbon dioxide when the bottle is opened and as it warms up.

**5**

- 5 MARKS      EQUATION AND ENERGY TERM OR ENERGY TERM CLEAR FROM DISCUSSION  
 BOTH TEMP. AND PRESSURE EXPLAINED  
 RESULTING  $CO_2$  AMOUNT STATED
- 4 MARKS      AS ABOVE BUT:  
 NO ENERGY TERM / EXPLANATION OR  
 AMOUNT OF  $CO_2(aq)$  NOT MADE EXPLICIT
- 3 MARKS      EXPLANATION OF TEMP OR PRESSURE AND STATEMENT OF OTHER
- 2 MARKS      TEMP OR PRESSURE EXPLAINED OR STATEMENT ABOUT TEMP & PRESSURE &  $CO_2(aq)$  AND EQUATION
- 1 MARK      STATEMENT ABOUT TEMP OR PRESSURE OR CORRECT EQUATION



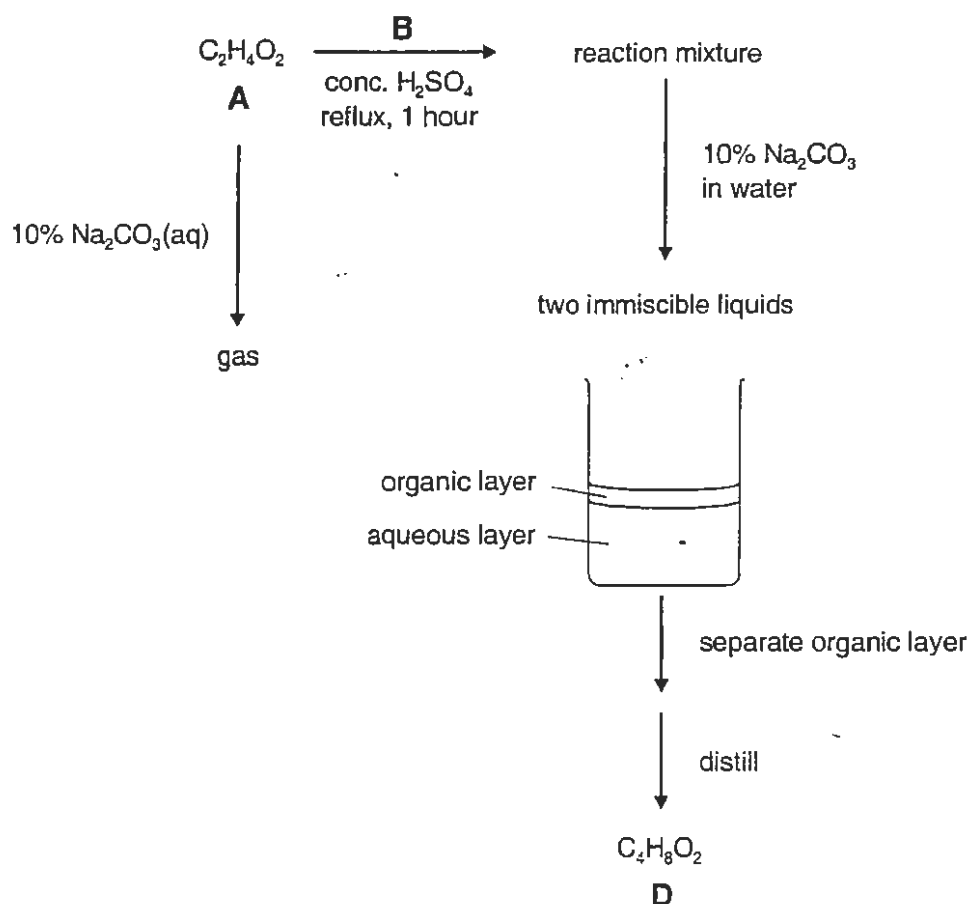
**Question 25** (9 marks)

The compound **A** ( $C_2H_4O_2$ ) reacts with 10% sodium carbonate solution liberating a gas that turns lime water milky.

When **A** is heated under reflux with another organic compound **B** in the presence of a little concentrated sulphuric acid, a new substance **D** ( $C_4H_8O_2$ ) can be obtained.

When the reaction is finished, the cooled reaction mixture is poured into a beaker containing an excess of 10% aqueous sodium carbonate solution. Two layers form. The organic layer is separated from the aqueous layer and then distilled to yield pure **D**.

The process is outlined below:

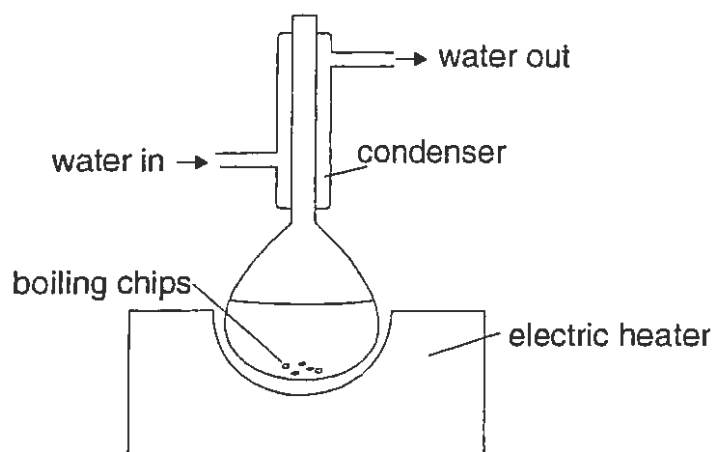


Question 25 continues on page 19

Marks

## Question 25 (continued)

- (a) Draw and label a diagram of the apparatus used to heat the reaction mixture under reflux. 3



- (b) Explain why reflux is used in this reaction. 2

*HIGH TEMPERATURE TO INCREASE RATE*

*CONDENSER PREVENTS LOSS OF MATERIALS FROM BOILING*

- (c) The yield of D was found to be 50%. Explain this result. 1

*IT IS AN EQUILIBRIUM REACTION OR AN EXPLANATION BASED ON THE EXPERIMENTAL METHOD E.G. LOSS IN WASHING, DRYING, DISTILLING*

**Question 25 continues on page 20**

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Class

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Candidate Number

Marks

Question 25 (continued)

- (d) Calculate the volume (at 25°C and 100 kPa) of CO<sub>2</sub>(g) produced when 2.54 g of A reacts completely with excess Na<sub>2</sub>CO<sub>3</sub>(aq).

3

$$n(A) = 2.54 / 60 = 0.0423 \text{ mol}$$

$$n(\text{CO}_2) = \frac{1}{2} \times n(A) = 0.212 \text{ mol}$$

$$V(\text{CO}_2) = n(\text{CO}_2) \times 24.79 = 0.525 \text{ L}$$

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 Class

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 Candidate Number

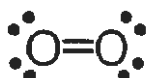
Marks

**Question 26** (5 marks)

Oxygen and its allotrope, ozone are both found in the Earth's atmosphere.

- (a) Compare the structure and bonding of these two allotropes and use diagrams to illustrate your answer. 3

DIAGRAMS

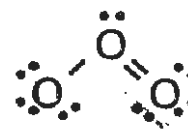
OXYGEN / O<sub>2</sub>

NON-POLAR

DIATOMIC

LINEAR

DOUBLE COVALENT

OZONE / O<sub>3</sub>

POLAR

TRIATOMIC

BENT

DOUBLE + SINGLE COVALENT

- (b) Explain how ozone occurs in the stratosphere. 1

MADE THERE – SIMPLY  $3O_2 \xrightarrow{UV} 2O_3$

DETAIL:  $O_2 + UV (\lambda < 240nm) \rightarrow 2O^\circ$

$2O^\circ + 2O_2 \rightarrow 2O_3$

$O^\circ$  IS A RADICAL – DON'T USE THE TERM "ATOM"

(INFO: UV(A) = 400 – 320nm, UV(B) = 320-280nm, UV(C) = <280nm)

- (c) A high altitude balloon measured the concentration of ozone as 1.23 mL per 100 litres of air. 1

Express this concentration of ozone in ppm.

$$[O_3] = 1.23 \text{ mL} / 100 \text{ L}$$

$$= 12.3 \text{ mL} / 1000 \text{ L}$$

$$= 12.3 \text{ ppm}$$

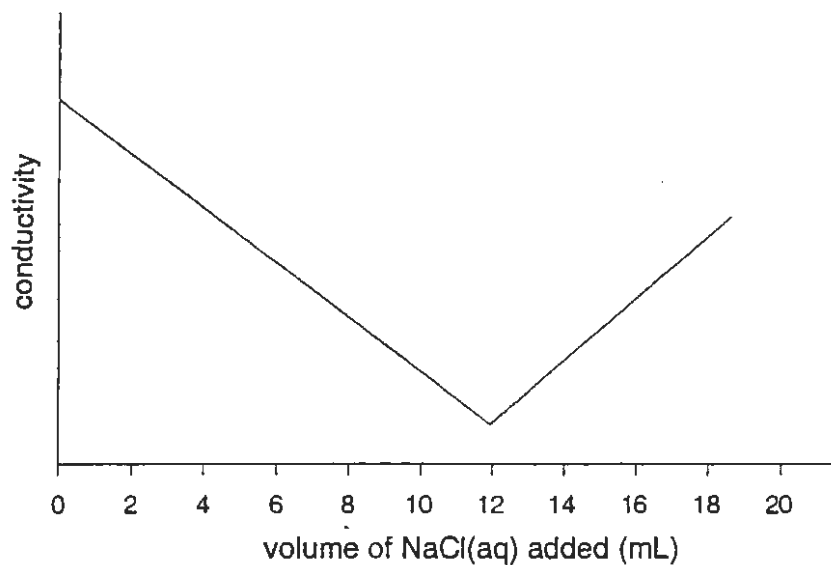
Class

Candidate Number

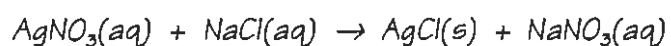
Marks

**Question 27** (5 marks)

25.00 mL of 0.025 M silver nitrate solution was titrated with sodium chloride solution of unknown concentration. A conductivity probe connected to a data logger was used to monitor the reaction. The results are shown below.



- (a) Write a balanced chemical equation for the reaction taking place. 1



- (b) What volume of sodium chloride solution was required for complete reaction? 1

~ 12 mL

**Question 27 continues on page 23**

Class

Candidate Number

Marks

Question 27 (continued)

- (c) Calculate the concentration of the NaCl(aq).

2

$$0.025 \times 25 = n = 12 \times X \text{ (SINCE 1:1 FROM EQUATION)}$$

$$\therefore X = 0.052 \text{ M}$$

$$\text{OR } n(\text{Ag}^+) = 0.025 \times 25 / 1000 = 6.25 \times 10^{-4} \text{ mol}$$

$$\therefore n(\text{NaCl}) = 6.25 \times 10^{-4} \text{ (SINCE 1:1 FROM EQUATION)}$$

$$\therefore [\text{NaCl}] = 6.25 \times 10^{-4} / (12 / 1000) = 0.052 \text{ M}$$

- (d) Why does the conductivity not drop to zero?

1

THERE ARE STILL  $\text{Na}^+(\text{aq})$  AND  $\text{NO}_3^-(\text{aq})$  IONS PRESENT

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 Class

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 Candidate Number

Marks

**Question 28** (7 marks)

Assess the impact of advances in polymerisation reactions on society and the environment.

7

6-7 MARKS *DESCRIBES ACCURATELY TWO ADVANCES IN POLYMERISATION REACTIONS ON BOTH SOCIETY AND THE ENVIRONMENT*

*AND*

*ASSESSES THE IMPACT OF THESE ADVANCES (I.E. MAKES A VALID JUDGEMENT ON THE VALUE OF THESE ADVANCES)*

4-5 MARKS *DESCRIBES ACCURATELY TWO ADVANCES IN POLYMERISATION REACTIONS ON BOTH SOCIETY AND THE ENVIRONMENT*

*OR*

*DESCRIBES ACCURATELY ONE ADVANCE IN POLYMERISATION REACTIONS ON BOTH SOCIETY AND THE ENVIRONMENT AND ASSESSES THE IMPACT OF THIS ADVANCE (I.E. MAKES A VALID JUDGEMENT ON THE VALUE OF THIS ADVANCE)*

*OR*

*NAMES TWO ADVANCES IN POLYMERISATION REACTIONS ON BOTH SOCIETY AND THE ENVIRONMENT AND ASSESSES THE IMPACT OF THIS ADVANCE (I.E. MAKES A VALID JUDGEMENT ON THE VALUE OF THIS ADVANCE)*

2-3 MARKS *DESCRIBES / NAMES ONE OR TWO ADVANCES IN POLYMERISATION REACTIONS ON EITHER SOCIETY OR THE ENVIRONMENT*

1 MARK *DESCRIBES / NAMES ONE OR TWO POLYMERISATION REACTIONS AND THE IMPACT ON EITHER SOCIETY OR THE ENVIRONMENT*

**Section II**

Total marks (25)

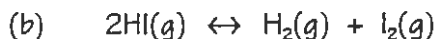
Attempt ONE question from Questions 29 - 32

Allow about 45 minutes for this Section

Answer the question in a writing booklet. Extra writing booklets are available.  
Show all relevant working in questions involving calculations.

## INDUSTRIAL CHEMISTRY

- (a) (i) NATURAL RUBBER FROM THE BARK OF RUBBER TREES (MANY OTHER EXMPLES)
- (ii) USED FOR CAR TYRES AND ELECTRICAL WIRE INSULATION  
THE MOST COMMON SYNTHETIC RUBBER IS STYRENE-BUTADIENE RUBBER (SBR)



$$K_c = \frac{[\text{H}_2][\text{I}_2]}{[\text{HI}]^2}$$

$$[\text{I}_2]_e = \frac{n_e(\text{I}_2)}{v(\text{I}_2)} = 2.8 \times 10^{-4} / 1 = 2.8 \times 10^{-4} \text{ mol / L}$$

$$[\text{H}_2]_e = [\text{I}_2] = 2.8 \times 10^{-4} \text{ mol / L}$$

$$\begin{aligned} n_e(\text{HI}) &= n_i(\text{HI}) - \text{USED } n(\text{HI}) \\ \text{WHERE USED } n(\text{HI}) &= 2n(\text{I}_2) \\ &= 2 \times 2.8 \times 10^{-4} \\ &= 5.6 \times 10^{-4} \end{aligned}$$

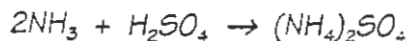
$$\begin{aligned} \therefore n_e(\text{HI}) &= 0.002 - 5.6 \times 10^{-4} \\ &= 0.00144 \text{ mol} \end{aligned}$$

$$\therefore [\text{HI}]_e = n_e(\text{HI}) / v(\text{HI}) = 0.00144 / 1 \text{ mol / L}$$

$$\begin{aligned} \therefore K_c &= [\text{H}_2][\text{I}_2] / [\text{HI}]^2 = (2.8 \times 10^{-4})(2.8 \times 10^{-4}) / (0.00144)^2 \\ &= 0.0378 \end{aligned}$$



(c) (i) FERTILISER E.G. AMMONIUM SULFATE



ALSO ACCEPTED:

ETHANOL  $\rightarrow$  ETHENE IF CONC.  $\text{H}_2\text{SO}_4$   
 ETHENE  $\rightarrow$  ETHANOL IF DIL.  $\text{H}_2\text{SO}_4$

(ii) FRASCH PROCESS

SUPERHEATED STEAM (165°C) PUMPED INTO UNDERGROUND  
 SULFUR DEPOSIT

SULFUR MELTS (119°C)

COMPRESSED AIR PUMPED INTO DEPOSIT – FORCES MOLTEN  
 SULFUR TO SURFACE

OR

COMPREHENSIVE DESCRIPTION FOR 2 MARKS

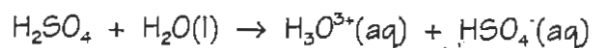
BRIEF DESCRIPTION FOR 1 MARK

PROPERTY

LOW MP OF SULFUR (119°C)

OR INSOLUBLE / UNREACTIVE IN  $\text{H}_2\text{O}$

(d) (i) MUST WEAR SAFETY SPEC, GLOVES, LAB COAT  
 MUST ADD SMALL AMOUNT OF CONC. ACID SLOWLY TO WATER –  
 WITH STIRRING  
 THIS AVOIDS THE POSSIBILITY OF CONC. ACID SPLASHING  
 THE REACTION IS STRONGLY EXOTHERMIC



(ii) EXPERIMENT – CONC.  $\text{H}_2\text{SO}_4$  AS A DEHYDRATING AGENT

SAFETY PRECAUTIONS AS IN (i)

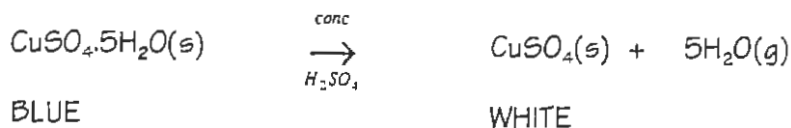
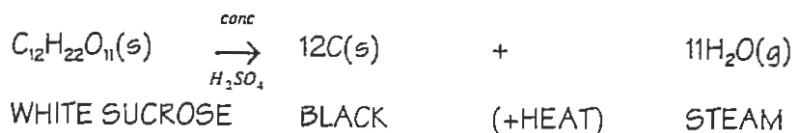
MUST:

CLEARLY DESCRIBE COLOUR CHANGE IN REACTION

WRITE BALANCED EQUATION FOR REACTION CITED

EXPLAIN WHY THE REACTION IS ONE OF DEHYDRATION

E.G.



OR

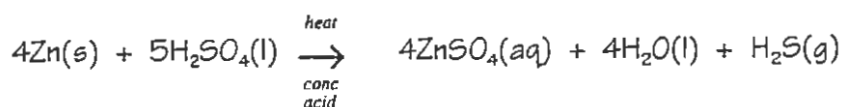
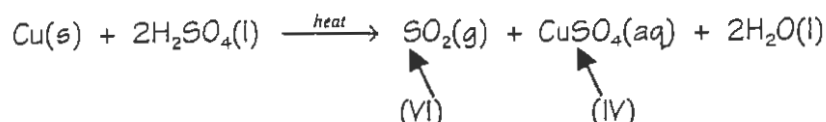
CON.  $H_2SO_4$  AS AN OXIDANT

SAFETY PRECAUTIONS AS IN (d)(i)

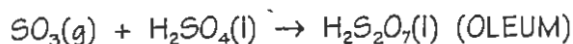
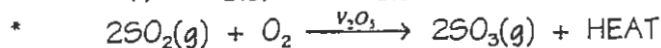
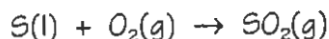
MUST:

CLEARLY DESCRIBE COLOUR CHANGE IN REACTION

WRITE BALANCED EQUATION FOR REACTION CITED

EXPLAIN WHY  $H_2SO_4$  IS ACTING AS AN OXIDANT

e) MULTI-STEP



\* KEY STEP

(1) REVERSIBLE – EQUILIBRIUM

EQUILIBRIUM YIELD – CONSIDER DE CHATELIERS PRINCIPLES

 $SO_3$  YIELD FAVOURED BY:

- LOW TEMP (FORWARD REACTION – EXOTHERMIC)
- INCREASE PRESSURE (FEWER MOLS ON RIGHT HAND SIDE)
- INCREASING CONCENTRATION OF REACTANT (E.G.  $O_2$ ) → FAVOURS RHS

BUT COMPROMISE CONSIDERING KINETICS

- HIGHER TEMP ( $\sim 500^\circ\text{C}$ ) TO MAKE RATE VIABLE
- PRESSURE 1 – 2 ATM (SUFFICIENTLY HIGH TO GIVE REASONABLE YIELD AND CHEAPER HIGH PRESSURE SYSTEM)  
(GAS MIX COOLED AFTER EACH PASS OVER CATALYST TO PREVENT BACKWARD REACTION)

COMPROMISE SITUATION MUST BE ARGUED LOGICALLY FOR FULL MARKS

## CHEMISTRY OF ART

- (a) (i) NAME + COMPOSITION / FORMULA + COLOUR
- (ii) NAME OR FORMULA 1 MARK  
 (1) + LOCATION / SOURCE + USE 2 MARKS  
 (2) + NEW LOCATION AND MINERAL OR NEW PIGMENT +  
 FORMULA OR SYNTHETIC METHOD 3 MARKS
- (b) (NAME + FORMULA) × 2 2 MARKS  
 (2) + (COLOUR + USE) × 2 3 MARKS  
 (3) + DISCUSSION (ESPECIALLY SAFETY) 4 MARKS

## REFERENCES USED FOR MARKING

- (1) TEXT-BOOK, MODULE 8 CHEMISTRY OF ART  
 (2) JLH HANDOUT – PIGMENTS, ART & DECORATION  
 (3) PIGMENTS PRESENTING THEIR PAST,  
 S FLEMING – CHEM. Br., 1976, 12, 182  
 (4) PIGMENTS THROUGH THE AGES  
<http://webexhibits.org/pigments> - ACCESSED DURING MARKING

INFORMATION NOT FOUND IN ANY OF THESE WAS MARKED WRONG

- (c) (i)  $\text{Na}^+ \rightarrow$  YELLOW FLAME  
 $\text{Ba}^{2+} \rightarrow$  GREEN FLAME  
 (NOT  $\text{Cu}^{2+}$  - THE SOLUTION WAS COLOURLESS AND THE PPT WAS WHITE)

$\text{K}^+$  WON'T INTERFERE WITH THE FLAME TEST, WHICH IS WHY  $\text{K}_2\text{CO}_3$  WAS USED

- (ii) FOR 3 MARKS:
- NON-LUMINOUS FLAME USED
  - BRIEF DESCRIPTION OF THE METHOD OF GETTING THE SAMPLE INTO THE FLAME
  - A STATEMENT ABOUT HOW THE RESULTS ARE USED  
 E.G. CHARACTERISTIC FLAME COLOUR  
 OR COMPARISON WITH KNOWN STDS.

- (d) (i) FOR 2 MARKS
- HOW EACH IS USED TO PREDICT  $e^-$  ARRANGEMENT  
I.E. PAULI: 2  $e^-$  PER ORBITAL  
HUND: DEGENERATE ORBITALS SINGLY OCCUPIED BEFORE ANY ONE DOUBLY OCCUPIED
  - FOR HUND IT HAD TO BE CLEAR THAT ORBITALS BEING CONSIDERED WERE SAME ENERGY / SAME SUBSHELL / DEGENERATE
  - FOR PAULI THE RESULT WAS IMPORTANT – I.E. 2 $e^-$  PER ORBITAL

- (ii) FOR 4 MARKS
- 3 MARK CONTENT AND ANOTHER REFERENCE TO THE STIMULUS MATERIAL PROVIDED E.G. BALMER SERIES REPRESENTS THE ENERGIES OF TRANSITIONS TO  $n = 2$ , OR LIMITING  $E$  IS IONISATION ENERGY

FOR 2 – 3 MARKS

EXPLANATION OF THE DISCRETE SPECTRAL LINES IN THE H EMISSION SPECTRUM IN TERMS OF ELECTRONS OCCUPYING DISCRETE ENERGY LEVELS/ORBITS OF FIXED RADII, AND REPRESENTING RELAXATIONS FROM HIGHER TO LOWER ENERGY LEVELS.

FOR 1 MARK

STATEMENT ABOUT THE HYDROGEN EMISSION SPECTRUM CONSISTING OF DISCRETE LINES

- (e) FOR 3 MARKS
- DESCRIPTION OF HOW THE TECHNIQUE WORKS

FOR 2 MARKS

COMMENT ABOUT THE USEFULNESS OF THE TECHNIQUE (E.G. DESTRUCTIVE, DEPTH PROFILING)

FOR 1 MARK

AN EXAMPLE OF AN ART WORK ANALYSED AND THE DATA OBTAINED