

Please check the examination details below before entering your candidate information

Candidate surname

Other names

**Pearson Edexcel**  
**International GCSE (9–1)**

Centre Number

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Candidate Number

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# Thursday 14 January 2021

Morning (Time: 1 hour 15 minutes)

Paper Reference **4CH1/2C**

## Chemistry

**Unit: 4CH1**

**Paper 2C**

**You must have:**  
 Calculator, ruler

Total Marks

### Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided  
– *there may be more space than you need.*
- Some questions must be answered with a cross in a box . If you change your mind about an answer, put a line through the box  and then mark your new answer with a cross .

### Information

- The total mark for this paper is 70.
- The marks for **each** question are shown in brackets  
– *use this as a guide as to how much time to spend on each question.*

### Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ►

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# The Periodic Table of the Elements

1	2	3	4	5	6	7	0	
7 <b>Li</b> lithium 3	9 <b>Be</b> beryllium 4	11 <b>Na</b> sodium 11	12 <b>C</b> carbon 6	13 <b>Al</b> aluminium 13	14 <b>N</b> nitrogen 7	15 <b>O</b> oxygen 8	16 <b>F</b> fluorine 9	17 <b>Ne</b> neon 10
19 <b>K</b> potassium 19	20 <b>Ca</b> calcium 20	23 <b>Sc</b> scandium 21	24 <b>Ti</b> titanium 22	25 <b>V</b> vanadium 23	26 <b>Cr</b> chromium 24	27 <b>Mn</b> manganese 25	28 <b>Fe</b> iron 26	29 <b>Co</b> cobalt 27
37 <b>Rb</b> rubidium 37	38 <b>Sr</b> strontium 38	39 <b>Y</b> yttrium 39	40 <b>Zr</b> zirconium 40	41 <b>Nb</b> niobium 41	42 <b>Mo</b> molybdenum 42	43 <b>Tc</b> technetium 43	44 <b>Ru</b> ruthenium 44	45 <b>Rh</b> rhodium 45
55 <b>Cs</b> caesium 55	56 <b>Ba</b> barium 56	57 <b>La*</b> lanthanum 57	72 <b>Hf</b> hafnium 72	73 <b>Ta</b> tantalum 73	74 <b>W</b> tungsten 74	75 <b>Re</b> rhenium 75	76 <b>Os</b> osmium 76	77 <b>Ir</b> iridium 77
87 <b>Fr</b> francium 87	88 <b>Ra</b> radium 88	89 <b>Ac*</b> actinium 89	104 <b>Rf</b> rutherfordium 104	105 <b>Db</b> dubnium 105	106 <b>Sg</b> seaborgium 106	107 <b>Bh</b> bohrium 107	108 <b>Hs</b> hassium 108	109 <b>Mt</b> meitnerium 109
133 <b>Cs</b> caesium 55	137 <b>Ba</b> barium 56	139 <b>La*</b> lanthanum 57	178 <b>Hf</b> hafnium 72	181 <b>Ta</b> tantalum 73	184 <b>W</b> tungsten 74	186 <b>Re</b> rhenium 75	190 <b>Os</b> osmium 76	192 <b>Ir</b> iridium 77
223 <b>Fr</b> francium 87	226 <b>Ra</b> radium 88	227 <b>Ac*</b> actinium 89	261 <b>Rf</b> rutherfordium 104	262 <b>Db</b> dubnium 105	266 <b>Sg</b> seaborgium 106	264 <b>Bh</b> bohrium 107	277 <b>Hs</b> hassium 108	268 <b>Mt</b> meitnerium 109
119 <b>In</b> indium 49	120 <b>Tl</b> thallium 81	121 <b>Pb</b> lead 82	122 <b>Bi</b> bismuth 83	123 <b>Po</b> polonium 84	124 <b>At</b> astatine 85	125 <b>Rn</b> radon 86	126 <b>Fr</b> francium 87	127 <b>Ne</b> neon 10
49 <b>In</b> indium 49	50 <b>Tl</b> thallium 81	51 <b>Pb</b> lead 82	52 <b>Bi</b> bismuth 83	53 <b>Po</b> polonium 84	54 <b>At</b> astatine 85	55 <b>Rn</b> radon 86	56 <b>Fr</b> francium 87	57 <b>Ne</b> neon 10
48 <b>Cd</b> cadmium 48	49 <b>In</b> indium 49	50 <b>Tl</b> thallium 81	51 <b>Pb</b> lead 82	52 <b>Bi</b> bismuth 83	53 <b>Po</b> polonium 84	54 <b>At</b> astatine 85	55 <b>Rn</b> radon 86	56 <b>Fr</b> francium 87
30 <b>Zn</b> zinc 30	31 <b>Ga</b> gallium 31	32 <b>Ge</b> germanium 32	33 <b>As</b> arsenic 33	34 <b>Se</b> selenium 34	35 <b>Br</b> bromine 35	36 <b>Kr</b> krypton 36	37 <b>Rb</b> rubidium 37	38 <b>Sr</b> strontium 38
29 <b>Cu</b> copper 29	30 <b>Zn</b> zinc 30	31 <b>Ga</b> gallium 31	32 <b>Ge</b> germanium 32	33 <b>As</b> arsenic 33	34 <b>Se</b> selenium 34	35 <b>Br</b> bromine 35	36 <b>Kr</b> krypton 36	37 <b>Rb</b> rubidium 37
28 <b>Ni</b> nickel 28	29 <b>Cu</b> copper 29	30 <b>Zn</b> zinc 30	31 <b>Ga</b> gallium 31	32 <b>Ge</b> germanium 32	33 <b>As</b> arsenic 33	34 <b>Se</b> selenium 34	35 <b>Br</b> bromine 35	36 <b>Kr</b> krypton 36
27 <b>Co</b> cobalt 27	28 <b>Ni</b> nickel 28	29 <b>Cu</b> copper 29	30 <b>Zn</b> zinc 30	31 <b>Ga</b> gallium 31	32 <b>Ge</b> germanium 32	33 <b>As</b> arsenic 33	34 <b>Se</b> selenium 34	35 <b>Br</b> bromine 35
26 <b>Fe</b> iron 26	27 <b>Co</b> cobalt 27	28 <b>Ni</b> nickel 28	29 <b>Cu</b> copper 29	30 <b>Zn</b> zinc 30	31 <b>Ga</b> gallium 31	32 <b>Ge</b> germanium 32	33 <b>As</b> arsenic 33	34 <b>Se</b> selenium 34
25 <b>Mn</b> manganese 25	26 <b>Fe</b> iron 26	27 <b>Co</b> cobalt 27	28 <b>Ni</b> nickel 28	29 <b>Cu</b> copper 29	30 <b>Zn</b> zinc 30	31 <b>Ga</b> gallium 31	32 <b>Ge</b> germanium 32	33 <b>As</b> arsenic 33
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23 <b>V</b> vanadium 23	24 <b>Cr</b> chromium 24	25 <b>Mn</b> manganese 25	26 <b>Fe</b> iron 26	27 <b>Co</b> cobalt 27	28 <b>Ni</b> nickel 28	29 <b>Cu</b> copper 29	30 <b>Zn</b> zinc 30	31 <b>Ga</b> gallium 31
22 <b>Ti</b> titanium 22	23 <b>V</b> vanadium 23	24 <b>Cr</b> chromium 24	25 <b>Mn</b> manganese 25	26 <b>Fe</b> iron 26	27 <b>Co</b> cobalt 27	28 <b>Ni</b> nickel 28	29 <b>Cu</b> copper 29	30 <b>Zn</b> zinc 30
21 <b>Sc</b> scandium 21	22 <b>Ti</b> titanium 22	23 <b>V</b> vanadium 23	24 <b>Cr</b> chromium 24	25 <b>Mn</b> manganese 25	26 <b>Fe</b> iron 26	27 <b>Co</b> cobalt 27	28 <b>Ni</b> nickel 28	29 <b>Cu</b> copper 29
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18 <b>Ar</b> argon 18	19 <b>K</b> potassium 19	20 <b>Ca</b> calcium 20	21 <b>Sc</b> scandium 21	22 <b>Ti</b> titanium 22	23 <b>V</b> vanadium 23	24 <b>Cr</b> chromium 24	25 <b>Mn</b> manganese 25	26 <b>Fe</b> iron 26
17 <b>Cl</b> chlorine 17	18 <b>Ar</b> argon 18	19 <b>K</b> potassium 19	20 <b>Ca</b> calcium 20	21 <b>Sc</b> scandium 21	22 <b>Ti</b> titanium 22	23 <b>V</b> vanadium 23	24 <b>Cr</b> chromium 24	25 <b>Mn</b> manganese 25
16 <b>S</b> sulfur 16	17 <b>Cl</b> chlorine 17	18 <b>Ar</b> argon 18	19 <b>K</b> potassium 19	20 <b>Ca</b> calcium 20	21 <b>Sc</b> scandium 21	22 <b>Ti</b> titanium 22	23 <b>V</b> vanadium 23	24 <b>Cr</b> chromium 24
15 <b>P</b> phosphorus 15	16 <b>S</b> sulfur 16	17 <b>Cl</b> chlorine 17	18 <b>Ar</b> argon 18	19 <b>K</b> potassium 19	20 <b>Ca</b> calcium 20	21 <b>Sc</b> scandium 21	22 <b>Ti</b> titanium 22	23 <b>V</b> vanadium 23
14 <b>N</b> nitrogen 7	15 <b>P</b> phosphorus 15	16 <b>S</b> sulfur 16	17 <b>Cl</b> chlorine 17	18 <b>Ar</b> argon 18	19 <b>K</b> potassium 19	20 <b>Ca</b> calcium 20	21 <b>Sc</b> scandium 21	22 <b>Ti</b> titanium 22
13 <b>Al</b> aluminium 13	14 <b>Si</b> silicon 14	15 <b>P</b> phosphorus 15	16 <b>S</b> sulfur 16	17 <b>Cl</b> chlorine 17	18 <b>Ar</b> argon 18	19 <b>K</b> potassium 19	20 <b>Ca</b> calcium 20	21 <b>Sc</b> scandium 21
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11 <b>B</b> boron 5	12 <b>C</b> carbon 6	13 <b>Al</b> aluminium 13	14 <b>Si</b> silicon 14	15 <b>P</b> phosphorus 15	16 <b>S</b> sulfur 16	17 <b>Cl</b> chlorine 17	18 <b>Ar</b> argon 18	19 <b>K</b> potassium 19
10 <b>Ne</b> neon 10	11 <b>B</b> boron 5	12 <b>C</b> carbon 6	13 <b>Al</b> aluminium 13	14 <b>Si</b> silicon 14	15 <b>P</b> phosphorus 15	16 <b>S</b> sulfur 16	17 <b>Cl</b> chlorine 17	18 <b>Ar</b> argon 18
9 <b>F</b> fluorine 9	10 <b>Ne</b> neon 10	11 <b>B</b> boron 5	12 <b>C</b> carbon 6	13 <b>Al</b> aluminium 13	14 <b>Si</b> silicon 14	15 <b>P</b> phosphorus 15	16 <b>S</b> sulfur 16	17 <b>Cl</b> chlorine 17
8 <b>O</b> oxygen 8	9 <b>F</b> fluorine 9	10 <b>Ne</b> neon 10	11 <b>B</b> boron 5	12 <b>C</b> carbon 6	13 <b>Al</b> aluminium 13	14 <b>Si</b> silicon 14	15 <b>P</b> phosphorus 15	16 <b>S</b> sulfur 16
7 <b>N</b> nitrogen 7	8 <b>O</b> oxygen 8	9 <b>F</b> fluorine 9	10 <b>Ne</b> neon 10	11 <b>B</b> boron 5	12 <b>C</b> carbon 6	13 <b>Al</b> aluminium 13	14 <b>Si</b> silicon 14	15 <b>P</b> phosphorus 15
6 <b>O</b> oxygen 8	7 <b>N</b> nitrogen 7	8 <b>O</b> oxygen 8	9 <b>F</b> fluorine 9	10 <b>Ne</b> neon 10	11 <b>B</b> boron 5	12 <b>C</b> carbon 6	13 <b>Al</b> aluminium 13	14 <b>Si</b> silicon 14
5 <b>N</b> nitrogen 7	6 <b>O</b> oxygen 8	7 <b>N</b> nitrogen 7	8 <b>O</b> oxygen 8	9 <b>F</b> fluorine 9	10 <b>Ne</b> neon 10	11 <b>B</b> boron 5	12 <b>C</b> carbon 6	13 <b>Al</b> aluminium 13
4 <b>He</b> helium 2	5 <b>N</b> nitrogen 7	6 <b>O</b> oxygen 8	7 <b>N</b> nitrogen 7	8 <b>O</b> oxygen 8	9 <b>F</b> fluorine 9	10 <b>Ne</b> neon 10	11 <b>B</b> boron 5	12 <b>C</b> carbon 6
3 <b>Li</b> lithium 3	4 <b>Be</b> beryllium 4	5 <b>N</b> nitrogen 7	6 <b>O</b> oxygen 8	7 <b>N</b> nitrogen 7	8 <b>O</b> oxygen 8	9 <b>F</b> fluorine 9	10 <b>Ne</b> neon 10	11 <b>B</b> boron 5
2 <b>He</b> helium 2	3 <b>Li</b> lithium 3	4 <b>Be</b> beryllium 4	5 <b>N</b> nitrogen 7	6 <b>O</b> oxygen 8	7 <b>N</b> nitrogen 7	8 <b>O</b> oxygen 8	9 <b>F</b> fluorine 9	10 <b>Ne</b> neon 10
1 <b>H</b> hydrogen 1	2 <b>He</b> helium 2	3 <b>Li</b> lithium 3	4 <b>Be</b> beryllium 4	5 <b>N</b> nitrogen 7	6 <b>O</b> oxygen 8	7 <b>N</b> nitrogen 7	8 <b>O</b> oxygen 8	9 <b>F</b> fluorine 9

1  
**H**  
hydrogen  
1

**Key**  
relative atomic mass  
atomic symbol  
name  
atomic (proton) number

Elements with atomic numbers 112–116 have been reported but not fully authenticated

\* The lanthanoids (atomic numbers 58–71) and the actinoids (atomic numbers 90–103) have been omitted.

The relative atomic masses of copper and chlorine have not been rounded to the nearest whole number.

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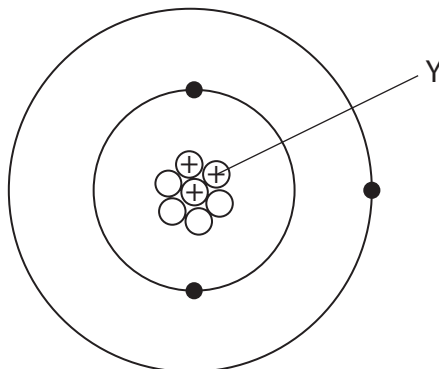
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Answer ALL questions. Write your answers in the spaces provided.

1 The diagram shows an atom of an element.



(a) (i) What is the name of the particle labelled Y? (1)

- A electron
- B ion
- C neutron
- D proton

(ii) Give the mass number of this atom. (1)

(iii) Name this element.  
Use the Periodic Table on page 2 to help you. (1)

(b) There are two isotopes of this element.  
Give one way, in terms of sub-atomic particles, that these isotopes are the same and one way that they are different. (2)

same .....

different .....

(Total for Question 1 = 5 marks)

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2 This question is about gases.

(a) The box gives the names of some gases.

argon	carbon dioxide	hydrogen	nitrogen	oxygen
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Use gases from the box to answer these questions.

Each gas may be used once, more than once or not at all.

(i) Name the most abundant gas in the Earth's atmosphere.

(1)

(ii) Name the gas that is a compound.

(1)

(iii) Name the least reactive of the gases.

(1)

(iv) Name the gas formed by the complete combustion of hydrocarbons.

(1)

(b) Describe the test for hydrogen gas.

(1)

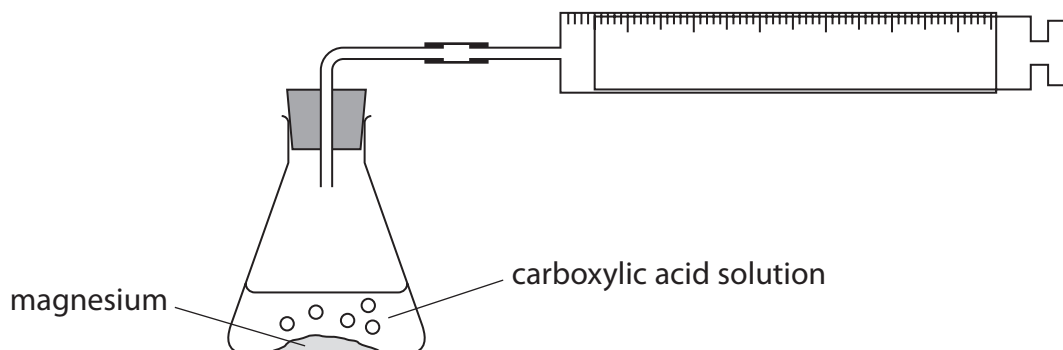
**(Total for Question 2 = 5 marks)**



3 This question is about carboxylic acids.

Solutions of carboxylic acids react with magnesium metal to form hydrogen gas.

A student uses this apparatus to investigate the time taken to produce  $10\text{ cm}^3$  of hydrogen gas from different carboxylic acids.



This is the student's method.

- pour some carboxylic acid solution into a conical flask
- add some magnesium powder
- quickly connect the gas syringe and start a timer
- record the time taken to collect  $10\text{ cm}^3$  of hydrogen gas

The student repeats the method with three other carboxylic acids.

(a) (i) All the carboxylic acids are of the same concentration.

Give two other variables the student should control in his investigation.

(2)

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2.....

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(ii) Give a reason why it is important to connect the gas syringe quickly.

(1)

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(b) The table shows the student's results.

Carboxylic acid	Formula of carboxylic acid	Time taken to produce 10 cm <sup>3</sup> of hydrogen in s				
		Experiment 1	Experiment 2	Experiment 3	Experiment 4	Mean time in s
Methanoic acid	HCOOH	48	50	47	49	49
Ethanoic acid	CH <sub>3</sub> COOH	61	63	60	61	61
Propanoic acid	CH <sub>3</sub> CH <sub>2</sub> COOH	69	93	70	71	
Butanoic acid	CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> COOH	83	85	82	81	83

(i) Calculate the mean (average) time for propanoic acid to produce 10 cm<sup>3</sup> of hydrogen gas.

(2)

mean time = ..... s

(ii) Deduce the relationship between the number of carbon atoms in the molecule and the time taken to produce 10 cm<sup>3</sup> of hydrogen gas.

(1)

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(c) An ester is formed by adding ethanoic acid to ethanol in the presence of sulfuric acid.

Give the displayed formula of the ester produced when ethanoic acid reacts with ethanol.

(2)

(Total for Question 3 = 8 marks)





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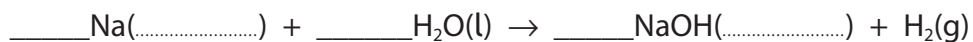


4 This question is about sodium and potassium.

A trough is filled with water and a few drops of phenolphthalein indicator are added.

(a) A small piece of sodium is dropped into the water. One of the products of the reaction is an alkali.

(i) Complete the chemical equation for the reaction of sodium with water. (2)



(ii) Identify the ion that causes the solution to become alkaline. (1)

(iii) Give three observations that would be made when sodium reacts with water. (3)

1.....

2.....

3.....

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(b) Explain why potassium is more reactive than sodium.

Refer to the electronic configurations of the atoms in your answer.

(3)

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**(Total for Question 4 = 9 marks)**



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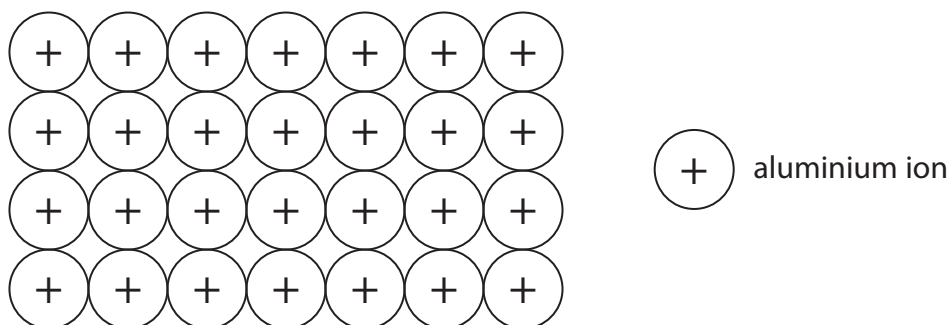
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5 This question is about the metal aluminium.

(a) Aluminium is malleable and conducts electricity.

The diagram shows the arrangement of the ions in aluminium metal.



(i) Explain why aluminium is malleable.

(2)

(ii) Explain why aluminium conducts electricity.

(2)

(b) Aluminium cannot be extracted by heating a mixture of carbon and aluminium oxide.

Give a reason why heating a mixture of aluminium oxide and carbon does not produce aluminium.

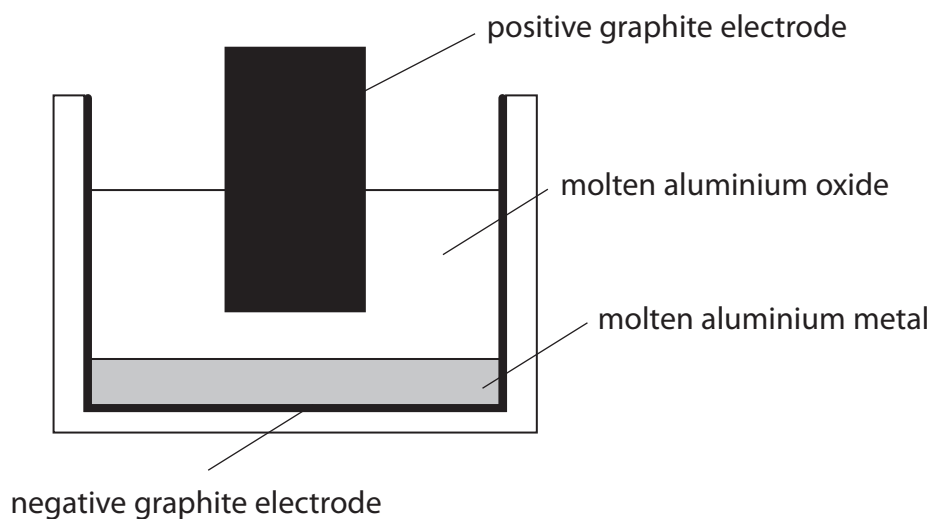
(1)



- (c) Aluminium is extracted industrially by the electrolysis of molten aluminium oxide  $\text{Al}_2\text{O}_3$  at a temperature of about  $950^\circ\text{C}$ .

Aluminium metal forms at the negative electrode and oxygen gas forms at the positive electrode. The positive and negative electrodes are made of graphite.

The diagram shows the apparatus used.



- (i) Explain how aluminium metal forms at the negative electrode.

(2)

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- (ii) Write an ionic half-equation for the formation of oxygen gas at the positive electrode.

(1)

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(iii) Suggest why carbon dioxide gas is also produced at the positive electrode.

(2)

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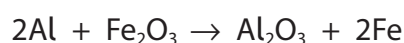
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(d) Aluminium reacts with iron(III) oxide. The reaction is exothermic.

The equation for the reaction is



(i) State how the equation shows that iron(III) oxide is reduced.

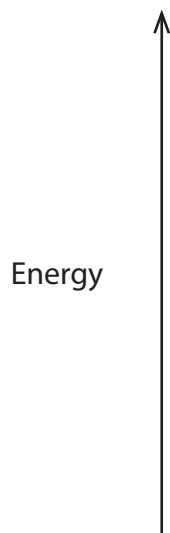
(1)

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(ii) Draw an energy level diagram for the reaction between aluminium and iron(III) oxide.

(3)



**(Total for Question 5 = 14 marks)**



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6 This question is about the insoluble salt silver chloride (AgCl).

Silver chloride can be made by the reaction between copper(II) chloride and silver nitrate.

(a) Describe how a student could prepare a pure, dry sample of silver chloride starting with copper(II) chloride solution and silver nitrate solution.

(4)

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(b) A student investigates the quantity of silver chloride produced when different volumes of silver nitrate solution are added to copper(II) chloride solution.

This is the student's method.

- pour  $5.0\text{ cm}^3$  of copper(II) chloride solution into a test tube
- add  $1.0\text{ cm}^3$  of silver nitrate solution to the test tube
- allow the silver chloride precipitate to settle
- measure the height of the precipitate

The student repeats the method using different volumes of silver nitrate solution.

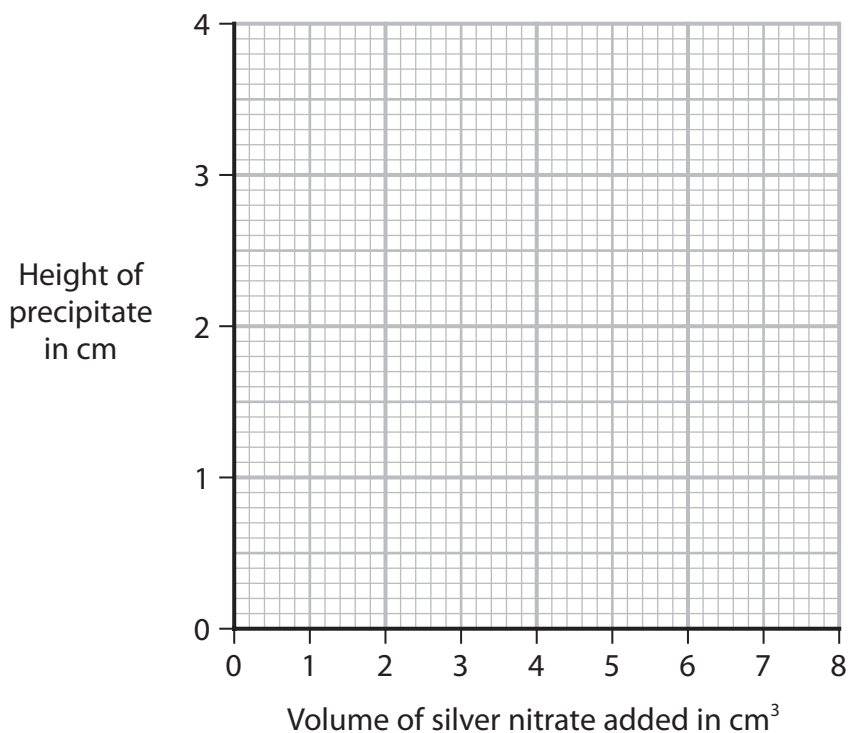
The table shows the student's results.

Volume of silver nitrate added in $\text{cm}^3$	Height of precipitate in cm
0.0	0.0
1.0	0.5
2.0	1.0
3.0	1.2
4.0	2.0
5.0	2.5
6.0	3.0
7.0	3.0
8.0	3.0



(i) Plot the student's results. (2)

(ii) Draw two straight lines of best fit, ignoring the anomalous result. (1)



(iii) Suggest a mistake the student made to cause the anomalous result. (1)

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(iv) Give a reason why the last three heights are the same. (1)

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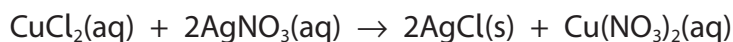
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(c) The equation for the reaction between copper(II) chloride and silver nitrate is



A student measures  $25.0 \text{ cm}^3$  of  $0.500 \text{ mol/dm}^3$  copper(II) chloride solution and reacts it with silver nitrate solution.

(i) Name a piece of apparatus suitable for measuring  $25.0 \text{ cm}^3$  of copper(II) chloride solution.

(1)

(ii) Calculate the maximum mass, in grams, of silver chloride that could be produced.

$[M_r \text{ of AgCl} = 143.5]$

(3)

maximum mass = ..... g

(iii) In an experiment using different solutions, the mass of silver chloride produced is  $0.744 \text{ g}$ .

The maximum mass of silver chloride that could be produced is  $0.850 \text{ g}$ .

Calculate the percentage yield.

(2)

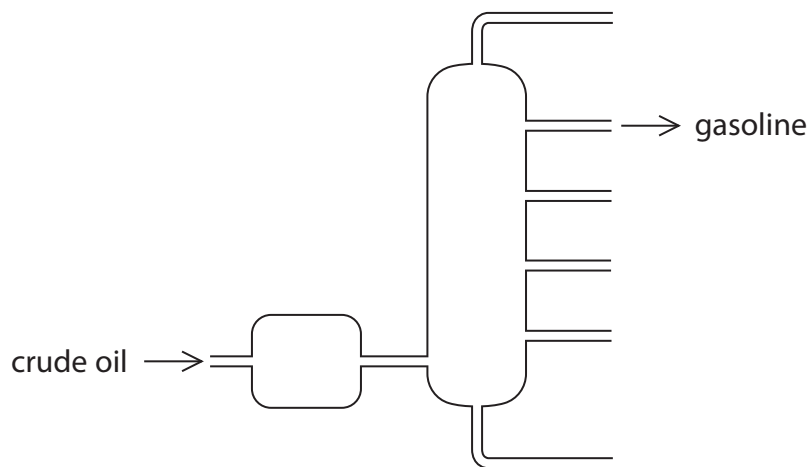
percentage yield = ..... %

**(Total for Question 6 = 15 marks)**



7 This question is about octane ( $C_8H_{18}$ ) which is produced in the gasoline fraction during fractional distillation of crude oil.

(a) The diagram shows a fractionating column.



Describe how crude oil is separated into fractions in the fractionating column.

(4)

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(b) Octane can also be produced by the process of cracking.

Give the conditions for cracking.

(2)

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(c) A car is driven at constant speed for 4.00 km.

The exhaust gases are collected and their volume at room temperature and pressure (rtp) is  $5.02 \times 10^5 \text{ cm}^3$ .

The exhaust gases include carbon dioxide and oxides of nitrogen.

The carbon dioxide is removed from the exhaust gases. The volume of the remaining gases at rtp is  $2.96 \times 10^5 \text{ cm}^3$ .

(i) Explain how oxides of nitrogen form in a car engine. (2)

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(ii) Give a reason why oxides of nitrogen should not be released into the atmosphere. (1)

.....

.....

(iii) Show that the car produces less than 100 g of carbon dioxide per km.  
[molar volume of carbon dioxide at rtp =  $24\,000 \text{ cm}^3$ ] (5)

**(Total for Question 7 = 14 marks)**

**TOTAL FOR PAPER = 70 MARKS**



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