



**Section A**

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

- 1 Choose from the following oxides to answer the questions.

**calcium oxide**

**carbon monoxide**

**copper(II) oxide**

**nitrogen dioxide**

**nitrogen monoxide**

**silicon dioxide**

**sulfur dioxide**

**water**

**zinc oxide**

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

Which oxide:

- (a) is used as a food preservative

..... [1]

- (b) is amphoteric

..... [1]

- (c) has a molecule that contains only 15 protons

..... [1]

- (d) has a high melting point because it has a giant covalent structure

..... [1]

- (e) reacts with dilute sulfuric acid to make a blue solution?

..... [1]

[Total: 5]

2 Part of the reactivity series is shown.

|           |               |
|-----------|---------------|
| calcium   | more reactive |
| aluminium | ↓             |
| manganese |               |
| zinc      | less reactive |

- (a) Predict the names of the products formed when manganese reacts with dilute hydrochloric acid.

.....  
 ..... [1]

- (b) A sample of manganese(II) carbonate,  $\text{MnCO}_3$ , is heated strongly.

Construct the equation for this reaction.

..... [1]

- (c) Powdered manganese is added to aqueous zinc sulfate to form aqueous manganese(II) sulfate,  $\text{MnSO}_4$ .

Construct an ionic equation, with state symbols, for this reaction.

..... [2]

- (d) Zinc powder, a reducing agent, is added to acidified aqueous potassium manganate(VII).

Describe the colour change during this reaction.

..... [1]

- (e) Aluminium is extracted by the electrolysis of aluminium oxide dissolved in molten cryolite.

- (i) Write the electrode equation for the formation of aluminium atoms at the cathode.

..... [1]

- (ii) Write the electrode equation for the formation of oxygen molecules at the anode.

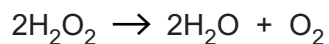
..... [1]

- (f) State one advantage of recycling aluminium.

..... [1]

[Total: 8]

- 3 The equation for the decomposition of hydrogen peroxide is shown.



A sample containing 1.00 mol of hydrogen peroxide is completely decomposed.

This sample releases 98.0 kJ of heat energy.

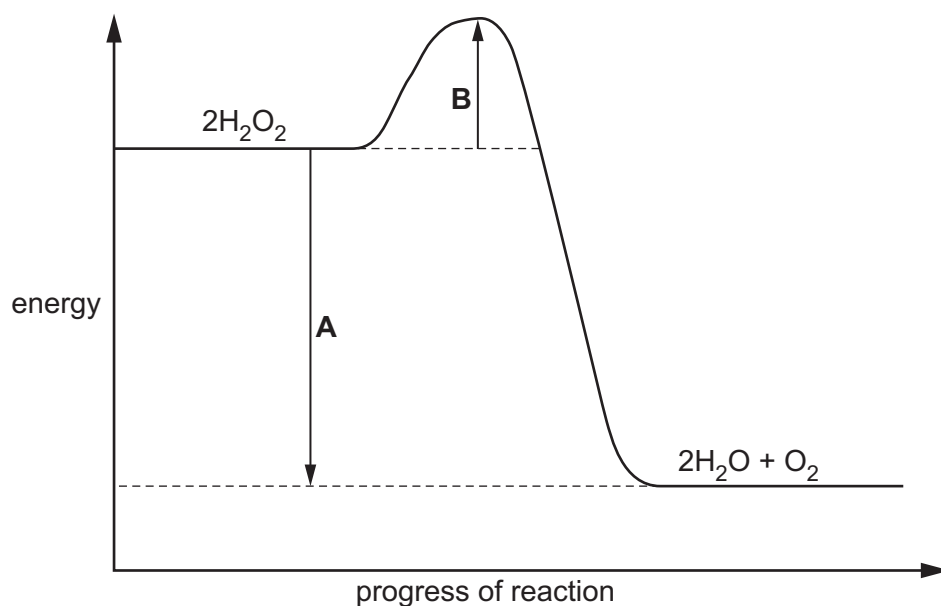
- (a) Calculate the heat energy released when 680 g of hydrogen peroxide is completely decomposed.

heat energy released ..... kJ [2]

- (b) Use ideas about bond breaking and bond forming to explain why the decomposition of hydrogen peroxide is exothermic.

.....  
.....  
..... [2]

(c) The energy profile diagram for the decomposition of hydrogen peroxide is shown.



Identify the energy changes.

change **A** .....

change **B** .....

[2]

(d) The rate of decomposition of hot  $\text{H}_2\text{O}_2$  is greater than that of cold  $\text{H}_2\text{O}_2$ .

Use ideas about particles to explain why.

.....  
.....  
..... [2]

[Total: 8]

4 The table shows some properties of five esters.

| name             | structure                                                               | relative molecular mass | melting point / °C | boiling point / °C |
|------------------|-------------------------------------------------------------------------|-------------------------|--------------------|--------------------|
| methyl ethanoate | $\text{CH}_3\text{COOCH}_3$                                             | 74                      | -98                | 57                 |
| ethyl ethanoate  | $\text{CH}_3\text{COOCH}_2\text{CH}_3$                                  | 88                      | -84                | 77                 |
| propyl ethanoate | $\text{CH}_3\text{COOCH}_2\text{CH}_2\text{CH}_3$                       | 102                     | -95                | 102                |
| butyl ethanoate  | $\text{CH}_3\text{COOCH}_2\text{CH}_2\text{CH}_2\text{CH}_3$            | 116                     | -78                | 126                |
| pentyl ethanoate | $\text{CH}_3\text{COOCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$ | 130                     | -71                | 148                |

(a) These esters are part of a homologous series.

State **two** characteristics of a homologous series.

1. ....  
.....
2. ....  
.....

[2]

(b) The next member of the homologous series is hexyl ethanoate.

Explain why it is more difficult to predict the melting point than the boiling point of hexyl ethanoate.

.....  
.....  
..... [1]

(c) At 25 °C ethyl ethanoate is a liquid.

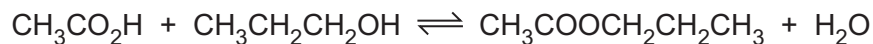
Explain how the data in the table shows this.

.....  
..... [1]

(d) State one use for an ester.

..... [1]

- (e) Propyl ethanoate is prepared by the reaction between ethanoic acid and propanol.



- (i) Calculate the maximum mass of propyl ethanoate that can be made from 7.20 g of ethanoic acid and excess propanol.

Give your answer to **three** significant figures.

mass of propyl ethanoate ..... g [2]

- (ii) The concentration of ethanoic acid is increased.

State and explain, in terms of particles, what happens to the rate of the forward reaction.

.....  
 .....  
 .....  
 ..... [3]

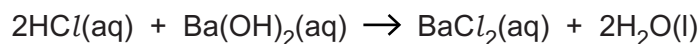
- (iii) The water formed in the reaction is removed.

State and explain what happens to the position of the equilibrium.

.....  
 .....  
 ..... [2]

[Total: 12]

- 5 Hydrochloric acid,  $\text{HCl}$ , reacts with barium hydroxide,  $\text{Ba}(\text{OH})_2$ , as shown.



A sample of  $25.0\text{ cm}^3$  of  $0.0500\text{ mol/dm}^3$   $\text{Ba}(\text{OH})_2$  is placed in a beaker.

Dilute  $\text{HCl}$  is added slowly, from a burette, to the  $\text{Ba}(\text{OH})_2(\text{aq})$  in the beaker.

A pH probe is used to measure the pH of the solution in the beaker until a total of  $40.0\text{ cm}^3$  of dilute  $\text{HCl}$  is added.

The table shows how the pH of the solution in the beaker changes.

| volume of dilute $\text{HCl}$ added / $\text{cm}^3$ | pH of the solution in the beaker |
|-----------------------------------------------------|----------------------------------|
| 0.0                                                 | 13.0                             |
| 5.0                                                 | 12.9                             |
| 10.0                                                | 12.5                             |
| 15.0                                                | 11.6                             |
| 20.0                                                | 7.0                              |
| 25.0                                                | 3.0                              |
| 30.0                                                | 1.6                              |
| 35.0                                                | 1.1                              |
| 40.0                                                | 0.9                              |

- (a) Explain, in terms of the ions present, why the pH of the solution in the beaker changes from 13.0 to 0.9.

.....  
 .....  
 ..... [2]

- (b) Use the data in the table to state the volume of dilute  $\text{HCl}$  that just neutralises all of the sample of  $\text{Ba}(\text{OH})_2(\text{aq})$ .

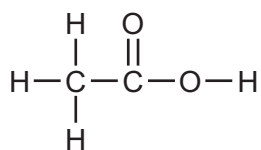
volume of dilute  $\text{HCl}$  .....  $\text{cm}^3$  [1]

(c) Use your answer to (b) to calculate the concentration, in  $\text{mol/dm}^3$ , of the dilute  $\text{HCl}$ .

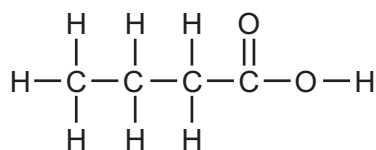
concentration of dilute  $\text{HCl}$  .....  $\text{mol/dm}^3$  [3]

[Total: 6]

6 The structures of two carboxylic acids are shown.



ethanoic acid

carboxylic acid **B**

(a) An isomer of carboxylic acid **B** has the name methylpropanoic acid.

(i) What is the name of carboxylic acid **B**?

..... [1]

(ii) What is the meaning of the term *isomer*?

.....

.....

..... [1]

(b) Vinegar contains ethanoic acid.

Describe the formation of vinegar from ethanol.

.....

.....

..... [2]

(c) Ethanoic acid reacts with calcium carbonate.

(i) Give the formula of the calcium salt formed in this reaction.

..... [1]

(ii) Name the other **two** products formed in this reaction.

..... and ..... [1]

[Total: 6]

## Section B

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

7 Carbon dioxide is a colourless gas found in air.

(a) The percentage of carbon dioxide in the air is increasing.

State one environmental problem caused by this increase.

..... [1]

(b) Carbon dioxide is a product of the complete combustion of octane,  $C_8H_{18}$ .

Construct the equation for this reaction.

..... [2]

(c) Fermentation of glucose produces carbon dioxide.

(i) Give the equation for the fermentation of glucose.

..... [1]

(ii) State **two** essential conditions needed for fermentation.

.....

..... [2]

(d) When warmed, solid carbon dioxide changes directly into a gas. It does **not** become a liquid.

Use the kinetic particle theory to describe the changes in **movement** and **arrangement** of the particles during this change of state.

.....

.....

.....

.....

..... [3]

(e) Explain why solid carbon dioxide does not conduct electricity.

.....

..... [1]

[Total: 10]

8 This question is about the chlorides of the elements in Period 3.

(a) State the electronic configuration of the positive ion in sodium chloride, NaCl.

..... [1]

(b) Magnesium chloride crystals can be prepared by reacting an insoluble base with an acid.

(i) Name an insoluble base and the acid that can be used.

insoluble base .....

acid .....

[1]

(ii) Describe the essential practical details for the preparation of pure magnesium chloride crystals.

.....

.....

.....

.....

..... [3]

(c) Anhydrous aluminium chloride contains 20.2% by mass of aluminium.

(i) Show that the empirical formula for anhydrous aluminium chloride is  $AlCl_3$ .

[2]

- (ii) A sample of anhydrous aluminium chloride has a mass of 2.34 g.

The sample contains 0.00876 mol of anhydrous aluminium chloride.

Calculate the relative molecular mass and give the molecular formula for anhydrous aluminium chloride.

relative molecular mass .....

molecular formula .....

[2]

- (d) Silicon(IV) chloride,  $\text{SiCl}_4$ , has a simple molecular structure.

Predict **one** physical property of silicon(IV) chloride at room temperature.

..... [1]

[Total: 10]

9 Iron is a transition element.

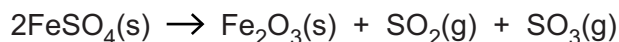
(a) State two physical properties of iron that are typical of a transition element.

1. ....
2. .... [2]

(b) Name an industrial process that uses iron as a catalyst.

..... [1]

(c) Iron(II) sulfate thermally decomposes to form iron(III) oxide, sulfur dioxide and sulfur trioxide.



(i) Explain how the equation shows that this reaction involves oxidation.

.....

..... [1]

(ii) A sample of 6.08 g of  $\text{FeSO}_4$  is heated until all the sample has thermally decomposed.

Calculate the volume of sulfur dioxide formed,  $\text{SO}_2(\text{g})$ , in  $\text{dm}^3$ , measured at room temperature and pressure.

volume of sulfur dioxide .....  $\text{dm}^3$  [3]

- (d) Iron(III) oxide reacts with dilute sulfuric acid to make iron(III) sulfate,  $\text{Fe}_2(\text{SO}_4)_3$ .

Construct the equation for this reaction.

..... [1]

- (e) Describe a chemical test that can be used to distinguish between aqueous solutions of iron(II) sulfate and iron(III) sulfate.

chemical test .....

result with iron(II) sulfate .....

result with iron(III) sulfate .....

[2]

[Total: 10]

- 10 Fractional distillation and cracking are important processes in the conversion of petroleum (crude oil) into useful substances.

(a) Complete the sentence about petroleum (crude oil).

Choose from the list.

**an alloy**

**a compound**

**an element**

**a mixture**

**a polymer**

**a salt**

Petroleum (crude oil) is ..... of hydrocarbons. [1]

(b) Fractional distillation separates petroleum (crude oil) into fractions such as paraffin (kerosene) and naphtha.

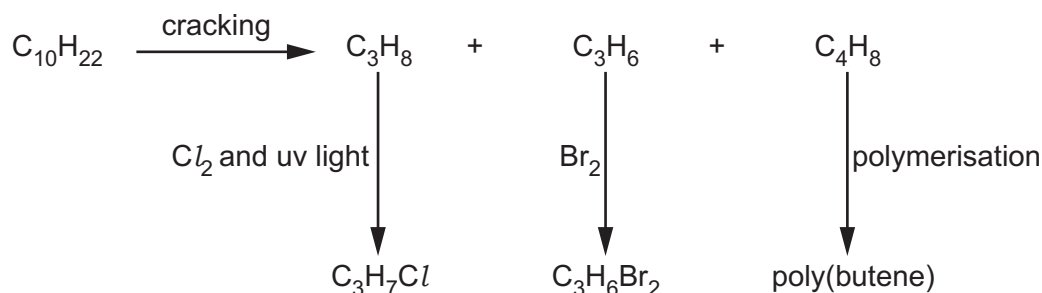
Give one use for the paraffin (kerosene) fraction.

..... [1]

(c) The naphtha fraction is used as a chemical feedstock.

One of the hydrocarbons in naphtha has the molecular formula  $C_{10}H_{22}$ .

The flow chart shows some compounds that can be made from  $C_{10}H_{22}$ .



(i)  $C_3H_8$  is an alkane and  $C_3H_6$  is an alkene.

Explain why, in terms of their general formulae,  $C_3H_8$  is an alkane and  $C_3H_6$  is an alkene.

.....  
 .....  
 .....  
 ..... [2]

- (ii) In the presence of uv light chlorine reacts with  $C_3H_8$ .

Two of the products formed are  $HCl$  and  $C_3H_7Cl$ .

What type of reaction takes place when  $C_3H_8$  reacts with chlorine?

.....

Give the formula of one other product of this reaction.

.....

[2]

- (iii) Describe the colour change when  $C_3H_6$  reacts with bromine.

.....

..... [1]

- (d) (i) Suggest a possible structure for  $C_4H_8$ .

[1]

- (ii) Draw the partial structure of poly(butene) that shows at least two repeat units.

[2]

[Total: 10]

**BLANK PAGE**

**BLANK PAGE**

---

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge Assessment International Education Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at [www.cambridgeinternational.org](http://www.cambridgeinternational.org) after the live examination series.

Cambridge Assessment International Education is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of the University of Cambridge Local Examinations Syndicate (UCLES), which itself is a department of the University of Cambridge.

The Periodic Table of Elements

| Group                      |                             |                                                                       |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                           |
|----------------------------|-----------------------------|-----------------------------------------------------------------------|---------------------------------|-----------------------------|------------------------------|-----------------------------|------------------------------|------------------------------|--------------------------------|-------------------------------|-------------------------------|-----------------------------|-----------------------------|-----------------------------|-------------------------------|------------------------------|---------------------------|
| I                          | II                          | 1<br>H<br>hydrogen<br>1                                               |                                 |                             |                              |                             |                              |                              |                                |                               |                               | III                         | IV                          | V                           | VI                            | VII                          | VIII                      |
| 3<br>Li<br>lithium<br>7    | 4<br>Be<br>beryllium<br>9   | Key<br>atomic number<br>atomic symbol<br>name<br>relative atomic mass |                                 |                             |                              |                             |                              |                              |                                |                               |                               | 5<br>B<br>boron<br>11       | 6<br>C<br>carbon<br>12      | 7<br>N<br>nitrogen<br>14    | 8<br>O<br>oxygen<br>16        | 9<br>F<br>fluorine<br>19     | 10<br>Ne<br>neon<br>20    |
|                            |                             |                                                                       |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                           |
| 11<br>Na<br>sodium<br>23   | 12<br>Mg<br>magnesium<br>24 |                                                                       |                                 |                             |                              |                             |                              |                              |                                |                               |                               | 13<br>Al<br>aluminium<br>27 | 14<br>Si<br>silicon<br>28   | 15<br>P<br>phosphorus<br>31 | 16<br>S<br>sulfur<br>32       | 17<br>Cl<br>chlorine<br>35.5 | 18<br>Ar<br>argon<br>40   |
| 19<br>K<br>potassium<br>39 | 20<br>Ca<br>calcium<br>40   | 21<br>Sc<br>scandium<br>45                                            | 22<br>Ti<br>titanium<br>48      | 23<br>V<br>vanadium<br>51   | 24<br>Cr<br>chromium<br>52   | 25<br>Mn<br>manganese<br>55 | 26<br>Fe<br>iron<br>56       | 27<br>Co<br>cobalt<br>59     | 28<br>Ni<br>nickel<br>59       | 29<br>Cu<br>copper<br>64      | 30<br>Zn<br>zinc<br>65        | 31<br>Ga<br>gallium<br>70   | 32<br>Ge<br>germanium<br>73 | 33<br>As<br>arsenic<br>75   | 34<br>Se<br>selenium<br>79    | 35<br>Br<br>bromine<br>80    | 36<br>Kr<br>krypton<br>84 |
| 37<br>Rb<br>rubidium<br>85 | 38<br>Sr<br>strontium<br>88 | 39<br>Y<br>yttrium<br>89                                              | 40<br>Zr<br>zirconium<br>91     | 41<br>Nb<br>niobium<br>93   | 42<br>Mo<br>molybdenum<br>96 | 43<br>Tc<br>technetium<br>— | 44<br>Ru<br>ruthenium<br>101 | 45<br>Rh<br>rhodium<br>103   | 46<br>Pd<br>palladium<br>106   | 47<br>Ag<br>silver<br>108     | 48<br>Cd<br>cadmium<br>112    | 49<br>In<br>indium<br>115   | 50<br>Sn<br>tin<br>119      | 51<br>Sb<br>antimony<br>122 | 52<br>Te<br>tellurium<br>128  | 53<br>I<br>iodine<br>127     | 54<br>Xe<br>xenon<br>131  |
| 55<br>Cs<br>caesium<br>133 | 56<br>Ba<br>barium<br>137   | 57–71<br>lanthanoids                                                  | 72<br>Hf<br>hafnium<br>178      | 73<br>Ta<br>tantalum<br>181 | 74<br>W<br>tungsten<br>184   | 75<br>Re<br>rhenium<br>186  | 76<br>Os<br>osmium<br>190    | 77<br>Ir<br>iridium<br>192   | 78<br>Pt<br>platinum<br>195    | 79<br>Au<br>gold<br>197       | 80<br>Hg<br>mercury<br>201    | 81<br>Tl<br>thallium<br>204 | 82<br>Pb<br>lead<br>207     | 83<br>Bi<br>bismuth<br>209  | 84<br>Po<br>polonium<br>—     | 85<br>At<br>astatine<br>—    | 86<br>Rn<br>radon<br>—    |
| 87<br>Fr<br>francium<br>—  | 88<br>Ra<br>radium<br>—     | 89–103<br>actinoids                                                   | 104<br>Rf<br>rutherfordium<br>— | 105<br>Db<br>dubnium<br>—   | 106<br>Sg<br>seaborgium<br>— | 107<br>Bh<br>bohrium<br>—   | 108<br>Hs<br>hassium<br>—    | 109<br>Mt<br>meitnerium<br>— | 110<br>Ds<br>darmstadtium<br>— | 111<br>Rg<br>roentgenium<br>— | 112<br>Cn<br>copernicium<br>— |                             | 114<br>Fl<br>flerovium<br>— |                             | 116<br>Lv<br>livermorium<br>— |                              |                           |

|             |                              |                            |                                 |                              |                             |                             |                             |                               |                            |                               |                              |                           |                               |                              |                              |
|-------------|------------------------------|----------------------------|---------------------------------|------------------------------|-----------------------------|-----------------------------|-----------------------------|-------------------------------|----------------------------|-------------------------------|------------------------------|---------------------------|-------------------------------|------------------------------|------------------------------|
| lanthanoids | 57<br>La<br>lanthanum<br>139 | 58<br>Ce<br>cerium<br>140  | 59<br>Pr<br>praseodymium<br>141 | 60<br>Nd<br>neodymium<br>144 | 61<br>Pm<br>promethium<br>— | 62<br>Sm<br>samarium<br>150 | 63<br>Eu<br>europium<br>152 | 64<br>Gd<br>gadolinium<br>157 | 65<br>Tb<br>terbium<br>159 | 66<br>Dy<br>dysprosium<br>163 | 67<br>Ho<br>holmium<br>165   | 68<br>Er<br>erbium<br>167 | 69<br>Tm<br>thulium<br>169    | 70<br>Yb<br>ytterbium<br>173 | 71<br>Lu<br>lutetium<br>175  |
| actinoids   | 89<br>Ac<br>actinium<br>—    | 90<br>Th<br>thorium<br>232 | 91<br>Pa<br>protactinium<br>231 | 92<br>U<br>uranium<br>238    | 93<br>Np<br>neptunium<br>—  | 94<br>Pu<br>plutonium<br>—  | 95<br>Am<br>americium<br>—  | 96<br>Cm<br>curium<br>—       | 97<br>Bk<br>berkelium<br>— | 98<br>Cf<br>californium<br>—  | 99<br>Es<br>einsteinium<br>— | 100<br>Fm<br>fermium<br>— | 101<br>Md<br>mendelevium<br>— | 102<br>No<br>nobelium<br>—   | 103<br>Lr<br>lawrencium<br>— |

The volume of one mole of any gas is 24 dm<sup>3</sup> at room temperature and pressure (r.t.p.).