**1** Phosphine, $PH_3$, has a similar chemical structure to ammonia, $NH_3$.

Ammonia acts as a base when it reacts with sulfuric acid.

**(a)** What is meant by the term *base*?

..... [1]

**(b)** Write a chemical equation for the reaction between ammonia and sulfuric acid.

..... [2]

[Total: 3]

**2** Aqueous potassium iodide reacts with aqueous copper(II) sulfate to produce iodine.

**(a)** Balance the chemical equation for this reaction.

$$KI + CuSO_4 \rightarrow CuI + I_2 + K_2SO_4$$ [2]

**(b)** Deduce the charge on the copper ion in CuI.

..... [1]

**(c)** In terms of electron transfer, explain why copper is reduced in this reaction.

..... [1]

**(d)** Identify the reducing agent.

..... [1]

[Total: 5]

**3** Displacement reactions occur between metals and metal ions.

Displacement reactions can be used to determine the order of reactivity of metals such as lead (Pb), nickel (Ni), and silver (Ag).

The ionic equation for a displacement reaction is shown.

$$Ni(s) + Pb^{2+}(aq) \rightarrow Pb(s) + Ni^{2+}(aq)$$

The ionic half-equations for this reaction are shown.

$$Ni(s) \rightarrow Ni^{2+}(aq) + 2e^-$$

$$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$$

The ionic half-equations show that electrons are donated by nickel atoms and accepted by lead ions.

**(a)**

**(i)** Identify the reducing agent in the displacement reaction. Give a reason for your answer.

reducing agent .....

reason ..... [2]

**(ii)** What is the general term given to the type of reaction in which electrons are transferred from one species to another?

..... [1]

**(b)** The ionic equation for another displacement reaction is shown.

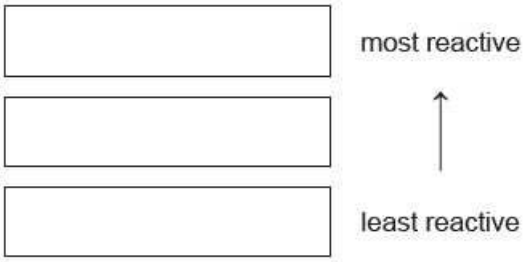
$$Pb(s) + 2Ag^{+}(aq) \rightarrow 2Ag(s) + Pb^{2+}(aq)$$

Write the **two** ionic half-equations for this reaction.

1 .....

2 ..... [2]

**(c)** Use the information in **(a)** and **(b)** to put the three metals lead, nickel and silver in order of reactivity.




[1]

[Total: 6]

**4** Zinc and copper are elements next to each other in the Periodic Table.

Zinc is obtained from zinc blende in a two-step process.

- In **step 1**, zinc blende is converted into zinc oxide.
- In **step 2**, zinc oxide is converted into zinc in a blast furnace.

Outline how each of these steps are done.

In your answer:

- give **one** chemical equation for each step
- describe how zinc is removed from the blast furnace in **step 2**.

**step 1** .....

.....

chemical equation .....

**step 2**.....

.....

chemical equation.....

removal of zinc in **step 2** .....

..... [5]

[Total: 5]

**5** Phosphorus(V) oxide, $P_4O_{10}$, is an acidic oxide.

Phosphorus(V) oxide, $P_4O_{10}$, reacts with aqueous sodium hydroxide to form a salt containing the phosphate ion, $PO_4^{3-}$. Water is the only other product.

Write a chemical equation for the reaction between phosphorus(V) oxide and aqueous sodium hydroxide.

..... [2]

[Total: 2]

**6** Phosphorus, $P_4$, reacts with air to produce phosphorus(V) oxide, $P_4O_{10}$.

**(a)** Write a chemical equation for this reaction.

..... [2]

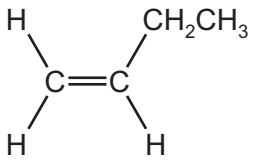
**(b)** What type of chemical reaction is this?

..... [1]

[Total: 3]

**7** Alkene **C** can be converted into a polymer.

**C**



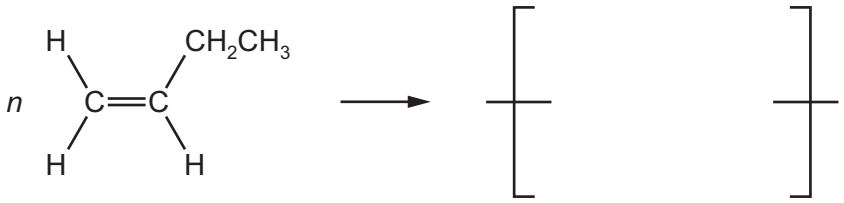

**(a)** What type of polymerisation occurs?

..... [1]

**(b)** Suggest the name of the polymer formed.

..... [1]

**(c)** Complete the chemical equation to show this polymerisation.




[3]

**(d)** State the empirical formula of the polymer formed.

..... [1]

[Total: 6]

**8** Rust contains iron(III) oxide.

Phosphoric acid, $H_3PO_4$, can be used to remove rust from an iron object and prevent further rusting.

**(a)** Write a chemical equation for the reaction between iron(III) oxide and phosphoric acid to form iron(III) phosphate and water.

..... [2]

**(b)** Iron(III) phosphate is an insoluble salt.

Suggest how the formation of iron(III) phosphate prevents further rusting.

.....

..... [1]

[Total: 3]

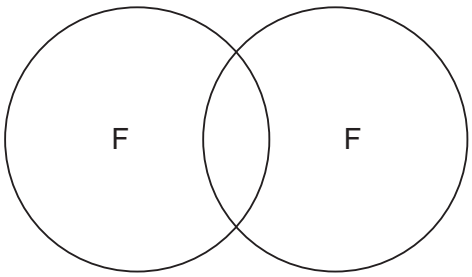
**9** Fluorine is a Group VII element. Fluorine forms compounds with metals and non-metals.

**(a)** Predict the physical state of fluorine at room temperature and pressure.

..... [1]

**(b)** Fluorine exists as diatomic molecules.

Complete the dot-and-cross diagram to show the electron arrangement in a molecule of fluorine. Show outer shell electrons only.




[2]

**(c)** Write a chemical equation for the reaction between sodium and fluorine.

..... [2]

**(d)** Explain why chlorine does **not** react with aqueous sodium fluoride.

.....

..... [1]

[Total: 6]

**10** Tetrafluoromethane and lead(II) fluoride are fluorides of Group IV elements. Some properties of tetrafluoromethane and lead(II) fluoride are shown in the table.

| property | tetrafluoromethane | lead(II) fluoride |
|---|---|---|
| formula | $CF_4$ | |
| melting point / °C | –184 | 855 |
| boiling point / °C | –127 | 1290 |

| | | |
|---|---|---|
| conduction of electricity when solid | non-conductor | non-conductor |
| conduction of electricity when molten | non-conductor | good conductor |

**(a)** What is the formula of lead(II) fluoride?

..... [1]

**(b)** What type of bonding is present between the atoms in tetrafluoromethane?

..... [1]

**(c)** What type of structure does solid lead(II) fluoride have?

..... [1]

**(d)** Explain, in terms of attractive forces between particles, why lead(II) fluoride has a much higher melting point than tetrafluoromethane.

In your answer refer to the types of attractive forces between particles and their relative strengths.

.....

.....

.....

..... [3]

[Total: 6]

**11** Titanium is extracted from an ore called rutile. Rutile is an impure form of titanium(IV) oxide, $TiO_2$.

Rutile is mixed with coke and heated in a furnace through which chlorine gas is passed. The product is gaseous titanium(IV) chloride, $TiCl_4$.

Titanium(IV) chloride is heated with an excess of magnesium, in an atmosphere of argon.

**(a)** Balance the chemical equation for the reaction.

$$TiCl_4 + \text{.....}Mg \rightarrow Ti + \text{.....}MgCl_2$$ [1]

**(b)** Titanium(IV) chloride can be reacted with sodium instead of magnesium.

The reaction between titanium(IV) chloride and sodium is similar to the reaction between titanium(IV) chloride and magnesium.

Write a chemical equation for the reaction between titanium(IV) chloride and sodium.

..... [1]

**(c)** Suggest why the reaction between titanium(IV) chloride and magnesium is done in an atmosphere of argon and **not** in air.

.....

..... [1]

[Total: 3]

**12** How would you show that an aqueous solution of ethanoic acid, $CH_3COOH$, is an acid **without** using an indicator or measuring the pH?

State the reagent you would use and give the expected observations.
Write a chemical equation for the reaction that you describe.

reagent .....

expected observations .....

.....

chemical equation ..... [3]

[Total: 3]

**13** Tetrafluoroethene is an unsaturated compound with the formula $C_2F_4$.

Tetrafluoroethene is the monomer used to make the polymer poly(tetrafluoroethene).

**(a)** What is meant by the term *unsaturated*?

.....

..... [1]

**(b)** Describe a test to show that tetrafluoroethene is unsaturated.

test .....

observations ..... [2]

**(c)** Draw the structure of a molecule of tetrafluoroethene. Show all of the atoms and all of the bonds.

[1]

**(d)** Tetrafluoroethene can be polymerised to form poly(tetrafluoroethene).

Draw **one** repeat unit of poly(tetrafluoroethene). Show all of the atoms and all of the bonds.

[2]

**(e)** Deduce the empirical formula of:

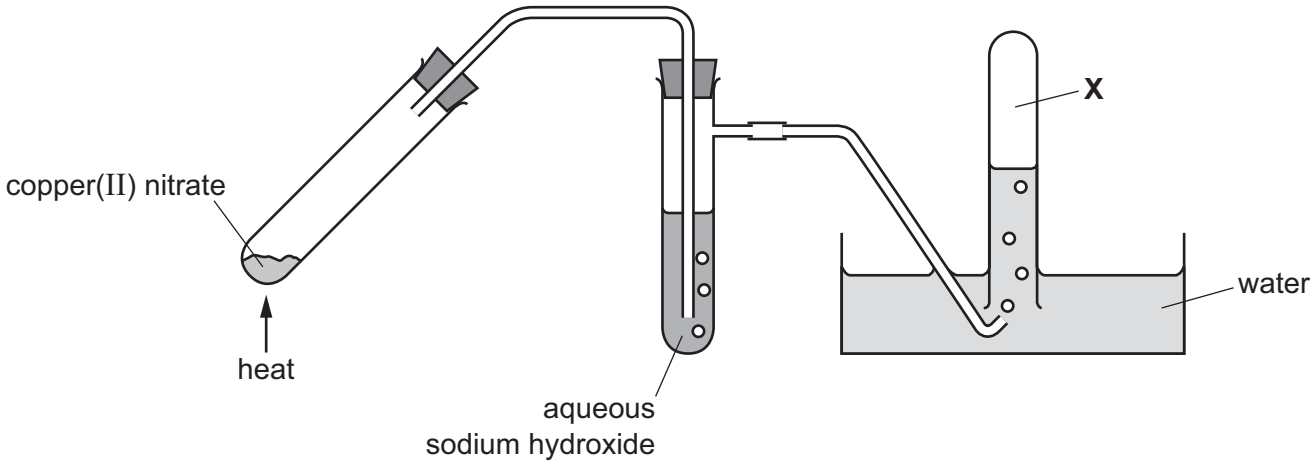
tetrafluoroethene .....

poly(tetrafluoroethene) ..... [2]

[Total: 8]

**14** Copper(II) nitrate decomposes when heated. Two gases, oxygen and nitrogen dioxide, and a solid are made in the reaction.

A sample of copper(II) nitrate was decomposed using the apparatus shown.




**(a)** Complete the chemical equation for the reaction.

$2Cu(NO_3)_2 \rightarrow O_2 + .....NO_2 + .....$ [2]

**(b)** Only oxygen gas is collected at **X**.

Explain why.

.....

..... [1]

[Total: 3]

**15** Dilute sulfuric acid is used to make salts known as sulfates.

A method consisting of three steps is used to make zinc sulfate from zinc carbonate.

**step 1** Add an excess of zinc carbonate to 20 $cm^3$ of 0.4 mol / $dm^3$ dilute sulfuric acid until the reaction is complete.

**step 2** Filter the mixture.

**step 3** Heat the filtrate until a saturated solution forms and then allow it to crystallise.

**(a)** Name a suitable piece of apparatus for measuring 20 $cm^3$ of dilute sulfuric acid in **step 1**.

..... [1]

**(b)** State **two** observations which would show that the reaction is complete in **step 1**.

1 .....

2 ..... [2]

**(c)** Why is it important to add an excess of zinc carbonate in **step 1**?

..... [1]

**(d)** What is meant by the term *saturated solution* in **step 3**?

.....

..... [2]

**(e)** The equation for the reaction is shown.

$$ZnCO_3(s) + H_2SO_4(aq) \rightarrow ZnSO_4(.....) + H_2O(l) + CO_2(g)$$

Complete the equation by inserting the state symbol for zinc sulfate.

[1]

**(f)** Name another zinc compound which could be used to make zinc sulfate from dilute sulfuric acid using this method.

..... [1]

**(g)** Suggest why this method would **not** work to make barium sulfate from barium carbonate and dilute sulfuric acid.

..... [1]

[Total: 9]

**16** Aqueous magnesium chloride is added to aqueous silver nitrate. A white precipitate forms.

Write an **ionic** equation for this reaction. Include state symbols.

..... [2]

[Total: 2]

**17** The Group II element, calcium, reacts with cold water to form two products:

- a colourless gas, **P**, which 'pops' with a lighted splint
- a weakly alkaline solution, **Q**, which turns milky when carbon dioxide is bubbled through it.

**(a)** Name gas **P**.

..... [1]

**(b)** Identify the ion responsible for making solution **Q** alkaline.

..... [1]

**(c)** Suggest the pH of solution **Q**.

..... [1]

**(d)** Write a chemical equation for the reaction of calcium with cold water.

..... [1]

[Total: 4]

**18** Copper(II) nitrate can be made by reacting copper(II) carbonate with nitric acid. One of the products is carbon dioxide.

**(a)** Write a chemical equation for the reaction of copper(II) carbonate with nitric acid.

..... [2]

**(b)** Carbon dioxide is added to the air by living things.

Name the chemical process by which living things add carbon dioxide to the air.

..... [1]

**(c)** Carbon dioxide is removed from the air by plants.

Name the chemical process by which plants remove carbon dioxide from the air.

..... [1]

[Total: 4]

**19** Dilute sulfuric acid reacts with bases, metals and carbonates.

Write chemical equations for the reaction of dilute sulfuric acid with each of the following:

**(a)** magnesium hydroxide

..... [2]

**(b)** zinc

..... [2]

**(c)** sodium carbonate.

..... [2]

[Total: 6]

**20** Sulfuric acid is manufactured by the Contact process. One step in the Contact process involves a reversible reaction in which sulfur trioxide, $SO_3$, is formed.

**(a)** Write a chemical equation for this reversible reaction. Include the correct symbol to show that the reaction is reversible.

..... [2]

**(b)** State the conditions and name the catalyst used in this reversible reaction.

temperature .....

pressure .....

catalyst ..... [3]

**(c)** Describe how the sulfur trioxide formed is converted into sulfuric acid in the next steps of the Contact process.

.....

.....

..... [2]

[Total: 7]

**21** Tin can be extracted by heating tin(IV) oxide with carbon. Carbon monoxide is the other product.

Write a chemical equation for this reaction.

..... [2]

[Total: 2]

**22** Tin is a metallic element in Group IV. Its main ore is cassiterite which is an impure form of tin(IV) oxide, $SnO_2$.
Tin also occurs in stannite, $Cu_2FeSnS_4$.

**(a)** Calculate the relative formula mass, $M_r$, of $Cu_2FeSnS_4$.

$M_r$ of $Cu_2FeSnS_4$ ..... [1]

**(b)** The $M_r$ of $SnO_2$ is 151.

Calculate the percentage of tin by mass in $SnO_2$.

percentage of tin by mass in $SnO_2$ ..... [1]

**(c)** The percentage of tin by mass in $Cu_2FeSnS_4$ is 27.6 %.

Use this information and your answer to **(b)** to suggest whether it would be better to extract tin from $SnO_2$ or $Cu_2FeSnS_4$.
Explain your answer.

.....

..... [1]

[Total: 3]

**23** The position of tin in the reactivity series is shown.

| | |
|---|---|
| iron | most reactive |
| tin | ↑ |
| copper | least reactive |

A student added iron to a solution containing $Sn^{2+}$ ions.

The student then separately added tin to a solution containing $Cu^{2+}$ ions.

Complete the ionic equations. If there is no reaction write 'no reaction'.

$Fe + Sn^{2+} \rightarrow$ .....

$Sn + Cu^{2+} \rightarrow$ ..... [2]

[Total: 2]

**24** Copper(II) nitrate, $Cu(NO_3)_2$, decomposes when it is heated. The only solid product is copper(II) oxide, CuO. There are two gaseous products. One of the gaseous products is oxygen.

**(a)** Describe a test for oxygen.

test .....

result ..... [2]

**(b)** Name the other gaseous product. Describe its appearance.

name .....

appearance ..... [2]

**(c)** Write a chemical equation for the thermal decomposition of copper(II) nitrate.

..... [1]

[Total: 5]

**25** Chloric(V) acid, $HClO_3$, is a strong acid. It can be made from calcium chlorate(V).

**(a)** Defne the term *acid* in terms of proton transfer.

..... [1]

**(b)** Complete the chemical equation to show $HClO_3$ behaving as an acid in water.

$HClO_3 + H_2O \rightarrow$ ..... + ..... [1]

[Total: 2]

**26** All compounds with the molecular formula $C_3H_6O_2$ can undergo complete combustion in an excess of oxygen.

Complete the chemical equation for this reaction.

$C_3H_6O_2$ + ..... → ..... + ..... [2]

[Total: 2]

**27** Calcium chlorate(V) undergoes thermal decomposition.

The only products are calcium chloride and a colourless gas.

**(a)** What must be done to calcium chlorate(V) to make it thermally decompose?

..... [1]

**(b)** Write a chemical equation for the thermal decomposition of calcium chlorate(V).

..... [2]

[Total: 3]

**28** Potassium reacts with bromine at room temperature to form potassium bromide.

Write a chemical equation for this reaction. Include state symbols.

..... [3]

[Total: 3]

**29** When chlorine gas is passed through aqueous potassium bromide, a redox reaction occurs. The ionic equation is shown.

$$Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$$

**(a)** Write an ionic half-equation showing what happens to the chlorine molecules, $Cl_2$, in this reaction.

..... [1]

**(b)** Explain why the bromide ions, $Br^-$, act as reducing agents in this reaction.

..... [1]

[Total: 2]

**30** Ethanoic acid, $CH_3COOH$, is a weak acid. It reacts with copper(II) carbonate to form the salt copper(II) ethanoate, $Cu(CH_3COO)_2$.

Write the word equation for the reaction between ethanoic acid and copper(II) carbonate.

..... [1]

[Total: 1]

**31** Propan-1-ol can be made from propene.

**(a)** Name the reagent and give the conditions needed to convert propene into propan-1-ol.

reagent .....

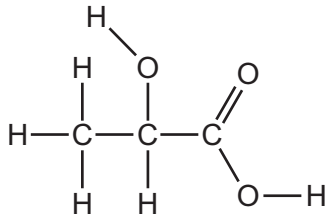
conditions ..... [2]

**(b)** Write a chemical equation for the complete combustion of propan-1-ol.

..... [2]

[Total: 4]

**32** One of the organic acids present in milk is lactic acid.
The structure of lactic acid is shown.



**(a)** On the structure shown draw a circle around the carboxylic acid functional group.

[1]

**(b)** Deduce the molecular formula of lactic acid showing the number of carbon, hydrogen and oxygen atoms.

..... [1]

[Total: 2]

**33** 25 $cm^3$ of a gaseous hydrocarbon, $C_xH_y$, were burnt in 150 $cm^3$ of oxygen. This was an excess of oxygen.

After cooling, the volume of the gases remaining was 100 $cm^3$. This consisted of 75 $cm^3$ of carbon dioxide and 25 $cm^3$ of unreacted oxygen. The water that was produced in the reaction was liquid.

All volumes were measured at the same temperature and pressure.

**(a)** What is meant by an *excess* of oxygen?

..... [1]

**(b)** What was the volume of oxygen that reacted with the hydrocarbon?

..... $cm^3$ [1]

**(c)** Complete the table to show the smallest whole number ratio of volumes.

| | volume of hydrocarbon reacted | : | volume of oxygen reacted | : | volume of carbon dioxide produced |
|---|---|---|---|---|---|
| **smallest** whole number ratio of volumes | | : | | : | |

[1]

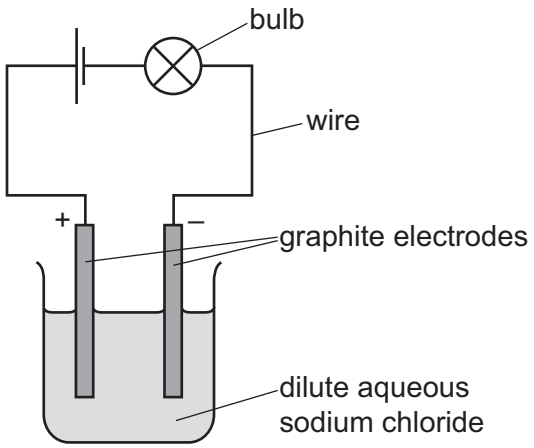
**(d)** Use your answer to **(c)** to balance the chemical equation. Deduce the formula of the hydrocarbon.

$C_xH_y(g)$ + .....$O_2(g)$ → .....$CO_2(g)$ + .....$H_2O(l)$

formula of the hydrocarbon = ..... [2]

[Total: 5]

**34** A student sets up the following electrolysis experiment.




**(a)** Define the term *electrolysis*.

.....

..... [2]

**(b)** The student observes bubbles of colourless gas forming at each electrode.

**(i)** Name the main gas produced at the positive electrode (anode).

..... [1]

**(ii)** Describe a test for the gas produced in **(b)(i)**.

test .....

result ..... [2]

**(iii)** Write the ionic half-equation for the reaction taking place at the negative electrode (cathode).

..... [1]

**(c)** Charge is transferred during electrolysis.

Name the type of particle responsible for the transfer of charge in:

the wires .....

the electrolyte. ..... [2]

**(d)** The student replaces the dilute aqueous sodium chloride with concentrated aqueous sodium chloride.

Suggest **two** differences that the student observes.

1 .....

2 ..... [2]

[Total: 10]

**35**

**(a)** Name the products formed when sodium nitrate is heated.

.....

..... [2]

**(b)** When copper(II) nitrate, $Cu(NO_3)_2$, undergoes thermal decomposition, three products are formed. One of the products is nitrogen dioxide, $NO_2$.

Write a chemical equation for the thermal decomposition of copper(II) nitrate.

.....

..... [2]

[Total: 4]

**36** Ethanol, $C_2H_5OH$, can be made by fermentation.

**(a)** Complete the chemical equation for the formation of ethanol by fermentation.

$$C_6H_{12}O_6 \rightarrow \text{.....}C_2H_5OH + \text{.....} \quad [2]$$

**(b)** State **two** conditions required for fermentation.

1 .....

2 ..... [2]

[Total: 4]

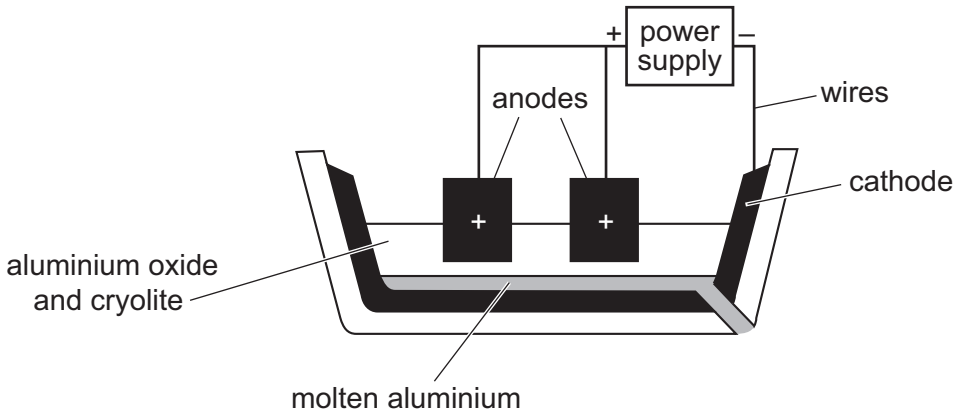
**37** A redox reaction occurs when magnesium is heated with iron(III) oxide.

Write a chemical equation for the reaction between magnesium and iron(III) oxide.

..... [2]

[Total: 2]

**38** Aluminium can be extracted by electrolysis using the apparatus shown.




**(a)** Name the type of particle responsible for the transfer of charge in

the wires, .....

the electrolyte. ..... [2]

**(b)** Give **two** reasons why cryolite is used.

1 .....

2 ..... [2]

**(c)** Write the ionic half-equation for the formation of aluminium during the electrolysis.

..... [1]

**(d)** Explain how carbon dioxide gas is formed at the anodes.

.....

.....

..... [3]

[Total: 8]

**39** Copper(II) nitrate undergoes thermal decomposition.

Balance the chemical equation for the thermal decomposition of copper(II) nitrate.

.....$Cu(NO_3)_2$ → .....CuO + .....$NO_2$ + .....$O_2$ [1]

[Total: 1]

**40** Dodecane is an alkane containing 12 carbon atoms. Ethanol can be manufactured from dodecane in a two-stage process.

In **stage 1**, each molecule of dodecane is converted into three molecules of ethene and one molecule of another hydrocarbon.

**(a)** Name the process which occurs in **stage 1**.

..... [1]

**(b)** Write a chemical equation for the reaction which occurs in **stage 1**.

..... [2]

In **stage 2**, ethene reacts with steam to produce ethanol.

**(c)** State **two** conditions needed for **stage 2**.

1 .....

2 ..... [2]

**(d)** Name the type of reaction which occurs in **stage 2**.

..... [1]

**(e)** Suggest how to test the purity of the ethanol produced.

.....

..... [2]

[Total: 8]