Chemical analysis – 2021/20 GCSE 21st Chemistry B

1. Nov/2021/Paper_J258/01/No.4

Amaya is given some coloured sweets.

She uses chromatography to find out the number of dyes in each sweet.

(a) (i) Amaya starts by drawing a line on a piece of filter paper using ink.

Describe **one** way in which Amaya can improve this part of her method.

.....

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

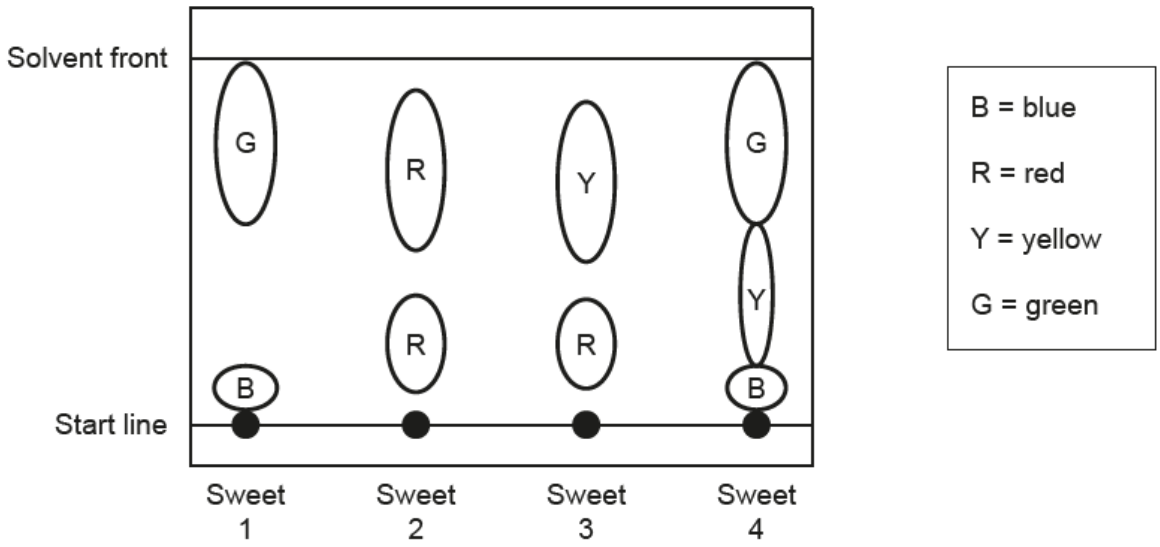
(ii) Give **one** reason for your answer to **(a)(i)**.

.....

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

(b) Sundip repeats the experiment, improving on Amaya's method.

Her results are shown in the chromatogram:



(i) Each sweet contains a mixture of dyes.

How many different dyes are there in all of the sweets that Sundip has used?

Use the chromatogram.

Total number of different dyes = ... **[1]**

(ii) Which dye is the **least** soluble in the solvent?

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

(iii) Give **one** reason for your answer to **(b)(ii)**.

.....

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

(iv) R_f values can be calculated using this equation:

$$R_f = \frac{\text{distance moved by dye}}{\text{distance moved by solvent front}}$$

Which dye has the largest R_f value?

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

(c) Ali has a mixture of carbon and copper sulfate crystals. Carbon is insoluble in water.

Complete the list to show the correct order of methods he needs to obtain pure copper sulfate crystals from the mixture.

Use the words.

You can use each word once, more than once, or not at all.

Crystallization **Dissolving** **Distillation** **Heating**

1 .....

2 Filtration

3 .....

4 .....

[3]

2. Nov/2021/Paper_J258/01/No.6

Blue copper sulfate crystals turn white when heated:

'blue copper sulfate' → 'white copper sulfate' + water

- Kai weighs out five different samples of 'blue copper sulfate'.
- He puts each sample in a test tube.
- He heats each test tube.
- He weighs each test tube and its contents after heating.
- He then calculates the mass of 'white copper sulfate'.

(a) **Fig. 6.1** shows a graph of his results:

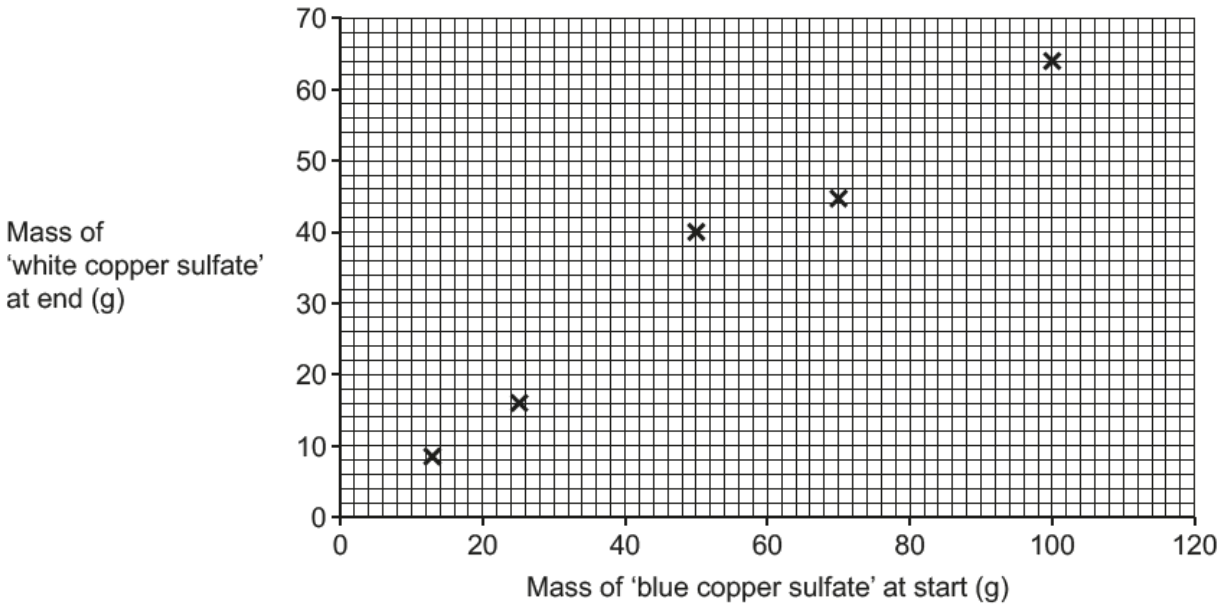


Fig. 6.1

One result does **not** fit the pattern.

(i) Put a (ring) around the result that does not fit the pattern in **Fig. 6.1**. **[1]**

(ii) Kai thinks he made a mistake when he was heating the 'blue copper sulfate' for this result.

Suggest the mistake Kai made.

.....

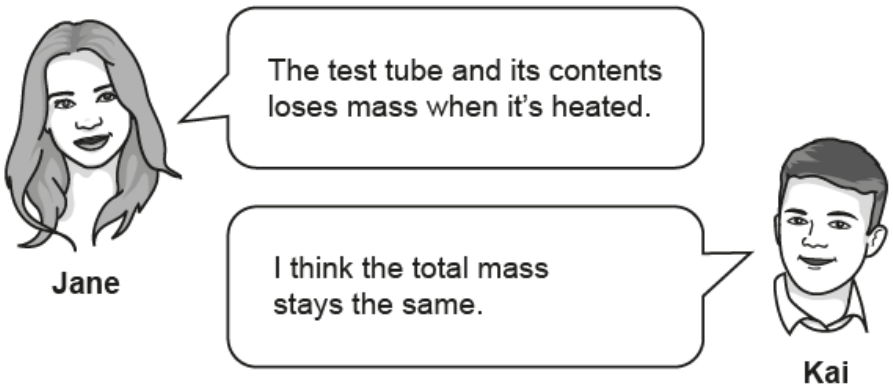
..... **[1]**

(b) Calculate the mass of 'white copper sulfate' that is made when 2.0 g of 'blue copper sulfate' is heated.

Use the equation: mass of 'white copper sulfate' × 1.5625 = mass of 'blue copper sulfate'

Mass of 'white copper sulfate' = ... g **[3]**

(c) Jane and Kai discuss the results:



Explain why Jane and Kai are **both** correct.

Jane .....

.....

Kai .....

.....

[2]

(d) 100 g of 'blue copper sulfate' gives 64 g of 'white copper sulfate'.

'blue copper sulfate' → 'white copper sulfate' + water

Calculate the mass of water that is formed.

Mass of water = ... g **[1]**

(e) Jane tests whether this reaction is reversible:

'blue copper sulfate' ⟶ 'white copper sulfate' + water

She adds water to 'white copper sulfate' in a test tube.
The solid turns blue and the test tube gets hot.

(i) Does her observation show that the reaction is reversible?

Yes ☐

No ☐

Explain your answer.

.....

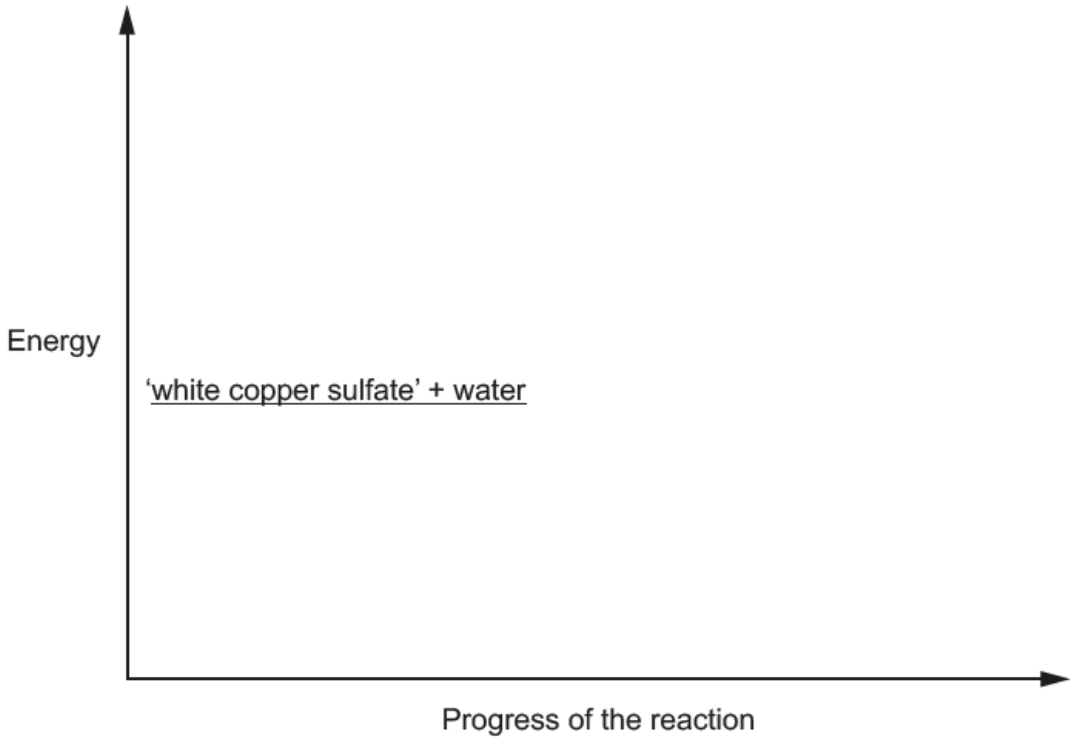
..... **[1]**

(ii) What name is given to a reaction that gives out heat?

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

(iii) Draw **one** line to show the energy level of 'blue copper sulfate' on the reaction profile in **Fig. 6.2**.

Label your line 'blue copper sulfate'.



[1]

Fig. 6.2

3. Nov/2021/Paper_J258/02/No.4

Many shops sell boxes of tablets to treat stomach upsets. Some of these tablets contain calcium carbonate, $CaCO_3$.

Jane does experiments to measure the mass of calcium carbonate in three different brands of tablets.

EasyCalm	**FeelRight**	**RumbleTum**
Pack size: 30 tablets	Pack size: 25 tablets	Pack size: 10 tablets

(a) Jane wants to make sure that the tablets she tests are representative of all the tablets in each brand.

What should Jane do to make sure her choice of tablets is **representative**?

Tick (✓) **two** boxes.

- Choose tablets at random from each box. ☐
- Choose tablets from more than one box of each brand. ☐
- Choose tablets that look the same. ☐
- Test every tablet from one box of each brand. ☐
- Test one tablet from each brand. ☐

[2]

(b) Jane reacts dilute hydrochloric acid with each tablet.
The equation shows the reaction that happens:

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

Which **two** statements explain why this reaction is a neutralisation reaction?

Tick (✓) **two** boxes.

- Heat is given off. ☐
- Calcium carbonate is made. ☐
- A salt and water form. ☐
- The acid is used up. ☐
- Hydrogen gas is given off. ☐

[2]

(c) Jane crushes each tablet and adds it to some water in a flask. She adds dilute hydrochloric acid from a burette until the solution is neutral.

The table shows the mean volume of dilute hydrochloric acid needed to neutralise one tablet from each brand.

Brand of tablet	**Mean volume of dilute hydrochloric acid needed (cm^3)**	**Mean mass of calcium carbonate in one tablet (mg)**
EasyCalm	10.5	1051
FeelRight	15.8	1582
RumbleTum	5.0	

(i) What else does Jane need to add to the flask before she starts her titration?

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

(ii) Give **one** reason for your answer to **(c)(i)**.

.....

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

(iii) Which brand of tablet contains the most calcium carbonate?

Put a (ring) around the correct answer.

EasyCalm **FeelRight** **RumbleTum**

[1]

(iv) Calculate the **relative formula mass** of calcium carbonate, $CaCO_3$.

Use the Data Sheet.

Relative formula mass = ... **[2]**

(v) Calculate the mean mass of calcium carbonate in **one RumbleTum** tablet.

Use the formula: mean mass of calcium carbonate (mg) = mean volume of hydrochloric acid (cm^3) × relative formula mass of $CaCO_3$

Use your answer to **(c)(iv)** and the information in the table.

Mean mass of calcium carbonate in one tablet = ... mg **[2]**

(d) The label shows all of the ingredients in FeelRight tablets.

FeelRight
Contains:
calcium carbonate
magnesium hydroxide

(i) How will magnesium hydroxide affect the volume of acid needed to neutralise each tablet of FeelRight?

.....

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

(ii) Give **one** reason for your answer to **(d)(i)**.

.....

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

4. Nov/2020/Paper_J258/01/No.7

Amir has a sample of a salt, **Salt A**, that is used as a fertiliser.

He does some tests to find out which elements are in the salt.

(a) **(i)** Amir finds that **Salt A** contains positive potassium ions.

Which colour flame does Amir see when he does a flame test?

Put a ring around the correct answer.

green **lilac** **red** **yellow**

[1]

(ii) Potassium is an element. It is an essential nutrient for plants.

Name **one** other element that is an essential nutrient for plants.

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

(b) Amir thinks **Salt A** is potassium sulfate.

Potassium sulfate contains K^+ ions and SO_4^{2-} ions.

What is the chemical formula of potassium sulfate?

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

(c) Amir tests **Salt A** to check it is potassium sulfate.

He dissolves some of **Salt A** in water and adds barium chloride solution.

Barium sulfate is formed.

(i) Describe the **colour** and **state** of the barium sulfate formed.

.....

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

(ii) Complete the word equation for the reaction.

potassium sulfate + barium chloride → barium sulfate + ...

[1]

(d) Amir tests another unknown salt, **Salt B**, by looking at its emission spectrum.

Some emission spectra are shown in **Fig. 7.1**:

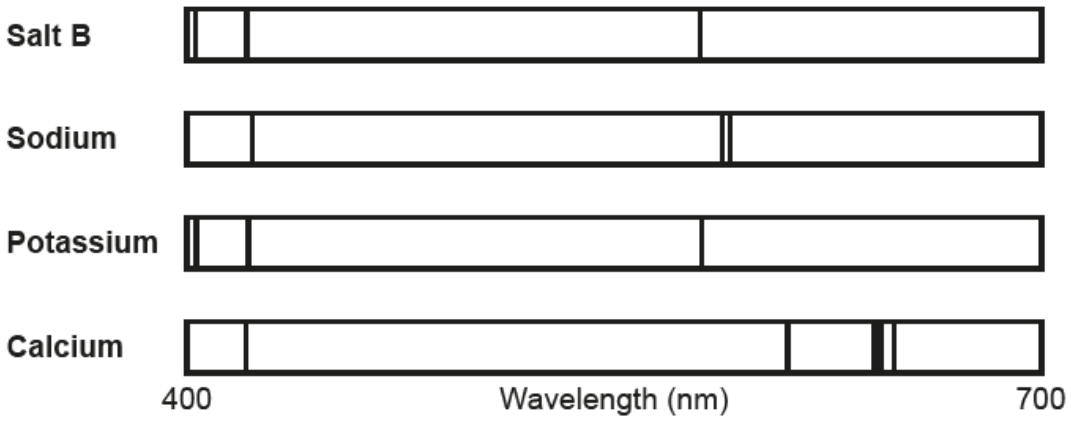


Fig. 7.1

(i) Using **Fig. 7.1**, name the metal ion in **Salt B**.

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

(ii) Convert 400 nm to metres.

Give your answer in **standard form**.

$1\,nm = 1 \times 10^{-9}\,m$

400 nm = ... m **[1]**

(e) Elements can be identified using flame tests or by comparing emission spectra.

Amir uses the internet to compare each method:

	Flame test	**Emission spectra**
Equipment cost	£10.15	£11 500
Sensitivity	Low	High
Speed	High	High
Accuracy	Low	High

Amir is given 0.01 g of a compound to analyse.

Amir decides to use a flame test rather than comparing emission spectra.

Give **one** advantage and **one** disadvantage of using a flame test rather than comparing emission spectra.

Advantage .....

.....

Disadvantage .....

.....

[2]

5. Nov/2020/Paper_J258/01/No.8

Titanium is used for hip replacements.

(a) Which term describes titanium?

Put a ring around the correct answer.

Group 1 metal **Group 7 element** **alloy** **transition metal**

[1]

(b) Titanium, Ti, can be made from titanium oxide by **two** methods.

Method 1 uses magnesium which reacts with titanium oxide:

$$2Mg + TiO_2 \longrightarrow Ti + 2MgO$$

Complete the sentences below, by putting a ring around the correct answers.

Use the symbol equation in **Method 1** to help you.

Magnesium is more reactive than **titanium oxide** / **titanium** / **magnesium oxide** .

Magnesium reduces **titanium oxide** / **titanium** / **magnesium oxide**

to **titanium oxide** / **titanium** / **magnesium oxide** .

[3]

(c) Calculate the relative formula mass of magnesium oxide (MgO).

Use the Periodic Table.

Relative formula mass = ... **[1]**

(d) Calculate the percentage of magnesium in magnesium oxide (MgO).

Use relative formula mass of magnesium = 24.

Percentage of magnesium = ... % **[2]**

(e) **Method 2** uses electrolysis to make titanium:

$$TiO_2 \longrightarrow Ti + O_2$$

Method 2 has a higher atom economy than **Method 1**.

(i) Some relative formula masses are given in the table.

Formula	Ti	O_2	TiO_2
Relative formula mass	47.9	32.0	79.9

Calculate the atom economy for **Method 2**.

Use the data from the table.

Use the formula: atom economy = $\frac{\text{mass of atoms in desired product}}{\text{total mass of atoms in reactants}} \times 100\%$

Give your answer to **1** decimal place.

Atom economy = ... % **[3]**

(ii) Look at the equations again for **Method 1** and **Method 2**.

Method 1: $2Mg + TiO_2 \longrightarrow Ti + 2MgO$

Method 2: $TiO_2 \longrightarrow Ti + O_2$

Explain why **Method 2** has a higher atom economy than **Method 1**.

.....

.....

.....

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

(f) Magnesium oxide (MgO) is formed in **Method 1**.

(i) **Fig. 8.1** shows the 'dot and cross' diagrams for a magnesium (Mg) atom and an oxygen (O) atom.

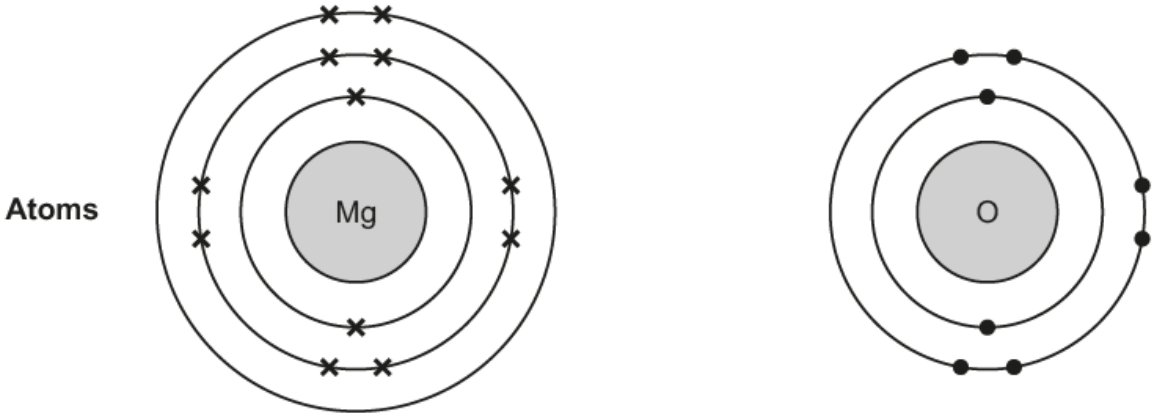


Fig. 8.1

Complete **Fig. 8.2** to show the 'dot and cross' diagrams for an Mg^{2+} ion and an O^{2-} ion.

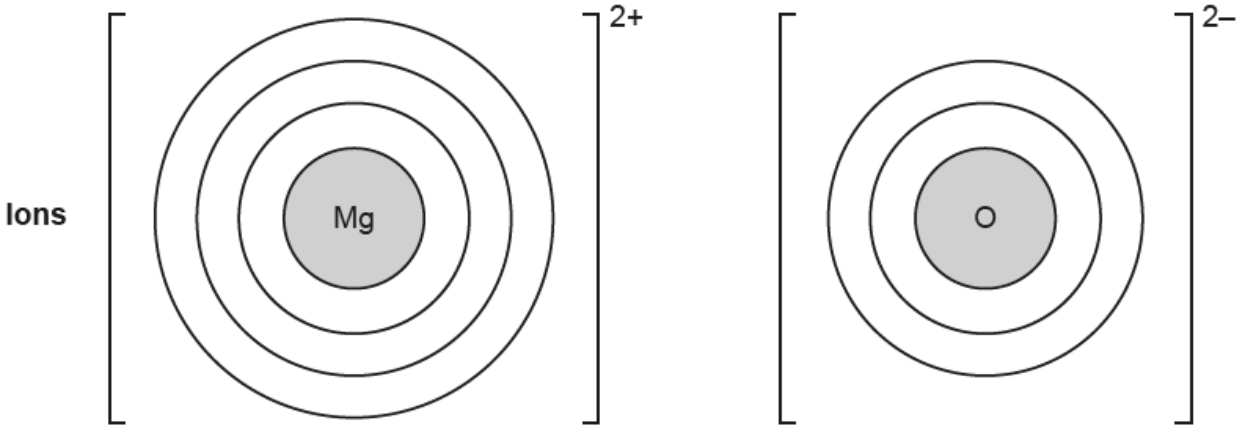


Fig. 8.2

[2]

(ii) Magnesium oxide can be formed by burning magnesium in oxygen.

Complete the balanced symbol equation for this reaction.

..... Mg + O_2 → ..... MgO

[1]

6. Nov/2020/Paper_J258/01/No.10

Sundip passes electricity through solutions of some ionic compounds and finds out what products are formed at the positive and negative electrodes.

(a) Here are Sundip's results.

Solution	Product at positive electrode	Product at negative electrode
concentrated sodium chloride	chlorine gas	hydrogen gas
dilute sodium chloride	oxygen gas	hydrogen gas
dilute copper chloride	chlorine gas	copper metal
concentrated copper sulfate	oxygen gas	copper metal
concentrated copper chloride	.....	.....
dilute sodium sulfate	.....	.....

(i) Complete the table by predicting the products formed at each electrode when electricity is passed through concentrated copper chloride and dilute sodium sulfate. **[3]**

(ii) Sundip uses tests to identify the gases formed in her experiments.

Draw lines to connect each **gas** to its correct **test and result**.

Gas	Test and result
	relights a glowing splint
chlorine	makes a lighted splint go 'pop'
oxygen	turns lime water milky
hydrogen	turns blue litmus red and then bleaches it
	turns red litmus blue and then bleaches it

[2]

(iii) Explain why, at the negative electrode:

- **copper** metal is formed when electricity is passed through dilute copper chloride, **but**
- **hydrogen** gas is formed when electricity is passed through dilute sodium chloride.

.....

.....

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

(b) This is a list of apparatus Sundip uses to pass electricity through the solution of dilute sodium chloride:

- electrodes
- leads and clips
- a battery
- a beaker
- the solution of sodium chloride.

Draw a labelled diagram in the **box** to show how Sundip sets up her experiment to pass electricity through the solution of dilute sodium chloride.

[2]

7. Nov/2021/Paper_J258/03/No.7

Amaya is given some coloured sweets. She removes the food colour from each sweet.
Each food colour contains a mixture of dyes.

(a) She uses chromatography to find out the number of dyes in each sweet:

- She draws a pencil line on a piece of filter paper **1 cm** from the bottom.
- She puts spots of food colour from each sweet on the pencil line.
- She places the filter paper in **2 cm** of water in a beaker.
- She waits for the water to rise to near the top of the filter paper.

There is a mistake in Amaya's method.

(i) Identify the mistake in Amaya's method.

.....

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

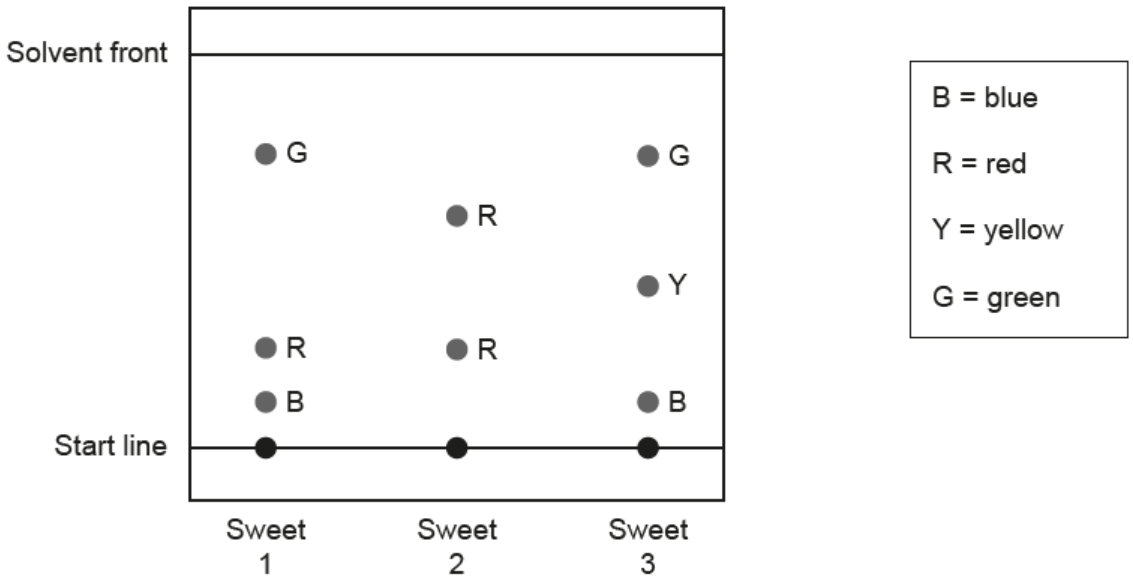
(ii) Why will this mistake stop Amaya from getting useful results?

.....

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

(b) Amaya corrects her method and does the chromatography correctly.

Her results are shown in the chromatogram:



(i) Amaya says, 'The chromatogram shows that there were a total of four different pure dyes used in the three sweets.'

Explain why this is incorrect.

.....

.....

.....

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

(ii) Which dye is the **most** soluble in water?

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

(iii) Give **one** reason for your answer to **(b)(ii)**.

.....

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

(iv) Calculate the R_f value for the **yellow** dye.

Use the chromatogram and the equation:

$$R_f = \frac{\text{distance travelled by solute}}{\text{distance travelled by solvent front}}$$

R_f value = ... **[2]**

(c) Ali has a mixture of carbon in copper sulfate solution. Carbon is insoluble in water.

Describe a method Ali can use to obtain pure copper sulfate crystals from the mixture.

.....

.....

.....

.....

.....

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

8. Nov/2021/Paper_J258/04/No.3

Some brands of tablets that treat stomach upsets contain calcium carbonate, $CaCO_3$.

Jane does experiments to measure the mass of calcium carbonate in each tablet for two different brands of tablets.

EasyCalm	**FeelRight**
Pack size: 25 tablets	Pack size: 40 tablets

(a) Jane wants to make sure that the samples she tests are representative of all the tablets in each brand.

(i) Why is it important to make sure that the samples are **representative**?

.....

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

(ii) What should Jane do to make sure her choice of tablets is representative?

Tick (✓) **two** boxes.

- Choose tablets at random from each box. ☐
- Choose tablets from more than one box of each brand. ☐
- Choose tablets that look the same. ☐
- Test each tablet under the same conditions. ☐
- Test every tablet from one box of each brand. ☐
- Test one tablet from each brand. ☐

[2]

(b) Jane reacts dilute hydrochloric acid with a tablet.
The equation shows the reaction that happens:

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

Which **two** statements explain why this reaction is a neutralisation reaction?

Tick (✓) **two** boxes.

- Carbon dioxide is made. ☐
- A solid reacts to form a solution. ☐
- A salt and water form. ☐
- The pH changes during the reaction. ☐
- The reaction fizzes. ☐

[2]

(c) Jane crushes each tablet and adds it to water. She adds an indicator to the water, then adds dilute hydrochloric acid from a burette until the indicator changes colour.

The table shows the mean volume of dilute hydrochloric acid needed to neutralise one tablet from each brand.

Brand of tablet	Mean volume of dilute hydrochloric acid needed (cm^3)	Mean mass of calcium carbonate in one tablet (g)
EasyCalm	10.5	1.05
FeelRight	15.8	

(i) Calculate the mean mass of calcium carbonate in **one FeelRight** tablet.

Use the formula: mean mass of calcium carbonate (g) = mean volume of hydrochloric acid (dm^3) × relative formula mass of $CaCO_3$

$1\,dm^3 = 1000\,cm^3$

Mean mass of calcium carbonate in one tablet = ... g **[3]**

(ii) Jane thinks her results are inaccurate because the tablets contain other ingredients. The labels show the other ingredient in each brand of tablet.

EasyCalm Tablets
Contains:
calcium carbonate
citric acid

FeelRight Tablets
Contains:
calcium carbonate
magnesium hydroxide

Explain how each of the other ingredients will affect the volume of acid needed to neutralise each tablet.

Citric acid .....

.....

.....

Magnesium hydroxide .....

.....

.....

[3]

9. Nov/2020/Paper_J258/03/No.1

Layla does a titration to find out the concentration of some sodium hydroxide solution. She reacts hydrochloric acid with the sodium hydroxide solution.

(a) Layla says, 'The titration uses a **neutralisation** reaction.'

Define a neutralisation reaction.

.....

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

(b) This is Layla's **incomplete** method for the titration:

- Put the hydrochloric acid in a burette.
- Put the sodium hydroxide solution in a flask.
- Add the hydrochloric acid to the sodium hydroxide solution.
- Stop adding the hydrochloric acid when the sodium hydroxide solution is neutralised.

(i) Layla needs to add another substance to the flask so that she knows when to stop adding the hydrochloric acid.

Which substance does Layla need to add, **and** what will she see?

Layla needs to add .....

Layla will see ..... **[2]**

(ii) Layla titrates the hydrochloric acid into a flask from a burette. She wants to make sure her final burette reading is as **accurate** as possible.

Describe **one** thing Layla can do to make her reading as accurate as possible.

.....

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

(c) **(i)** Layla's results for her rough titration are shown in **Table 1.1**.

Complete **Table 1.1** by calculating the volume for the rough titration.

	Rough titration
Initial burette reading (cm^3)	0.90
Final burette reading (cm^3)	25.80
Volume for the rough titration (cm^3)	.....

Table 1.1

[1]

(ii) Layla's repeat readings for her careful titrations are shown in **Table 1.2**.

	First titration	Second titration	Third titration	Fourth titration
Volume (cm^3)	24.55	24.95	24.65	24.60

Table 1.2

Layla calculates that the mean titration volume is 24.60 cm^3.

Explain why Layla is correct.

Use the information in **Table 1.2** and a calculation in your answer.

.....

.....

.....

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

(iii) Calculate the mass of acid in 1 cm^3 of hydrochloric acid.

Use the formula: mean titration volume = $\frac{0.0908}{\text{mass of acid in 1 cm}^3 \text{ of hydrochloric acid}}$

Give your answer to **2** significant figures.

Mass of acid in 1 cm^3 of hydrochloric acid = ... g **[4]**

10. Nov/2020/Paper_J258/03/No.5

Amir is given a solution of potassium sulfate, which can be used as a fertiliser.

(a) He carries out a flame test on the solution.

(i) Describe how Amir does the flame test.

.....

.....

.....

.....

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

(ii) What colour does Amir see when he carries out the flame test on potassium sulfate?

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

(b) Write a **balanced symbol** equation for the reaction of potassium sulfate (K_2SO_4) solution with barium chloride ($BaCl_2$) solution.

Show state symbols.

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

(c) Amir has a sample of another fertiliser, **Fertiliser E**.

He looks at the emission spectra of **Fertiliser E** and potassium sulfate:

(i) What can Amir conclude about **Fertiliser E** from these emission spectra?

.....

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

(ii) Compounds can be analysed using a flame test **or** an emission spectrum.

State **one** advantage of using an emission spectrum to analyse compounds.

.....

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

11. Nov/2020/Paper_J258/04/No.7(c)

(c) Some fertilisers contain more than one compound mixed together.

Which **two** compounds, when mixed together, contain the three elements nitrogen, phosphorus and potassium?

Put a (ring) around the **two** correct answers.

$Ca(NO_3)_2$ $Ca_3(PO_4)_2$ NH_4NO_3 KNO_3 K_2SO_4

[1]