

**Surname:**

**First Name:**

**Current School:**



Shrewsbury  
School

# SHREWSBURY SCHOOL

## SIXTH FORM ENTRANCE EXAMINATION 2023 ENTRY

### CHEMISTRY (1 Hour)

#### Instructions to candidates:

Answer **ALL THIRTY** questions from **SECTION A** on the grid provided **and**  
Answer **TWO** of the **THREE** questions from **SECTION B** in the spaces provided

**Section A** is worth **30 marks** and **Section B 20 marks**.  
50 marks in total.

You may use a calculator.  
You are provided with a **copy of the Periodic table**



## SECTION A

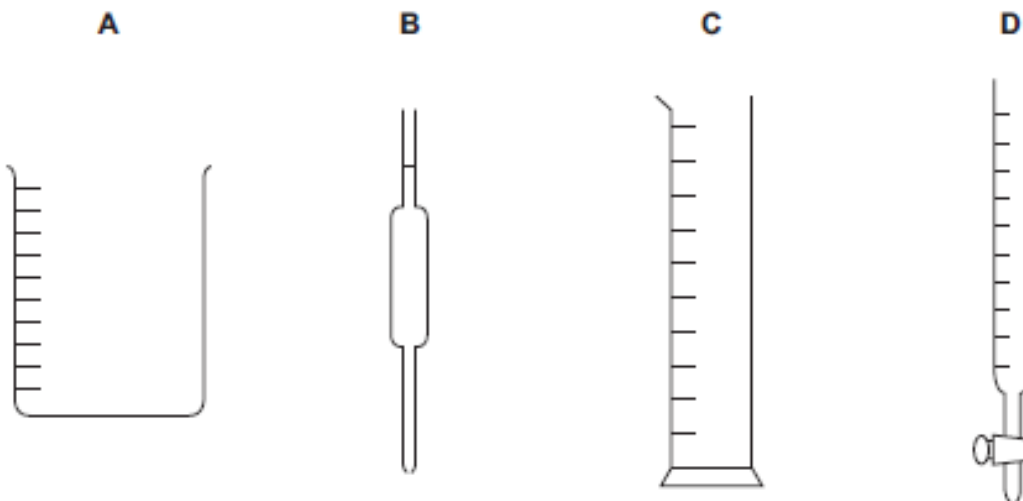
Answer all questions – circle the correct letter for each question below.

1	A	B	C	D
2	A	B	C	D
3	A	B	C	D
4	A	B	C	D
5	A	B	C	D
6	A	B	C	D
7	A	B	C	D
8	A	B	C	D
9	A	B	C	D
10	A	B	C	D
11	A	B	C	D
12	A	B	C	D
13	A	B	C	D
14	A	B	C	D
15	A	B	C	D
16	A	B	C	D
17	A	B	C	D
18	A	B	C	D
19	A	B	C	D
20	A	B	C	D
21	A	B	C	D
22	A	B	C	D
23	A	B	C	D
24	A	B	C	D
25	A	B	C	D
26	A	B	C	D
27	A	B	C	D
28	A	B	C	D
29	A	B	C	D
30	A	B	C	D

Answer **ALL** questions from **SECTION A** on the grid provided.

**Question 1**

Which diagram shows a burette?



**Question 2**

Decane has a freezing point of  $-30^{\circ}\text{C}$  and a boiling point of  $174^{\circ}\text{C}$ .

A small sample of decane is placed in an open beaker in an oven at a temperature of  $120^{\circ}\text{C}$  and at atmospheric pressure for 24 hours.

What happens to the sample of decane?

- A It boils.
- B It evaporates.
- C It melts.
- D It sublimes.

**Question 3**

A student put exactly  $25.00\text{ cm}^3$  of dilute hydrochloric acid into a conical flask.

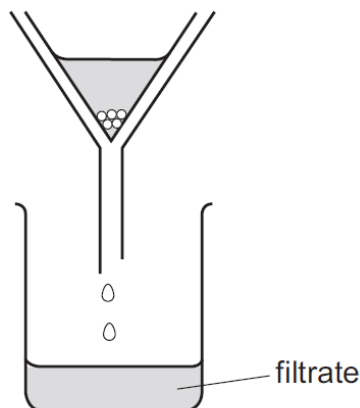
The student added 2.5 g of solid sodium carbonate and measured the change in temperature of the mixture.

Which apparatus does the student need to use?

- A balance, measuring cylinder, thermometer
- B balance, pipette, stopwatch
- C balance, pipette, thermometer
- D burette, pipette, thermometer

#### Question 4

A student separates sugar from pieces of broken glass by dissolving the sugar in water and filtering off the broken glass.



What is the filtrate?

- A broken glass only
- B broken glass and sugar solution
- C pure water
- D sugar solution

#### Question 5

Two isotopes of carbon are  $^{12}\text{C}$  and  $^{14}\text{C}$ .

Which statement about these two isotopes is correct?

- A Their electronic structure is different.
- B They have different numbers of nucleons.
- C They have different numbers of protons.
- D They have the same number of neutrons.

#### Question 6

The element livermorium, Lv, was discovered in the year 2000.

Which statement predicts what will happen to an Lv atom when it forms an  $\text{Lv}^{2-}$  ion?

- A The atom will gain two electrons.
- B The atom will lose two electrons.
- C The atom will lose two protons.
- D The atom will gain two protons.

**Question 7**

Which substance is a diatomic covalent compound?

- A  $Cl_2$                       B  $HCl$                       C  $H_2O$                       D  $MgO$

**Question 8**

The formula of sodium chlorate(V) is  $NaClO_3$ .

What is the relative formula mass of sodium chlorate(V),  $NaClO_3$ ?

- A 52.0                      B 74.5                      C 106.5                      D 223.5

**Question 9**

The temperature decreases when aqueous ethanoic acid reacts with solid sodium carbonate to form a salt.

Which type of reaction and energy change occur?

	type of reaction	energy change
A	neutralisation	endothermic
B	neutralisation	exothermic
C	redox	endothermic
D	redox	exothermic

**Question 10**

Which gas is used as a fuel?

- A helium  
B hydrogen  
C nitrogen  
D oxygen

**Question 11**

Element X has a high density, a high melting point and a high electrical conductivity.

It forms many coloured compounds.

Element X and many of its compounds act as catalysts.

What could be the atomic number of X?

- A 19                      B 26                      C 33                      D 35

**Question 12**

The noble gases are in Group VIII of the Periodic Table.

Which statement explains why noble gases are unreactive?

- A They all have eight electrons in their outer shells.
- B They all have full outer shells.
- C They are all gases.
- D They are all monoatomic.

**Question 13**

What are the products of the reaction between sodium and water?

- A hydrogen and sodium hydroxide
- B hydrogen and sodium oxide
- C oxygen and sodium hydroxide
- D oxygen and sodium oxide

**Question 14**

Which row describes what happens to the particles in solid iodine when it is heated and turned into a gas?

	separation of particles	speed of particles
A	closer together	faster
B	closer together	slower
C	further apart	faster
D	further apart	slower

**Question 15**

How many protons, neutrons and electrons are there in one atom of the isotope  ${}_{13}^{27}\text{Al}$ ?

	protons	neutrons	electrons
A	13	13	13
B	13	14	13
C	14	13	13
D	14	14	13

**Question 16**

Which row shows the properties for an ionic compound?

	volatility	electrical conductivity when solid
<b>A</b>	high	good
<b>B</b>	high	poor
<b>C</b>	low	good
<b>D</b>	low	poor

**Question 17**

In the preparation of zinc sulfate crystals, excess zinc oxide is added to dilute sulfuric acid.

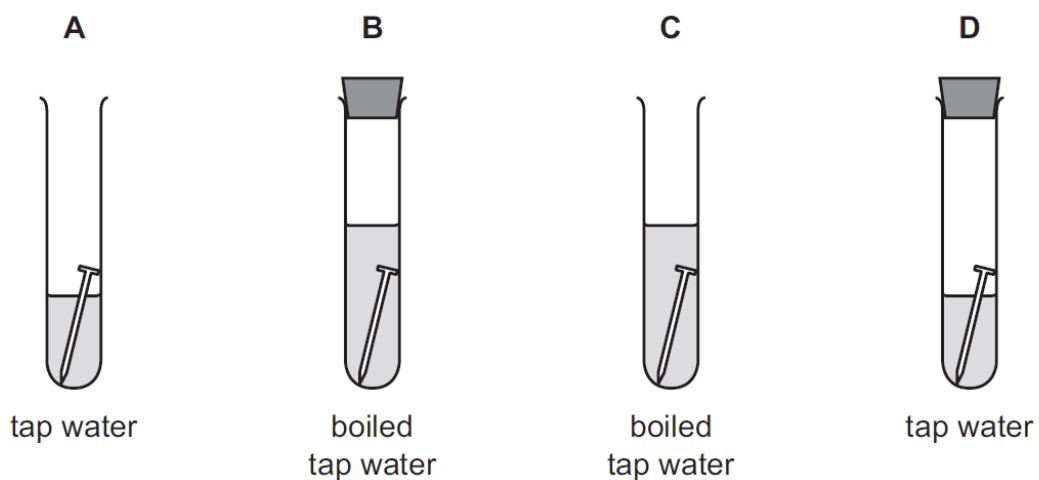
Why is an excess of zinc oxide added?

- A** to make sure crystals are formed and not powder
- B** to avoid filtering the mixture
- C** to use up all of the sulfuric acid
- D** to use up all of the zinc oxide

**Question 18**

Four different test-tubes containing water and an iron nail are left for two weeks.

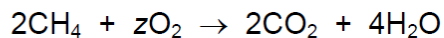
Which nail showed the least amount of rusting?





**Question 19**

A chemical equation for the complete combustion of methane is shown.



What is the value of  $z$ ?

- A** 2                      **B** 3                      **C** 4                      **D** 6

**Question 20**

The formula of an aluminium ion is  $\text{Al}^{3+}$ .

What is the formula of aluminium sulfate?

- A**  $\text{Al}_2\text{SO}_4$               **B**  $\text{Al}(\text{SO}_4)_2$               **C**  $\text{Al}_2(\text{SO}_4)_3$               **D**  $\text{Al}_3(\text{SO}_4)_2$

**Question 21**

Which statement about carbon is correct?

- A** Diamond and graphite both have simple molecular structures.  
**B** Diamond and graphite are both used to make cutting tools.  
**C** Each carbon atom in diamond is bonded to three other carbon atoms.  
**D** Graphite conducts electricity and has a giant covalent structure.

**Question 22**

Which statements about the effect of increasing the temperature on the rate of a reaction are correct?

- 1 It increases the rate of a reaction.
- 2 It increases the activation energy.
- 3 It increases the frequency of collisions.

- A** 1, 2 and 3              **B** 1 and 2 only              **C** 1 and 3 only              **D** 2 and 3 only

**Question 23**

Chlorine reacts with ethane to produce chloroethane and hydrogen chloride.



The reaction is exothermic.

The bond energies are shown in the table.

bond	bond energy in kJ/mol
C-Cl	+340
C-C	+350
C-H	+410
Cl-Cl	+240
H-Cl	+430

What is the energy change for the reaction?

- A -1420 kJ/mol
- B -120 kJ/mol
- C +120 kJ/mol
- D +1420 kJ/mol

**Question 24**

Which row describes the properties of an acid?

	property 1	property 2
<b>A</b>	proton acceptor	pH less than 7
<b>B</b>	proton acceptor	pH more than 7
<b>C</b>	proton donor	pH less than 7
<b>D</b>	proton donor	pH more than 7

**Question 25**

A period of the Periodic Table is shown.

group	I	II	III	IV	V	VI	VII	VIII
element	R	S	T	V	W	X	Y	Z

The letters are not their chemical symbols.

Which statement is correct?

- A** Element R does not conduct electricity.
- B** Elements R and Y react together to form an ionic compound.
- C** Element Z exists as a diatomic molecule.
- D** Element Z reacts with element T.

**Question 26**

All metal nitrates are soluble in water.

All metal chlorides are soluble except silver and lead.

All metal carbonates are insoluble except sodium and potassium.

Which aqueous solutions produce a precipitate when mixed together?

- 1 silver nitrate + sodium carbonate
- 2 silver nitrate + sodium chloride
- 3 barium nitrate + potassium chloride

- A** 1 and 2 only    **B** 1 and 3 only    **C** 2 and 3 only    **D** 1, 2 and 3

**Question 27**

Which process does **not** produce a greenhouse gas?

- A** acid rain on limestone buildings
- B** combustion of wood
- C** digestion in cows
- D** zinc reacting with sulfuric acid

**Question 28**

Fuel X produces carbon dioxide and water when it is burned in air. So does fuel Y.

What could X and Y be?

	X	Y
<b>A</b>	C	H <sub>2</sub>
<b>B</b>	C	C <sub>8</sub> H <sub>18</sub>
<b>C</b>	CH <sub>4</sub>	H <sub>2</sub>
<b>D</b>	CH <sub>4</sub>	C <sub>8</sub> H <sub>18</sub>

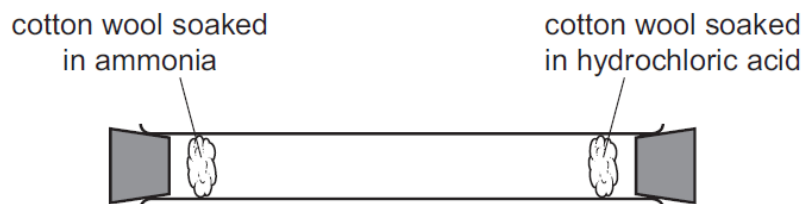
**Question 29**

Which statement is correct for **all** metals?

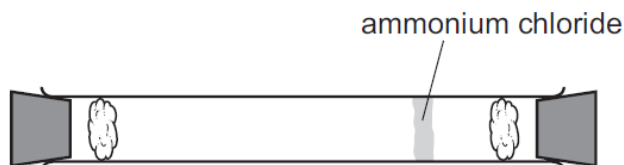
- A** They conduct electricity when molten.
- B** They gain electrons when they form ions.
- C** They have a low density.
- D** They have a low melting point.

### Question 30

An experiment is set up as shown.



After several minutes, a white ring of ammonium chloride appears as shown.



Which statement explains the observation after several minutes?

- A Ammonia gas diffuses faster than hydrogen chloride gas because its molecules have a lower molecular mass.
- B Ammonia gas diffuses faster than hydrogen chloride gas because its molecules have a higher molecular mass.
- C Ammonia gas diffuses slower than hydrogen chloride gas because its molecules have a lower molecular mass.
- D Ammonia gas diffuses slower than hydrogen chloride gas because its molecules have a higher molecular mass.

**END OF SECTION A**

**Section B** [Answer **TWO** of the **THREE** questions]

**Question 1**

- (a) Atoms are made of protons, neutrons and electrons. Atoms of the same element are known as isotopes.

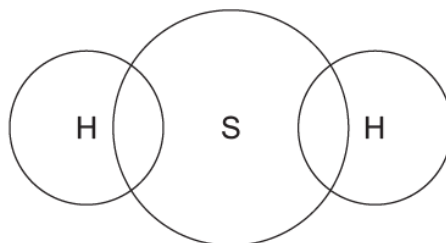
Complete the table.

particle	relative charge	relative mass
electron		$\frac{1}{1840}$
neutron		
proton	+1	

[2]

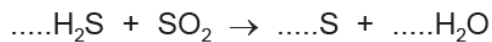
- (b) Hydrogen sulfide has the formula  $H_2S$ .

- (i) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of hydrogen sulfide. Show outer shell electrons only.



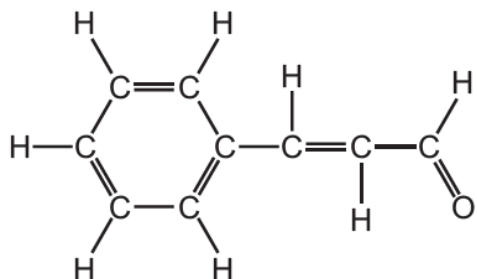
[2]

- (ii) Balance the chemical equation for the reaction of hydrogen sulfide with sulfur dioxide shown.



[1]

- (c) Toothpaste also contains cinnamal.  
The structure of cinnamal is shown.



Deduce the formula of cinnamal to show the number of atoms of carbon, hydrogen and oxygen.

..... [1]

- (d) Ester Y has the following composition by mass:

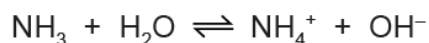
C, 48.65%; H, 8.11%; O, 43.24%.

Calculate the empirical formula of ester Y.

empirical formula = ..... [2]

- (e) Ammonia and hydrazine are weak bases.

The chemical equation for the reaction between one molecule of ammonia and one molecule of water is shown.



- (i) State the meaning of the term *base*.

..... [1]

- (ii) Write a chemical equation for the reaction between one molecule of hydrazine,  $\text{N}_2\text{H}_4$ , and one molecule of water.

..... [1]

[Total: 10]

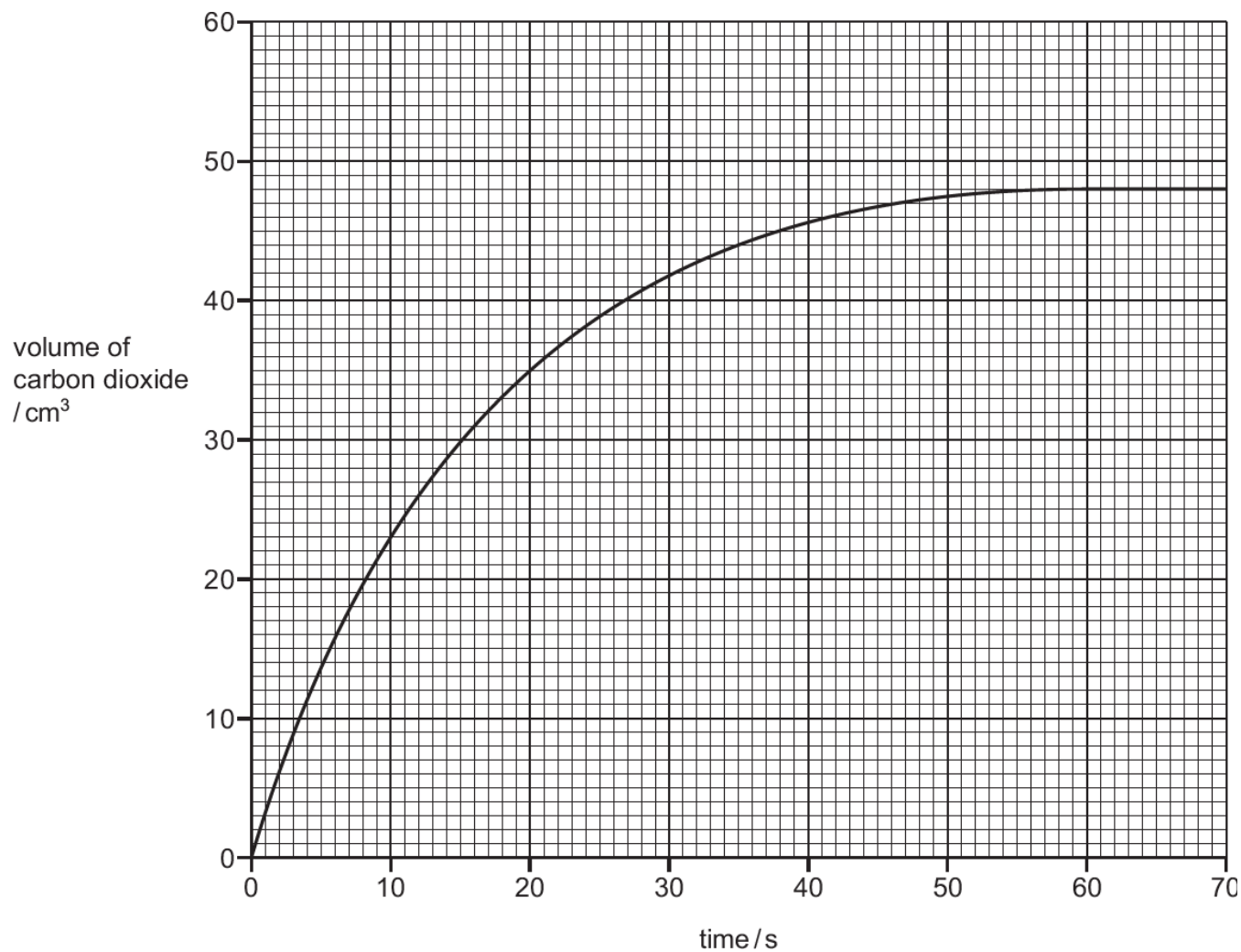
## Question 2

A student investigates the reaction of small pieces of calcium carbonate with dilute hydrochloric acid. The hydrochloric acid is in excess.



The rate of reaction is found by measuring the volume of carbon dioxide gas produced as time increases.

The results are shown on the graph.





(a) Deduce the volume of carbon dioxide gas at 35 s.

volume = ..... cm<sup>3</sup> [1]

(b) The experiment is repeated at a higher temperature.

All other conditions stay the same.

Draw a line **on the grid** to show how the volume of carbon dioxide gas produced changes as time increases. [2]

(c) Describe the effect each of the following has on the rate of reaction of calcium carbonate with dilute hydrochloric acid.

All other conditions stay the same.

- The reaction is carried out using a higher concentration of hydrochloric acid.

.....

- The reaction is carried out using powdered calcium carbonate.

.....

[1]

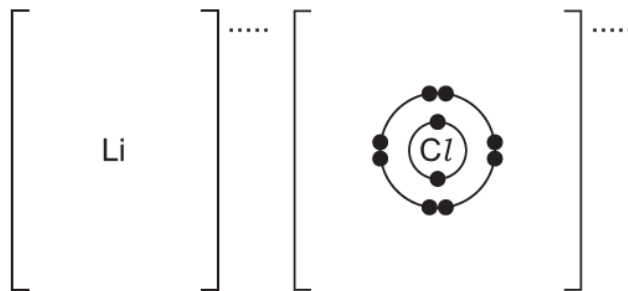
(d) When 0.11 g of calcium carbonate is used, 25 cm<sup>3</sup> of carbon dioxide gas is produced.

Calculate the mass of calcium carbonate needed to produce 100 cm<sup>3</sup> of carbon dioxide gas.

mass of calcium carbonate = ..... g [1]

(e) Lithium chloride,  $\text{LiCl}$ , is an ionic compound.

Complete the dot-and-cross diagram to show the electron arrangement and charges of the ions in lithium chloride.



[2]

(f) Explain, in terms of attractive forces between particles, why  $\text{LiCl}$  is a solid at room temperature but  $\text{NCl}_3$  is a liquid with a relatively low boiling point.

.....

.....

.....

..... [3]

[Total: 10]

**Question 3**

(a) A student determines the concentration of a solution of dilute sulfuric acid,  $\text{H}_2\text{SO}_4$ , by titration with aqueous sodium hydroxide,  $\text{NaOH}$ .

**step 1** 25.0 cm<sup>3</sup> of 0.200 mol/dm<sup>3</sup>  $\text{NaOH}$  is transferred into a conical flask.

**step 2** Three drops of methyl orange indicator are added to the conical flask.

**step 3** A burette is filled with  $\text{H}_2\text{SO}_4$ .

**step 4** The acid in the burette is added to the conical flask until the indicator changes colour. The volume of acid is recorded. This process is known as titration.

**step 5** The titration is repeated several times until a suitable number of results is obtained.

(i) Name the piece of apparatus used to measure exactly 25.0 cm<sup>3</sup> of 0.200 mol/dm<sup>3</sup>  $\text{NaOH}$  in **step 1**.

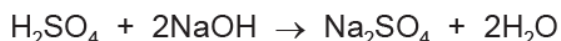
..... [1]

(ii) State the colour change of the methyl orange indicator in **step 4**.

from ..... to ..... [1]

(iii) 20.0 cm<sup>3</sup> of  $\text{H}_2\text{SO}_4$  reacts with 25.0 cm<sup>3</sup> of 0.200 mol/dm<sup>3</sup>  $\text{NaOH}$ .

The equation for the reaction is shown.



Calculate the concentration of  $\text{H}_2\text{SO}_4$  using the following steps.

- Calculate the number of moles in 25.0 cm<sup>3</sup> of 0.200 mol/dm<sup>3</sup>  $\text{NaOH}$ .

..... mol

- Determine the number of moles of  $\text{H}_2\text{SO}_4$  that react with the  $\text{NaOH}$ .

..... mol

- Calculate the concentration of  $\text{H}_2\text{SO}_4$ .

..... mol/dm<sup>3</sup>  
[3]

