

Stage 1 

Creating graphs



Introduction

In this lesson we will cover the mathematical skills needed to create a graph in science.

Learning objectives

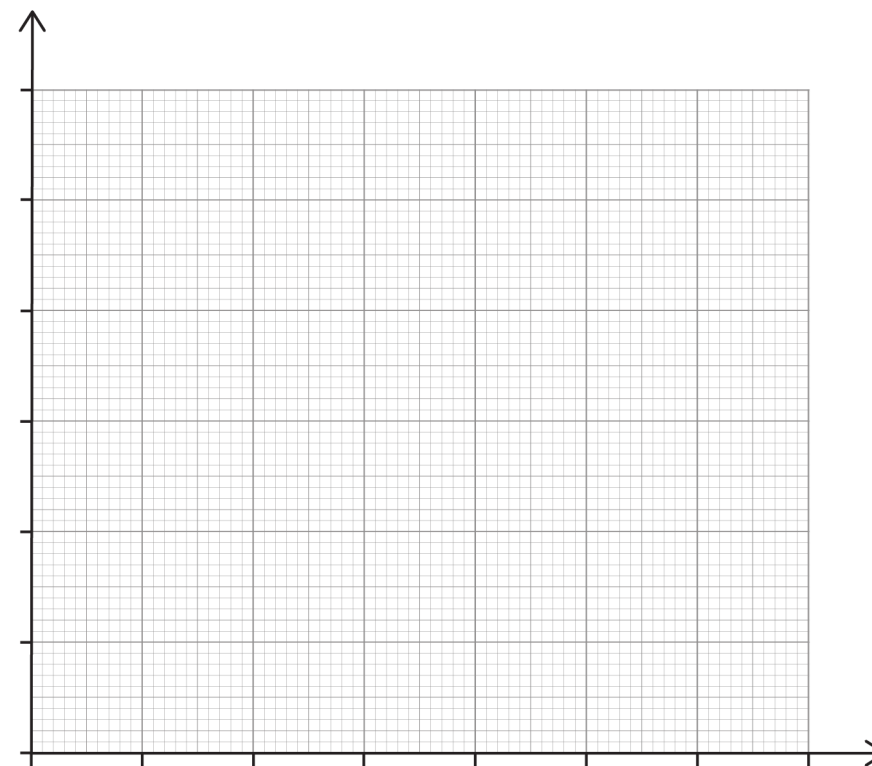
1. Translate information between graphs and tables.
2. Design suitable scales for the axes on a graph.
3. Plot coordinates accurately onto a graph.
4. Draw an appropriate line of best fit.



Lesson question

Imagine you are investigating the volume of gas produced over time when magnesium ribbon reacts with hydrochloric acid. Here are the experimental results:

Time (s)	Volume of gas (cm ³)
0	0
10	12
20	22
40	38
60	48
80	53
90	54
100	53
120	54



Produce a graph to represent the data:

1. Design **suitable scales**.
2. **Plot** the results.
3. Draw a **line of best fit**.
4. Describe the **trend**.



Lesson question – vocabulary

- A **scale** is a set of marks on the axes with **equal** intervals.
- A **suitable scale** is one which enables the data to be plotted clearly and accurately making full use of the graph paper.
- **Plot** means marking the corresponding coordinates onto the graph accurately and precisely using the scales.
- A **line of best fit** is a line which passes close to most of the plotted points. It does not have to pass through every point but should have the same number of points on each side of the line. The line of can be straight or a curve.
- **Trend** relates to the general direction of how a variable changes over time, indicated by the line of best fit – for example, whether the values are increasing, decreasing, or staying the same as one variable changes.



Choosing a suitable scale for each axis

Before choosing a scale, we need to know the **range** of the data.

- Look at the smallest value in each column.
- Look at the largest value in each column.

What is the range of this data?

Time (s)	Temperature (°C)
0	20
20	35
40	48
60	57

What is the range of this data?

The scale should:

- cover the full range of data
- use simple **intervals** such as 1, 2, 5 or 10
- make good use of the graph paper provided

What scale would be suitable for the x and y axes for this table of data?

Choosing a suitable scale for each axis – answers

- The range for time is 0 to 60.
- The range for temperature is 20 to 57.

There will be several possible scales depending on the graph paper provided. Some suggestions are provided below:

- x -axis scale: start x -axis at 0 and use intervals of 5, 10 or 20 units up to a maximum of 70 or 80.
- y -axis scale: start y -axis at 20 and use intervals of 5 up to a maximum of 60 or start y -axis at 10 and use intervals of 5 or 10 units.



Coordinate pairs 1

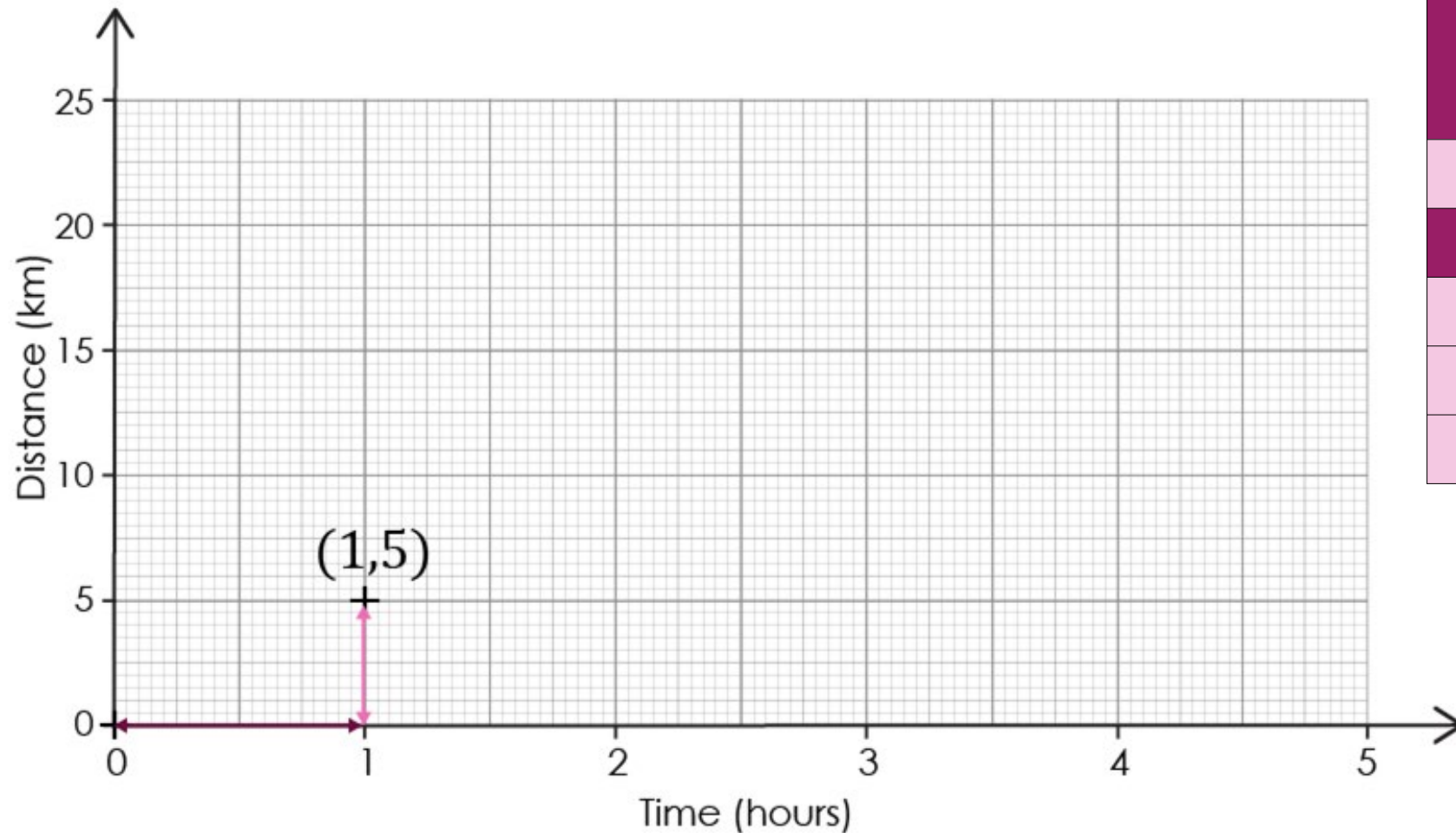
Each row in a table gives a coordinate pair to plot such as (1, 5).

- The first coordinate value (1) represents x . This value gives an instruction to move horizontally 1 unit along the x -axis from the origin.
- The second coordinate value (5) represents y . This value instructs us to move vertically upwards 5 units from the x -axis.
- The combination of these movements give the position of the plotted point (1, 5).

Time (hours)	Distance (km)
0	0
1	5
2	10
3	15
4	20

Coordinate pairs 2

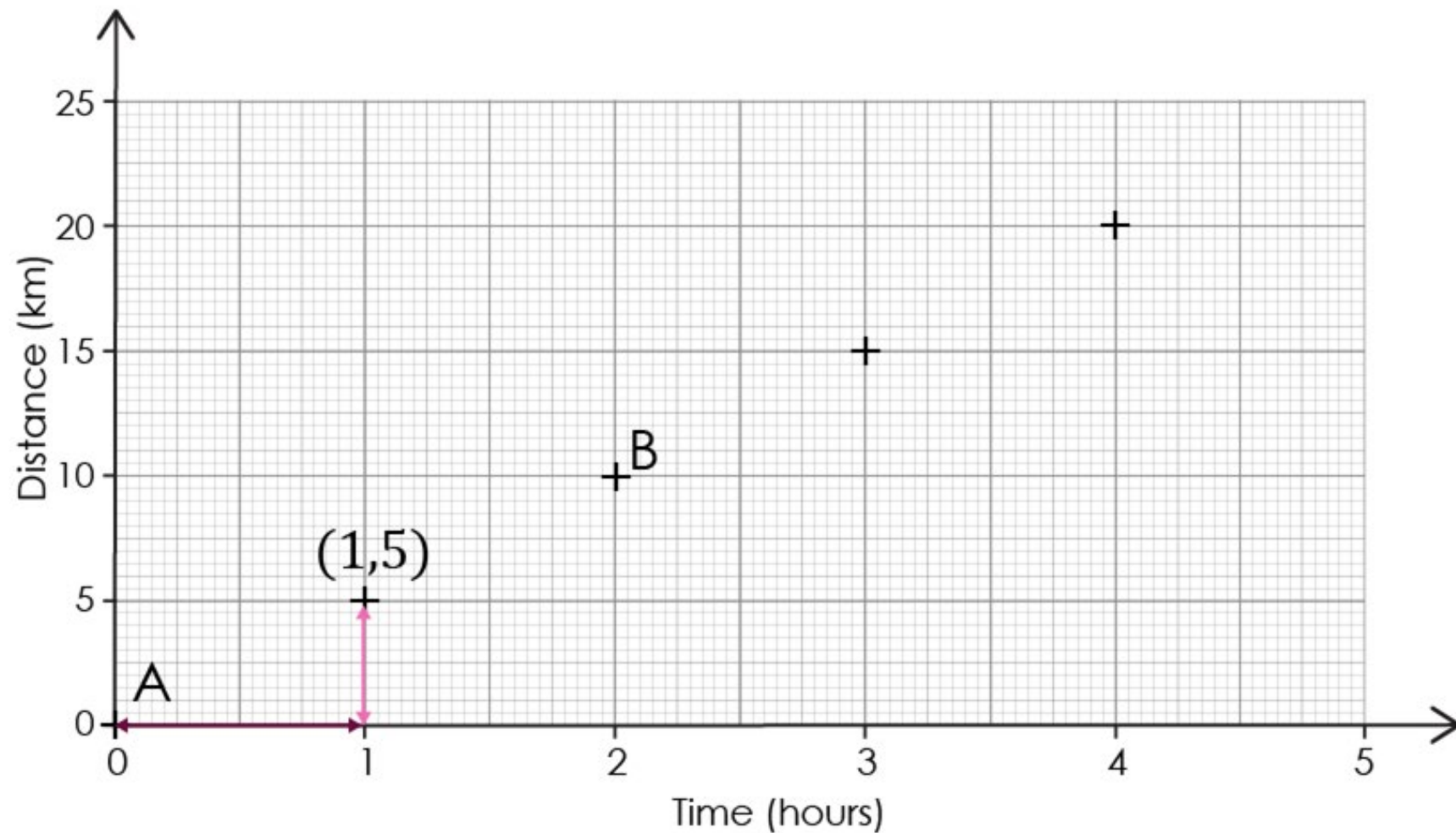
Mark this point (1, 5) carefully using a cross, or other symbol, with a sharp pencil.



Time (hours)	Distance (km)
0	0
1	5
2	10
3	15
4	20

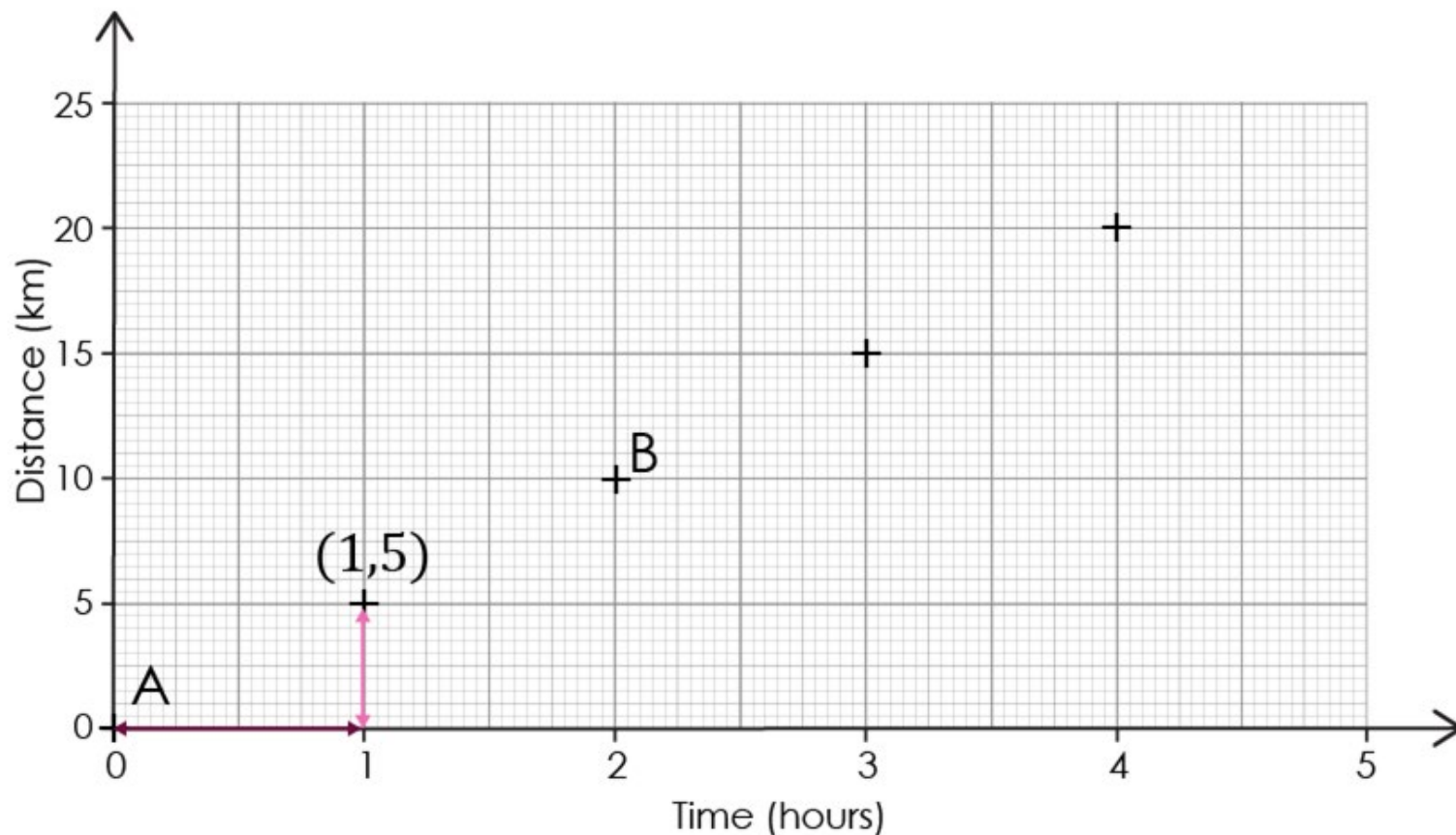
Coordinate pairs – activity

What are the coordinate pairs for points A and B?



Coordinate pairs – answers

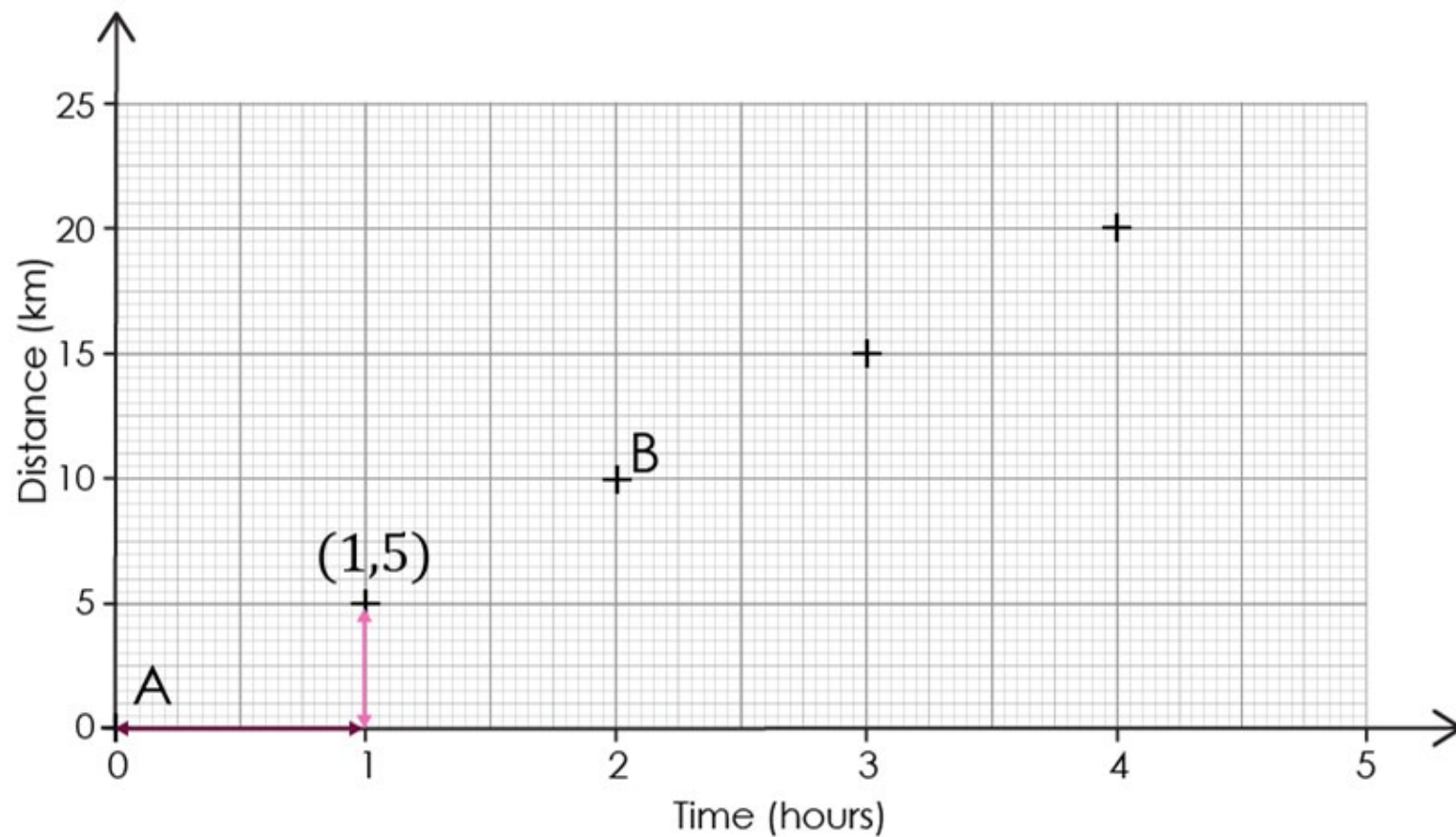
- Point A is $(0, 0)$. This is also called the origin.
- Point B is $(2, 10)$: along the x -axis 2 units and the y -axis 10 units.





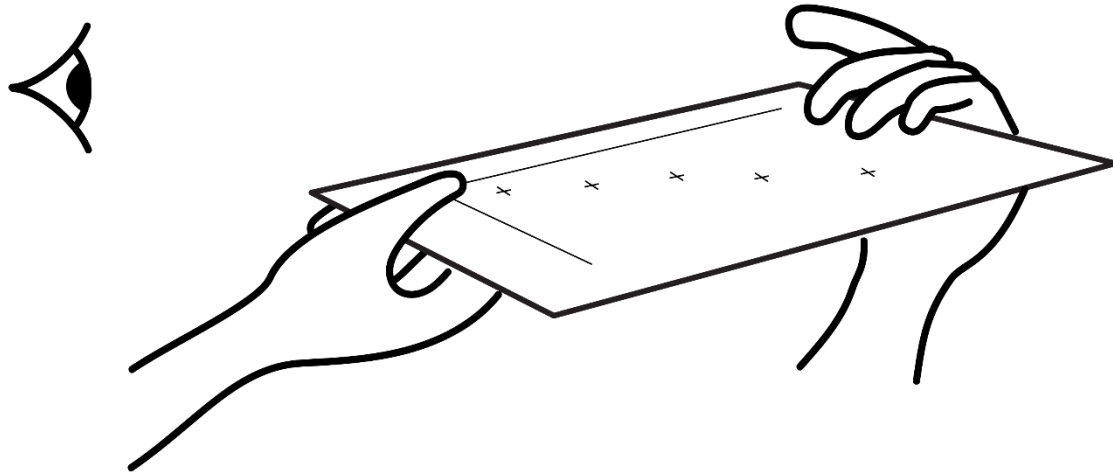
Coordinate pairs – practice

Time (hours)	Distance (km)
0	0
1	5
2	10
3	15
4	20





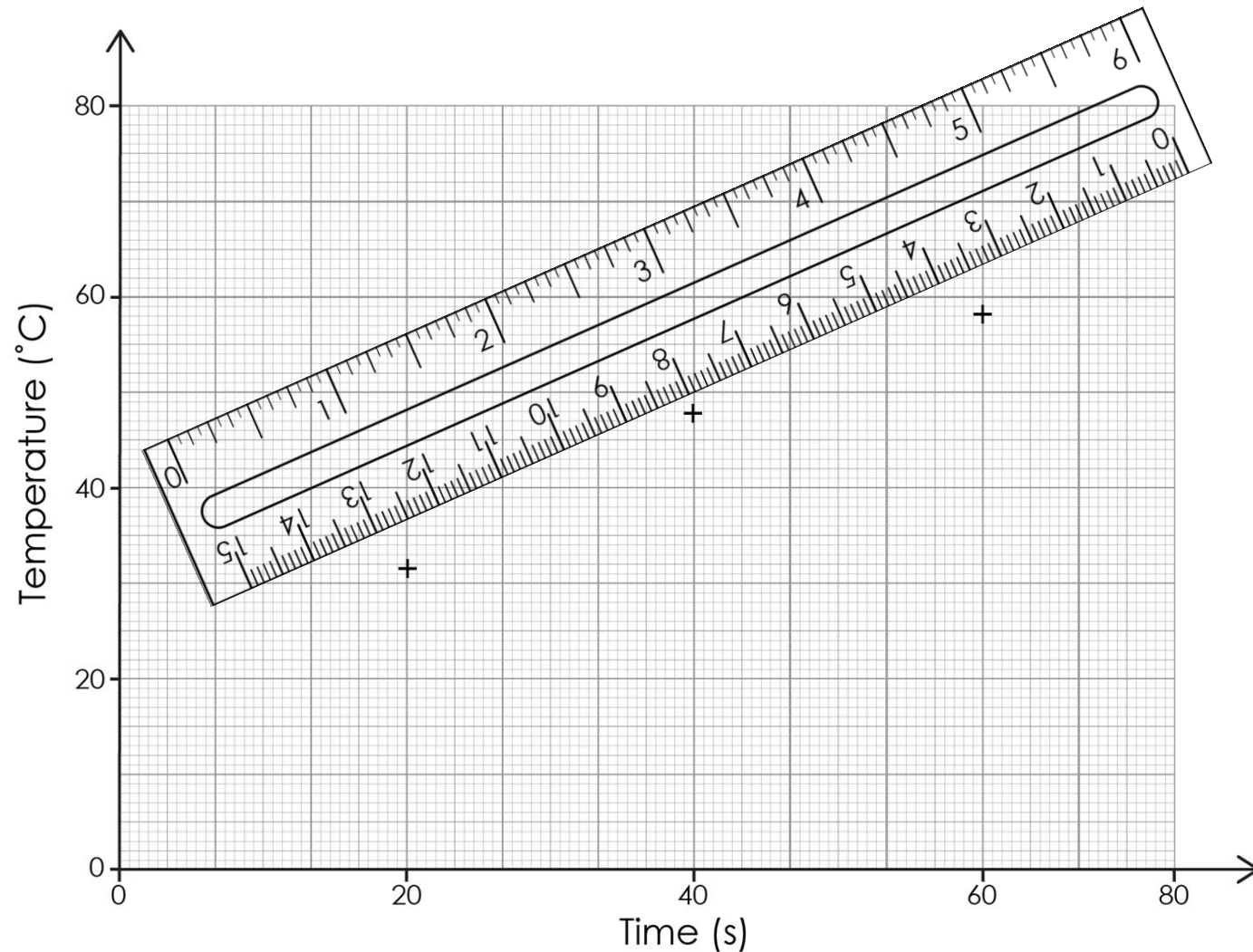
Drawing line of best fit



Hold the graph paper up to your eye and look along the points.

Does it look as if the points are in **straight line** or a **curved line**?

Drawing a straight line of best fit



If they are straight: **position** a ruler over the points and **draw** a line of best fit with a sharp pencil.

The line should pass through, or as close as possible to, as many points as possible.



Drawing a curved line of best fit

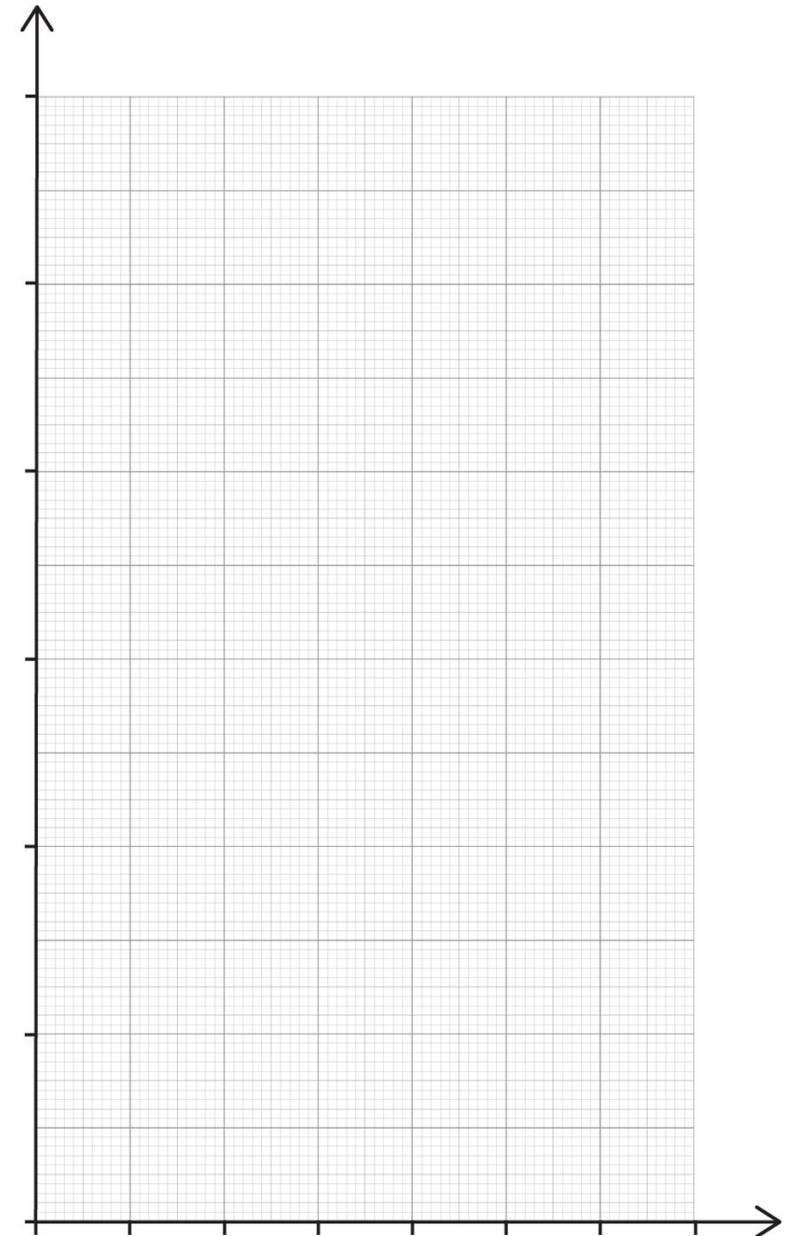
Time (minutes)	Temperature (°C)
0	80
2	61
4	49
6	41
8	36
10	33
12	30



Drawing a curved line of best fit – worked example

Time (minutes)	Temperature (°C)
0	80
2	61
4	49
6	41
8	36
10	33
12	30

- Decide upon suitable scales for this graph.
- Plot the coordinate pairs.
- Take a pencil and draw the curved line in one movement, so it passes as close to as many points as possible.
- Do not sketch the line.

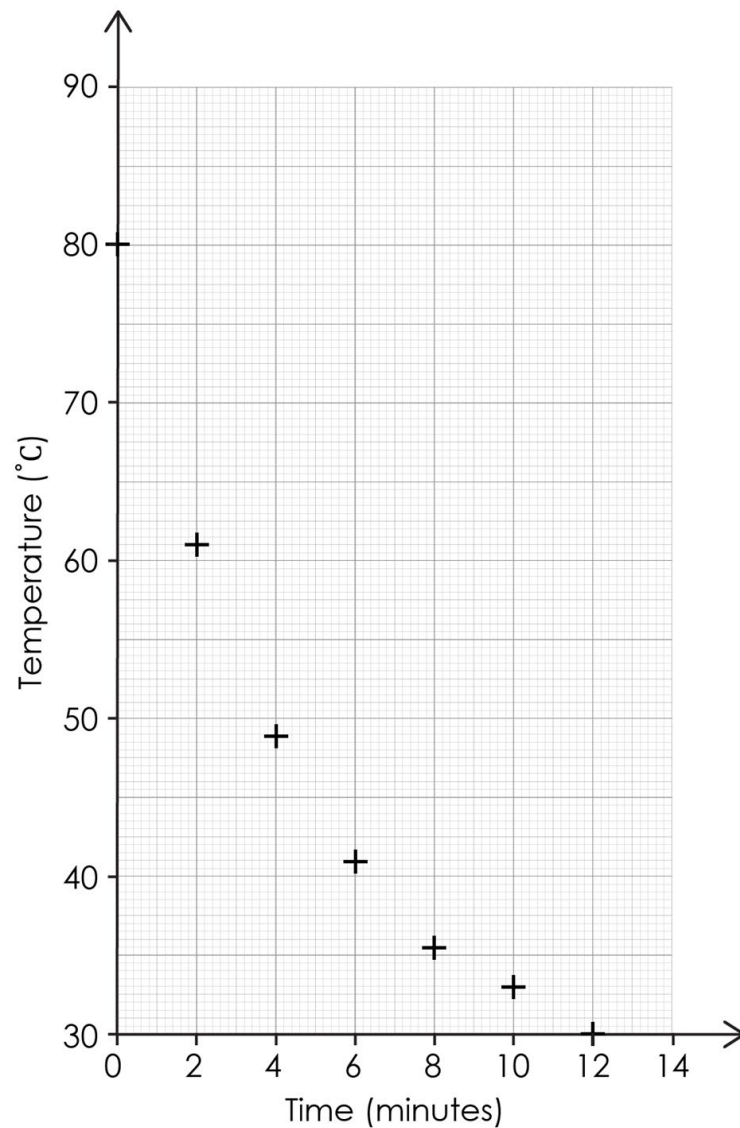




Drawing a curved line of best fit – worked example 2

Time (minutes)	Temperature (°C)
0	80
2	61
4	49
6	41
8	36
10	33
12	30

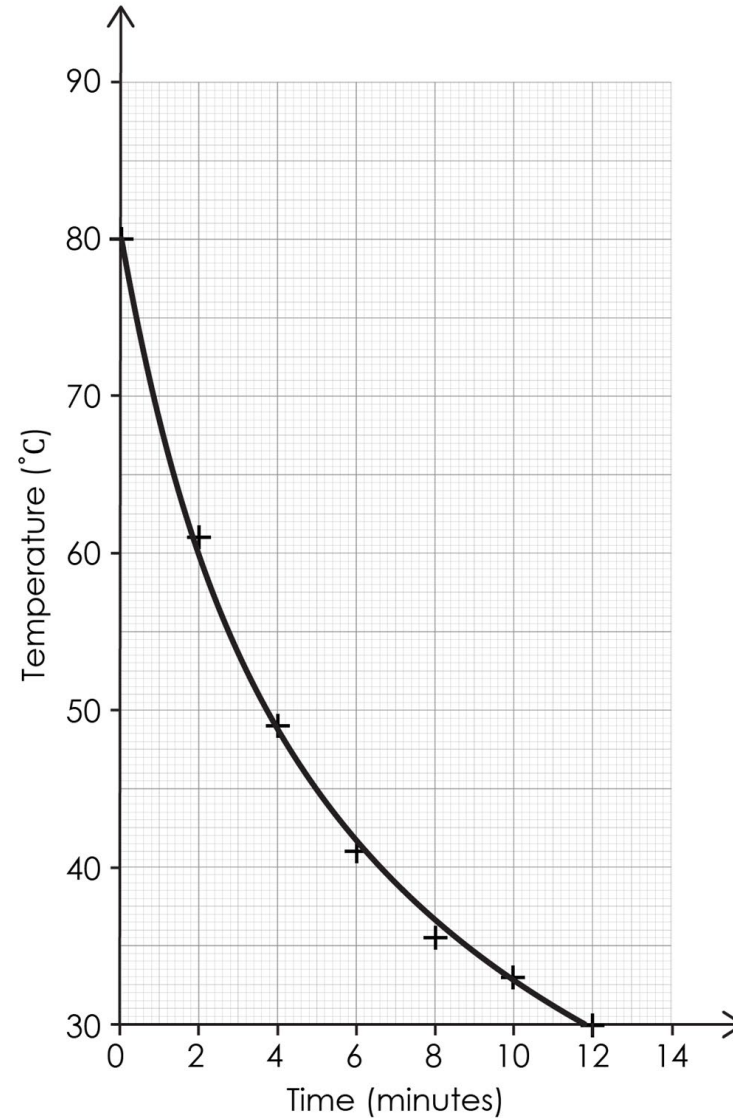
Draw a curved line of best fit.





Drawing a curved line of best fit – option 1

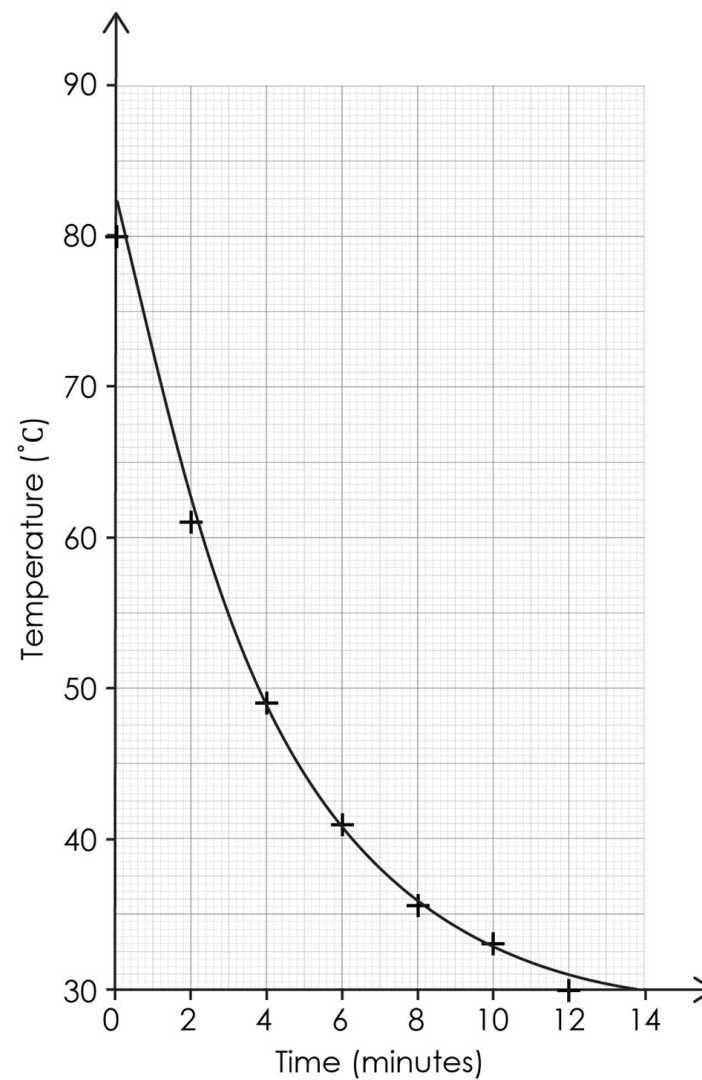
Time (minutes)	Temperature (°C)
0	80
2	61
4	49
6	41
8	36
10	33
12	30





Drawing a curved line of best fit – option 2

Time (minutes)	Temperature (°C)
0	80
2	61
4	49
6	41
8	36
10	33
12	30





Differences between mathematics and science

Terminology

Mathematics uses the term coordinates or coordinate pairs.

Science uses the terms **independent** (what the scientist chooses to change) and **dependent** (what is measured) **variables**. The independent variable is usually plotted on the x -axis.

Axes

Graphs in mathematics often use matching scales on both axes.

Science graphs typically have different scales to suit each variable.

Lines of best fit

In mathematics, the line of best fit is usually a straight line which passes through most of the points, reflecting an exact mathematical relationship.

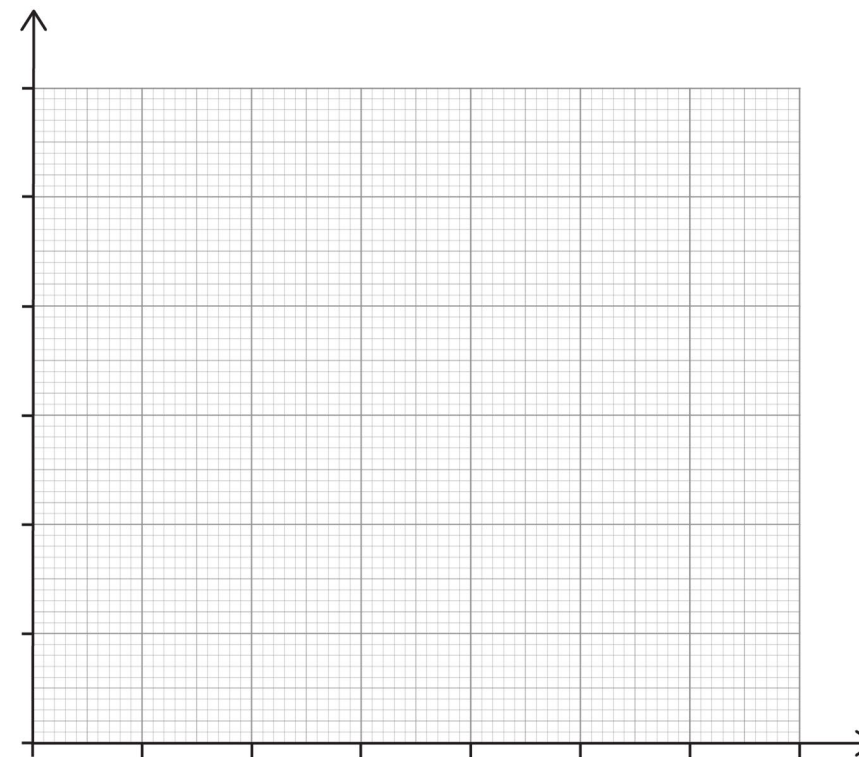
In scientific graphs, the line of best fit can be straight, or it can be a curve showing the overall trend. Experimental data is not perfect and so the points may be scattered above or below the line.



Returning to the lesson question

Imagine you are investigating the volume of gas produced over time when magnesium ribbon reacts with hydrochloric acid. Here are the experimental results:

Time (s)	Volume of gas (cm ³)
0	0
10	12
20	22
40	30
60	48
80	53
90	54
100	53
120	54



Produce a graph to represent the data:

1. Design **suitable scales**.
2. **Plot** the results.
3. Draw a **line of best fit**.
4. Describe the **trend**.



Apply your learning – design suitable scales

Imagine you are investigating the volume of gas produced over time when magnesium ribbon reacts with hydrochloric acid. Here are the experimental results:

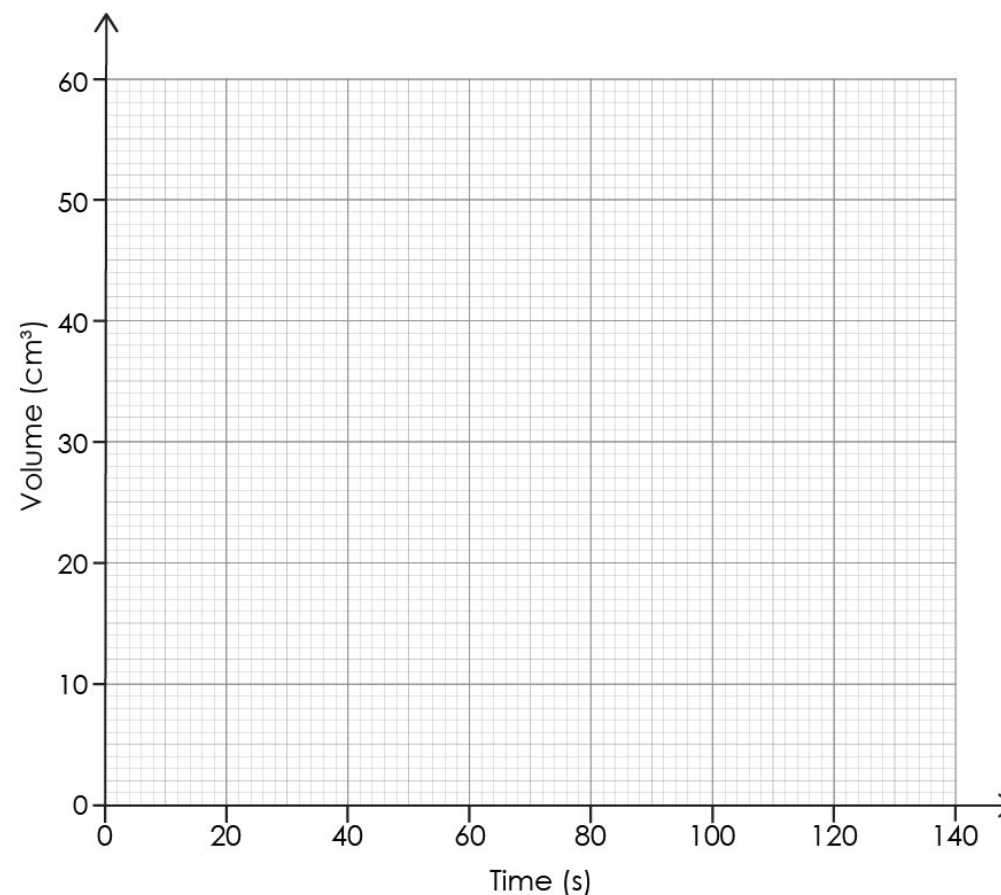
Time (s)	Volume of gas (cm ³)
0	0
10	12
20	22
40	30
60	48
80	53
90	54
100	53
120	54

- a) Which variable should be plotted on the x -axis? What label would be added?
- b) Explain why both axes should start at zero for this experiment.
- c) What is the range of data for both the independent and dependent variables?
- d) Why is it important that the graph uses most of the space on the paper?

Apply your learning – plot the results

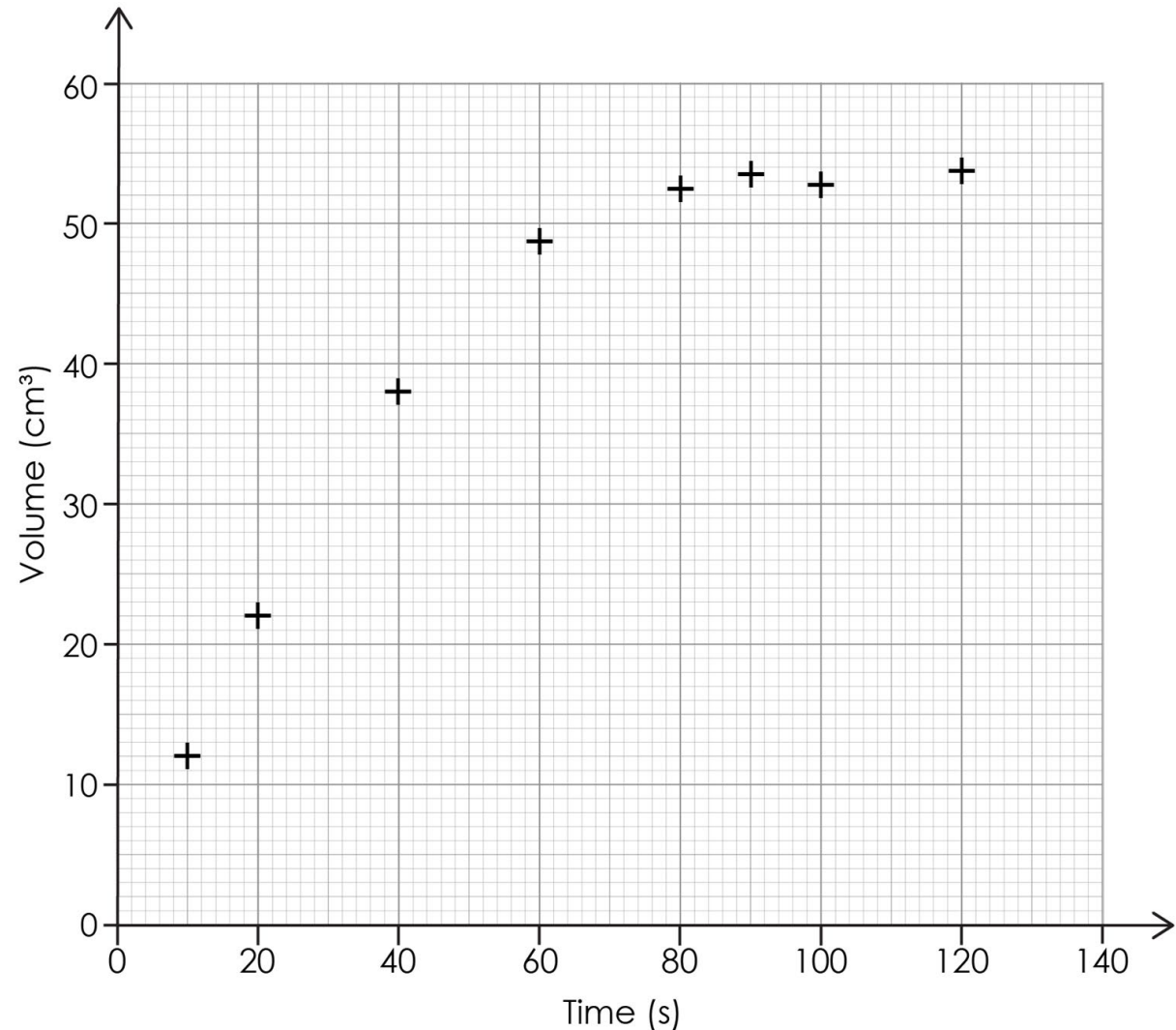
Imagine you are investigating the volume of gas produced over time when magnesium ribbon reacts with hydrochloric acid. Here are the experimental results:

Time (s)	Volume of gas (cm ³)
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20	22
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60	48
80	53
90	54
100	53
120	54



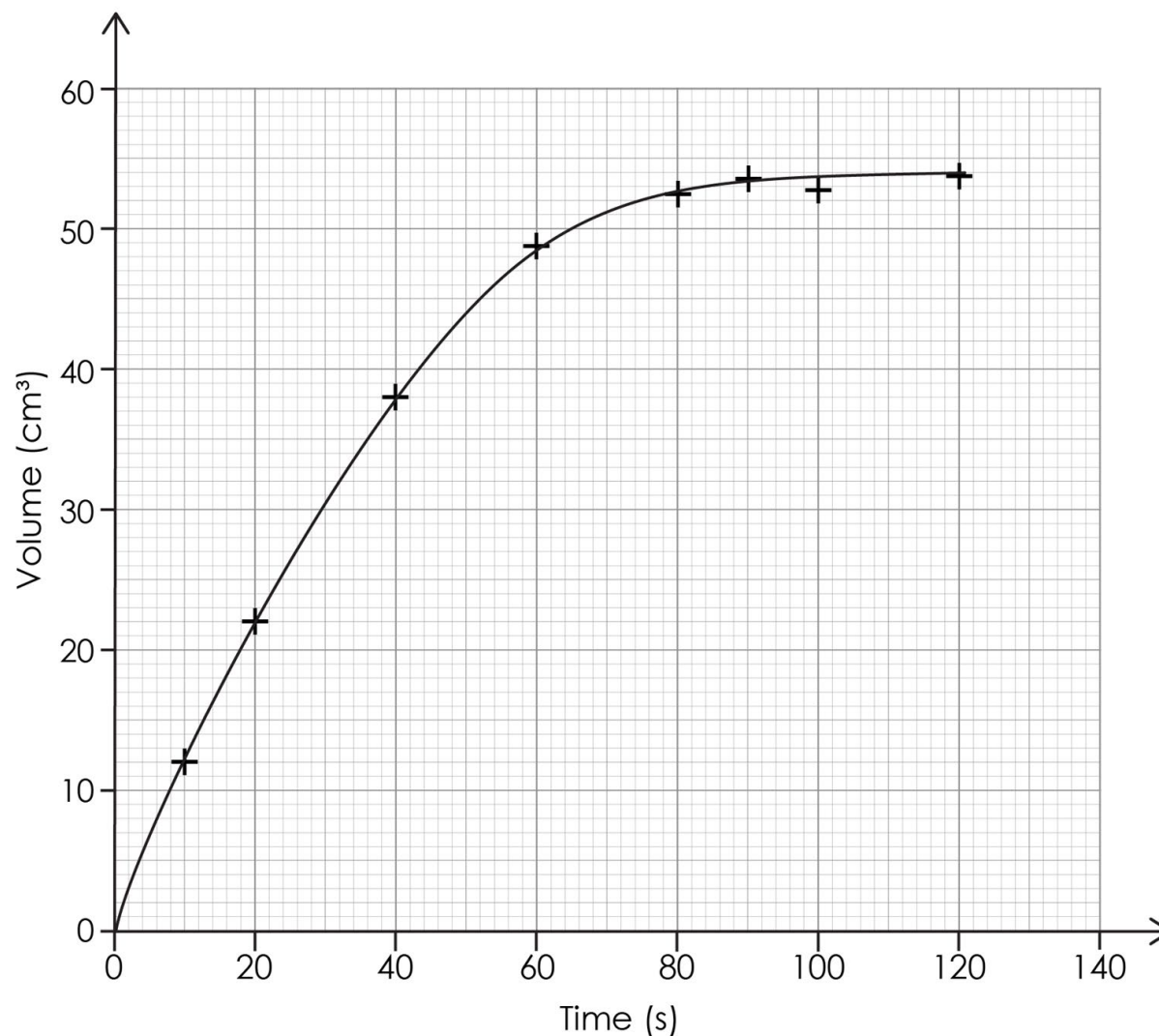
Apply your learning – draw the line of best fit

- a) What is the shape that the line of best fit should follow?
- b) Why might the plotted points not form a perfect line or curve?
- c) What does the line of best fit tell us?
- d) Why is a line of best fit more useful than joining the dots?



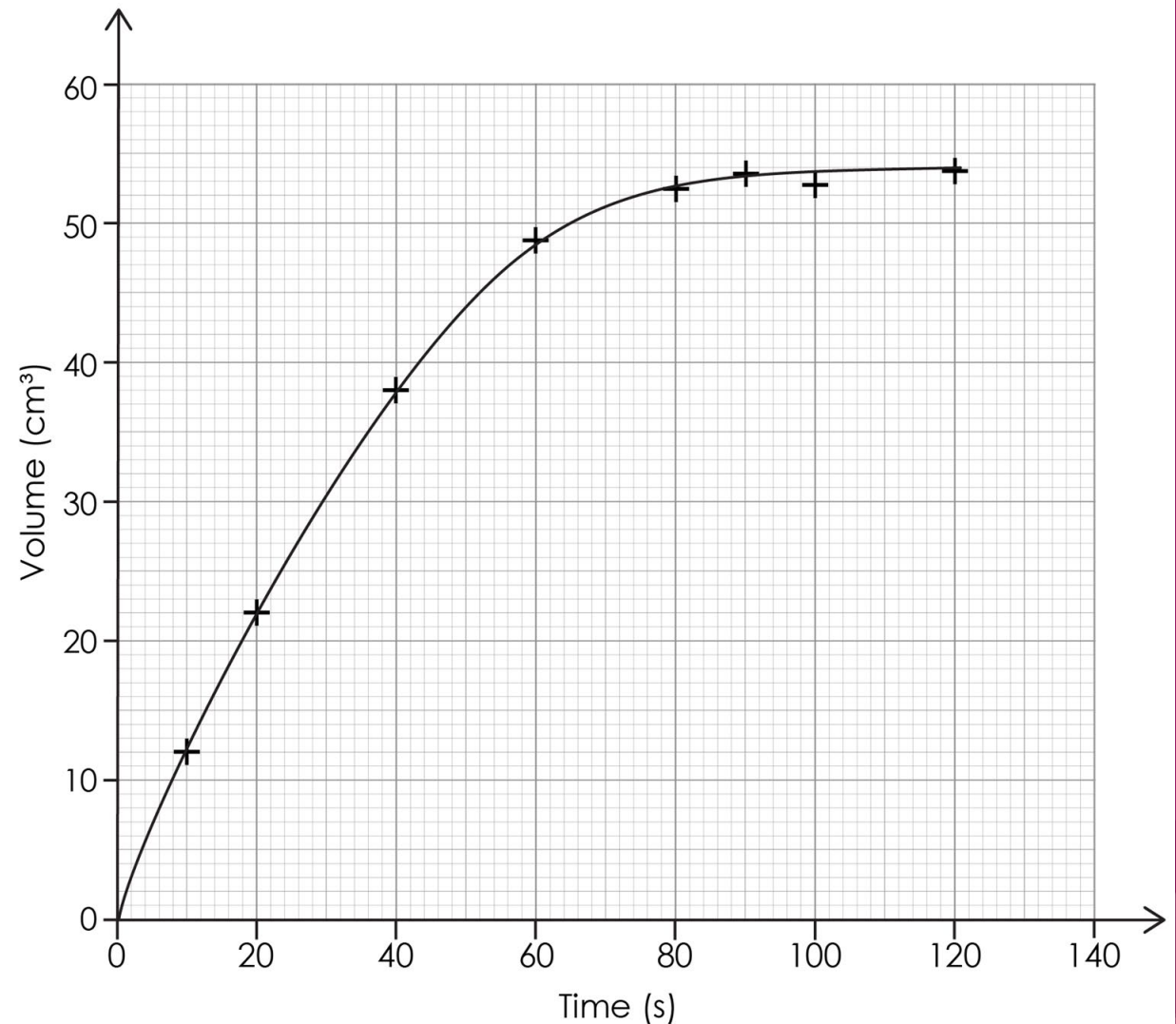
Apply your learning – line of best fit – answers a–b

- a) The line of best fit will start off steep and straight showing a fast increase, then it curves and becomes less steep and finally it becomes horizontal showing no more increase.
- b) The plotted points do not form a perfect line because there are always small errors when measuring in experiments. It can be hard to read the exact volume or the exact time on a stopwatch.



Apply your learning – line of best fit – answers c–d

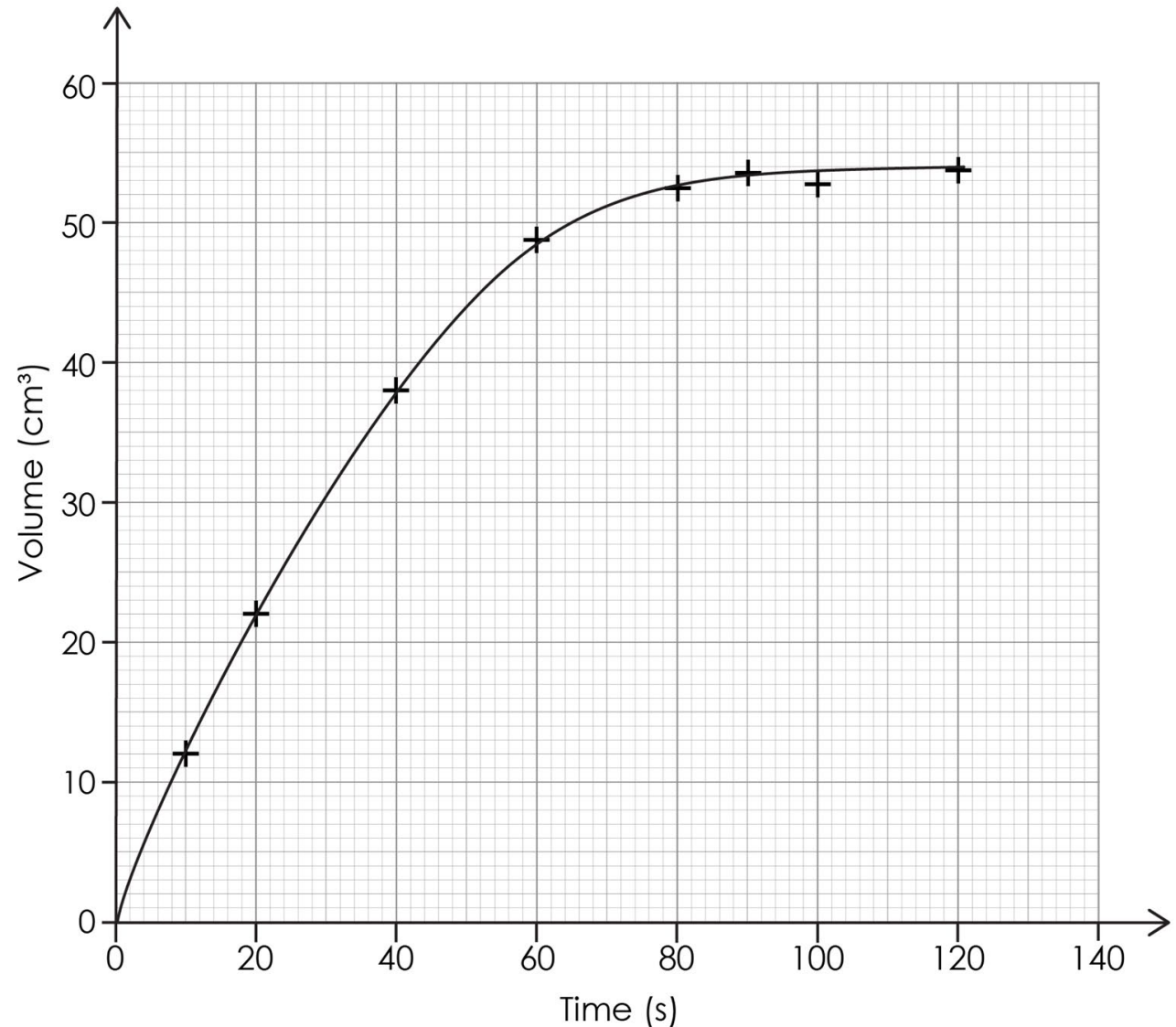
- c) The line of best fit shows the overall trend or pattern in results and smooth out any small random errors.
- d) Joining the dots can produce a zig-zag line that includes all the errors, and this can make interpreting the pattern more challenging. The line of best fit also helps us to predict values which we did not measure.





Apply your learning – describe the trend

- a) How does the volume of gas change as time increases?
- b) When does gas production slow down? How do you know?
- c) When does the reaction appear to stop or reach a maximum volume? How do you know?



Apply your learning – describe the trend – answers

- a) The volume of gas increases as time increases.
- b) This occurs more quickly at first because the line is steeper and then slows off at about 20 seconds.
- c) The maximum volume is reached around 90 seconds as the line levels off.

