Stage 1

Interpreting graphs

ROYAL SOCIETY OF CHEMISTRY

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Introduction

In this lesson we will cover the maths skills used to answer a graph question.

Learning objectives

1. Describe and compare patterns and trends in data.
2. Understand how the variables are related to each other.
3. Use data to draw conclusions about chemical reactions.

Why does data analysis matter?

Data on its own does not provide much information.

Chemists analyse the data to see if there are any **patterns** or **trends**. This can help us to understand more about what is happening during a reaction.

Data **analysis** is used to make **conclusions** about the chemical processes and reactions.

The skills used in chemistry are the same as those we use in mathematics.

The main difference between maths and chemistry is that the data we analyse in chemistry will be from experiments and so it is **not always perfect.**

- Why might data in chemistry not be perfect?

Lesson question

Imagine you are investigating how the concentration of hydrochloric acid affects the volume of carbon dioxide gas produced when it reacts with marble chips over 60 seconds.

Here are the results:

Concentration (mol/dm^3)	Volume of gas (cm^3)
0.5	15
1.0	30
1.5	45
2.0	60

a) Plot a graph of the **bivariate** data.
b) Describe the **pattern** seen.
c) What is the relationship between the **variables**?
d) Write a **conclusion** for this investigation.

Bivariate data

In maths, data can be described as univariate or bivariate.

Univariate means there is **one** variable. If we measured the travel time for teachers to get to school, the variable is travelling time.

Bivariate data means **two** variables, so there are two sets of data.

For example, we could investigate how stirring affects how quickly salt dissolves in water. We would change the number of stirs and measure how long it takes for the salt to disappear.

In science, we use the terms **independent** and **dependent variables**.

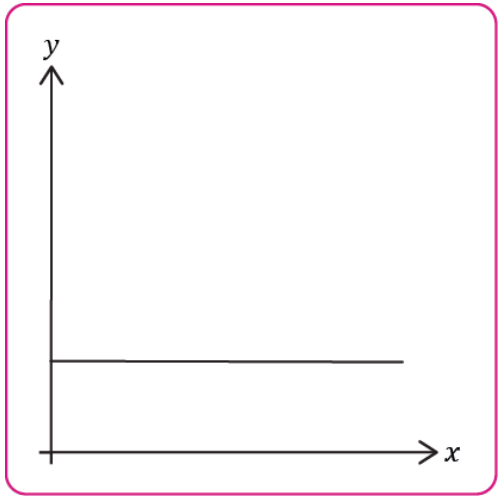
- What do these terms mean?
- What are the independent and dependent variables in the example given above?

Relationship between variables

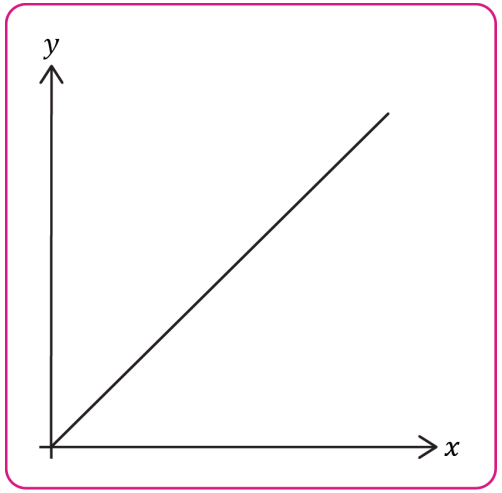
Activity

Use the words listed below to describe the relationship between the variables in these examples:

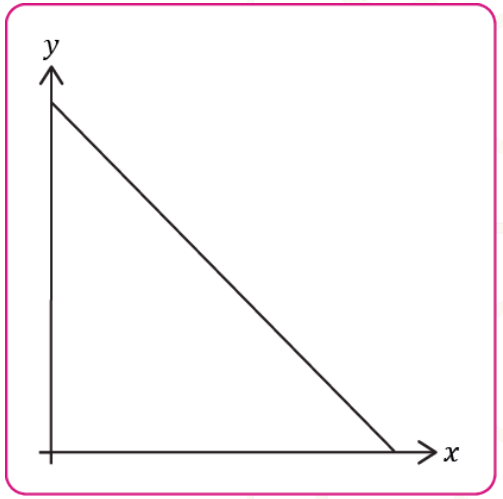
- positive linear relationship
- negative linear relationship
- no relationship



A.



B.



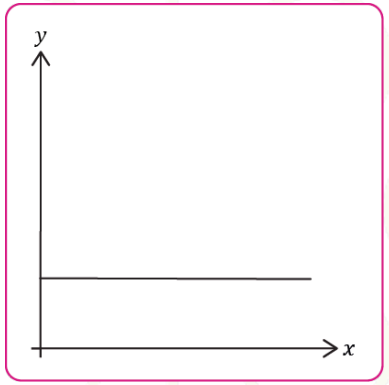
C.

Relationship between variables – answers

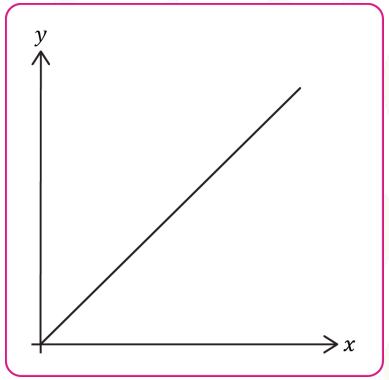
A. No relationship: as A increases B does not change. The variables are not linked to each other.

B. Positive linear relationship: As A increases so does B at a constant rate forming a straight line.

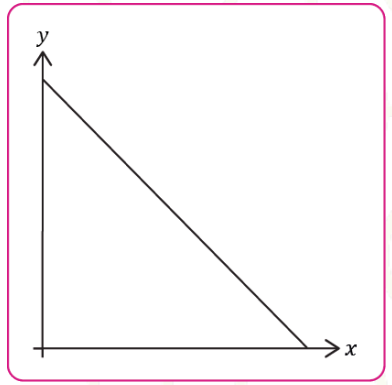
C. Negative linear relationship: As A increases B decreases at a constant rate forming a straight line.



A.



B.



C.

Patterns in data

What is a pattern?

A pattern is when we notice that things happen in a repeatable and predictable way.

Patterns can show up as:

- things which repeat regularly
- relationships between variables
- trends over time

Patterns in data 2

We know that group 1 metals all react with water. This reactivity is a pattern which repeats as we go down group 1.

Lithium

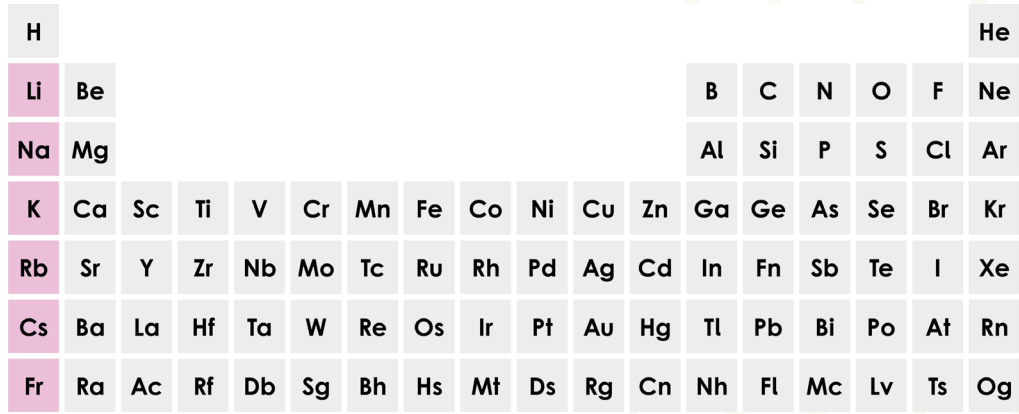
Sodium

Potassium

Rubidium

Caesium

reactivity



We would probably see a repeatable pattern occur if we measured the temperature of the air in the classroom at 8 am each morning and again at 2 pm over 5 days.

What pattern might we notice?

Trends

What is a trend?

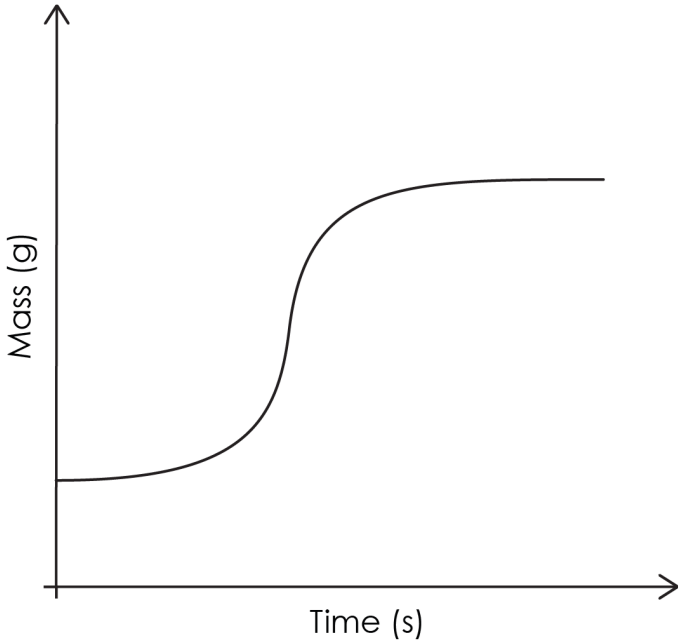
- A **trend** is the general direction that data is moving in over time.
- When we analyse data, we notice if the data is generally increasing, decreasing or staying the same.
- If we heat a beaker of water with a Bunsen burner, we know that the temperature of the water will increase over time. This is an **upward trend**.
- If we place a hot beaker of water in a fridge, we know that the temperature of the water will decrease over time. This is a **downward trend**.

Looking for patterns and trends in our data helps us understand what is happening in chemical reactions.

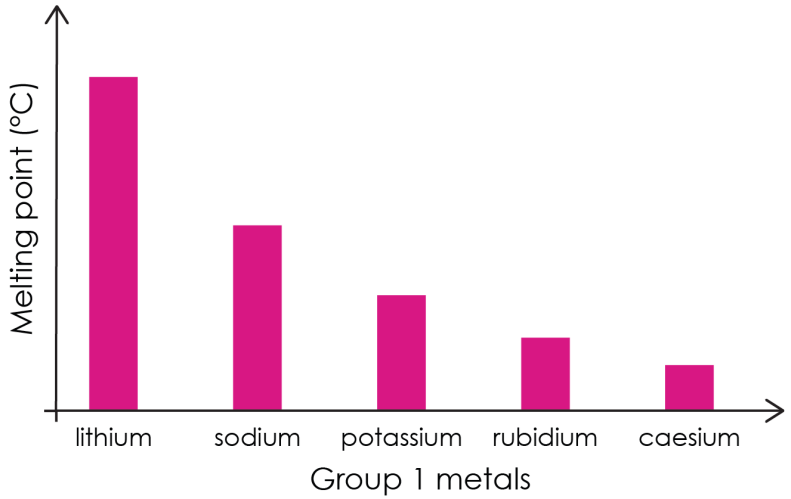
Pattern or trend?

Look at each graph. Decide if it shows:

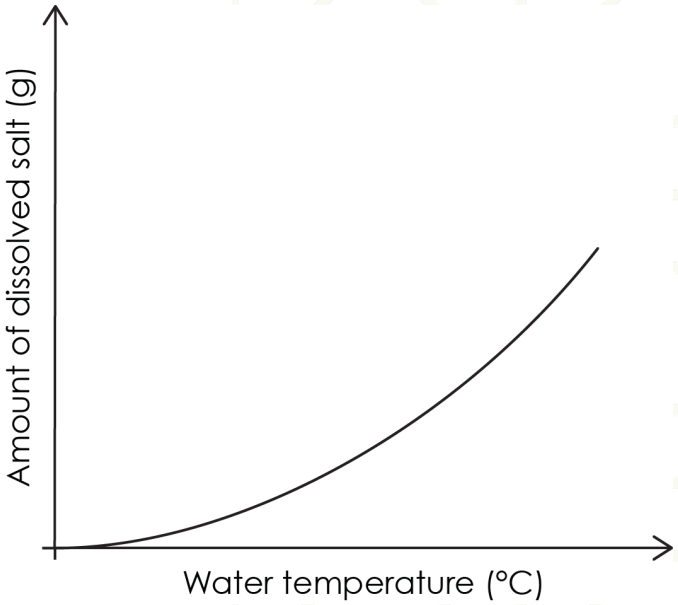
- a pattern
- a trend
- both



A.



B.



C.

Activity

Pattern or trend? Answers

A. It is a trend because it is happening over time.

B. It is a pattern but not a trend. It is a consistent relationship between the melting point and group 1 metals.

C. It is a pattern but not a trend. It shows a clear relationship between the two variables – water temperature and solubility.

Variables and tables

Activity

A variable is something that can change or be measured in an experiment.

Identify the different types of variable in this experiment:

A student investigates how the temperature of water affects how much salt can be dissolved in it.

- What is the independent variable?
- What is the dependent variable?
- What variables should be controlled?

Design a suitable table to record the results for this experiment.

From table to graph

In maths we record data in tables. This data forms coordinates or ordered pairs which are plotted onto a graph to see if there are any trends or patterns.

Data table

Temperature (°C)	Amount of salt dissolved (g /100 g of water)
20	32
40	44
60	61
80	83

Ordered pair

Each row forms an (x, y) coordinate

(**20**, **32**)
(40, 44)
?
?

What are the missing coordinates?

Plotting

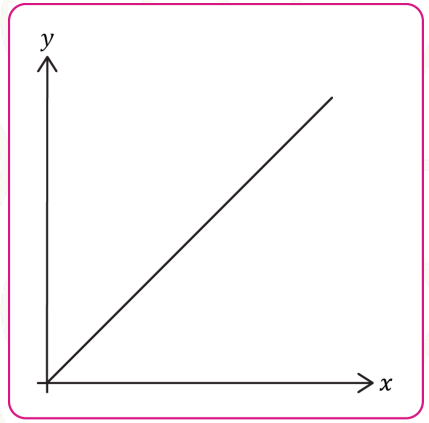
Plot the x value (20) on the x-axis. Plot the y value (32) on the y-axis.

Proportional

In maths, we can describe relationships between variables as directional proportional or inversely proportional.

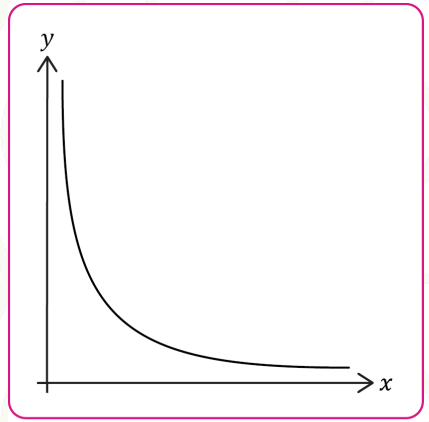
Directly proportional

- The variables move in the same direction at a constant rate.
- As one variable increases then the second variable will also increase proportionally. If one variable doubles, then the other will also double.
- On a graph, this is a straight line passing through the origin.



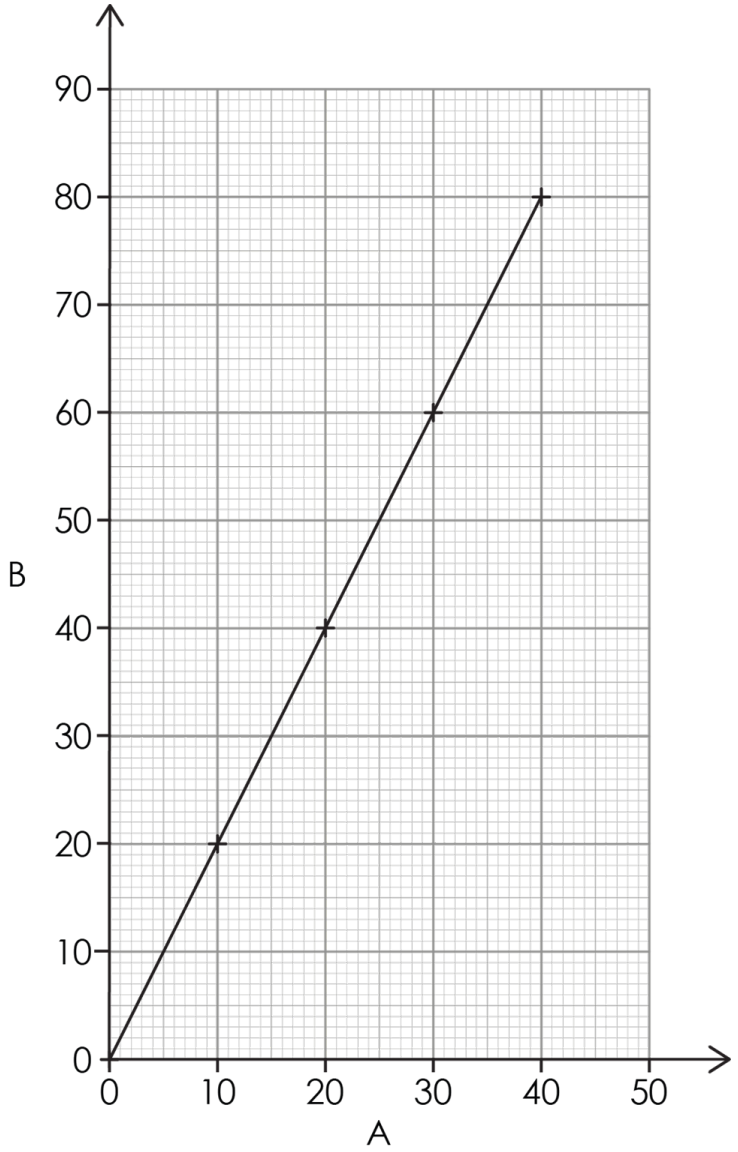
Inversely proportional

- As one variable increases, the other variable will decrease in a specific way. If one variable doubles then the other will halve.
- The data will form **a curve** rather than a straight line which never touches the axes.



Relationships between the variables 1

Describe what you see.

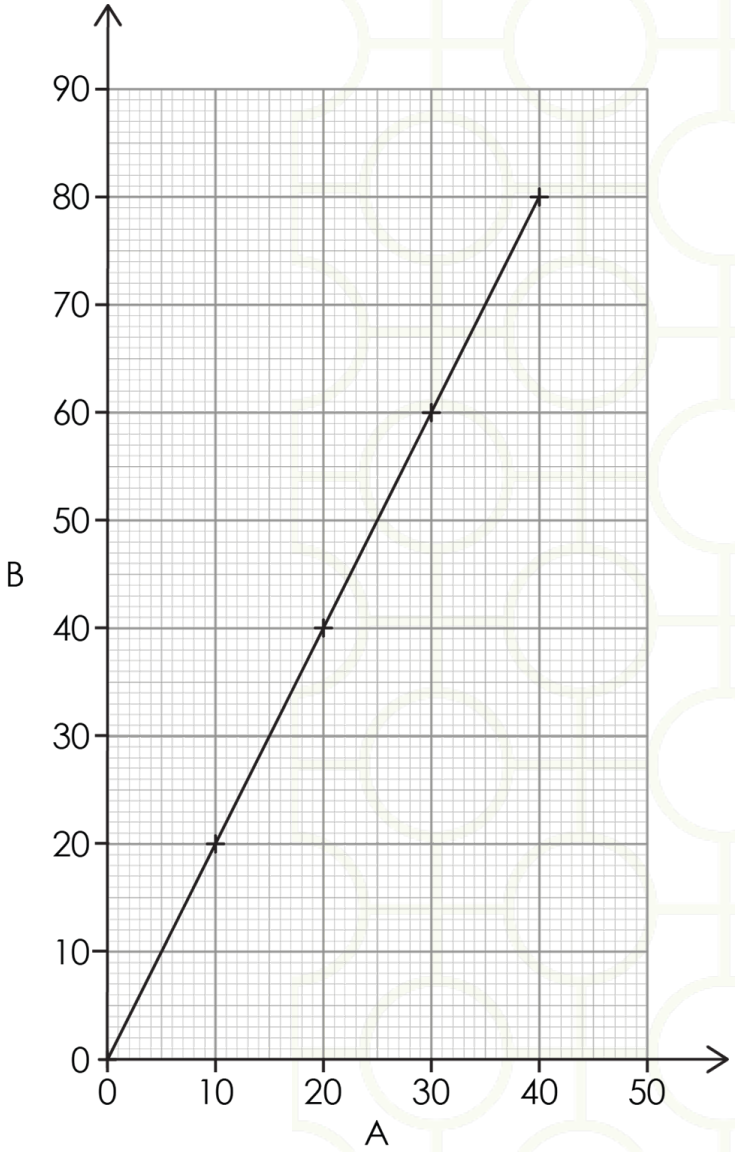


Activity

Relationships between the variables 1 – answers

Answers

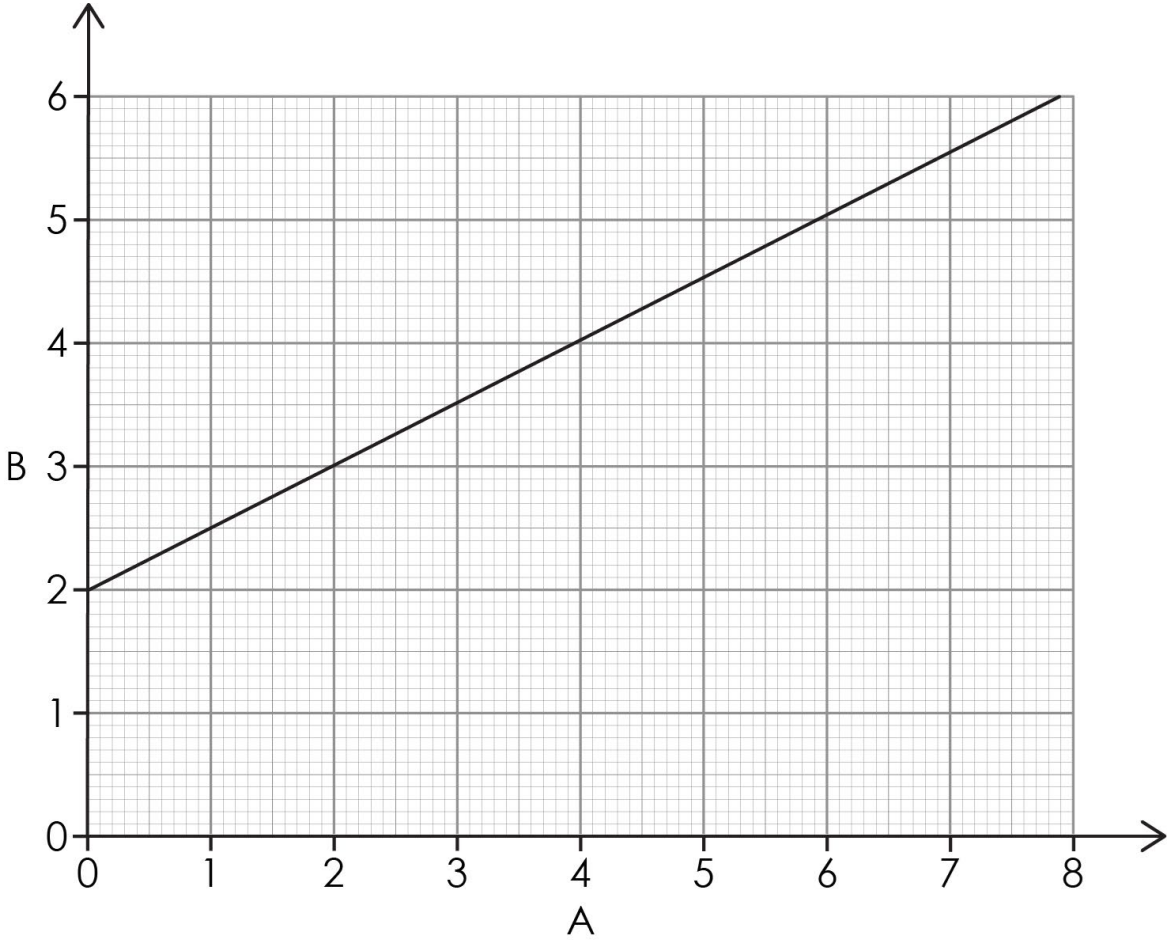
- As A increases, so does B.
- There is a positive correlation between A and B.
- The variables are directly proportional because it is a straight line passing through the origin.
- This is a linear relationship.



Relationships between the variables 2

Activity

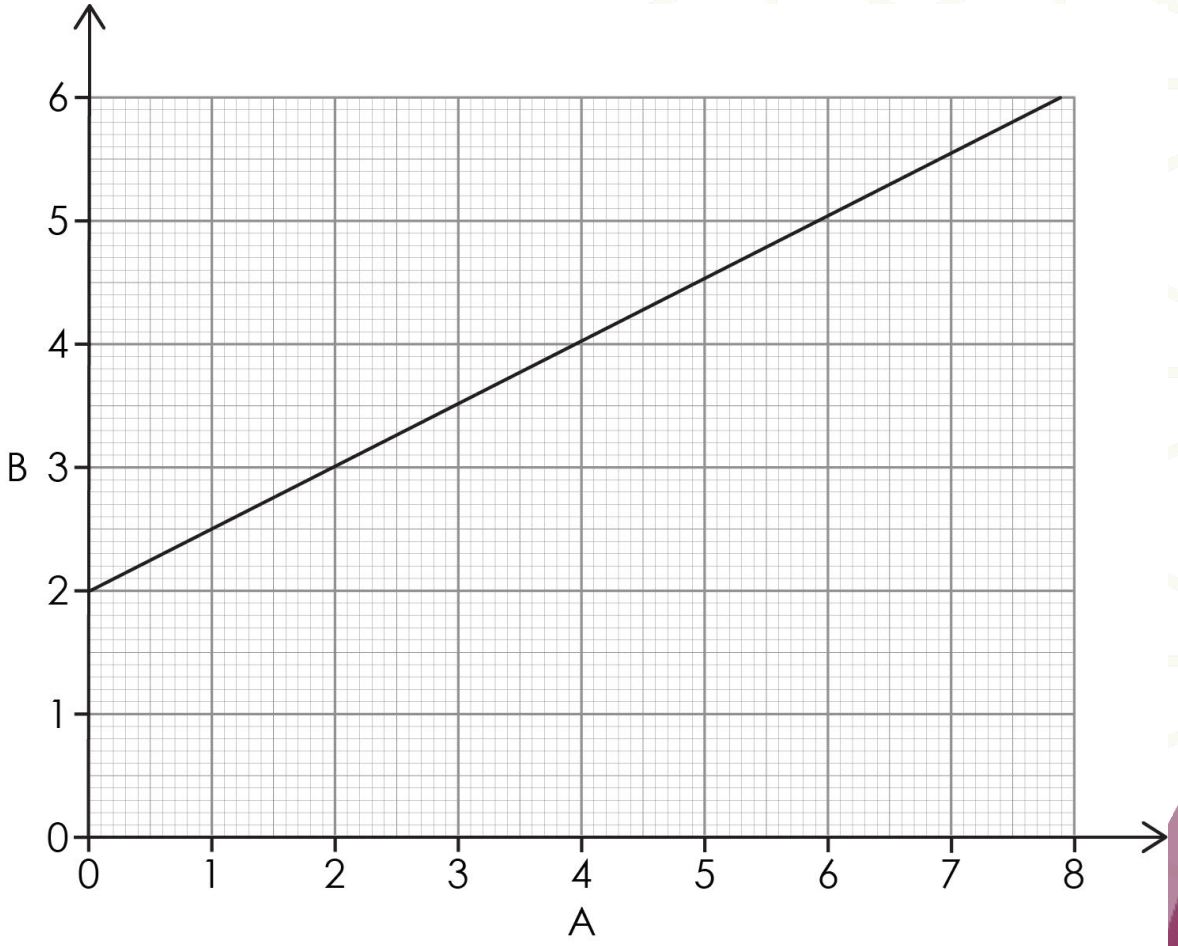
Describe what you see.



Relationships between the variables 2 – answers

Answers

- Both variables increase.
- As A increases so does B.
- There is a positive correlation between A and B because there is an upward trend.
- This is a linear relationship because an equal change in one variable corresponds to an equal change in the other variable.



Relationships between variables 3

Activity

Look at the table of data.

a) Is this bivariate data?
b) What is the trend being shown?
c) What happens to B when A increases?
d) Is this a linear or non-linear relationship?
e) Between A = 4 and A = 8, the value for B drops by 30. What happens to the value of B between A = 20 and A= 24?
f) What type of relationship is shown here?

Variable A	Variable B
4	60
8	30
12	20
16	15
20	12
24	10
40	6

Relationships between variables 3 – answers

Answers

Look at the table of data.

a) Yes – there are two variables (A and B).

b) B decreases rapidly at first, then more slowly.

c) Downward/decreasing trend.

d) Non-linear – the points form a curve, not a straight line.

e) B drops by 2 (much less than the 30 at lower values).

f) Inversely proportional – when A doubles, B halves.

Variable A	Variable B
4	60
8	30
12	20
16	15
20	12
24	10
40	6

Writing a conclusion

After we have analysed the data from an experiment we write a conclusion.

A good conclusion will:

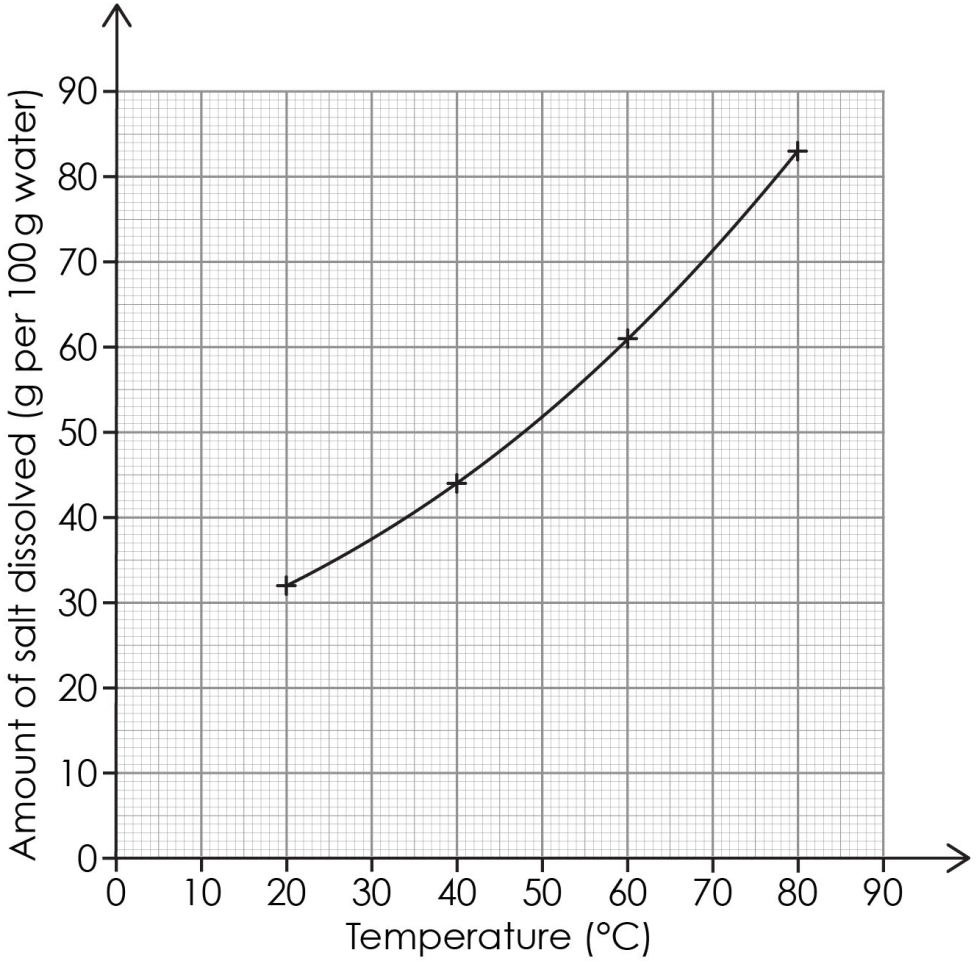
- describe any pattern or trend clearly
- state the relationship between the variables
- include actual data
- explain what has happened.

Write a conclusion for this bivariate data.

Temperature (°C)	Amount of salt dissolved (g/100g of water)
20	32
40	44
60	61
80	83

a) Draw a graph.
b) Is there a pattern?
c) Is it a linear or curved relationship?
d) Why does this pattern occur?

Writing a conclusion – example graph



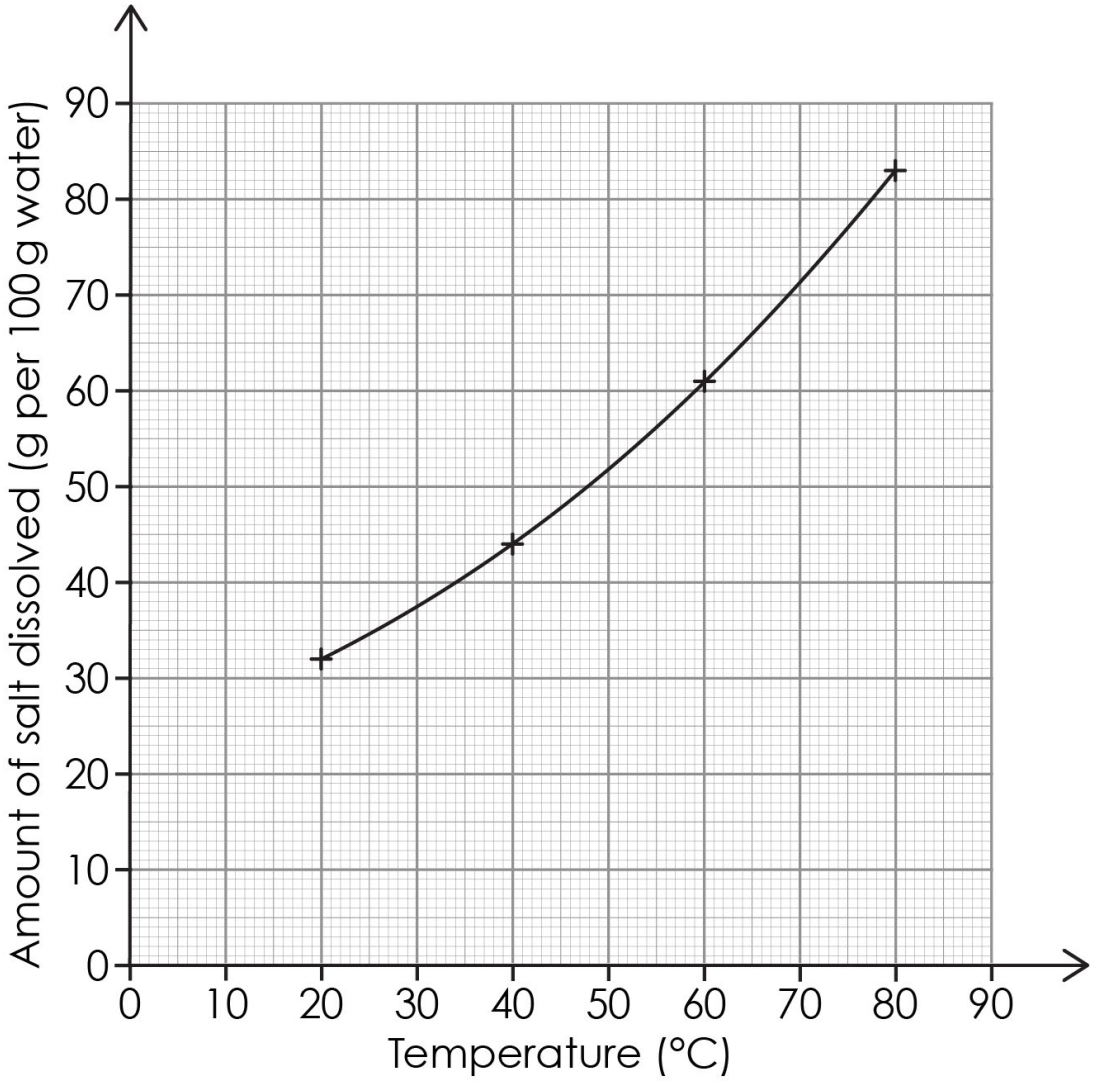
Write a conclusion for this bivariate data.

Temperature (°C)	Amount of salt dissolved (g/100g of water)
20	32
40	44
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80	83

a) Draw a graph.
b) Is there a pattern?
c) Is it a linear or curved relationship?
d) Why does this pattern occur?

Answer

Writing a conclusion – writing frame

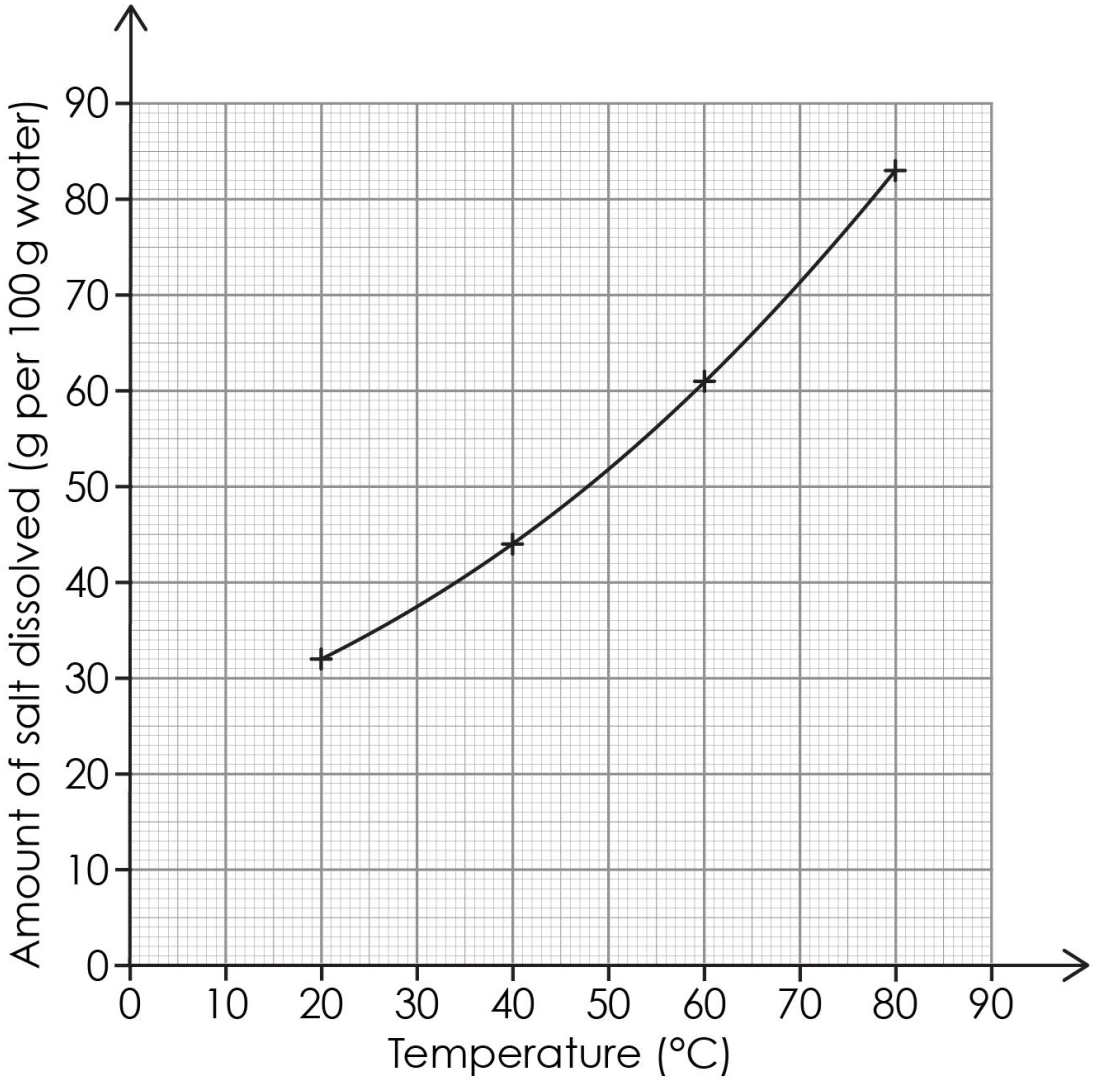


The graph shows that as _____ increases, _____ also increases.

This is a linear/nonlinear relationship. The points form a _____ showing the increase in amount dissolved was not _____.

Answer

Conclusion



The graph shows that as temperature increases, the amount of salt dissolved also increases.

This is a nonlinear relationship. The points form a curved line, showing the increase was not at a constant rate.

Answer

Returning to the lesson question

A learner carried out an investigation to see how the concentration of hydrochloric acid affected the volume of gas collected in 60 seconds during a reaction.

Here are the results:

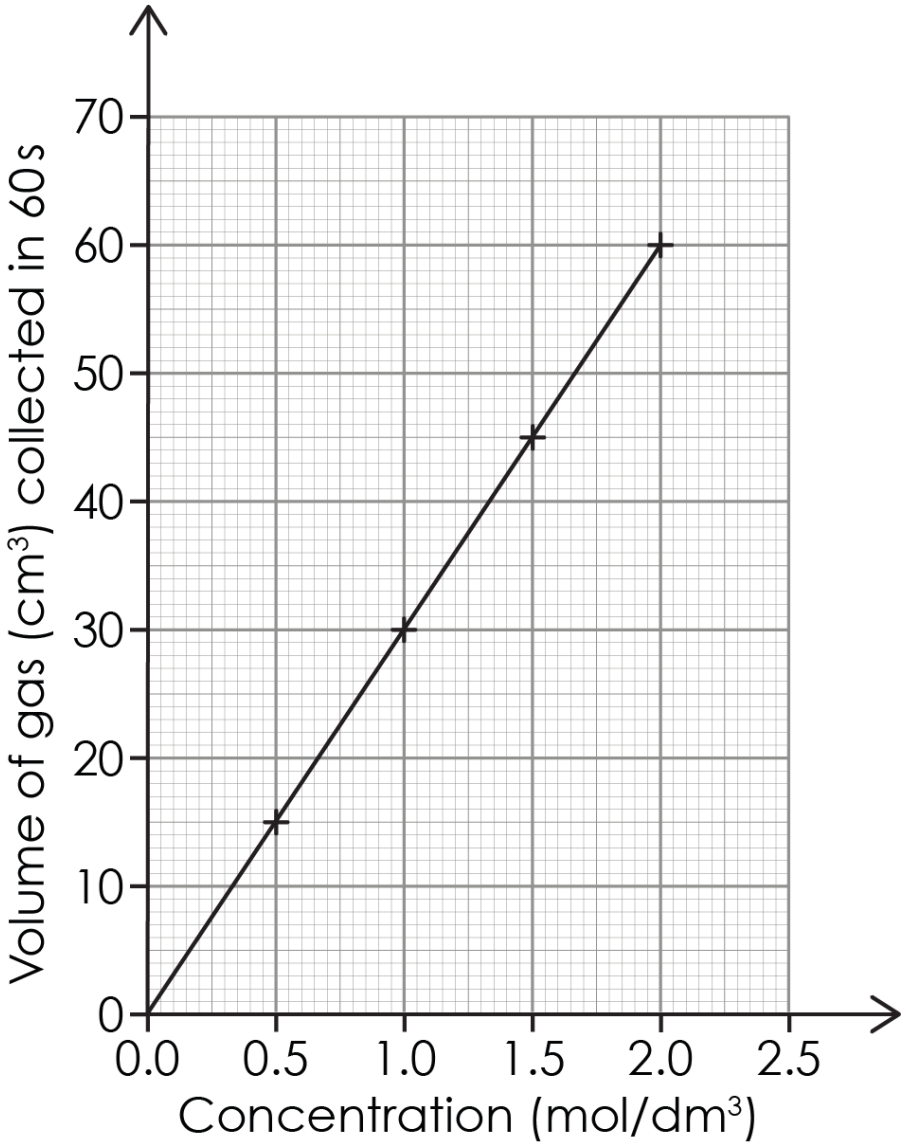
Concentration (mol/dm^3)	Volume of gas (cm^3)
0.5	15
1.0	30
1.5	45
2.0	60

a) Plot a graph of the **bivariate** data.
b) Describe the **pattern** seen.
c) What is the relationship between the **variables**?
d) Write a **conclusion** for this investigation.

Lesson question

Returning to the lesson question – answer a

a)



Returning to the lesson question – answers b–d

b) As concentration increases the volume of gas increases. When the concentration doubles then the volume of gas doubles.

c) The relationship is linear because the points form a straight line. It is directly proportional because the line passes through the origin.

d) The volume of gas produced is directly proportional to the concentration of acid used. When concentration doubles from 0.5 to 1.0 mol/dm^3 the volume of gas doubles from 15 cm^3 to 30 cm^3.