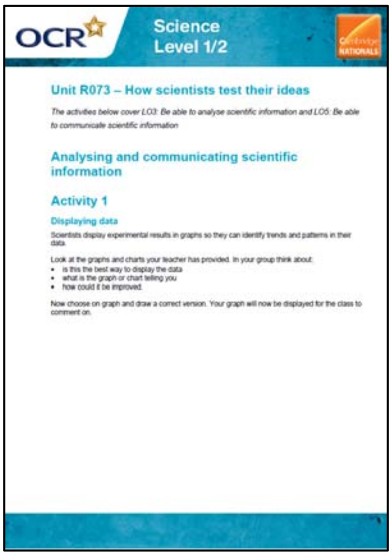
Unit R073 – How scientists test their ideas

Analysing and communicating scientific information

Instructions and answers for teachers

These instructions should accompany the learner tasks - OCR resource 'Analysing and communicating scientific information', which supports Cambridge Nationals in Science Level 1/2 Unit R073 – How scientists test their ideas.

The learner tasks cover LO3 – Be able to plan a scientific investigation and LO5 – Be able to communicate scientific information.



Science
Level 1/2

Unit R073 – How scientists test their ideas

The activities below cover LO3: Be able to analyse scientific information and LO5: Be able to communicate scientific information

Analysing and communicating scientific information

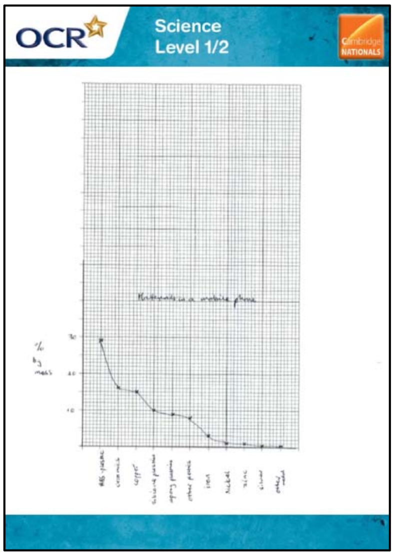
Activity 1

Displaying data

Scientists display experimental results in graphs so they can identify trends and patterns in their data.

Look at the graphs and charts your teacher has provided. In your group think about:
- is this the best way to display the data
- what is the graph or chart telling you
- how could it be improved.

Now choose on graph and draw a correct version. Your graph will now be displayed for the class to comment on.



Associated Files:
Analysing and communicating scientific information
Graphs handout

Expected Duration:

Activity 1a – 15 minutes
Activity 1b – 15 minutes
Activity 1c – 10 minutes
Activity 2 – 1 hour
Activity 3 – 1 hour

Activity 1

Displaying data

Scientists display experimental results in graphs so they can identify trends and patterns in their data.

Look at the graphs and charts your teacher has provided. In your group think about:
- *is this the best way to display the data*
- *what is the graph or chart telling you*
- *how could it be improved.*

Now choose on graph and draw a correct version. Your graph will now be displayed for the class to comment on.

Introduce the need to display results appropriately so that trends and patterns can be identified more easily. Use the whiteboard to display bar charts and line graphs. Key points here are for learners to understand that:

- bar charts are only suitable for discrete data
- the independent variable is plotted on the x axis
- the line of best fit could be straight or a curve depending on data.
- for some experiments joining the points together is more appropriate e.g. enzymes.

Students PEE (point, evidence, explain) what information is given, is the format suitable and how could it be improved working in groups of three. Each group then provides feedback to the class on one graph and provides a “correct” version. All correct versions can then be displayed for future reference.

Materials required

A range of different graphs and bar charts illustrating good and bad practice. Ensure that at least one illustrates that the line of best fit may not go through the origin.

Examples are provided as an appendix to this document.

Graph paper for student use.

Activity 2

How useful is my data?

This task links to R071 LO2.

A student is concerned about the effects of radioactivity. He wants to find out if there is a link between the activity of a radioactive source and the time that the source has been decaying.

The student uses a GM tube and counter to measure the count rate from protactinium (a radioactive source).

The results of the experiment are given below

Time of decay in seconds	***Number of counts in 10s***			***Mean count in 10s***
	Trial 1	***Trial 2***	***Trail 3***	
0	*66*	*65*	*67*	
30	*52*	*55*	*53*	
60	*39*	*38*	*41*	
90	*27*	*29*	*30*	
120	*23*	*24*	*24*	
150	*16*	*17*	*17*	
180	*14*	*13*	*13*	
210	*12*	*12*	*11*	
240	*11*	*11*	*10*	
270	*8*	*7*	*8*	
300	*9*	*8*	*9*	

- *Complete the results table.*
- *Plot a graph of the mean count against the time of decay.*
- *Choose suitable scales and label the axes.*
- *Now plot the highest and lowest count at each decay time and join these points with a vertical line.*
- *Complete the graph by drawing a suitable line.*

The aim of this task is for students to appreciate that more information can be obtained from a graph by applying certain techniques.

The use of range bars can be introduced as a way of looking at the precision of the data. This is one way of considering the level of uncertainty of the data.

The rate can also be obtained by calculating the gradient of a graph.

The closeness of the points to a line of best fit can also be used to consider level of uncertainty and may identify anomalous results.

For this task the results of an investigation are provided. Teachers may wish to demonstrate the investigation but it is not necessary.

Sample results

Time of decay in seconds	Number of counts in 10s			Mean count in 10s
	Trial 1	Trial 2	Trail 3	
0	66	65	67	66.0
30	52	55	53	53.3
60	39	38	41	39.3
90	27	29	30	28.7
120	23	24	24	23.7
150	16	17	17	16.7
180	14	13	13	13.3
210	12	12	11	11.7
240	11	11	10	10.7
270	8	7	8	7.7
300	9	8	9	8.7

Activity 3

What is the relationship between the temperature of the Haber Process and the yield of ammonia produced?

This task links to R071 LO7.

A chemical engineer wants to know whether she can improve the efficiency of a Haber Process plant. She varies the temperature at which the reaction to make ammonia takes place. The process is run at five different temperatures. Each time the engineer dissolves the ammonia produced in water. These samples of ammonia solution can then be titrated with hydrochloric acid to find out the concentration of the ammonia.

The table below shows the temperature she used for the five samples.

Sample of ammonia solution	Temperature of Haber Process in °C
1	550
2	500
3	450
4	400
5	350

Method

You will be using samples of the ammonia solutions numbered 1 – 5.

1. *Using a measuring cylinder or pipette, measure 25cm^3 of the first ammonia solution into a comical flask.*
2. *Add a few drops of a suitable indicator e.g. methyl orange*
3. *Set up the burette and fill it with the dilute hydrochloric acid provided.*
4. *Add the acid from the burette carefully until the indicator just changes colour from orange/yellow to pink.*
5. *Record the volume of acid used in the titration.*
6. *Repeat this titration twice more.*

7. *Now repeat the whole experiment using each of the solutions of ammonia.*
8. *Record your results in a suitable table.*

- *Work out the mean volume of acid used to neutralise the ammonia at each temperature and put your results in your table.*
- *Draw a graph of volume of acid used against temperature of the Haber process. Make sure you choose suitable scales, label the axes and complete the graph with a suitable line.*
- *Describe any pattern in your results.*
- *Write about any unexpected results.*

To find out whether she can improve the efficiency of the Haber process plant the engineer needs to know the yield of ammonia at each temperature.

If the Haber process had converted all of the reactants to ammonia (100% yield) then the solution would have needed 95cm^3 of acid to neutralise it.

The % yield of ammonia can therefore be worked out using the formula:

$$\% \text{ yield} = \frac{\text{actual volume of acid needed} \times 100}{\text{volume of acid needed for 100\%}}$$

- *Calculate the % yield of ammonia for each temperature.*
- *Write a report for the engineer explaining how she can improve the efficiency of the Haber process plant.*

Students work in groups to collect data. They are then required to display the data in an appropriate table, calculate the mean and draw a graph.

They will be able to identify trends, relationships between variables and consider the uncertainty of the data.

More able students will also be able to calculate the % yield.

This experiment will provide another opportunity to consider risk assessment if required.

Students are provided with 5 different concentrations of ammonia solution labelled 1 –5, representing ammonia made at different temperatures. Students titrate with hydrochloric acid.

Materials required

standard titration equipment: burette + clamp stand, measuring cylinder or pipette, conical flask, funnel

0.1 mol/dm^3 hydrochloric acid

methyl orange or screened methyl orange

5 different concentrations of ammonia – see table below

Target molarity in mol/ dm^3	Volume of 1 mol/dm^3 ammonia in cm^3	Total volume of solution in dm^3
0.2	200	1
0.14	140	1
0.1	100	1
0.08	80	1
0.06	60	1

Guidance notes

The 5 different concentrations of ammonia solution need to be made up as precisely as possible. The stock solution of 1 mol/dm^3 ammonia needs to be freshly prepared from diluting 57cm^3 of 35% (0.880) ammonia and making up to 1 dm^3.

The colour change for methyl orange is orange/yellow to pink and for screened methyl orange it is green/grey to purple.

Sample results

Temperature of Haber Process in °C	Sample number	Volume of acid used in titration in cm^3		
		Attempt 1	**Attempt 2**	**Attempt 3**
550	1	15.1	14.9	15.0
500	2	19.8	20.0	19.9
450	3	25.0	25.1	30.6
400	4	35.1	34.9	35.0
350	5	50.2	50.0	50.2

A chemical engineer wants to know whether she can improve the efficiency of a Haber Process plant. She varies the temperature at which the reaction to make ammonia takes place. The process is run at five different temperatures. Each time the engineer dissolves the ammonia produced in water. These samples of ammonia solution can then be titrated with hydrochloric acid to find out the concentration of the ammonia.

Top Tips for displaying data

1. Make sure before you start that you really know what data you are trying to display. Will you need to plot a bar chart or a line graph? Most experiments will need a line graph.
2. Which is the independent variable? This is the value you were choosing to change when doing an experiment. E.g. If you were investigating the effect of temperature on the release of a gas in a reaction then temperature would be the independent variable.
3. Which is the dependent variable? In the example above the release of the gas is the dependent variable.
4. The independent variable is always plotted on the x axis (the horizontal axis).
5. The dependent variable is plotted on the y axis (the vertical axis).

6. Now look at the values you have for both variables. What is the lowest and highest? You now need to select an appropriate scale for each axes. Remember your graph should cover at least half a page of graph paper.
7. Draw a line for each axis and label it. Put in the values for each axis. Write a title on your graph.
8. Now plot you points. Be as accurate as you can. Mark the points with either a small cross or a clear dot. Check you plotting to make sure they are correct.
9. If you are going to use range bars then you mark with a short horizontal line the highest and lowest value for each point with a small dot on the line for the mean value.
10. Draw a line of best fit through your results. The experiment you are doing may require you to join the plotted points together – check with your teacher. Remember the line of best fit could be a straight line or a curve.
11. If you have a point which looks way out – it may be an anomalous result and should not be included in the line of best fit.
12. You should have a minimum of 5 points to plot.