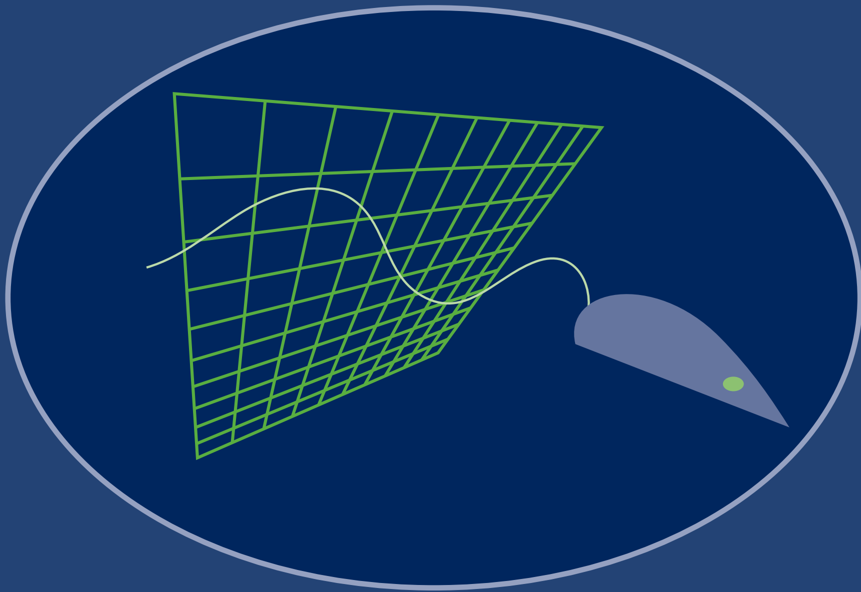
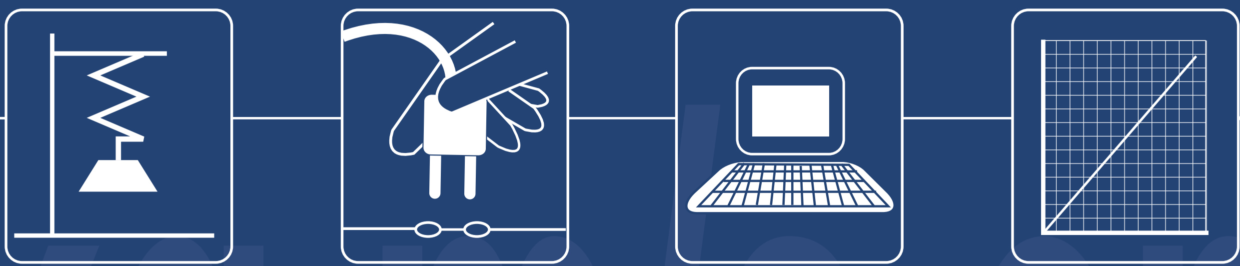
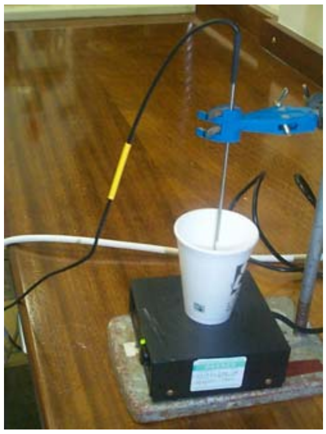


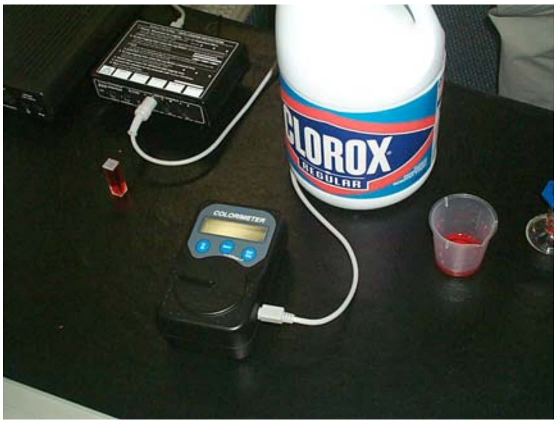
Datalogging in Practice



Roger Frost

Definitive guides





 www.organic.rogerfrost.com

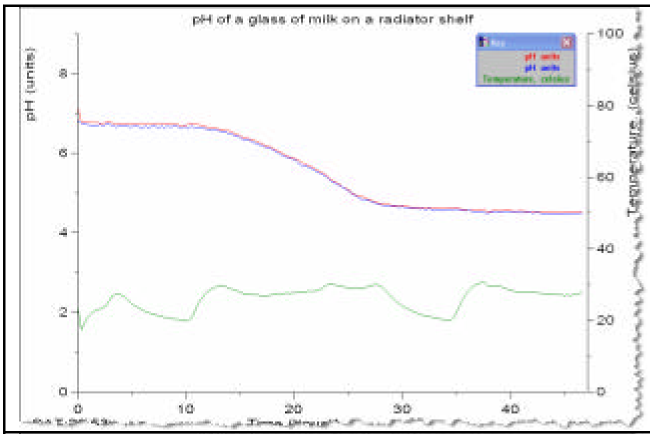
01763 209109

Lipase turns milk fat to acid

Here we monitor an enzyme catalysed reaction. We use a pH probe to detect an increase in fatty acids. Two pH probes allow us to compare rates with and without 'bile' as emulsifier. Washing up liquid is a good substitute for 'bile'. Cream, alkalinised to pH 8 using sodium carbonate, is the milk fat source. Lipase from www.ncbe.reading.ac.uk

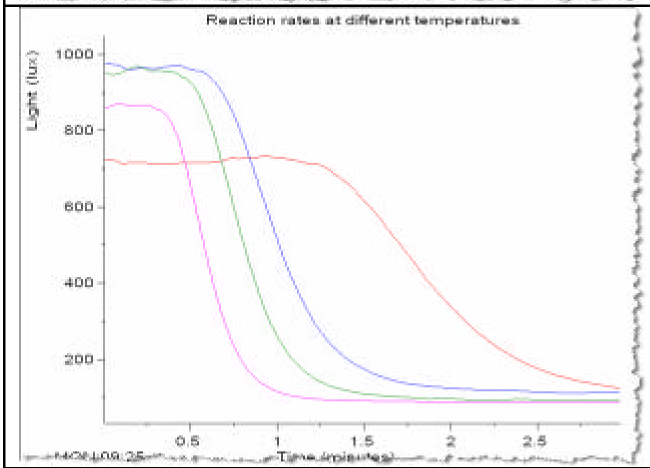
Settin g up

1. Plug two pH sensors into the data logger. Restart the software.
2. Check that you have two clean pH probes that give similar pH readings in water – and that these are steady. Change the probes or move clear of electrical interference if they are.
3. Set the software to record for 30 minutes
4. Place a pH electrode in a boiling tube with 5ml of alkaline cream. You need two of these.
5. Put the tubes in a warm place.
6. Start recording and check that you *are* recording for goodness sake
7. Add two drops of 'bile' to one tube. Or try something else.
8. Add 5 ml 2% well-mixed, lipase suspension to both tubes. Mix well.
9. Sketch the graph you expect to see.
10. Save the result. Copy the graph to a PowerPoint slide.Label the graphs.



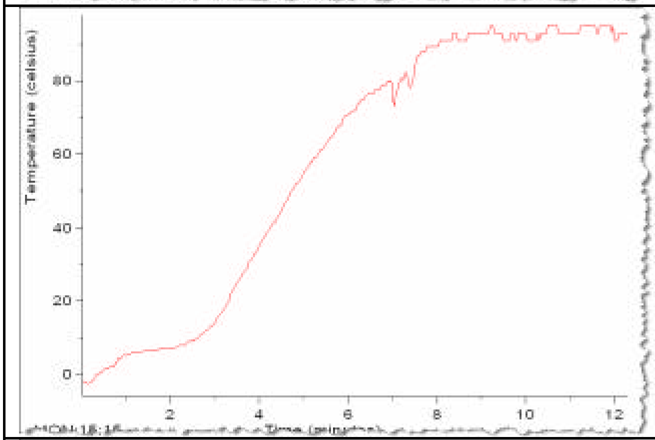
Concepts: digestion, enzymes

Milk as it sours - File: Enzymes - Milk ***



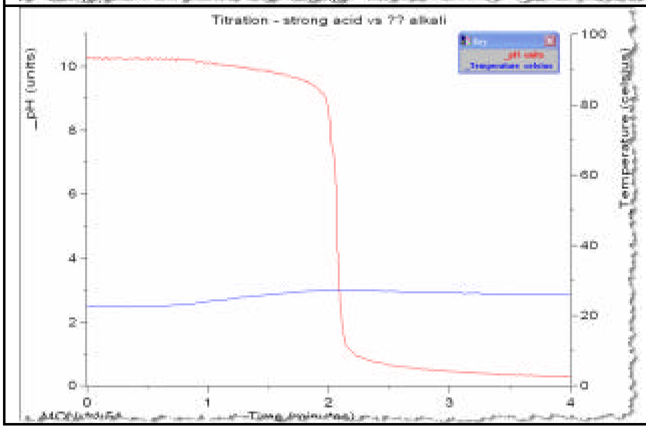
Concepts: reactions, reaction rates

Rate of reaction – File: Rates - Thio ***



Concepts: change of state, particles

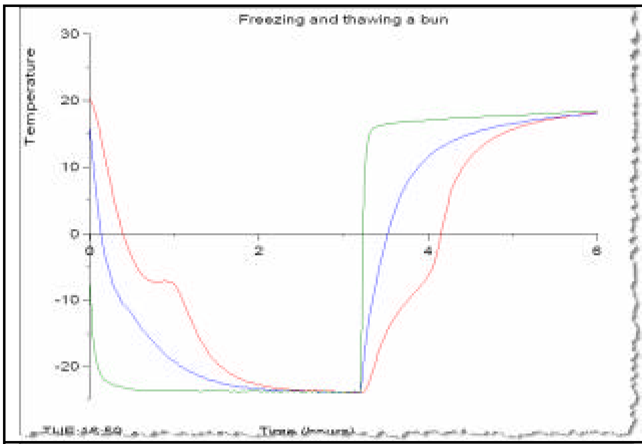
Ice heated - File: Melting point - ***



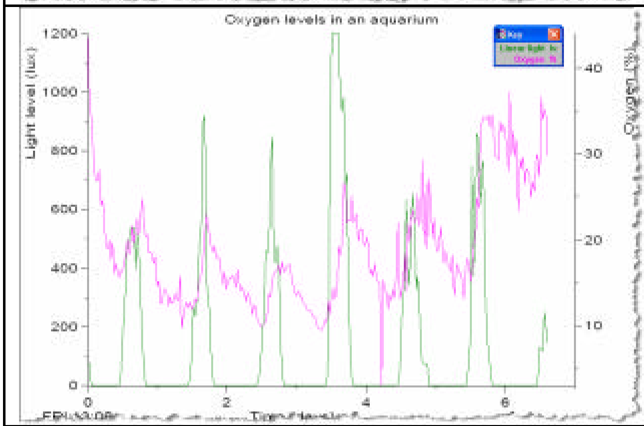
Concepts: acids, bases, pH, neutralisation

Acid drips into alkali - File: Acids - ***

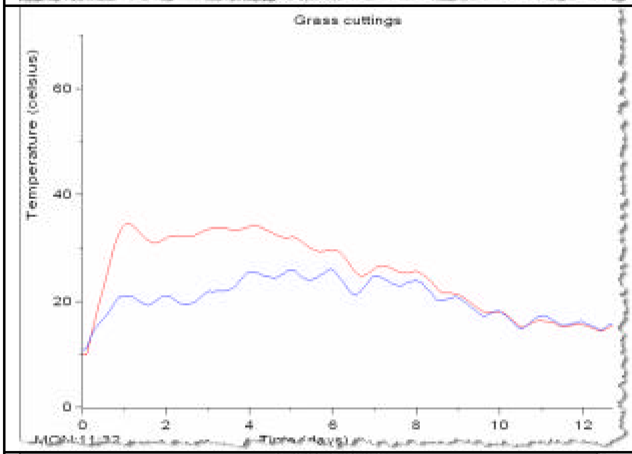
Handling data from experiments – www.rogerfrost.com



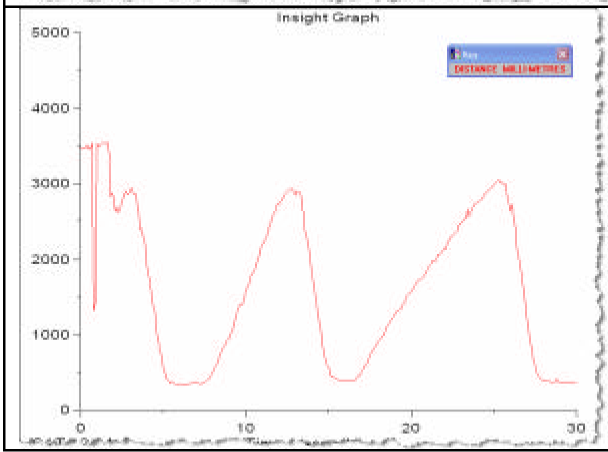
Concepts: change of state, latent heat
Freezing a bun - File: Latent heat - bun ***



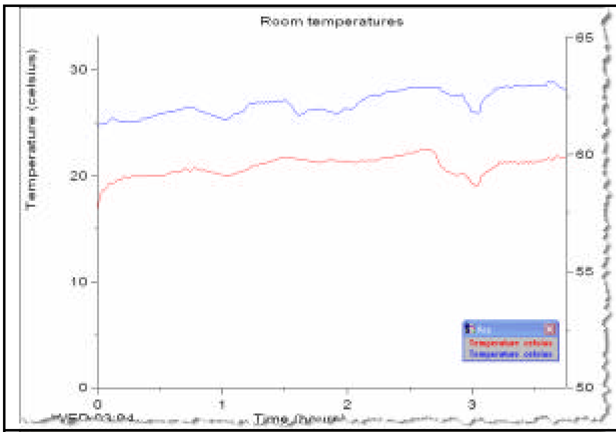
Concepts: photosynthesis, environment
Elodea in a tank - File: Photosynthesis - Aquarium



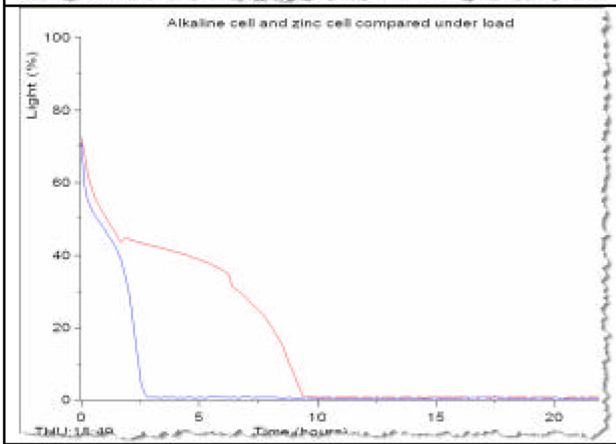
Concepts: fermentation
Grass ferment - File: Environment - Grass ***



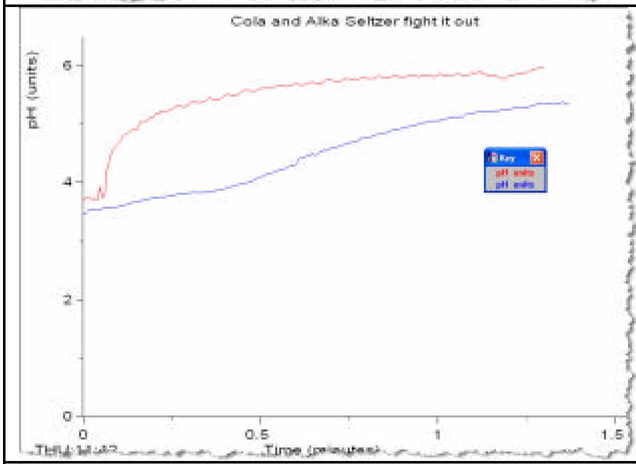
Concepts: distance – time graph; speed
Walking to distance sensor - Lost File: xxx distance.sid



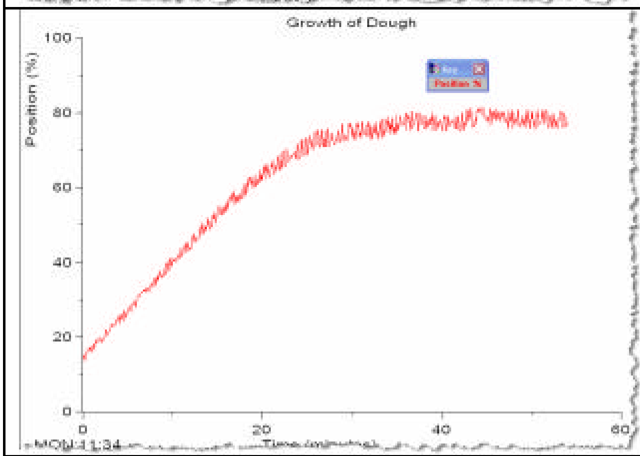
Concepts: measurement; environment
Room temperatures inside and outside - File Environment - Temperatures in a Room.sid



Concepts: electrical circuits; cells
Two batteries work to exhaustion
Electricity - Batteries.sid



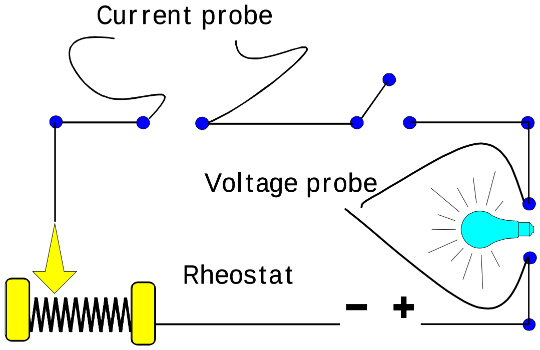
Concepts: acids, bases, pH, neutralisation
Alkaseltzer in Cola - Lost File: xxx cola.sid



Concepts: useful microorganisms; enzymes; reactions
Rise of bread dough - File: Yeast - dough.sid

Current, voltage and electrical components - teacher

This demonstration is about the way that current varies with voltage in resistors, filament bulbs, diodes, light dependent resistors and thermistors.

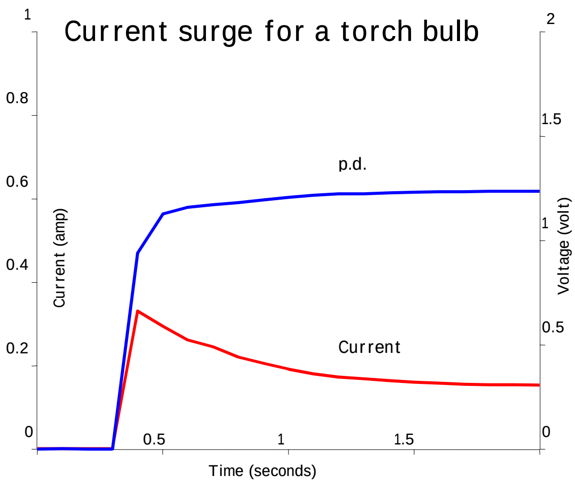


What you need

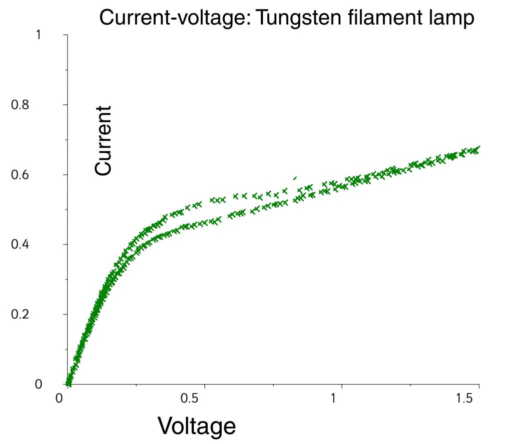
Lamp (3.5V), cell, silicon diode, 10 ohm resistor, rheostat, wires, sensors to measure amps and volts.

What to do

- How does a fuse work? How do fuses vary? Why do mains lamps, like the OHP bulb, tend to blow when switched on? Discuss your ideas for a few minutes.
- Look at the current surge when a lamp is switched on. Set up a 3.5V lamp in series with a toggle switch, a cell and current measuring sensor. Record the current surge.



- What might cause the surge? Recall Ohm's law: if the voltage is the same, what must have changed?
- Set up a circuit to record the current and voltage for the lamp. Use the rheostat as a potential divider and monitor current and voltage. Move the slider up and down once over 10 seconds and the lamp will brighten and dim. Discuss the result.



- Plot current over voltage. As a low voltage changes to high, note how rapidly the current increases. Current is on the y-axis because it is the dependent variable (in the previous lesson you plotted voltage against current).
- Keep the axis as they are, start recording and move the slider up and down as before. You will see two separate lines.
- Repeat for a resistor and a diode.
- Draw current-voltage curves for a lamp, resistor and diode. Under each graph explain the differences between them.

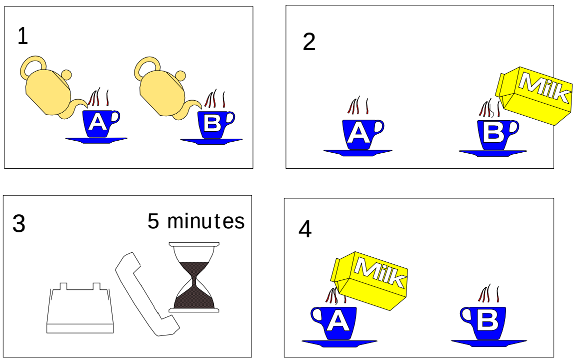
Extra

- How can we reduce current surge? (The answer is in the type of switch).
- There are two lines for the current – voltage plot for a tungsten lamp. One line is for the bulb coming on. What is the other line? Why are there two lines?
- What might a resistor be useful for?
- What might a diode be useful for?

Teachers note – see over

Cooling - the coffee quandary

This exercise shows you how to handle data and illustrates some ideas about hot and cold things cooling.
The telephone rang as you made a coffee. Should you add the milk now or when you finish the call? One answer is to make a guess and hope you're right. Another is to deal with it scientifically and do an experiment.



What you need

2 x 250 cm^3 beakers, 2 x 10 cm^3 beakers, 100 cm^3 measuring cylinder, 2 x temperature sensors, clamps and stand to hold probes.

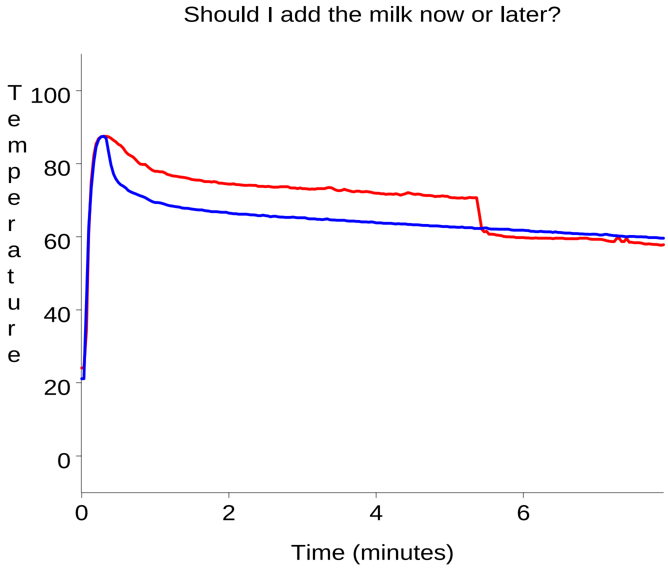
What you could do

Boil the kettle. Put a temperature sensor into each of two cups and start recording. Pour hot water into the cups and add milk to one of them. About five minutes later add milk to the second cup. After a few more minutes of recording save the results on the computer. Do not stir the cups.

Teachers note

This exercise is an introduction to handling data and investigating heat loss. A version, with a results file, can be found at Schools Online Science at Sheffield Hallam University. Find the Internet link at *www.rogerfrost.com*.

Results



Open the results file in your software to answer the following questions.

1. At what time did I add the hot water to the cups?
2. At what time did I add the milk to the first cup?
3. At what time did I add the milk to the second cup?
4. Which graph line shows the cup where I added the milk after a call?
5. Look back at the problem. If I wanted cooler coffee, would it be better to add the milk before, or after the call?
6. Take readings from the graph to see how much of a temperature difference this makes? What do you think? Was it worth the trouble?
7. Do you think I should have stirred the cups?
8. As a good kitchen scientist, I made sure the experiment was done very scientifically. List things that I must have done that I didn't tell you about.

What you might find out

- Would it be better to pour the water from the kettle before, or after taking the call?
- Which cools faster in the fridge, a bowl of warm jelly or a bowl of hot jelly?

Goldilocks & the three bears

To recap on the story: father bear's porridge in a large bowl was too hot, mother's was middling hot, but the porridge in baby bear's small bowl was just right. Why should that be?

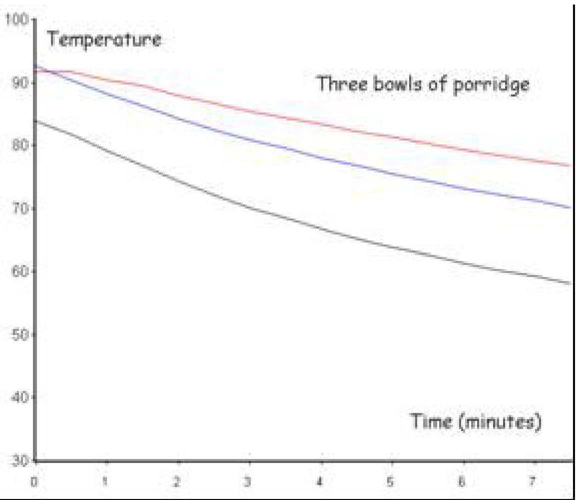
What you need

Three cereal bowls or beakers of different sizes, hot water and three temperature sensors.

What to do

Suspend the temperature probes in the cereal bowls or beakers with a clamp or masking tape.
Fill each container with hot water (or porridge). Place in a large bowl of hot water to equalise the temperatures.
Measure the temperatures over 15 to 20 minutes.

Results



The graph here shows a result of the Goldilocks and the three bears story - try these questions:

1. Which graph shows the cooling of the large bear's porridge? Add labels to the graphs to say which trace is which.
2. How do you know that the bowls of porridge all cooled from the same starting temperature? What could have been done about this?
3. Replay the experiment by moving a cursor over the graph, then ask: How do the graphs show that the bowls cool at different rates?
4. There are several ways to show how the bowls cool differently. Your teacher will show you one of these ideas:
   - Measure how many degrees each bowl drops in temperature.
   - Measure how long it took for the temperature of each bowl to drop by 10 °C.
   - Measure the average temperature of each trace to show which stays hot the longest.

Extra

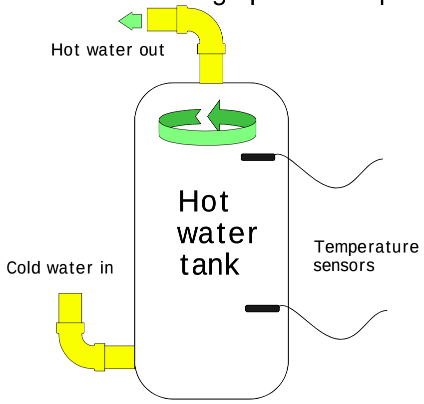
- Measure the area under each trace to show which stays hot the longest.
- Measure the average gradient (= the rate of change of temperature) of each trace.
- Fit a function (a line or a curve equation) to each trace and use an equation to give a measure of the cooling.
- Find an indication of Newton's law of cooling in the graph. In other words, can you fit a power regression line to the graphs here. You will see a better curve by changing the scale of the time axis.

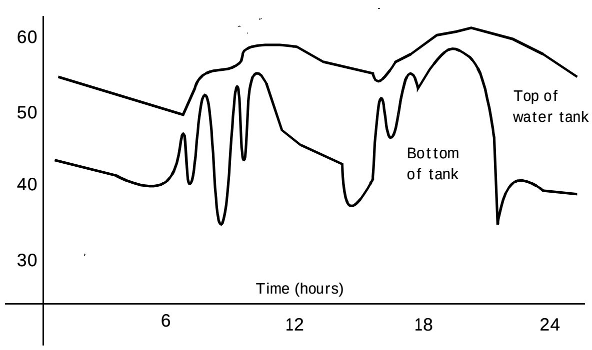
Teachers note

This experiment models the fable by monitoring the temperature of three containers of porridge. The lower trace is the cooling curve of the tiny bowl of porridge. One point in passing is that having taught students to religiously keep the variables in an experiment the same some insist on using the same amount of water in each beaker.
(Results by Peter Adams using Tain equipment and software - www.tain.com.au)

Heat - hot water tanks

Many houses keep a store of hot water in a tank. A separate boiler heats the tank for a while in the morning, and again in the evening. When someone draws hot water it leaves by a pipe at the top of the tank and is replaced by cold water which enters through the bottom. As part of a maths project, they recorded the temperature of the tank for a whole day. One temperature probe logged the temperature at the top of the tank, and one logged the bottom. The graph is shown here and the questions show how this scenario was used to introduce graphical interpretation.



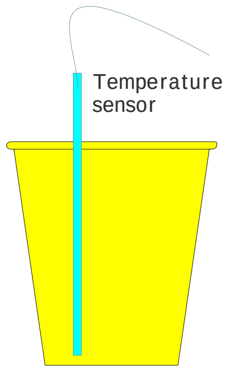


- At what time was the hot water first run?
- When is the demand for hot water heaviest?
- During which hours did the boiler work?
- Use the graph to suggest when the heating should best come on and go off.
- Why does one graph vary more that the other?

(Adapted from 'Everyday Graphs' at The Shell Centre, Nottingham University. Nice ideas at www.nottingham.ac.uk)

Cooling- do hot things cool faster?

A straightforward exercise that shows how fast things cool and leads into a topic on energy and insulation. Here you place hot and warm beakers of water in the freezer and measure the rate of cooling.



What you need

Freezer, up to 4 hours, plastic beakers with hot and warm liquid, two temperature sensors, tape to hold the probes, data logger and mains power adapter. Monitor the temperature for a few hours.

Results

The hot beaker cools faster - you can measure the rate of temperature change in a variety of ways - for example fit a line to the trace and read off the gradient. Whether it will freeze faster is another matter - just remember that you are measuring the performance of the freezer. For example, placing a hot liquid in a freezer may cause the thermostat to switch in and keep the compressor at work. In that sense a hot liquid could well freeze faster.

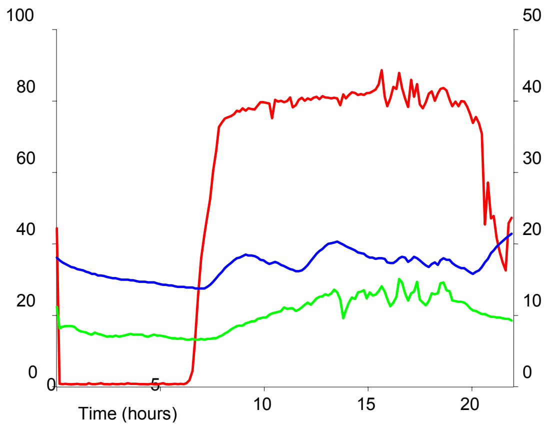
Heat - central heating

The time of year when the air temperature is at some extreme is a good time to use temperature probes to examine how well the heating (or cooling) system is working. For example, your school heating timer may be set to switch on a couple of hours before people arrive in school. This begs the question: what is the evidence to say when the system should switch on and off. Logging the room and the radiator temperatures over a day or so provides the answer.
The resulting graph can serve as an introduction to temperature and graphs. You can set questions about the graph for homework. If you have access to a computer suite the class might analyse the data as shown opposite.
This idea has been used on countless in-service data logging training courses. It gives confidence in collecting data away from the computer, in annotating graphs and in uploading data to the computer. Typically, we set up our data loggers in the hotel bar and measured temperature, light and sound levels through the evening. From these you might find the room warming up, the bell ringing for 'last orders'

What you need

A data logger, light sensor and two temperature sensors. The light sensor acts as a day / night marker and if you include a sound sensor you will gain an idea of when the room is occupied.

Results



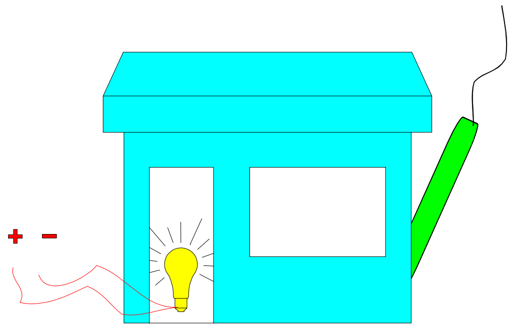
1. Study the graph and label the places when
   a) the heating switches on
   b) the room reaches a comfortable temperature
   c) the room is in use
   d) the heating switches off
   e) the room temperature falls to an uncomfortable level.
2. How long does it take for the room to warm up after the heating is turned on?
3. How long does it take for the room to cool down after the heating is turned off?
4. How long does it take for the people in the room to increase its temperature? Do you think people make useful heaters?
5. What advice would you give to the school administration about their heating policy?

Heat - keeping warm

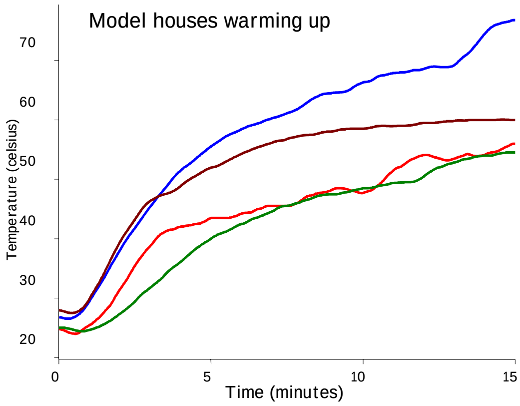
We need to keep our homes warm in cold weather and as economically as possible. There are ways to insulate your home and keep the heat in, and in this investigation you can try some out with cardboard model houses. Here you can see the effect of wall and loft insulation, as well as compare single and double glazed windows. For our model central heating systems we used electrical light bulbs. To measure how quickly the houses got warm, we used temperature sensors connected to the computer.

What you could do

Set up two single-glazed houses, one with loft insulation and one with loft and wall insulation.
Set up another two houses, one with double-glazing and one with single glazing.
Switch on all the heaters at the same time and get the computer to record how they warm.



Results



These graphs show how the houses warm up. From top to bottom the graphs are: loft and wall insulation then loft insulation, double-glazing and then single glazing. Find the file and open it in your data handling software.

Look at the results

1. Why are the temperatures of the houses increasing?
2. Why do the graphs seem to level off instead of continuing to rise forever?
3. How do the graphs tell you that wall insulation helps?
4. How do the graphs tell you whether single or double-glazing is better?
5. Tricky this: which of the graphs tells you that loft insulation helps?

Extra

6. Measure the temperatures at which the graphs level off. Do these help you to compare the usefulness of loft insulation.
7. Measure the average gradient (or steepness) of the graphs. Do these help you to compare the usefulness of loft insulation?
8. Which is the best way to compare these graphs: by their levelling off temperature or their steepness?

What you might do

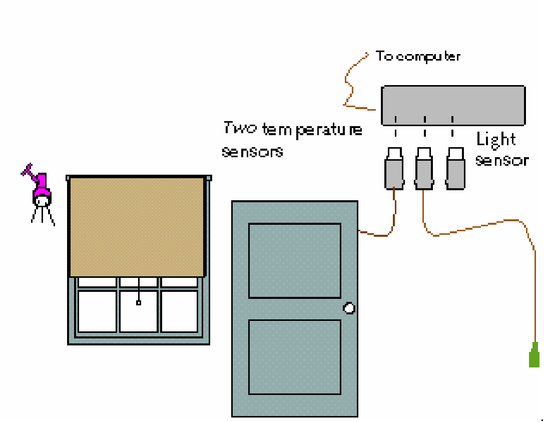
- Try a similar experiment but warm your houses until they reach a steady temperature. Then measure how fast they cool. Is this a better way of studying insulation?
- There are other ways to heat the houses. You might instead place a hot block of metal in each house and see how well the house keeps it warm.
- Find out how much double glazing cost and how much heat energy you can save by using it. Calculate how long it would take to pay for its installation.

Teachers note

This is a graph handling exercise looking at insulation and heat loss. Find details of how to build a spreadsheet to calculate insulation gains and costs in 'The IT in Secondary Science Book'. Thanks for the experiment results to Martin King, formerly of Verulam School, UK. A version of this page can be found at Schools Online Science at Sheffield Hallam University - a link is available at www.rogerfrost.com on the Internet.

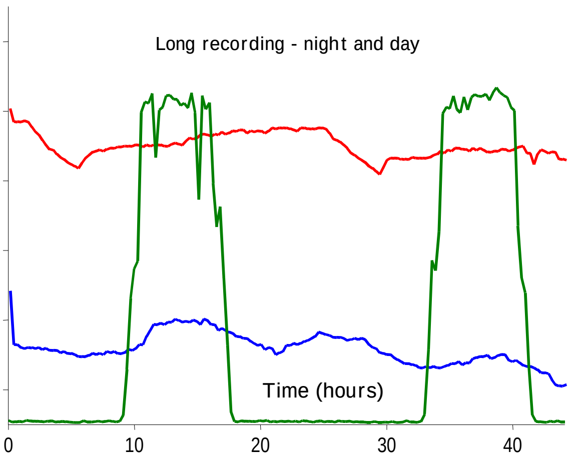
Heat - day and night graph story

It was a cold day and the central heating was keeping us cosy indoors. We knew that the heating system has a thermostat and it cuts off a boiler when the room is warm enough. But there's just a thin piece of glass between the outside and us and we wondered if it really helped keep the heat in.



What you could do

Put a light sensor and a temperature sensor outside a window. These measure the light level and temperature. Put another temperature sensor indoors and connect the three sensors to a data logger. Get the data logger to take readings from the sensors for two days and nights.



Graph shows the temperature and light level starting at midnight. Find the file and open it in your software.

Results

1. Label the traces that show the temperatures inside, outside and the light level.
2. What happens to the temperature in the small hours of the morning?
3. When does the heating turn on?
4. Do you think the heating is 'on' for too long?
5. Which of the two days was warmer and sunnier?
6. Why do you think the light level trace 'wobbles'?
7. At what time of day is the light level greatest? Is this what you expected?
8. When does it start to get warmer outside?
9. What time does it get light in the morning.? What time does it get dark at night?
10. How long it is between daybreak on one morning, and daybreak on the next?.
11. What is the temperature difference between the inside and outside? How does this vary during the day?
12. Estimate how long it would take for the inside temperature to match the outside if the heating was not working.

Extra

- Compare a room that is heated with an outside store that is not.
- Compare a room that gets lots of sun with one that gets little.
- Compare the inside and outside temperatures with double and single glazed windows.
- Find out how long it takes for the heating to warm up the school.

Teachers note

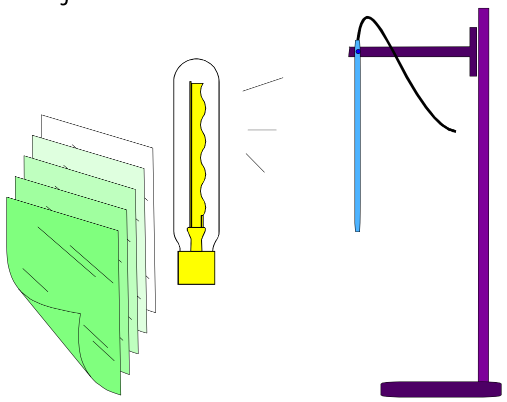
This exercise serves as an introduction to graphs as well as handling ideas about insulation and heat loss. A version with results can be found at Schools Online Science at Sheffield Hallam University on the Internet - find the link at www.rogerfrost.com

Radiation - heat absorption by clothing

They say that wearing light coloured clothing in hot weather helps you to stay cool. To test this idea, we will heat different coloured fabrics with a lamp and record their temperatures.

What you might do

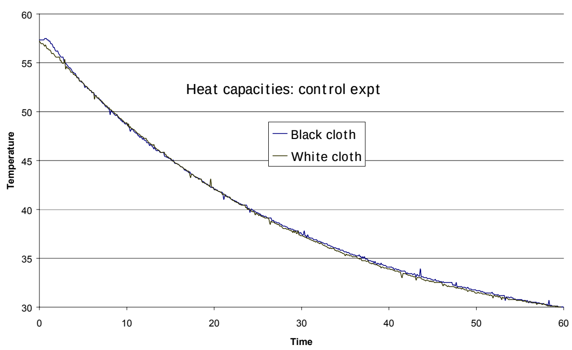
Hang one piece of coloured material from a clamp stand, about 300mm from a radiant lamp. Start recording and switch on the lamp. Measure the temperature of the fabric over the next few minutes.



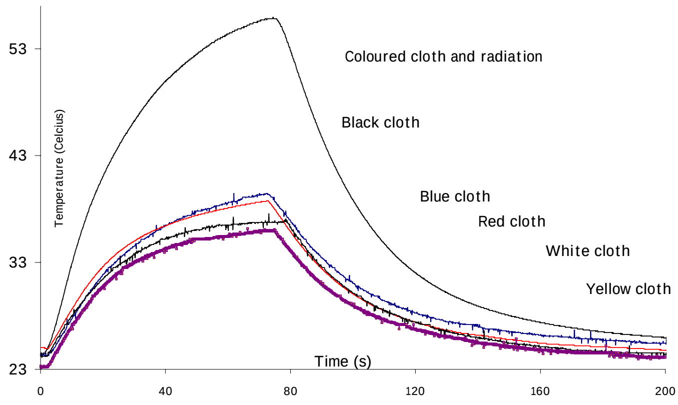
Teachers note

One suggestion is to attach the material around the barrel of a slide projector lens with a rubber band, or instead hanging the material in air about 300mm from a floodlight. Start the illumination from 'off' rather than leaving it on all the time. Illuminate the material until its temperature starts to plateau - then repeat with each different colour for the same length of time. Consider how you can analyse the data and where in this set of questions you would stop.

Experiment results using Tain's small thermistor temperature sensors - with thanks to Tom Howard. Download the software and data from <u>www.tain.com.au</u>. The data was exported to MS Excel. The graph below shows that the heat capacities of the fabrics were similar.



Results



1. Which colour fabric gets the hottest in this experiment? How does the graph show you this?
2. Which of the coloured fabrics would be best to wear on a hot day? How does the graph help you to choose?
3. The fabrics were illuminated for the same length of time and then allowed to cool. At what time was the lamp switched off?
4. Which part of your graph shows how well the fabric absorbs heat? Which part of your graph shows how well the fabric loses heat?
5. Take a reading from each graph to compare the fabrics. How do the fabrics compare?
6. You might use other ways to compare the fabrics: the average temperature, the rate of temperature change or the area under each graph. Try these and report what you find.

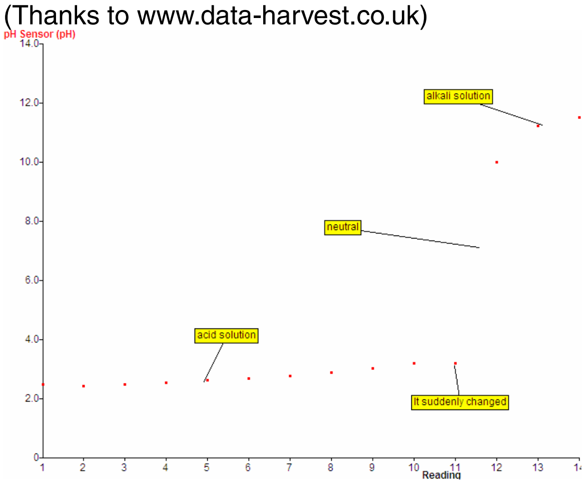
What you need

Temperature sensor (e.g. small sensitive type), light source such as a slide projector or 150W floodlight, coloured pieces of fabric of the same material - 100 mm or more square, clamp stand, bulldog clips or clothes pegs.

Acids - teaching notes

With countless readings to be taken, the acid-alkali titration is an experiment that merits help from a computer. There are various approaches to dripping acid into alkali and measuring the pH. In the examples that follow, we show how you can get very useful results if you allow acid to drip into alkali and make no effort to measure the acid volume. We offer three quick and painless approaches for three different school levels.

If you prefer, you can measure the acid volume. Since few of us have a 'drop-counter' or similar you do have to measure the volume of acid manually. You need to get your software to record one reading at a time. You add acid, press a button to take a reading, add more acid and so on. Here's an example using Data Harvest's software. You should be able to see the dot that is plotted each time. Having made the plot, you annotate it, print it and draw your best fit curve.
(Thanks to www.data-harvest.co.uk)



Other approaches follow

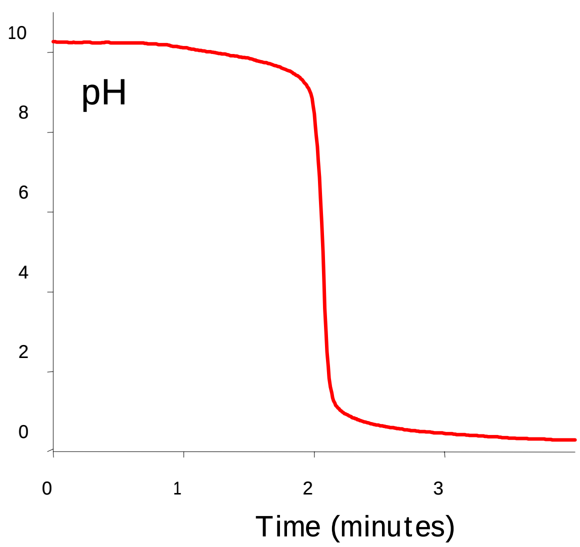
How to illustrate the basic idea about pH and neutralisation:

What you need

Burette with 0.1M hydrochloric acid, clamp and stand, flask with 0.1M sodium hydroxide, 20 cm^3 measuring cylinder, pH indicator and pH probe/sensor in a clamp. A magnetic stirrer helps but you will still obtain a pH curve without.

Place pH indicator and 10 cm^3 of alkali in a flask. Place acid in a burette and measure the pH as you allow the acid to drain out at full speed. This will give you a graph of pH against time that you can re-label as 'time that the acid dripped for'. The pH indicator is not essential, but it helps.

Titration - strong acid vs alkali



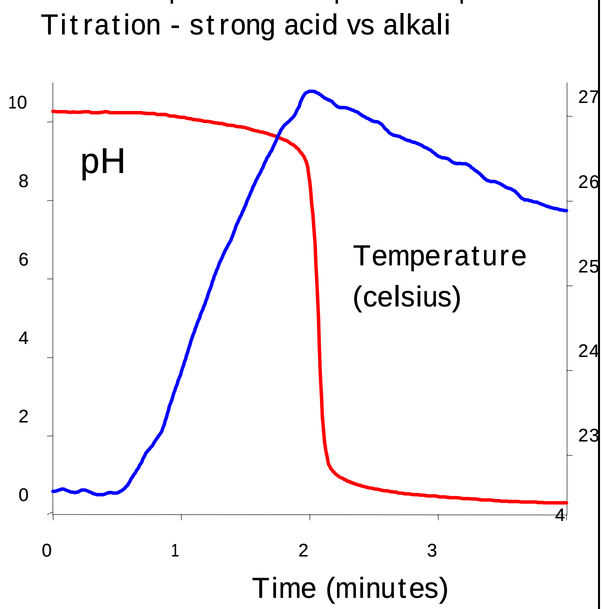
How to illustrate ideas about the heat of neutralisation:

What you need

Burette filled with 2M hydrochloric acid, clamp and stand, temperature sensor, flask with 2M sodium hydroxide, pH indicator and a pH probe/sensor. A magnetic stirrer is recommended.

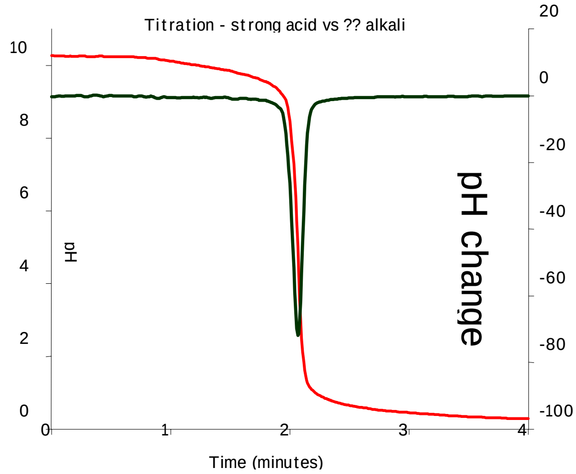
What to do

Place pH indicator, 10 cm^3 of alkali and a pH probe in a flask. Use more concentrated solutions. Place acid in a burette and measure both the pH and the temperature as you allow the acid to drain out rapidly. This will give you graphs of pH and temperature against time. The temperature of the flask peaks at the point of neutralisation - because after this point no heat is produced. After this point the solution cools, partly because of the added cool liquid. Mouse over the graph, discuss what happened and annotate the graph with these points. Zoom in on the temperature scale and discuss the reason for the temperature peak. The peak should correspond to the equivalence point.



How to find an equivalence point:

When you have a pH v 'time acid dripped for' graph, you can find the point at which the pH changed fastest using a differential plot. You ask the software to plot $\frac{\delta pH}{\delta T}$ or the gradient of the pH curve during the titration.

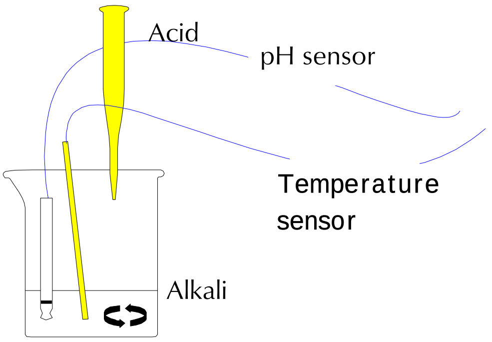


Acids - heat of neutralisation

When acid reacts with alkali not only does the pH change but the reaction gives out heat too. In today's activity, you will see these pH and temperature changes as we use computer sensors to display them as they change.
You may already know and expect that the pH will drop as the alkali is neutralised, but what do you think will happen to the temperature?

What you need

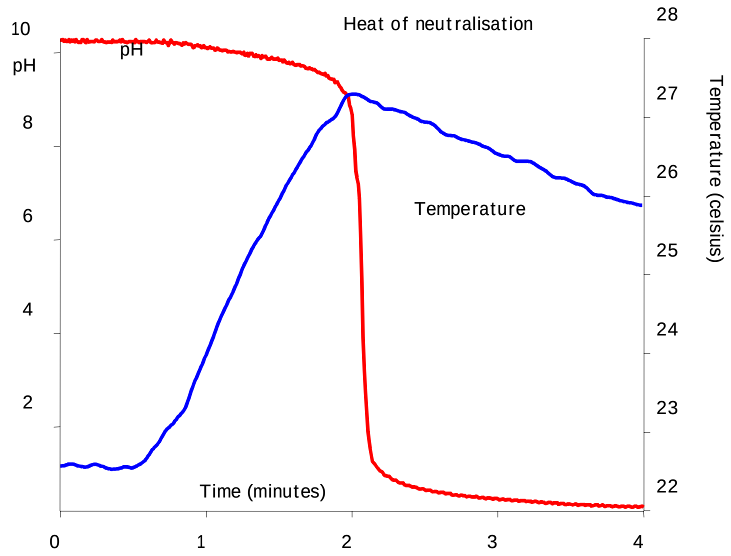
Burette with 2M hydrochloric acid, clamp/stand, temperature sensor, flask with 2M sodium hydroxide, pH indicator and a pH probe/sensor. A magnetic stirrer may be useful while a pH buffer solution will help to check the accuracy of the pH sensor.



What to do

Place pH indicator, 10 cm^3 of alkali, a temperature probe and a pH probe in a flask.
Fill the burette with acid.
Check the pH sensor reads correctly by testing a buffer solution with a pH we know.
Start the computer recording as you allow the acid to drain rapidly out of the burette.
A graph of pH and temperature against the time the acid was left to drain.

Results



1. What does the pH graph tell you about the reaction between acid and alkali?
2. Does the pH change most slowly - at the beginning, the middle or the end of the titration?
3. When does the pH change most rapidly?
4. How does the graph show you that the mixture is getting warmer?
5. If required, expand the temperature axis to show the changes more clearly. At what pH does the mixture start to cool?
6. Why does the temperature of the mixture appear to start to cool?

Extra

- Find the point at which the pH changes most rapidly by calculating an integral line from the pH graph. Change the axis if necessary to show this on the screen. What is the significance of this point?
- Similarly, find the point at which the temperature changes most rapidly. Does this, or should this match with the change in pH.

Teachers note

See the previous pages for the teaching context.

How to illustrate ideas about the shapes of titration curves of weak and strong acids:

Perform four titrations by allowing the burette to drain as you record the pH:

- Strong acid into strong alkali
- Strong acid into weak alkali
- Weak acid into weak alkali
- Weak acid into strong alkali.

This will show you quite good titration curve shapes and equivalence points without worrying about the liquid volumes required for neutralisation. See the tartaric acid curve overleaf.

What you need

Burette, 0.1M hydrochloric acid, 0.1M ethanoic acid, clamp/stand, temperature sensor, pH probe/sensor, flask, 0.1M sodium hydroxide, 0.1M ammonium hydroxide. A magnetic stirrer is essential.

What to do

Place 10 cm^3 of strong alkali and a pH probe in a flask. Pour acid into a burette and measure the pH as you allow the acid to drain out rapidly. Some say that you should maintain the head of liquid in the burette to give a steady flow rate - but this might not be necessary. Very soon you will have a graph of pH against time that you should save on disc. Repeat the experiment using 10 cm^3 of weak alkali and again save the result on disc. You may be able to add the second graph onto the first but appreciate that an error on the second experiment risks spoiling the first result - hence always save between runs. Many data logging programs will allow you to load in graphs from separate experiments.
When the acid has drained, rinse the burette with water, rinse again with weak acid, and then fill with weak acid. Now titrate this into 10 cm^3 of weak alkali and later into 10 cm^3 of strong alkali.

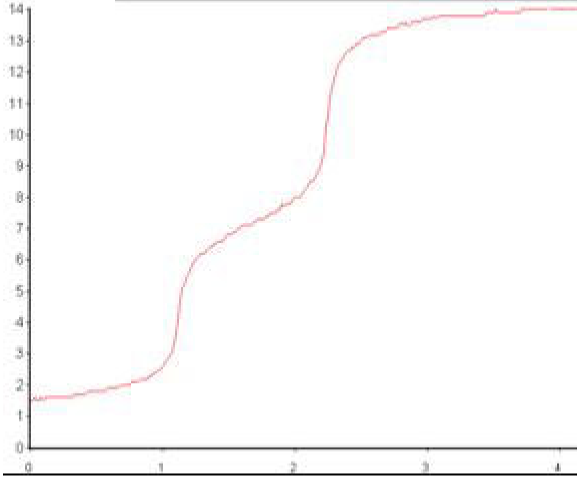
Results

You should have four graphs that you can mouse over in turn, discuss and annotate with the key learning points. Use the software to 'switch off' the four graphs and then discuss them two at a time. Find out:

- The pH of each of the four solutions
- The equivalence point of each of the four titrations by choosing the mid point of each curve
- The equivalence point of each of the four titrations by calculating the gradient of the pH curve during the titration or the differential $\frac{\delta pH}{\delta T}$
- The normal pH of the salt solutions from the four titrations

Acids - multi-protic acids

An impressive result for an experiment taking 5 minutes. Allow a burette full of sodium hydroxide to drain into a flask containing phosphoric acid and take pH readings with a pH probe. Unusually, this acid has more than one proton and behaves as if it was two acids.



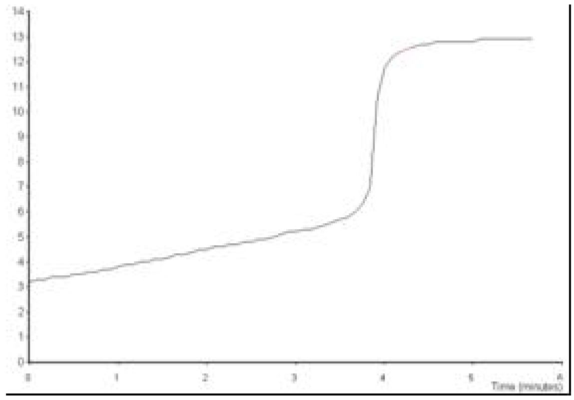
The two equivalence points of phosphoric acid are shown on the graph. You can find their actual pH values by plotting a differential of the pH readings. ***(Results by John Gipps using Tain equipment & software** www.tain.com.au**)***

What you need

50 cm³ 1M phosphoric acid in a burette - i.e. I would do this upside down, clamp/stand, 20 cm³ 1M sodium hydroxide in a flask, pH probe/sensor and a magnetic stirrer.

Acids - strong alkali and a weak acid

A classic result as a burette full of sodium hydroxide was allowed to drain into a flask with tartaric acid. The titration of a strong alkali against a strong acid would yield a neutral salt and an equivalence point at pH7. Tartaric acid is a weak acid and a solution of sodium tartrate will yield a slightly alkaline solution. The equivalence point correspondingly appears on the alkaline side of neutral as this result shows.



(Results by John Gipps using Tain equipment & software** www.tain.com.au**)

What you need

50 cm³ 1M tartaric acid in a burette - i.e. I would do this upside down, clamp/stand, 20 cm³ 1M sodium hydroxide in a flask, pH probe/sensor and a magnetic stirrer.

Evaporation - how to make a drink cool

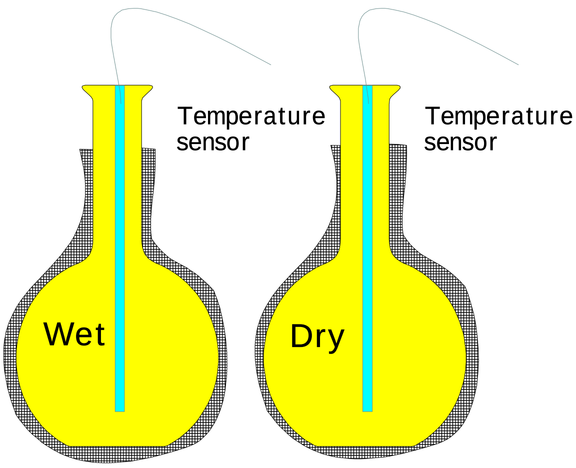
If you're going out and travelling light, the last thing you'd take is a cool box, let alone a fridge. What you need of course is an old sock plus the wisdom of centuries of people who lived in hot climates.

Before you need your drink, stick an old (and hopefully clean) sock over your drink bottle, wet it well and leave it in the shade. If you're lucky a breeze will be blowing and after a while the sock will have dried out. What is more, the drink will be cooler - even than the shade. Does this really work? Here's how we set about testing this in the lab

What you need

2 round flasks or drink bottles, 2 x clamp and stand, pipette, elastic bands, 2 x pieces of towel to fit flask, two temperature probes, data logger, paper towels, a desk fan and warm water.

What to do:



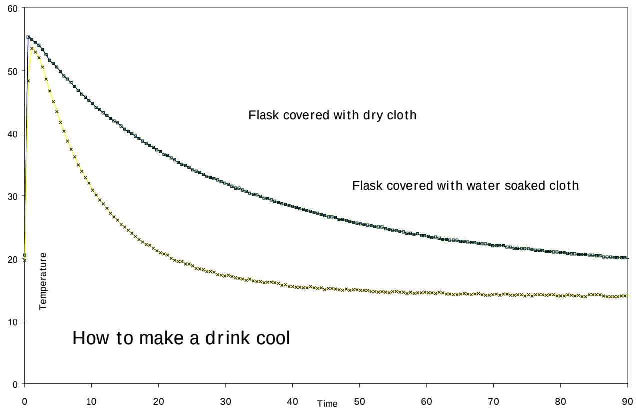
Clamp the flasks and wrap each flask with towel using elastic bands. Place a temperature probe in each flask.

Use the "Setting up" sheet to get the data logger ready. Start recording.

Fill each flask with warm water and soak the material around one of them.

Leave for at least 20 minutes - or until the temperatures are steady.

Load your results into the computer to print them. Pack away



Using the results

1. Add a title and label which line is which.
2. How does the graph show that the drink cools?
3. Which flask cools down more rapidly?
4. How long would you recommend leaving the drink before drinking? Draw a vertical line on your graph to show when the drink has become reasonably cool?
5. Estimate how many degrees cooler was the drink wrapped in wet towel?
6. Explain how this experiment was a fair test.
7. Explain how it works - remembering 'kinetic theory' and that temperature is a measure of how fast the molecules move.

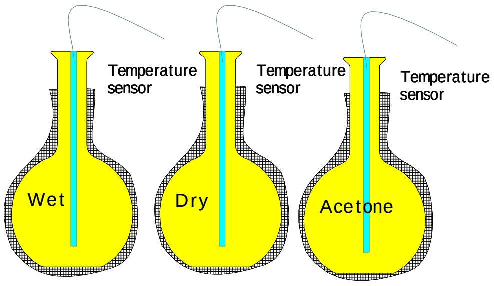
Teachers note

This is a demo or class experiment with homework. You could use it to teach about evaporation and cooling. (Idea and results from Chris Sharples, York, UK - visit www.yorkschools.org.uk for further examples from the York Schools Science and IT Together Project.)

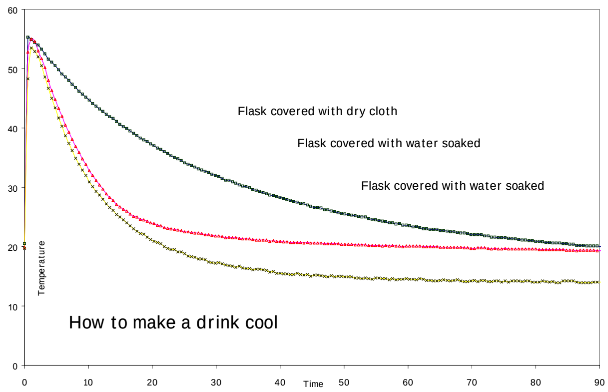
Evaporation - how to make a drink cool - data analysis

What to do

In this experiment we wrapped three warm drink cans with towel. We wet one towel with water, another with acetone solvent and then measured the temperatures of the three drinks for a while.



Results



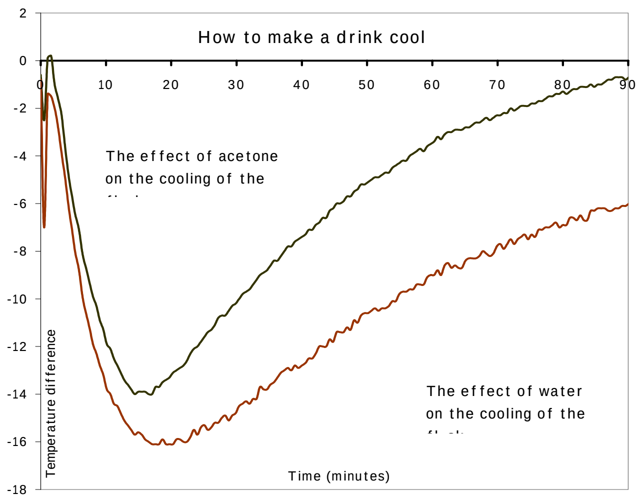
Use our data file in your software to answer these questions:

1. The acetone had evaporated after just 15 minutes while the water took over 90 minutes to dry. Use these facts to label which line is which.
2. How does the graph show that the drinks cool?
3. Which flask appears to cool down more rapidly?
4. How long would you recommend leaving the drink before drinking?
5. How many degrees cooler was the drink wrapped in the wet towel?
6. How many degrees cooler was the drink wrapped in the acetone towel?
7. How many degrees cooler was the drink wrapped in the dry towel? Why did it cool?
8. You could say that the best cooler achieves the coolest temperature the soonest. Which appears to be better for cooling, acetone or water?

Extra

You can handle your results in another, even better way. All three flasks have cooled down. The dry towel tells us how much the flasks would have cooled anyway. What we will do is to subtract its temperature from all the other temperatures.

1. Use your software to subtract the dry temperature line from the water temperature line.
2. Now subtract the dry temperature line from the acetone temperature line.
3. Plot your results to obtain a graph like the one below. The part of the line below 'zero' tell you how fast things cool.
4. Find a way of measuring how fast the temperature of each line falls.



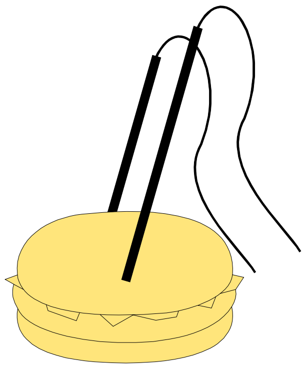
Graph shows how much the acetone and water helped the flasks to cool.

Freezing and melting

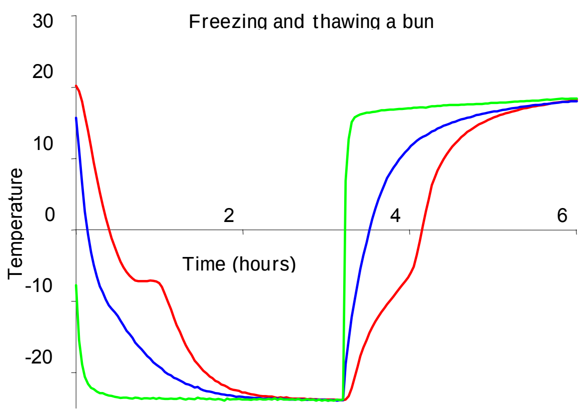
My scientist friend wanted to see what happens when things are put in the freezer. He took a bread roll and used sensors to see how the temperature changed as it froze and thawed.

What you can do

Take three temperature sensors and place one sensor deep inside a bread roll, one probe under its crust and one in the freezer itself. When the temperature is steady, remove from the freezer and allow to thaw.



Results



Graphs of temperature against time can show us how things freeze and thaw. Open the file using software that lets you take readings from a graph.

Look at the results

1. One probe was placed deep inside the roll, one probe was placed in the crust, and one was placed in the freezer itself. Look at the graph lines, and label which line is which.
2. What is the normal temperature of the freezer?
3. He had to open the freezer door, how long did the air in the freezer take to get back to normal?
4. You'll notice two kinks in the top line. What might be happening at those kinks?
5. There is water in the centre of the roll. What is its temperature and why doesn't it freeze at 0 °C?
6. Why isn't there a kink in the middle line?
7. Why might the kinks have different shapes?

Extra

- What is the rate of temperature change for each graph during the cooling?
- What do these gradients tell you about packing freezing food for storage?
- How would those kinks be different if the freezer was more powerful and room temperature was warmer?
- How would your results look if you used fatty food?

Teachers note

This is a data handling exercise illustrating ideas about freezing, melting, latent heat and depression of freezing point. Results by Laurence Rogers, Leicester University Software Insight 2 published byLogotron. Activity developed for Schools Online Science at Sheffield Hallam University. A version of this page is available on the Internet from a link at www.rogerfrost.com

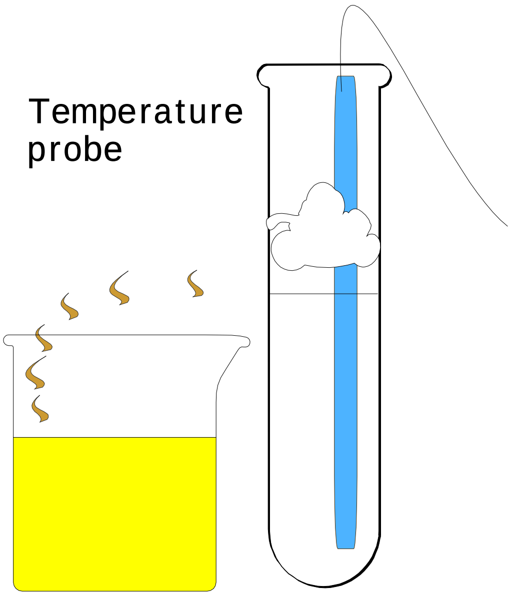
Freezing - energetics

Energy can be produced, or taken in, when substances change state. See what happens here when a liquid cools into a solid.

What you need

Test tube, temperature probe, hot tube holder, tuft of cotton wool, beaker of hot water, sodium thiosulfate pentahydrate. Safety goggles.

What to do



Half fill a test tube with sodium thiosulfate crystals and plug the top to keep out dust. Place the tube in a beaker of hot water to melt. Remove the tube and leave it to stand and cool.
Place a temperature probe in the liquid, and record the temperature as it turns solid again.

Results

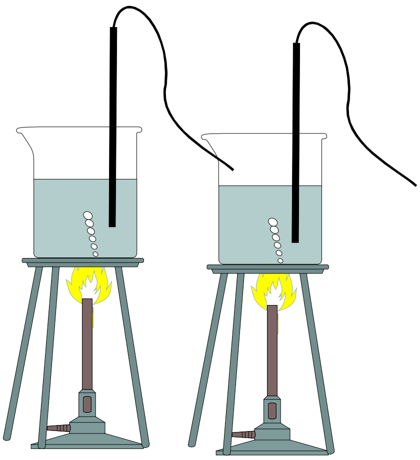
1. Does the thiosulfate cool steadily? If not, describe how it cools.
2. How does your graph show that the cooling produce heat or take it in?
3. Why does the thiosulfate keep cooling after it turns solid?

Teachers note

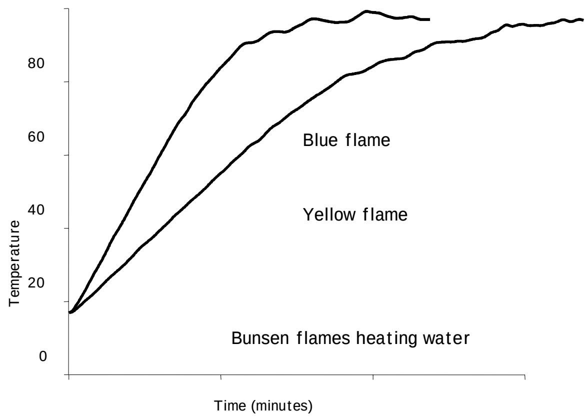
This is a class experiment for work on particle theory, states of matter and energy changes. Adapted from 'Classic Chemistry experiments' published by the Royal Society of Chemistry, London. See www.rsc.org.uk

Fuels - comparing yellow and blue flames

Traditionally, children's first lesson in the science lab has been to compare the blue and yellow flames of a Bunsen burner. But try this experiment in two other contexts, the first where you introduce measuring temperature, the second where you quantify the output of the two types of flame. In both cases you measure the temperatures of two beakers of water as they are heated. You can discuss ways to measure the rate of heating from the graph (for example, measure which flame produced the greatest temperature rise in any one minute). With older groups you can try other measures - the overall gradient, gradient of a best fit line, or even area under each graph.



Results

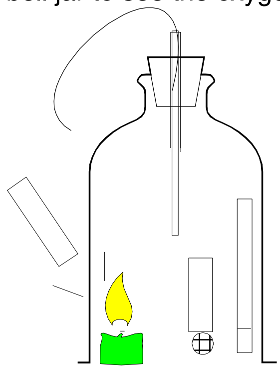


What you need

Two Bunsen burners, beakers, temperature sensors, clamps to hold probes, tripods and gauze.

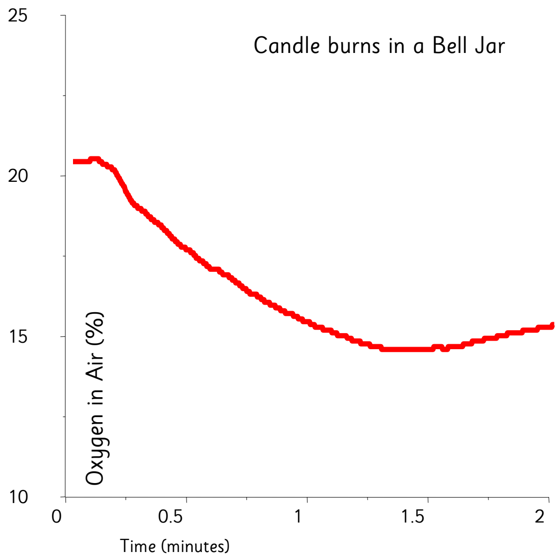
Fuels - candle burning

Burning a candle in a bell jar and seeing the oxygen level fall is a neat party piece. You need to have a well-treated oxygen probe that has had time to 'settle'. You can add other sensors – a light sensor to catch the point of extinguishing, a temperature sensor to record the energy produced and a humidity sensor to respond to the moisture produced. The extra sensors add to the difficulty but the oxygen one is key. When the readings start to level out, re-admit air into the bell jar to see the oxygen level increase.



What you need

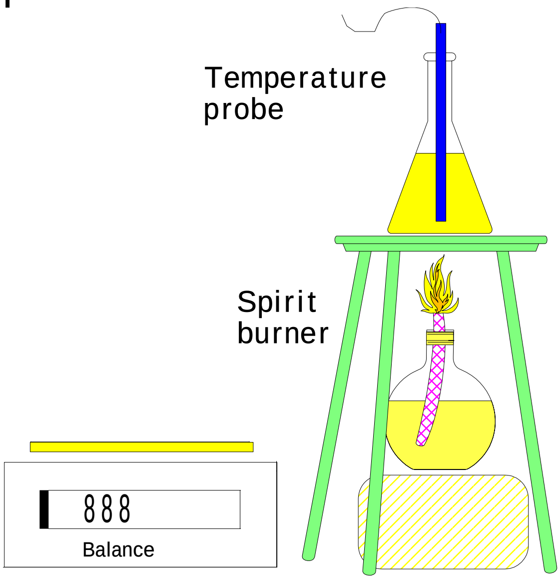
Bell jar, candle, humidity, temperature sensor, light sensor, oxygen sensor and probe



A candle burns in a bell jar as the oxygen level is monitored by a Data Harvest oxygen probe. Many thanks to Barbara Higginbotham at www.data-harvest.co.uk

Fuels - combustion of alcohol

In this activity you will measure the heat produced by an amount of burning fuel. A temperature probe will record the heat produced.



What you need

Spirit burners with methanol, ethanol, propanol, butanol, 250 cm³ flask, clamp and stand, temperature probe, 100 cm³ measuring cylinder, balance. Safety precautions.

What to do:

Weigh your spirit burner. Clamp a flask with 100 cm^3 water and a temperature probe above the burner. Start recording and light the burner. Extinguish the burner when the temperature has risen about 40°C. Weigh the burner and work out how much alcohol was used. Save your results

Results

Take readings from the graph to record the temperature change produced by the burning alcohol. You need to work out how much heat was produced per gram of fuel. Here is a calculation that allows you to compare the fuels

Temperature change produced per gram fuel = temperature rise / mass of alcohol used

Extra

Instead, you can calculate the actual heat produced per mole of fuel:

Heat produced =
Temperature rise x volume of water x specific heat capacity of water

$$\text{Number of moles of fuel used} = \frac{\text{Mass used}}{\text{Molecular mass}}$$

$$\text{Heat produced per mole of fuel} = \frac{\text{Heat produced}}{\text{Number of moles of fuel used}}$$

Teachers note

Use this in work on heats of reaction, bond energies. (Method adapted from 'Classic Chemistry experiments' published by the Royal Society of Chemistry, London. See www.rsc.org.uk)

Latent heat - cooling curves

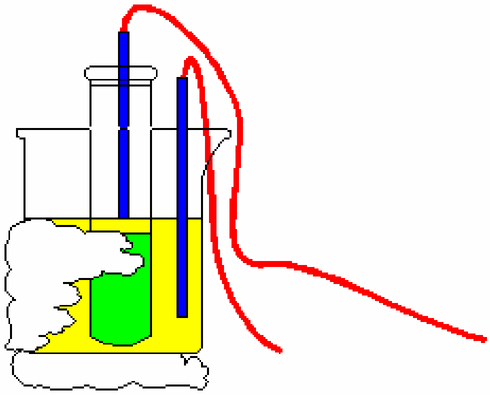
When a liquid changes state, cooling down is not so straightforward. The graph shows the temperature change as liquid stearic acid turns solid. As it sets heat energy is needed to make the solid. If that is not clear, this experiment aims to make it so.

What you need

Boiling tube with stearic acid or biphenyl, beaker insulated with cotton wool, elastic band, clamp for two temperature probes, beaker of hot water to melt the material.

What you could do

One-third fill a boiling-tube with stearic acid and put this in hot water to melt. Place temperature probes in the tube and another in an insulated beaker of water. The probes should hang in the liquids. Start recording - do not stir. Record until the two graphs meet.



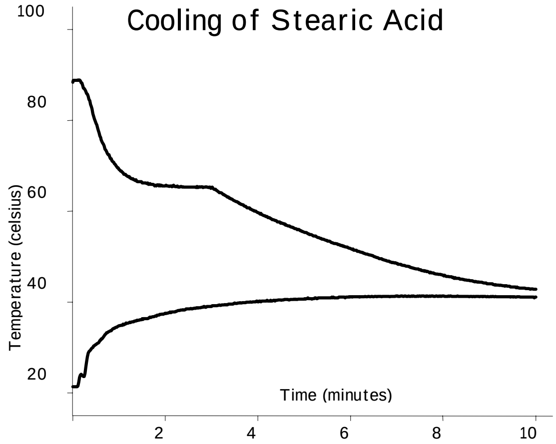
Two temperature sensors are used to measure the cooling. One is in the stearic acid, and one is in the water.

What do you think will happen to the temperature of the stearic acid during the cooling?

What do you think will happen to the temperature of the water during the experiment?

Now open the results file in your software.

Look at the results



1. How does the graph show you that the stearic acid is getting cooler?
2. Describe the unusual way in which the stearic acid cools.
3. How would the graphs look if we had taken results for another 10 minutes.
4. Stearic acid is a liquid at 90°C and solid at room temperature. At what temperature does it appear to set solid?
5. Why does the temperature continue to fall after it has set solid?
6. What happens to the temperature of the water all this time? How does the water gain its heat?
7. Why doesn't the temperature of the stearic acid change as it sets solid?
8. How do you know that stearic acid loses heat while its temperature doesn't change?
9. If you heated some ice, would it melt and produce a steady or a kinked graph?
10. If you froze some water, would it freeze and produce a steady or a kinked graph?

Teachers note

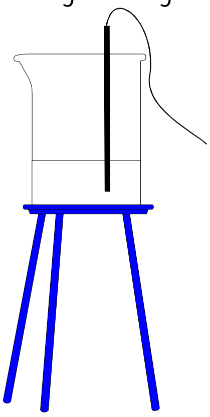
The stearic acid used here may have been impure. The water bath insulation and lack of stirring is a point of contention. Results for this data handling exercise with thanks to Laurence Rogers, Leicester University. Software Insight 2 published byLogotron. Developed for Schools Online Science at Sheffield Hallam University. A version is available via www.rogerfrost.com.

Latent heat - heating ice

You might think that when you heat ice it gets warmer bit by bit - but that is not exactly true. To see what happens we will heat some ice and use a sensor to take the temperature until it boils.

What you could do

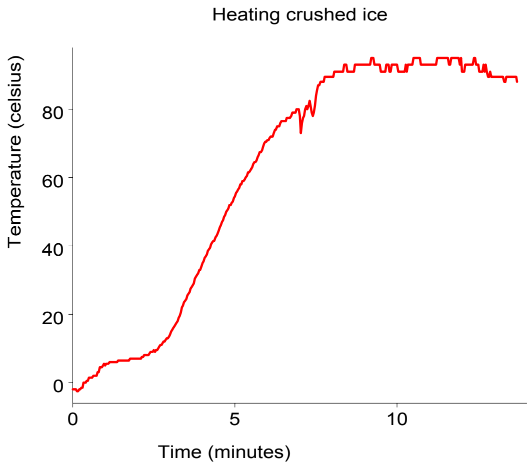
Heat a beaker of ice with a temperature sensor taking readings in its centre. Stir frequently.

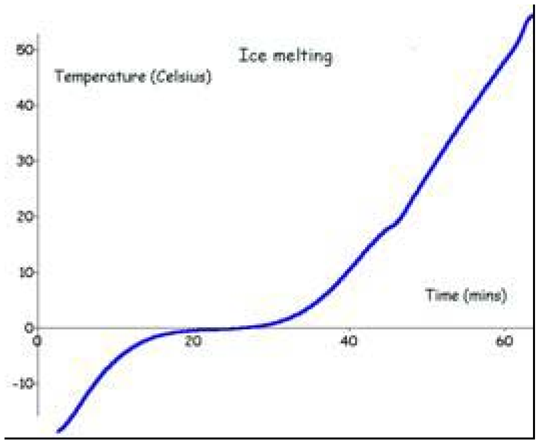


Teachers note

Use this data handling exercise (or class experiment) to look at the melting and boiling points of water and introduce latent heat. You could set up a second beaker look at the effect of salt on melting and boiling points. Similarly, with flameless heating, you could look at the behaviour of alcohol.

(Results by Martin King, formerly of Verulam School, Hertfordshire using Insight 2 Software from Logotron. Find the first results file at www.rogerfrost.com. The activity was developed for Schools Online Science at Sheffield Hallam University www.shu.ac.uk. Second results graph by Fourier Systems, Israel. This was heated slowly by an electric calorimeter. Recorded with DBLab software from Scientific and Chemical Supplies, UK).





The top graph shows what happens when we heat ice. We were not happy about the readings - the probe was resting on the bottom of the beaker. The second one is good though.

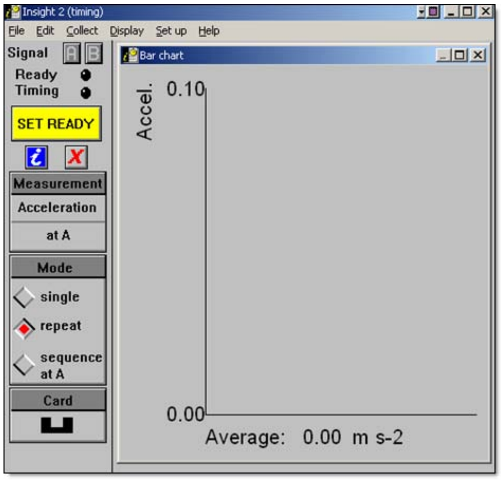
Look at the results

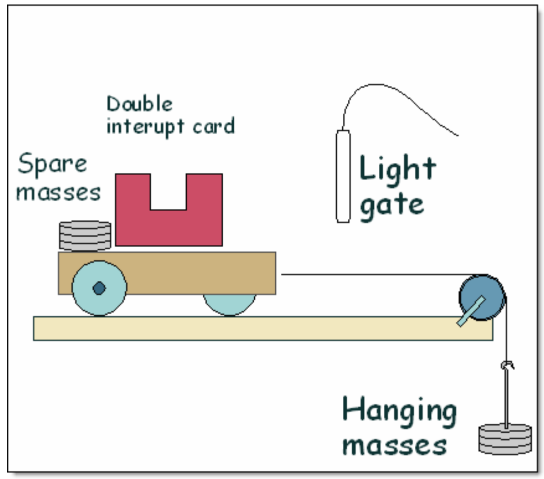
How long did we leave our water boiling for?
Why doesn't the temperature go on rising forever?
How many flat patches are there in the graph?
What is happening during these flat patches?
Why does the temperature start rising immediately after the first flat patch?
Something is wrong with our first experiment, what exactly do you think it is?
Why put the probe in the centre of the ice?

What you might do

Find out how the graph would look if salt was mixed with the ice before the experiment started.

Force, mass & acceleration





1. Plug one light gate into socket 1 of your data logger
2. Close down Insight Sensing and use instead Insight Timing
3. Choose File / Interface to check that Insight is set for your interface.
4. Measure the length of the 'Interrupt card' segment (~2.95cm).
5. Click 'Time' a couple of times so that it changes to 'Acceleration'
6. Click START and enter the length of the 'Interrupt' i.e. 2.95cm
7. Set up the apparatus - there is no need to get the surface level.
8. Start with a single mass on the hanger, let the trolley run and measure its acceleration three times. Do this until you have confidence in your result.
9. Move a mass from the hanger to the trolley and measure the acceleration again three times.
10. Repeat until you have six sets of readings with different accelerating forces.

11. Your results should be in a table like this:

Measured acceleration	Force (Newton)	Average of 3 'a' readings

Get the software to average sets of acceleration readings
Plot the averaged accelerations (y-axis) against Force (x-axis).

Extra:
Use Edit / 'Trial Fit' to do a straight line fit on the graph
What causes this line to miss the origin? Is some force lost somewhere?
If F=ma, what does the gradient of the graph measure?
The gradient is a measure of the mass in motion (trolley plus all the weights).

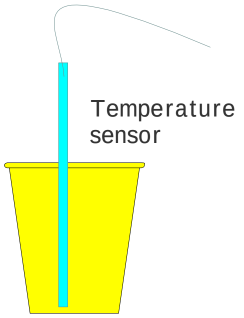
As $\frac{a}{f}=\frac{1}{m}$ the gradient must be $\frac{1}{mass}$.

Reactions - plaster of Paris

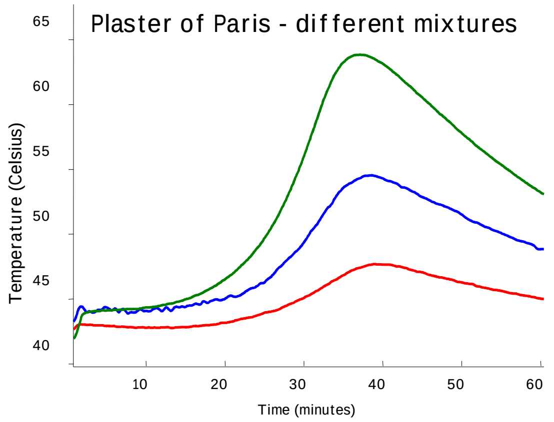
Plaster of Paris is that white powder you mix with water and pour into moulds to set. You can make models with it - hospitals make casts for broken limbs with it. When you mix them they give off heat - a sure sign that a chemical reaction is taking place. But does it matter how much water you use? Can water affect the rate of this reaction?

What you can do

Take three identical amounts of plaster of Paris and place a temperature probe in each. Cover the probes with 'cling film' to protect them. Add three different amounts of water to each, mix and record the temperature changes over the next hour.



Results



Graph shows the changing temperatures of three different water-plaster mixtures. The middle trace had the least water added. The bottom trace had the most. Open the file in your software.

Look at the results

1. Describe how the temperature in the top trace changes over time.
2. The middle trace had the least water added. The bottom trace had the most. Which do you think is the optimum (or 'best') mixture for plaster and water?
3. How does the amount of water added to the Plaster affect the temperature it reaches?
4. Would you say that the reactions get faster or slower over time?
5. Why would a reaction start off slow and speed up over time?

Extra

- At what times do the graphs peak? Why might this happen at different times?
- The total volume of each experiment was different. Does that spoil our results?
- Is there an optimum amount of water to use to make plaster? Try the experiment using measured amounts of water. Record the temperatures and the time the plaster took to set.

Teachers note

You might use this data handling exercise to discuss reaction rates, exothermic reaction and the stoichiometry of reactions, The reaction is auto-catalytic - heat produced helps to increase the rate of reaction. Results by Laurence Rogers, Leicester University. Questions suggested by a teacher panel in Leeds. Developed for Schools Online Science at Sheffield Hallam University - an Internet link to a similar activity is at www.rogerfrost.com

Rate of reaction - thiosulfate concentration

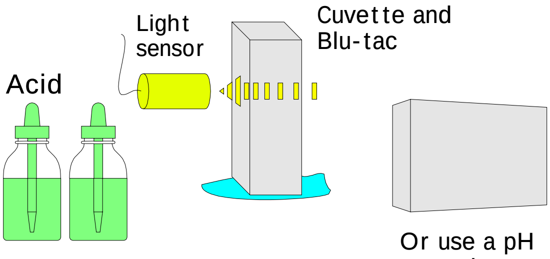
In this activity we measure how fast sodium thiosulfate and acid react when mixed in different concentrations. A light sensor will measure fast a precipitate of sulfur forms when the chemicals mix.

What you need

0.1M sodium thiosulfate, 0.1M hydrochloric acid, 2 x 50 cm³ measuring cylinder and 5 cm³ syringe, cuvette or a plastic box used to store pH paper, 250 cm³ beaker, light sensor, temperature sensor, water bath at 50°C.

If you use a colorimeter sensor, choose a red filter and zero its reading with a cuvette of water. Avoid fumes from the mixed chemicals.

What to do



Connect the light sensor to the interface arranged as shown. Get the software ready to measure the light level, start recording and watch the trace on the computer screen as you cover the sensor. The trace should fall. Measure 50 cm³ of sodium thiosulfate into a beaker. Use a syringe to add 5 cm³ acid to this and immediately pour some of the mixture into the cuvette. Record the falling light level for about 4 minutes as you note the change on the screen.

The experiment

You need to repeat this reaction with different mixtures, and also attend to some points:
Check that your set up will not be affected by stray light.
Decide when you will start the machine recording and be consistent about it.
Find out how to save your results between each run of the experiment.

Volume of thiosulfate	Volume of acid	Volume of water	Thio-sulfate conc.	Rate of the reaction
50 cm³	5 cm³	0 cm³	E.g. '50'	
40 cm³	5 cm³	10 cm³		
30 cm³	5 cm³	20 cm³		
20 cm³	5 cm³	30 cm³		
10 cm³	5 cm³	40 cm³		

Results

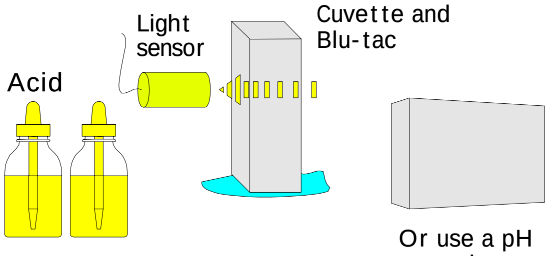
1. Use your data handling software to make a table like the one above.
2. Add the thiosulfate concentrations as explained by your teacher.
3. Find out how to measure the rate of each of the reactions and add the results to your table.
4. Plot the Rate of the reaction against the Thiosulfate concentration
5. Discuss the graph pattern in your experiment report.

Teachers note

Do a calculation or use nominal thiosulfate concentrations such as 50, 40, 30 and so on. The values will not affect the shape of the final graph.

Rate of reaction - temperature

If you were a chemical manufacturer you would be interested in finding ways to increase the rate of production.
There are ways to affect the rate of a chemical reaction. In this activity we will see how fast sodium thiosulfate and acid react when these chemicals are warmed.
These chemicals form a precipitate of sulfur - and we can use a light sensor connected to a computer to measure how fast this forms.



What you need

0.1M sodium thiosulfate, 0.1M hydrochloric acid, 2 cm³ syringe, cuvette or a plastic box formerly used to store pH paper, felt pen to draw a fill mark on the cuvette, coffee stirrer, 50 cm³ beaker, light sensor, thermometer or temperature sensor, water bath at 50 °C.

If you use a colorimeter sensor, choose a red filter and be sure to zero its reading with a cuvette of clear water. Avoid fumes from the mixed chemicals.

What to do

Measure the temperature of the reactants during the reaction with a temperature sensor. This helps you calculate the average temperature of the reaction mixture and record this for the experiment.
Set up the light sensor. Start recording and watch the trace on the computer screen as you cover the sensor. The trace should fall.
Pour sodium thiosulfate into a cuvette up to the fill mark. Use a syringe to add 2 cm^3 acid to this and stir the contents of the cuvette.
Record the falling light level for about 4 minutes.

The experiment

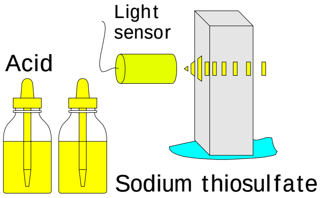
1. Repeat this reaction at four different temperatures, and also attend to some points:
2. Check that your set up gives a good response on screen and will not be affected by stray light.
3. Decide when you will start the machine recording and be consistent about it.
4. Warm up your chemicals and check their temperature as they may cool.
5. Save your results between each run of the experiment.

Handling the results

See over

Rate of reaction - temperature

In this activity you see how a higher temperature affects the rate of a reaction.
Adding hydrochloric acid to sodium thiosulfate solution turns the solution cloudy. We measure how fast this occurs by the amount of light passing through it. If the reaction works faster it will go cloudy faster. We tried the reaction at 70°C; 53°C; 43°C and 32°C.

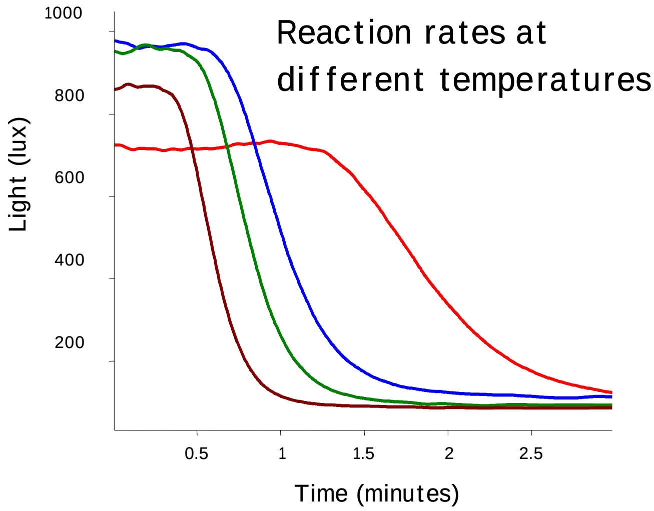


Look at the results

1. Why do the traces go *down* the screen?
2. We monitored this reaction at the four different temperatures given above. Label the graphs to show which graph line corresponds to which temperature.
3. Sketch the graph you would expect if you were to do another run at 20 °C.
4. Use the graph to find the time when each reaction stopped turning cloudy. What is the pattern between the times and the temperatures?
5. Use your spreadsheet software to plot the time readings against temperature.
6. Use this new graph to say what effect temperature has upon the time the reaction takes to stop.
7. What should a chemical manufacturer do to increase the rate of chemical production? How could this INCREASE the manufacturer's costs of production?
8. The lamp moved in one experiment. How did it affect the readings?

Teachers note

A data handling exercise - method on previous sheet. Results by Martin King, formerly of Verulam School. Results can be found at Schools Online Science at www.shu.ac.uk. Experiment from Insight 2 Teaching and Learning guide - published byLogotron



Graphs of light level against time show us how quickly a reaction occurs.

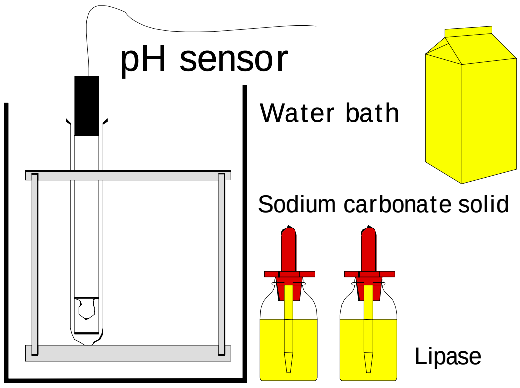
Extra

There are other ways to measure the rate of the reaction from these graphs. Here you can try and compare them:

1. Use the graph to find the time when each reaction started turning cloudy.
2. Find the steep part of the graph and measure the average rate of change for each reaction.
3. Find the steep part of the graph, fit a straight-line equation to each trace and measure the intercepts on the x-axis.
4. Find the point halfway between the starting light level and the final light level for each reaction.
5. Calculate an integral line for each trace and use this to produce a measure of each reaction rate.
6. Fit an equation to each trace and find the initial rate of each reaction.
7. Use your software to plot temperature against these different measures of the reaction rate. Compare these and discuss which ones provide 'the best' approach.
8. If your graphs appear noisy, use your software to remove the noise and leave a smooth graph line

Enzymes - lipase and emulsifier

Fats, such as the fats in milk, need to be digested by your body. They are broken down into fatty acids and glycerol by an enzyme called lipase. The body uses bile to emulsify the fat first, but how effective is this? A pH sensor can monitor the formation of fatty acids as lipase digests the fat. To make this natural process work in the laboratory, we will do the experiment at body temperature.

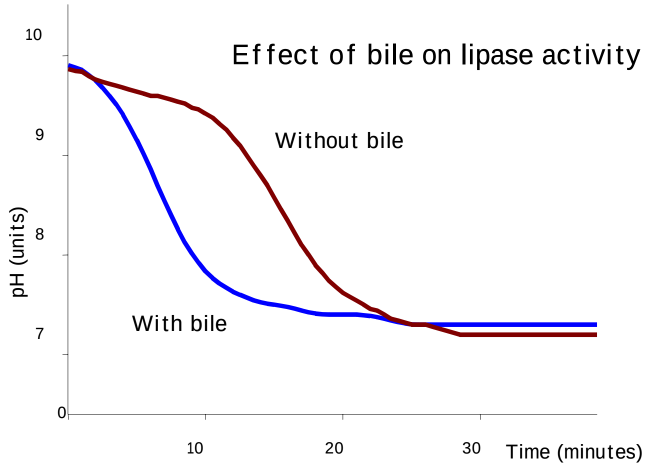


What you need

2 boiling tubes, tube rack, 2 pH probes and adapters, buffer solution to check pH probes, water bath at 30 to 40°C, fresh or UHT milk, 2% lipase in water (keeps for 24 hours in a fridge), solid sodium carbonate.
solution and green coloured detergent.

What to do

Add 5 cm^3 of milk to two boiling tubes in a water bath. Add a few drops of 'bile' to one. Check the pH with the electrode and add sodium carbonate to bring
both tubes to pH 9. This prevents it becoming acid too soon.
Start recording, add 5 cm^3 lipase solution to each tube and measure the pH for around 40 minutes.



Results

1. Predict how the graph will appear before you see your results.
2. Label the points on the graph where digestion appears to start and finish. Discuss how you could use the graph to measure the rate of the reaction.
3. How do your graphs show that one reaction is faster than the other is?
4. Why should your two graphs start and end at the same pH?

Teachers note

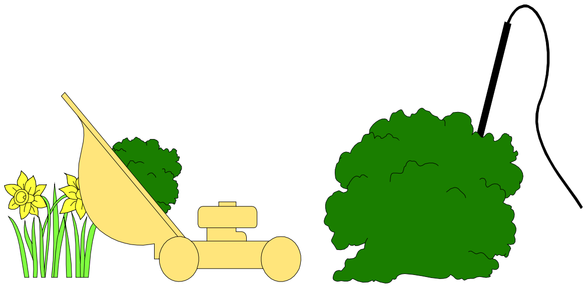
This demonstration may help in topics on enzymes and digestion. Set it up at the start of the lesson and look at the results at the end. Things are harder with one probe - with a long lesson you could just run through it twice. During the reaction, increasing acidity slows the reaction down so we add sodium carbonate to make the starting pH higher. Add too much sodium carbonate and it will buffer the effect of the enzyme. Keep pH electrodes wet. You can also compare the digestion of fat in homogenised and regular milk. Adapted from the 'Digestion' module of the Data Harvest publication, 'Practical Science with Microcomputers' and developed for the Wellcome Trust workshops on data logging in physiology.

Fermentation - is cut grass dead?

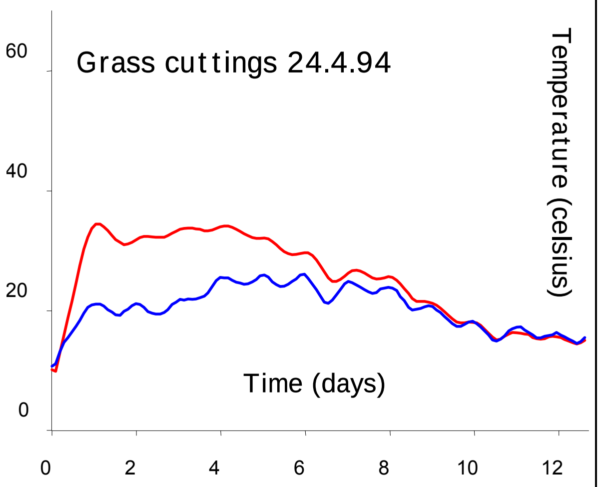
When you cut the grass you remove its source of vital materials. The cut leaf 'dies'. But leave a pile of grass in the garden and it seems to be warm and alive. What's happening? Indeed, when does it die?

What you can do

My colleague, Laurence Rogers cut his lawn and put the cuttings in a heap. He placed two temperature sensors in the pile of grass - one was deep in the middle, the other rested near the surface. Finally, he left the computer to record how the temperature changed.



The results



The graph shows the changing temperature of a pile of cut grass. Open the results file in your software and try the following questions

Look at the results

1. One grass trace came from the probe deep in the middle, the other came from near the surface. Which trace do you think is which?
2. What is the highest temperature recorded by each probe?
3. Why is one temperature more than the other?
4. Why are the temperatures gently fluctuating? Measure the time interval between the small peaks on the traces for a clue.
5. Why do the temperatures finally drop to the same level?

Extra

- We forgot to do a control experiment! What could we have done?
- The surface temperature is the control experiment. Use your software to subtract its readings from the middle temperature. You should have a new trace.
- Use the new trace to say when life in the pile of grass finally ceased.

What you can do

Would a pile of rotting vegetables behave in this way? See if your pile shows a similar temperature peak and fall. Don't forget to do a control experiment this time.
Use your sensors to find how hot a pile of grass can get. (Care - fire risk!)

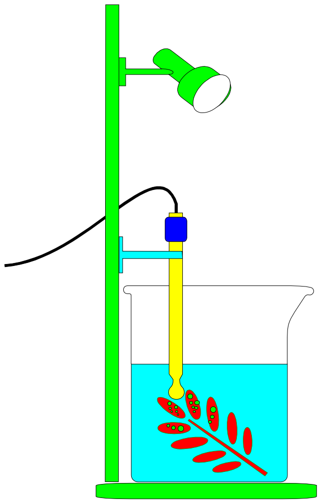
Teachers note:

This is a data handling exercise. Results with thanks to Laurence Rogers. Uses Insight 2 Software published byLogotron. Activity developed for Schools Online Science at Sheffield Hallam University www.shu.ac.uk. Find a version of this activity on the Internet - the link is at www.rogerfrost.com

Carbon dioxide measurement

Carbon dioxide uptake can be also monitored using a pH electrode. A data logger can collect the readings automatically over a few days. Carbon dioxide sensors do exist, but tend to be expensive. Place a pH electrode in a flask with sodium hydrogen carbonate solution and fresh Elodea. Clamp the electrode close to the plant where it will monitor small changes in pH due to the use of CO_2 by the plant. Place a light sensor nearby and connect the sensors to a data logging system. Leave for a day or so to obtain a graph like the one below. This graph shows how the pH around a plant changes over a day. Note how small but evidently significant the pH change actually is. I would not balk at or try to smooth the noise in the graph - it adds a very real imprint. (Results with thanks to Dr Gary Skinner, Bedales School, UK)

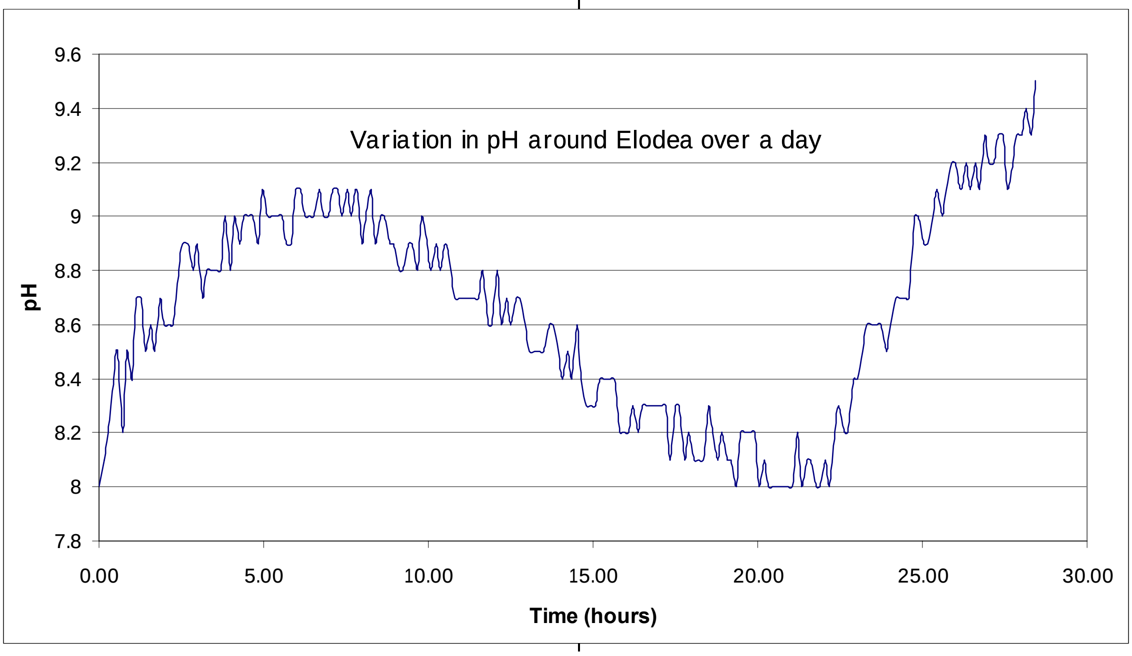
A variation on this - to show the effect of light level in the space of a lesson - replaces natural light with a strong light source. This causes a temperature change of a few degrees and not only affects the plant's activity but also the response of the probe. To avert this, place the flask in a water bath to dissipate the heat from the source or place a glass tank between the light and the flask.



You can now investigate the effect of light level on carbon dioxide uptake. Cover the flask with foil until you are ready to begin. Start recording and continue for about thirty minutes. For the first ten minutes cover the flask with foil, for the next ten remove the foil and for the final ten switch on a second bright light source.

On many logging systems you can't reliably use a pH probe and an oxygen probe in the same liquid.

A related experiment can be found at ***Enhancing Science with IT Classroom activities*** available at the UK Virtual Teacher's Centre on the Internet.



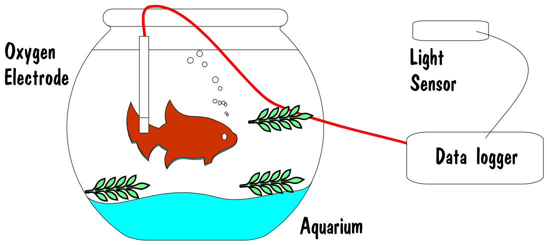
Photosynthesis - aquarium

There's some pond weed and some green algae in the aquarium. If they are living, and they are, they must be doing something - why would the pet shop say that the plants were good for the fish, and yet they do not eat them.

In fact, the plants are producing oxygen but that is hard to see. An oxygen sensor helps us 'see' when the oxygen level changes on a computer screen.

Plants need light so you might expect that day and night affects them. A light sensor will help us check when it is day time.

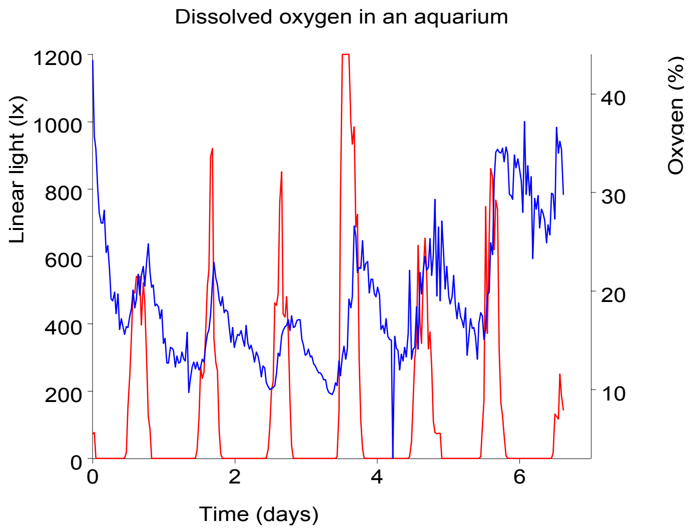
What to do



Place an oxygen sensor in an aquarium and set up a light sensor nearby. Connect to a data logger and let it measure undisturbed for several days. Data loggers automatically take readings from sensors over long periods of time.

Look at the results

1. Find the results file and open it in your data handling software. Look at the light level graph: How many days did this experiment run for?
2. How many troughs are there in the graph?
3. What do the troughs correspond to?
4. What is the time interval between each peak on the graph?
5. What time of day do the peaks in the graph correspond to?
6. Why are the light peaks at different heights?
7. Although the oxygen graph is noisy, how many peaks does it have?



8. How do the oxygen peaks match with the light level peaks?
9. Why might the oxygen level reach a peak after the light level does?
10. At what time of day do the plants produce the most oxygen? At what time of day do the plants produce the least oxygen? What does this tell us?
11. What are the plants doing in the aquarium? How is this good for the fish?
12. How can the fish breathe at night-time?

Extra:

- Why do you think the graph is 'noisy'? Get your software to smooth the graph. Does this still give a fair picture of the experiment?
- Does this cyclical pattern work the same in a running stream?
- What happens to the oxygen levels and the light levels when plants overgrow in a river?

Teachers note

Use this exercise after you have set up this experiment. (Results file by Laurence Rogers, University of Leicester. Activity developed for Schools Online Science at Sheffield Hallam University. Find the worksheet on the Internet at www.shu.ac.uk)