

INSULATION AND CONDUCTION

thermal and electrical insulation and conduction

Science background for teachers

VOCABULARY

Names of a variety of materials;

polystyrene, foam, wool and names of metals-copper, iron, tin, lead and alloys, brass, bronze, silver

Associated words;

temperature, thermometer, degrees Celsius, thermal, conductor, insulator, conduct, insulate, predict, measure, volume, cubic centimetres (cm³)

Apart from heating and cooling appliances, objects in a room will be at the temperature of that room, even if they appear to feel warmer or colder. This is a difficult concept for children to comprehend. How hot something feels has as much to do with the **thermal conductivity** of that object as its actual temperature. Thermal conductivity is the ability to transfer heat from one object to another or away from your hand to the object. Thus wood and metal at the same temperature will feel very different because metal is a good **thermal conductor**, will conduct heat away from your hand and thus feel cold. Wood is a poor conductor, heat is not conducted away so it feels warm.

Conversely, some materials do not transfer heat easily but slow it down, these are poor thermal conductors but good **thermal insulators**. These materials keep things warm but also prevent cold things from warming up. As well as wood, air is a good thermal insulator, as is any material that has air trapped in it such as expanded polystyrene, foam, fibreglass and wool. Air molecules are moving around randomly, at a distance from each other so heat energy will not pass from one to another very quickly. Children need to understand that these materials do not actually make us warm but keep the natural body warmth in.

Objects that start out hotter or colder than room temperature because they have been heated or cooled will eventually reach the temperature of the room. For example, hot water and ice-cold water will both reach room temperature if left in a room for an appropriate period of time.

Materials which are part of a working electrical circuit are **electrical conductors**, they allow electricity to flow. All metals are conductors. **Electrical insulators** do not allow this to happen. This includes all other common materials, except for **graphite** (as in pencil leads) which is a

Good **thermal conductor** are generally also good **electrical conductors**,... **BUT** graphite is a better **electrical** than **thermal** conductor.

SKILLS

- Using a thermometer with care and, for older children, understanding minus numbers.
- Accurately measuring volume.
- Recording results in chart form and, for older children, constructing a line graph. ICT can be used here.

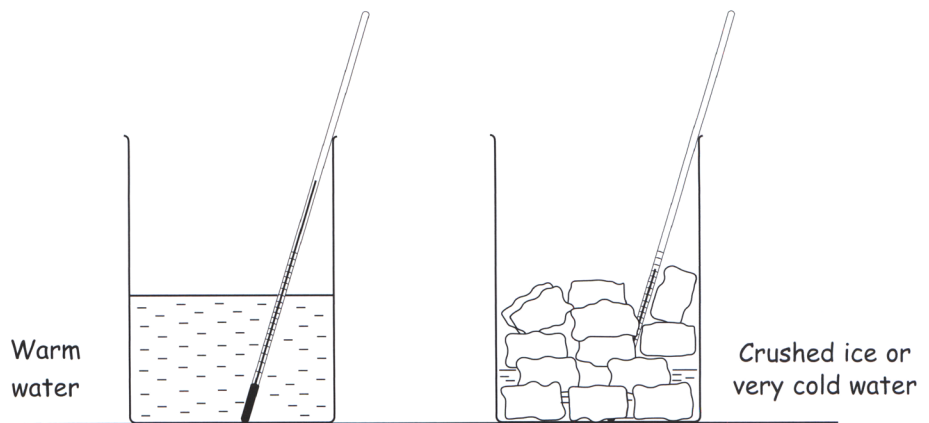
Key ideas and activities

Feeling materials is not an accurate measure of their temperature

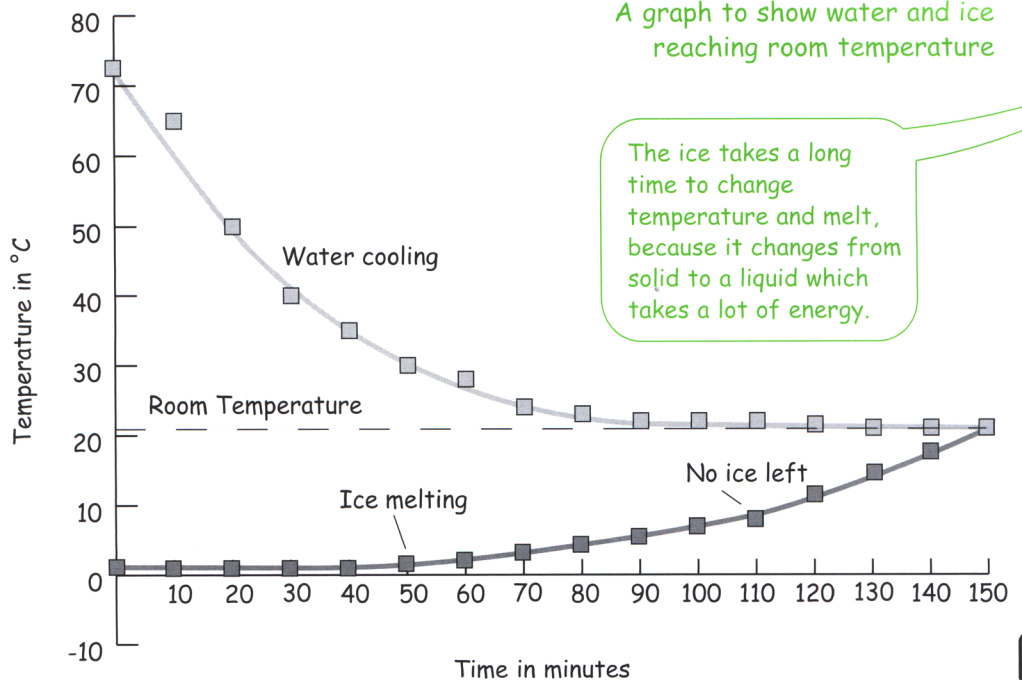
(a) Give each group of children three bowls of water, hot, cold and warm. The children take it in turn to put one hand in hot and the other in the cold water. After a minute they then put both hands in the warm water. The water will feel different to each hand. They can also take the temperature of each bowl of water as an exercise in reinforcing or teaching the use of a thermometer. Put a piece of metal and a piece of wood in the refrigerator, get the children to then feel them. They feel they are at different temperatures, but are they? A thermometer taped to the material shows that they are the same temperature.

Hot things cool down and cool things warm up to eventually reach the temperature of their surroundings

Have two containers containing identical volumes of water, one very cold and the other one hot. Put thermometers in each and take the temperature at regular intervals until both reach room temperature. This will take some time, and could be done alongside another activity but it is an excellent activity for older children to do and then to construct a line graph. It is also ideal for datalogging if you have the equipment. Compare the final temperatures of the liquids with the temperature of the room.



Room temperature was 21°C.



Some materials are better thermal insulators than

Safety!

- Mercury thermometers are not advised for 5-11 year old children, use thermometers that read to 110 °C.
- Ice should not be used straight from the freezer.
- Care must be taken using hot water and any glass equipment.
- Safety issues should be discussed with the children.

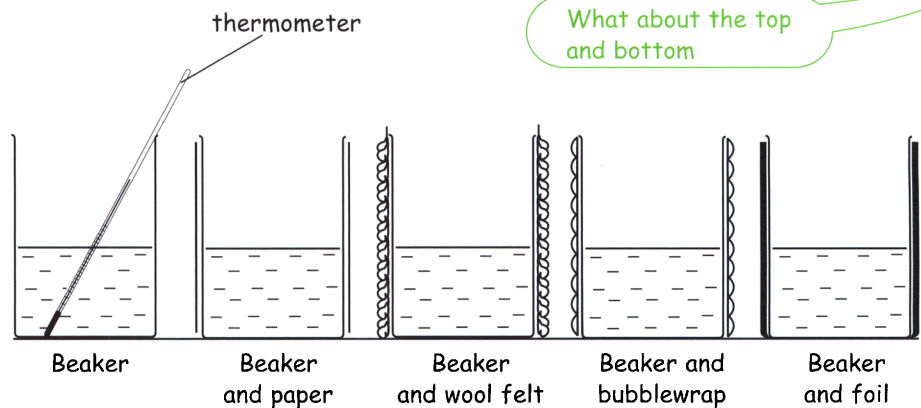
Discuss how we keep things and ourselves warm, including inventions such as the vacuum flask. A simple starter activity is to put hot water in two beakers, wrap one in a material (a woolly hat!) the other is left unwrapped. Ask the children to predict which will cool down first and why. Leave thermometers (or temperature probes) in each and see which one cools down first. A parallel activity can be set up at the same time using ice.

The concept cartoons *Ice pops* and *Snowman* could be used. A good opportunity to **investigate** the best material for keeping different things warm/cold. A variety of problems could make this investigation relevant to everyday situations or a story/poem stimulus could be used such as the story of Goldilocks. Different groups could **investigate** different aspects of the situation eg

- (a) Find the material to wrap the bowls to keep the three bears porridge warm!
- (b) Keep the frozen peas cold/the cakes warm for Red Riding Hood on the way to grandma.
- (c) Keep the tea in the teapot warm and the boiled eggs warm for breakfast.

Younger children may need help planning this, but essentially the children are testing a variety of materials.

Use the same area of material to cover the beaker and keep the volume of water the same.

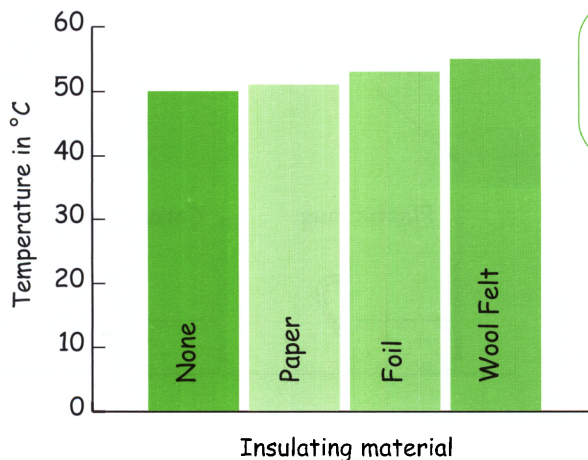


What about the top and bottom

A chart to show the temperature of water after 15 minutes for a selection of materials

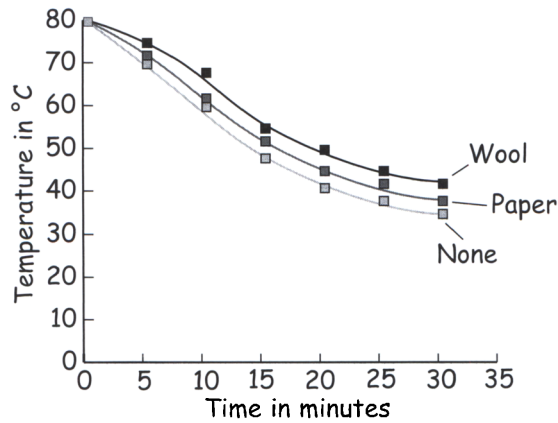


Graphing package



Use the same dimensions for the material and same volume of water.

A graph to show the rate of cooling of water in insulated beakers



Use different coloured pencils to plot the results from the different insulating materials.

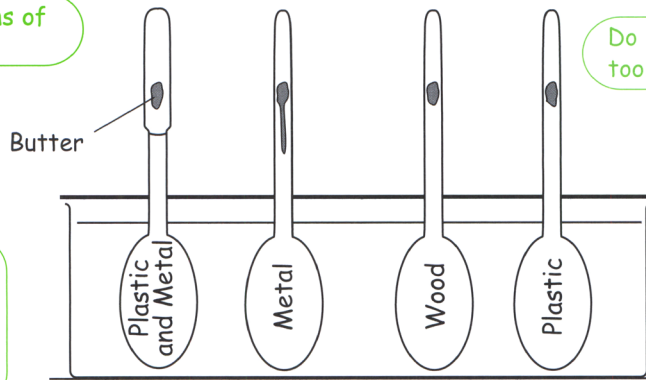
Some materials are better thermal conductors than others

(a) At the simplest level children can stand spoons/rods made from plastic, metal, wood and glass in very hot water. If blobs of butter are put on the handle of the spoons, the good conductor melts it first. To eliminate the effect of the hot air rising from the container and melting the butter, stick the spoons through a cover or lid. Older or more able children could compare rods of different metals if you have them.

Try to find spoons of a similar size.

Do not put the butter too far up the spoon.

Cover the container with a lid to stop hot air melting the butter.



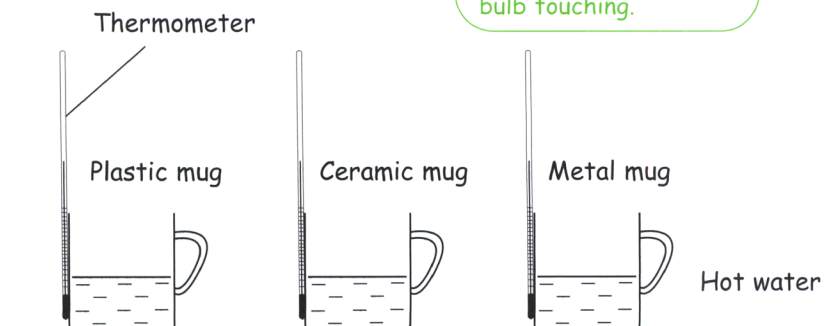
Cut holes in card, cling film or foil and sit it on the top.

Hot water in a plastic or Pyrex® bowl.

(b) For a quantitative result for older children use mugs of the same size but different materials. Tape thermometers to the outsides of plastic, metal and ceramic mugs and fill them with hot water. The temperature rises visibly at very different rates and could also be timed. What happens to the temperature of the water inside the mugs?

Try to get mugs of similar thickness.

Tape the thermometer to the mug with the bulb touching.



(c) **Investigate** 'All metals are good thermal conductors'. Compare metals only.

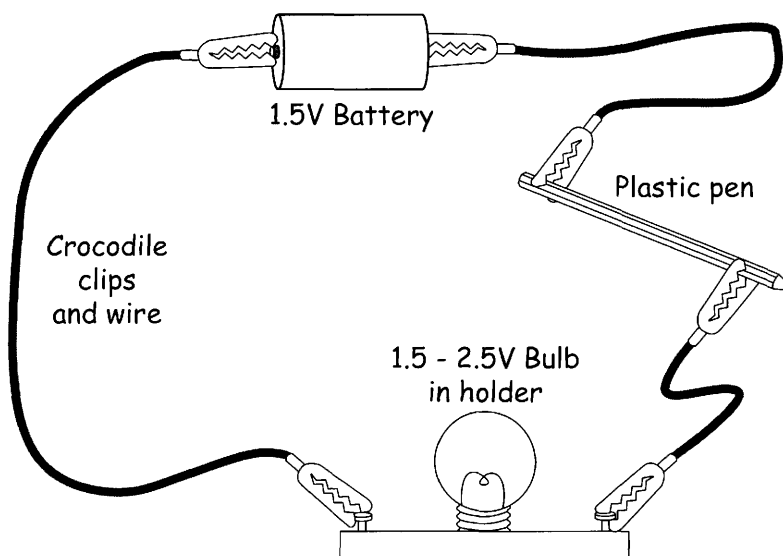
Some materials are better electrical conductors than others

Metals are good conductors of electricity, most other materials are not



There is an opportunity here to discuss conservation of energy in terms of insulating our homes and not wasting heat. Older children may also discuss why it is warmer on a cloudy night and the 'greenhouse effect'. This is a good opportunity to use books and CD-ROMs to find out more about this.

A simple classification **investigation** which children could plan themselves to see which materials will conduct electricity. The children need knowledge of a simple circuit in order to do this and first test it out by touching the crocodile clips together. Then they try completing the circuit with a variety of different materials bridging the crocodile clips. They can construct a chart of results. Through discussion get the children to make generalisations about the fact that the **metals conduct** and that most other materials do not.



Object	Material	Conducts Electricity	
		Prediction	Results
Pen	Plastic	No	No

- (a) Get the children to test a greater variety of metals than they did for the previous activity.
- (b) A good time to discuss general 'safety of electricity' issues with children as in the home, railway lines, overhead cables and pylons. Electricity providers are usually very willing to come and give a talk and show a video.

star* Poetry

by Michael Rosen

Woolly Hats This poem can be used with any age group especially younger children discussing the properties of the materials of clothes that we wear.

Wooden Spoon This poem may need more explanation with a discussion about cooking utensils and would be a good springboard for the conduction activity.

Tank Jacket This poem may need a lot more discussion with younger children but is very appropriate for an investigation into the properties of thermal insulation for older children.

Simplicity of Electricity This is about electrical conduction and may be more appropriate as part of a topic on electricity.

Woolly Hats

In winter
when we go for walks we take hot drinks
in flasks
and we bury them deep
in our bags
wrapped up in woolly hats

In summer
when we go for walks
we take cold drinks
in flasks
and we bury them deep
in our bags
wrapped up in woolly hats



Wooden Spoon

He wouldn't use
a wooden spoon
but a wooden spoon
would do.

With it being so hot
in the cooking pot
a wooden spoon
would keep cool.

Wouldn't you sooner
use a wooden spoon

if you knew
the pot was hot?

Maybe you would.
Maybe not.

Tank Jacket

My dad said
the new tank
in the cupboard
needs a jacket.

I thought
a jacket?
What does it need
a jacket for?
It's not going out.
It hasn't got arms.
It hasn't got anything
to put in pockets.

My dad said,
the new tank
in the cupboard
needs a jacket.

So he went out
and brought it back,
and put it on the tank.

It didn't have sleeves.

It didn't have pockets.
The tank's not going out.

What a waste of money.

Simplicity of Electricity

The simplicity
of electricity
is that it never tires
of going down wires.

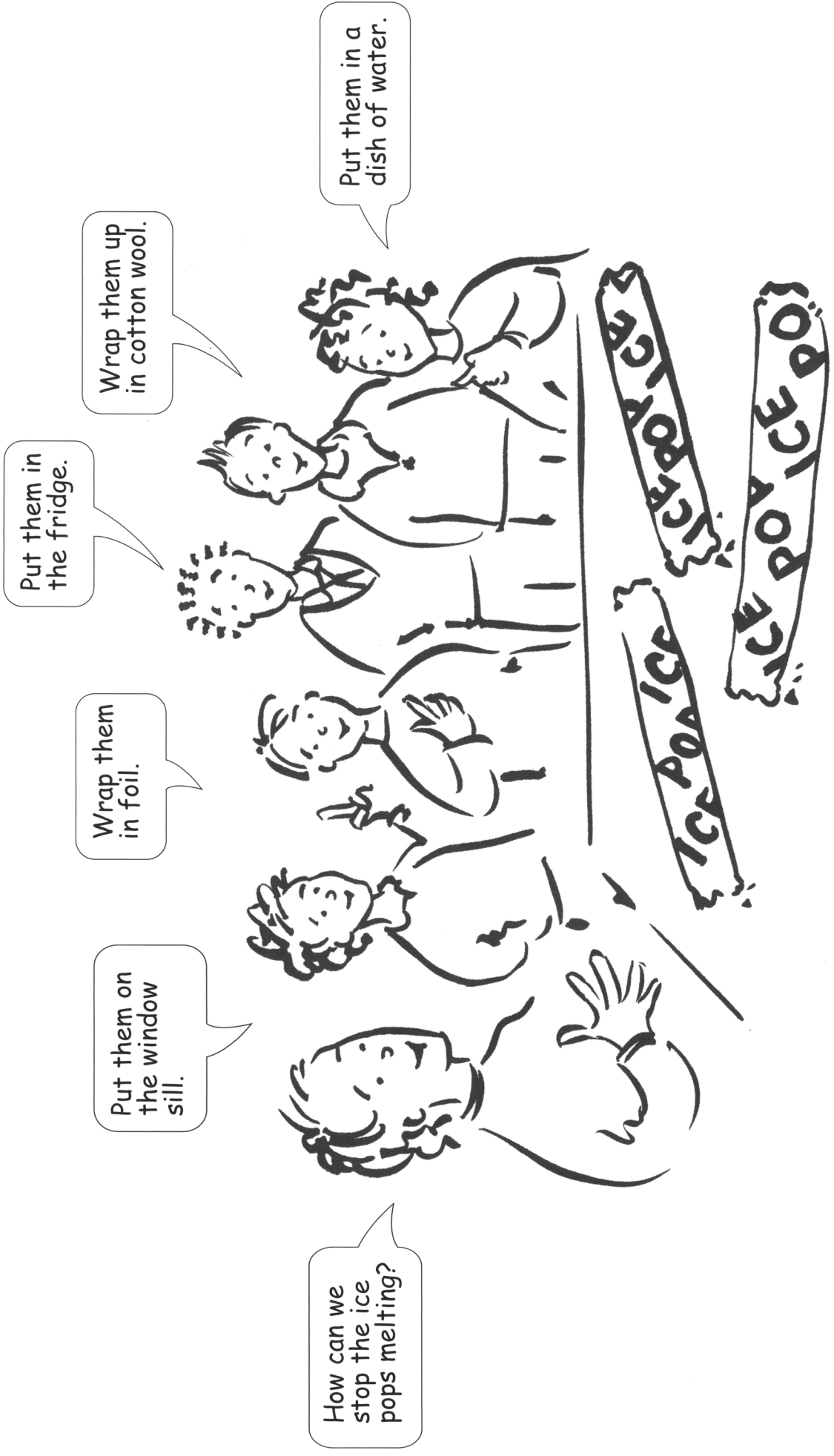
The invention of plugs
was to stop mugs
who touch wires
becoming electric fires.

The simplicity
of electricity
is that it seems to know
it cannot flow
through plastic.

Fantastic!

ICE POPS

RS•C



How can we stop the ice pops melting?

Put them on the window sill.

Wrap them in foil.

Put them in the fridge.

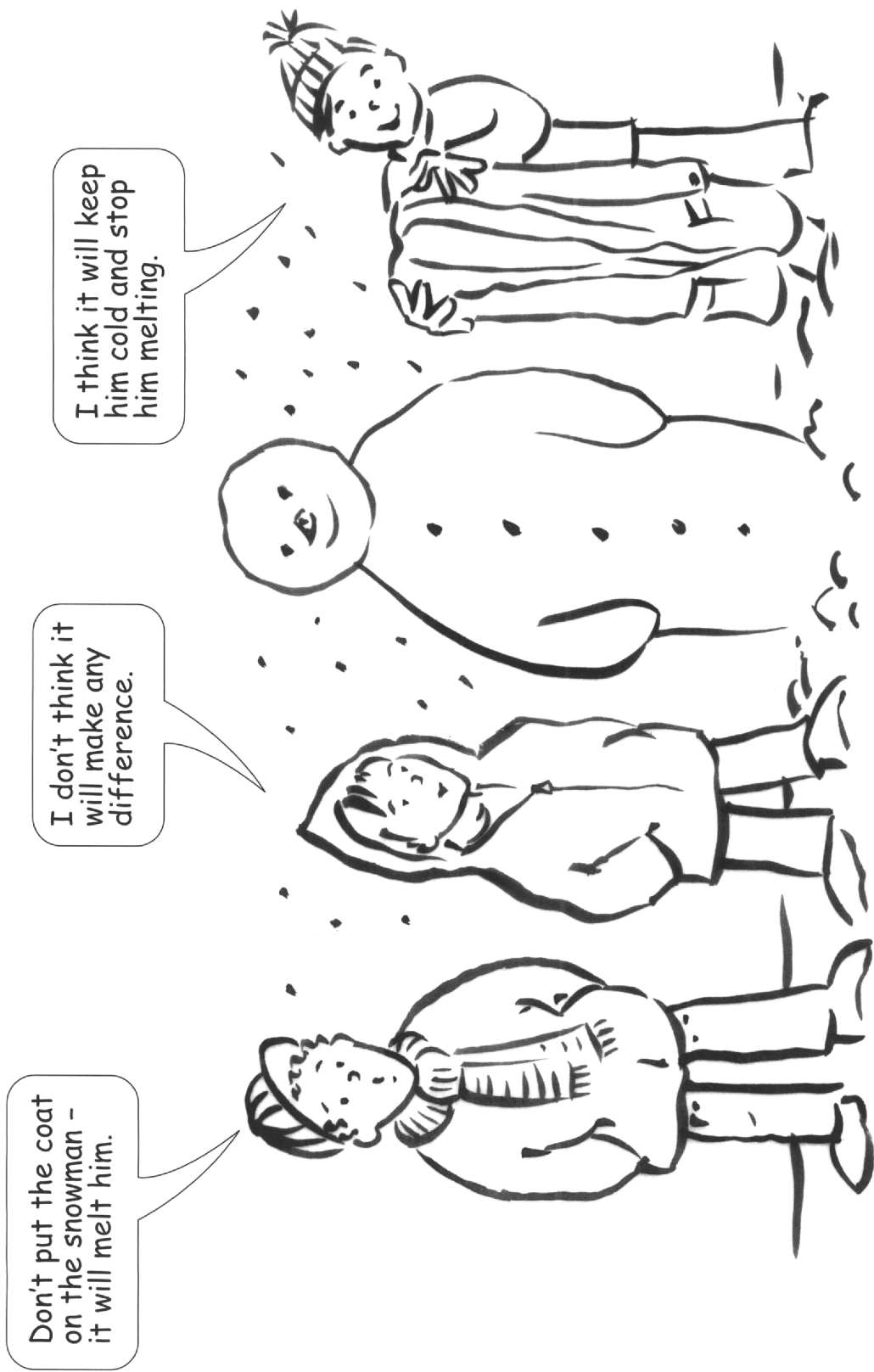
Wrap them up in cotton wool.

Put them in a dish of water.



SNOWMAN

RS•C



CONCEPT CARTOONS

- Snowman** The issue in this concept cartoon is whether the coat is an insulator or whether it actually generates heat. Some children may believe that warm clothes make you warmer by making more heat, and they will expect the coat to generate heat and melt the snowman faster. However others will realise that the coat is simply an insulator which will tend to keep heat away from the snowman and prevent it from melting quickly. The situation shown in the concept cartoon can be investigated using real snow. Alternatively it can be modelled with ice inside a coat, glove or sock; the top half of a plastic mineral water bottle, filled with water and frozen, will make a good model snowman. The thickness, colour and nature of the material that the coat is made from can also be investigated.
- Ice pops** All of the predictions in this concept cartoon can be directly investigated by the children. Some of them are likely to think that aluminium foil is an insulator; that cotton wool makes things warmer; that water will keep the ice pop cold; and that things will stay frozen inside a refrigerator. In each case they will be surprised by their observations! This can lead on to a whole series of follow up investigations on conductors, insulators and heat transfer.

