B5: HEAT ENERGY BY RADIATION

Overview

Radiation is energy that originates in space. Our star, the **Sun**, is the **source** of this radiation energy on Earth. This energy is in the form of waves called **electromagnetic waves** such as **visible light**, **ultraviolet**, **X-rays**, **radio waves**, **gamma radiation**, **infrared radiation**, or **microwaves**. These activities concentrate on one form of radiant energy, namely infrared radiation in the form of **heat energy**. In **B5 ACTIVITY 1 (I): WHAT COLOUR SURFACES ABSORB HEAT?** students compare two different colours to see which absorbs the most heat. In **B5 ACTIVITY 2: WHAT TYPES OF SURFACES ABSORB HEAT?** two different surfaces are tested to see which absorbs the most heat. The heat source is an infrared (IR) bulb. Using the more sensitive digital thermometers or temperature sensors instead of the conventional liquid-in-glass thermometers allows for precise temperature readings.

In **B5 ACTIVITY 3: SOLAR HOUSE HEATING** students investigate the role played by glass in heat increase, and see how black card can transform visible light to heat (infrared radiation).

Suggested approaches:

- Start with a short brainstorm to ascertain what the students know about radiation as a form of heat transference.

  ? ***How do we receive heat energy from the Sun?***

  ? ***Does the nature or colour of the radiation surface play a part?***
- As the students carry out the two activities **B5 ACTIVITY 1 (I): WHAT COLOUR SURFACES ABSORB HEAT?** and **B5 ACTIVITY 2: WHAT TYPES OF SURFACES ABSORB HEAT?**, they could draw flow charts or posters to indicate the pathways involved. Using some cans with smooth exteriors alongside those with ridges, whilst keeping the same colour ranges, would demonstrate an interesting contrast.
- Another possible investigation would be to see if using different materials as covers (instead of paper) for the cans affected the outcome.
- As a follow-up exercise, students could research the role played by both surface texture and colour in buildings.

B5 ACTIVITY 1 (I): WHAT COLOUR SURFACES ABSORB HEAT?

Background

After this investigation the students will have a better understanding of the effect that colour has on heat absorption.

Equipment required (per group):

- Two used food cans of similar size and similar external surfaces
- Different coloured paper to cover the outside of the cans
- Digital thermometer
- Stopwatch
- A source of heat (i.e. an infrared (IR) bulb, heater or lamp)

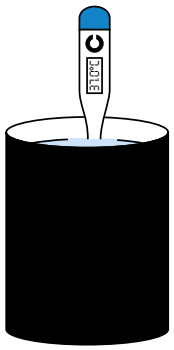

Figure 28

Figure 29: heater or IR lamp

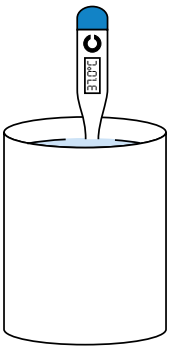

Figure 30

What to do:

1. Fill both containers with water of the same temperature.
2. Place both cans at equal distances from the heater or IR bulb (but not too close).
3. Record the temperature of both cans at two-minute intervals until they arrive at the same final temperature.
4. Graph the results and compare them with the results of other pairs who used different contrasting colours.

B5 ACTIVITY 1 (II): HOT BOXES (ALTERNATIVE ACTIVITY)

Equipment required (per group):

- Four ice cubes
- Four sheets of coloured paper (if possible use the same colours as in the previous activity)
- A few sheets of newspaper
- Heater (or warm sunlight)
- Pair of scissors
- Sellotape or glue
- Timer

What to do:

1. Using the template shown in Figure 31, make four boxes of different colours. Each one must be big enough to hold one ice cube. Fold and cut as indicated. Glue corners A and C to side 1. Glue corners B and D to side 2.
2. Place the sheet of newspaper near a heater or in a sunny spot and lay the boxes side by side with the opening facing away from the heat source.
3. Place an ice cube in each box and start the timer.

   ? ***Predict which ice cube will melt first.***

   Record the time each ice cube takes to completely melt.

   ? ***Compare these results with your predictions – were they similar or quite different?***
4. Construct a suitable graph which compares the melt times of the different colours.

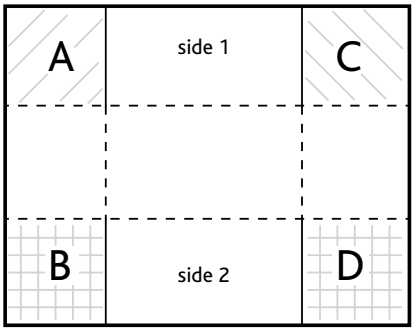

Figure 31

B5.1 Discussion points: Hot Colours

1. Should we wear white or black clothes on a hot day?
2. Should the exterior of a house be brightly painted?
3. What colour should a flat roof be painted?
4. Space shuttles are exposed to intense heat radiation on return to Earth. To protect them from these high temperatures, the surface is covered with tiles. The colour of these tiles is critical. Do you think the tiles are black or white? Give a reason for your answer.
5. What about solar panels? What colour are they?
6. White is the predominant building colour in some Mediterranean countries. Why do you think this is?

B5 ACTIVITY 2: WHAT TYPES OF SURFACES ABSORB HEAT?

Background

This activity challenges students to think about how the texture of a surface affects heat absorption – will a smooth surface absorb better than a rough one?

Equipment required (per group):

- Two used food cans with smooth exteriors
- Two used food cans with ridged exteriors
- Heater or an IR lamp
- Stopwatch
- Tea light
- Matches or lighter
- Tweezers or similar
- Thumbtacks

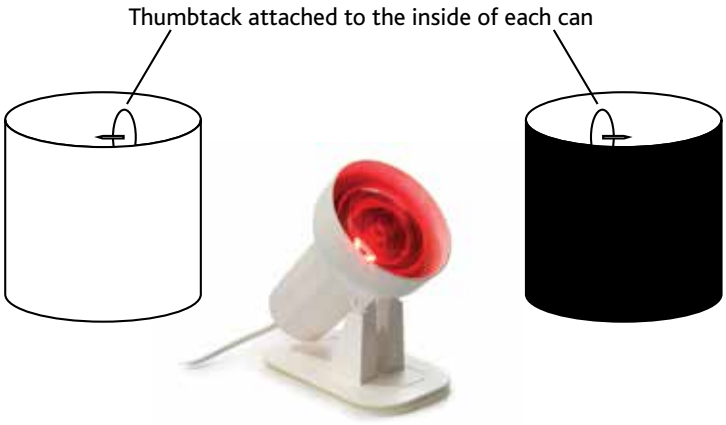

Figure 32

What to do:

1. Light the tea light.
2. When enough wax has melted, use the tweezers to dip the head of a thumbtack into the melted wax and then fix the thumbtack onto the inside of the can as shown in Figure 32. Repeat for the second can.
3. Place both cans at an equal distance from the lamp.
4. Switch the lamp on and, at the same time, start the stopwatch.
5. Time how long it takes for each tack to drop down. Note when you see the tack fall off, rather than when you hear the sound of it hitting the bottom of the can.
6. Repeat the above steps using different combinations of both surface types and colours.
7. Draw suitable graphs for the results and comment on them.

Discussion point:

- A useful follow-up research project is an investigation of the role played by both surface texture and colour on the exteriors of buildings across the world.

B5 ACTIVITY 3: SOLAR HOUSE HEATING

Background

This activity provides students with some experimental evidence of the **greenhouse effect**, as well as introducing them to **convection currents** as a means of heating houses using the Sun's heat. Again, use is made of the **thermofilm** and the **calibration chart** from **B1 ACTIVITY 3 (II): CALIBRATING THERMOFILM**.

Dark coloured materials absorb **infrared radiation** and **emit** the radiation readily. However, **glass is opaque to infrared radiation**.

During the investigation thermofilm, fixed onto black card which is inside a boiling tube, registers a rise in temperature. As it is the infrared radiation that, emitting heat energy, causes a change in temperature, students may ask why the temperature rises in the boiling tube.

The light energy from the lamp will pass through the glass tube. The black card will transform this visible light into infrared (heat). This in turn raises the temperature of the card as seen by the colour change of the thermofilm.

Students will now need to **explain** the rise in temperature. Because glass is opaque to infrared radiation, the air inside the tube is heated, so it rises to the top. This is why adding layers of glass to the outside of a building can result in heat gain inside.

Suggested approaches:

- Start with a short brainstorming session to learn what the students know about the greenhouse effect. Some key terms can be suggested.
  - ? ***Is global warming a problem or not?***
  - ? ***What if the Earth's surface was minus 20°C, the same temperature as the moon?***
  - ? ***There is a current focus on climate change and sustainability – why is there a focus on these issues now and what has using energy from the Sun got to do with it?***
- Let the students' ideas stand, and come back to them after the activity.

Equipment required (per group):

- Boiling tube
- Bung to fit boiling tube
- Test tube rack
- Two strips of thermofilm (10 cm x 5 cm) each on black card
- Lamp (an incandescent lamp is best)
- An energy efficient bulb
- Calibration chart for the thermofilm from **B1 ACTIVITY 3 (II): CALIBRATING THERMOFILM**

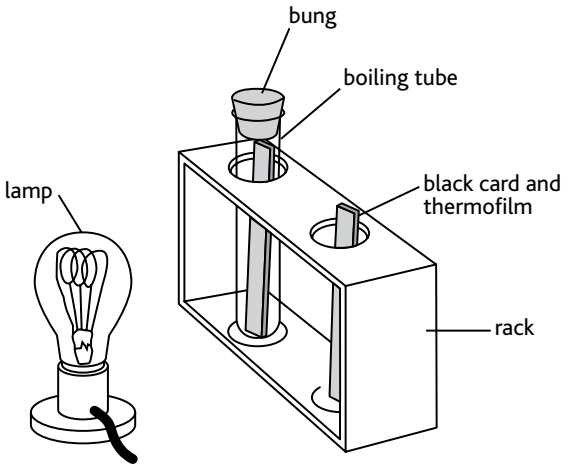

Figure 33

What to do:

1. Put one of the black strips with thermofilm into the boiling tube. Bung it and place it in the rack as shown in Figure 33, making sure that the thermofilm is facing the lamp.
2. Place the second strip in the rack near the boiling tube as shown in Figure 33 making sure this thermofilm is also facing the lamp.
3. Place the lamp about 40 cm from each strip.
4. Switch on the lamp.

   Observe and **record** any colour changes on the strips.
5. Using the calibration chart, relate the colour changes to the appropriate temperature.

   If there are changes, are they surprising ones?

   Why?

   Do you think we would obtain the same result if we used an energy efficient bulb?
6. Repeat the experiment using an energy efficient bulb and compare your predictions with the outcome.

Resource:

- Click here to view this activity online from the National Stem Centre, UK.