Solids, liquids and gases

Introduction

Using a particle model to explain the behaviour of matter is one of the Big Ideas of science education. Children entering secondary school may have encountered the particle model, but may not be aware of how external conditions may influence particle behaviour. Micro:bit devices can be programmed to simulate particle behaviour, and encourage an exploration of the effects of different conditions.

Figure 1 Water in microgravity aboard the International Space Station

Space context

Materials used in space exploration are exposed to a wide range of conditions not experienced on Earth. These materials need to be carefully selected for their ability to withstand extremes of temperature, pressure, acceleration, and to continue to function effectively. Some experimental rovers are powered using a fuel cell. Gas molecules combine to generate electricity, forming a liquid in the process. The liquid is then converted back to gases using an external energy source such as solar radiation. It is essential that the 'fuels' used in this system do not change state to a solid by exposure to low temperatures or extreme pressure.

Prior Knowledge

On Earth matter exists in three states – solid, liquid or gas. (Later in school students will learn about plasmas). Many materials can be changed from one state to another by changes in pressure or temperature. Students will usually think of water as a liquid, but will also recognise that by heating water it can be converted to a gas, and by cooling it can be converted to a solid. These properties can be explained using a particle model. The particles of water (molecules) do not themselves change state in extremes of temperature, but their behaviour with other particles does change. In solids, the particles are bound together in a rigid lattice. In liquids the particles are still packed together but are free to move in relation to each other. In gases the particles are not bound and are free to move randomly.

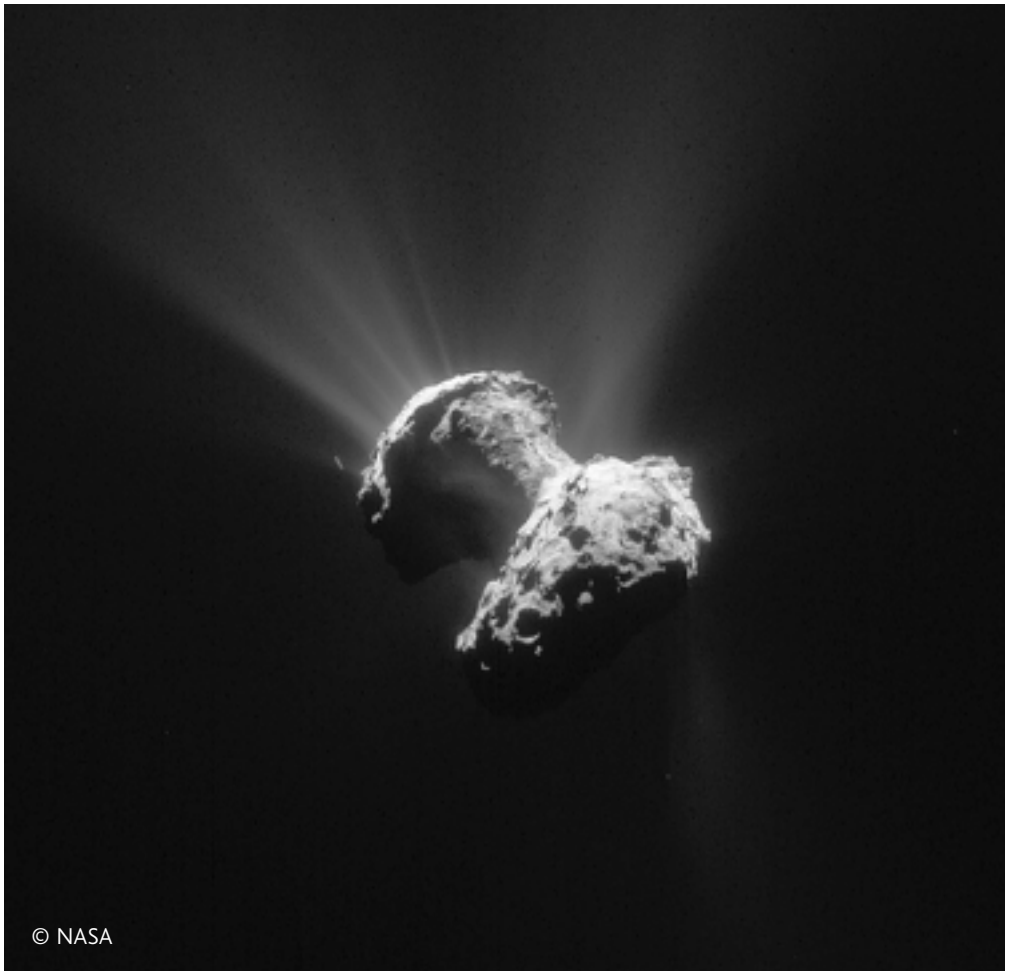

Figure 2 Heating by sunlight causes substances in this comet to change state, creating the 'coma'

Learning intentions

Recognise the differences in particle behaviour in solids liquids and gases.
Simulate the effect of heating and cooling on states of matter.
Make links between movement of particles and heating.

By adjusting inputs in Micro:bit code, students will be able to change the properties of the material being modeled in the simulation.

Resources

- Micro:bit and connecting lead to computer
- Battery pack
- Computer with access to Micro:bit web site to download code

Preparation

The code for this activity is available here

Once the code has been downloaded it needs to be compiled and flashed to the Micro:bit. Additional help is available here

To start the procedure, press the reset button on the rear of the device.

Lesson activity

When the procedure is first run on the Micro:bit device, the LED display simulates a group of particles in solid phase. Shaking the device increases the 'energy' of the particles, as shown by increasing the intensity of the display. Further shaking results in the display simulating melting and then evaporation to a gas as the particles become widely distributed. The display will return to simulated liquid phase if allowed to stand.

Challenge the students to change the display from liquid to gas phase. Discuss possible explanations for the link between movement and change of state.

Challenge the students to change the display to solid phase – they will need to 'leave it to cool', i.e. to transfer heat energy back to the surroundings.

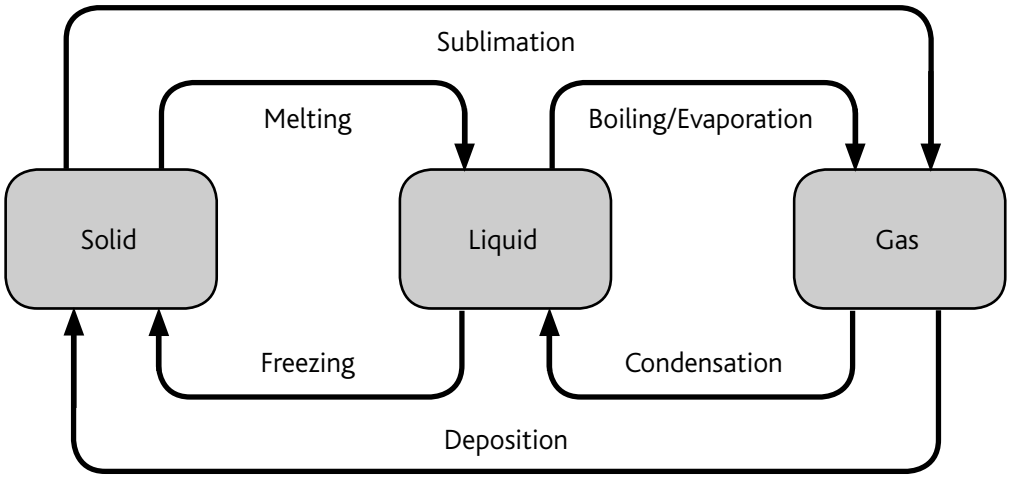

Image: © Wikimedia Commons

Discuss which materials exist on Earth in three distinct phases and those that do not. Get students to explain the behaviour of materials such as iodine and solid carbon dioxide.

In space, materials will experience extremes of temperature – very low temperatures outside the Earth's atmosphere, particularly in shadow or moving away from the Sun; and very high temperatures on re-entry to the Earth's atmosphere, or when travelling close to the Sun.

By editing the marked sections of the Micro:bit code, students can change the melting point and boiling point to match those of different materials. This can then be used to simulate the effect of space travel on the states of a number of different materials used in space, such as water, oxygen, ceramic, aluminium.

NASA publishes numerous articles on research into the development and use of new materials. (see example in links section below). Ask the students to write about the use of materials in space, linking their research to the Micro:bit activities in this lesson.

Assessment opportunities

You can assess students understanding of the particle model of solid, liquid and gas through discussion and their explanation how the Micro:bit procedure represents that model. They should be able to point out strengths and weaknesses in the simulation.

Students should be aware of the effect of changing conditions on solids, liquids and gases. This could be assessed through extended writing about the use of different materials used in space flight.

Ask students to create a sketch graph to illustrate the movement of particles at different temperatures, and to indicate on their graph solid, liquid and gas phases.

Taking it further

Find the melting and boiling points of a range of different materials that are used in space.

Adjust the code in the Micro:bit procedure to default to gases and solids.

Links

Teacher support on Micro:bit site

BBC Bitesize Solids liquids and gases

NASA site describing research into the use of fuel cells

NASA article describing the development of new materials for use in space