UK Atomic Energy Authority

Materials Testing Workshop

Teachers' Pack KS2

Contents

This materials testing workshop contains a series of activities which explore the differences between common materials and help to highlight why we use different materials for different purposes. The activities in this pack are best suited for Key Stage 2 pupils and can be run as one approximately 60 minute workshop or be used as the basis for a series of workshops. The activities below can also be run individually or in combination to suit particular groups.

All the activities in this pack are fun, not especially complex to set up and have fairly short kit lists. Activity 2 includes building a simple circuit, therefore contains underlying science which can go into further depth if desired, meaning that this teachers' pack can be used with pupils of different ages and levels. Please visit the appendices, the risk assessment and the accompanying PowerPoint slides to make the most of the information available in this teachers' pack.

English KS2 Curriculum Links

ELECTRICITY

- construct a simple series electrical circuit, identifying and naming its basic parts, including cells, wires, bulbs, switches and buzzers
- recognise some common conductors and insulators, and associate metals with being good conductors

MAGNETISM

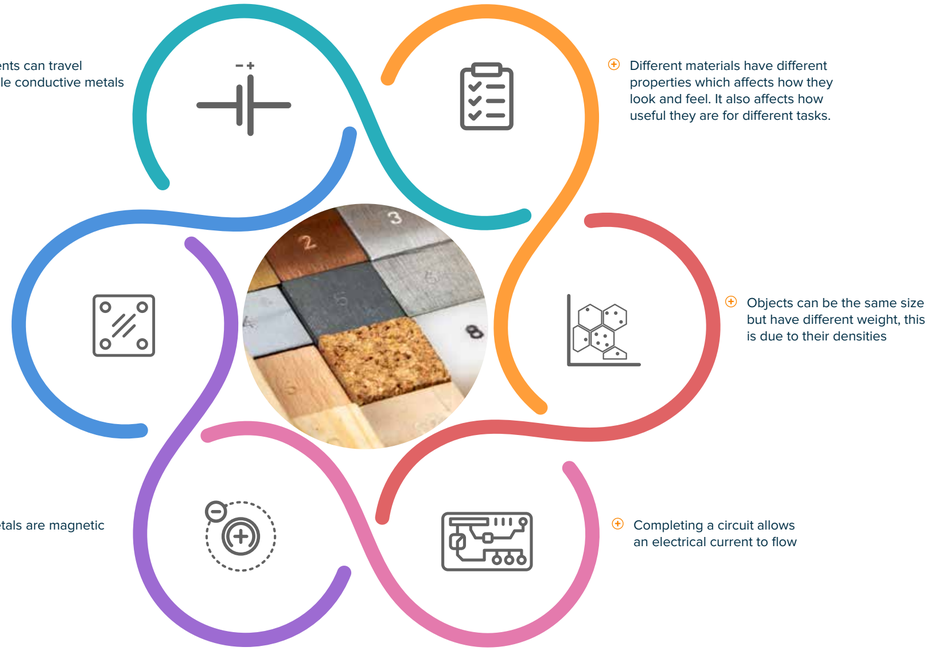
- notice that some forces need contact between 2 objects, but magnetic forces can act at a distance
- observe how magnets attract or repel each other and attract some materials and not others
- compare and group together a variety of everyday materials on the basis of whether they are attracted to a magnet, and identify some magnetic materials

MATERIALS

- Most metals are strong, hard and shiny materials that can be hammered into different shapes without breaking. They are good *conductors* of heat and electricity and some are magnetic
- Plastics are materials made from chemicals and are not found in nature. They are strong and waterproof. They can be made into any shape by applying heat. Plastics are not magnetic. They are good *insulators* and don't conduct heat or electricity.
- Glass is made by melting sand and other minerals together at very high temperatures. It is normally *transparent* and can be made into different shapes. Thick glass can be strong, but thin glass breaks easily.
- Wood comes from trees. It is strong, flexible and long-lasting. It is an insulator of heat and electricity.

Learning Objectives

- Electrical currents can travel through multiple conductive metals
- Different materials have different properties which affects how they look and feel. It also affects how useful they are for different tasks.
- Metals conduct electricity, woods and plastics do not
- Objects can be the same size but have different weight, this is due to their densities
- Not all metals are magnetic
- Completing a circuit allows an electrical current to flow



Equipment List

- **Density cube set** – pre made cube set (as shown) or if that is not available then various metallic and non-metal materials can be used (density test will be impacted if the items are not all the same size)
- **Bar magnets** – preferably labelled North and South
- **Weighing scales** – accurate to 1g if possible
- **Circuit** - wires, clips, batteries, cell/battery holder, LED light bulb. See appendix
- **Worksheet** – see accompanying document
- **Risk Assessment** – see Page 16

Introduction

Our solar system's star, the Sun, emits huge amounts of light and heat. Light and heat are two forms of energy. But where does this energy come from?

Inside the sun, a reaction called fusion takes place. Scientists and engineers are very interested in fusion as it releases huge amounts of energy. They want to recreate this kind of reaction, essentially building our very own star on earth, and capture the energy it releases to power our homes, industries and transport. Fusion energy production is a carbon-free process at the point of generation and does not create greenhouse gases such as methane, CO2 or NOx gases.

The three states of matter are, solid, liquid and gas. In a solid, the particles (atoms or molecules) are close together and have very little energy. In a liquid, the atoms or molecules are better able to move around, allowing the liquid to flow. Liquids will take the shape of their container. In a gas, the particles have a lot of kinetic energy and are able to move freely, filling the available space. These three states of matter are the most familiar to us here on Earth.

The Sun is a rather different environment, with the centre of the sun being around 15 million°C. Consequently, the behaviour of the particles in the Sun does not correspond to that of a solid, liquid or gas. The Sun is a different state of matter, called a plasma!

There are some plasmas that you may have encountered before: lightning, neon lights, the northern lights/auroras, electric sparks and plasma globes.

How do the particles behave in stars and in other plasmas? Firstly, plasmas are hotter or higher energy than solids, liquids and gases. This means that the particles move around more and they move faster. In a plasma, the tiny electrons are stripped away from the nucleus of the atoms, where the much larger protons and neutrons are. This results in a hot and charged plasma which can be moved using magnets!

BONUS FACT

In plasma, the particles are in such a high energy state that when they bump into each other the they can 'fuse' together and release energy, like in the sun.

Stars are made of plasma, and If scientists and engineers are to create a sun on earth and hold it inside a fusion energy machine, one of their challenges is figure out what they must build this machine out of so that it doesn't melt of become damaged. Currently there are no know materials that can survive temperatures anywhere near 15 million°C!

Instead of attempting to create a material that can survive contact with the centre of the sun, scientists and engineers created the **tokamak**. A tokamak is a doughnut-shaped machine which uses large electromagnets to induce a magnetic field. The plasma, which is charged, swirls around in the tokamak, and is pushed away from the walls of the machine by the electromagnetic field.

Oxfordshire is home to JET and MAST-U, two tokamaks. At the end of 2023, JET ran its last experiments. Now a new round of experiments begins – how to take apart and inspect a fusion machine. MAST-U is a different shape to JET and many other tokamaks in that it is spherical, it has the shape of a cored apple. Finally, the UKAEA is planning to build the world's first prototype fusion energy powerplant, called STEP, to be built in North Nottinghamshire.

FAQ: Why doesn't the machine melt if it's holding something hotter than the sun?

Plasma is charged, this means that it can be moved and manipulated using magnets. Large electromagnets surround the walls of the tokamak and 'push' hot plasma away from the walls. This means that the hot plasma never comes into physical contact with the machine itself so it doesn't become damaged.

The insides of fusion energy machines are also often coated with 'protective tiles', these tiles are made of (or coated in) heat resistant materials which help to protect the machine from the plasma.

The activity in this booklet explores how different materials have different properties which can make them useful for specific tasks, and how material science plays a huge role in fusion energy research today.

Activity 1: Describe the look and feel of the materials

WITH THE CLASS IN PAIRS

Each pair should be given the equipment from the Equipment List.

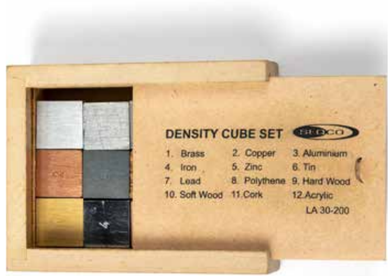
Materials make up everything around us. Everything in your classroom is made of a material whether it's a wooden table, a plastic chair, a nylon carpet or a glass window.

Different materials have different properties which make them useful for specific jobs. The elements that are used to create a material and the way that those elements are 'packed together' has an impact on the properties of that material.

Bricks are made of clay, that means they can be very strong and are good for building houses, but clay is opaque so it cannot be seen through. Windows are made of glass; glass cannot withstand the impact that bricks can without breaking but it is transparent making it a perfect material for windows. This shows how a materials properties impact its potential uses.

Before beginning a science experiment it can often be useful to inspect your samples and write down any findings.

During this first activity simply feel and observe the different materials. Is it shiny or dull? Does it have a golden, brown, or silver colour, or something different? Is it light or dark? Is it see through or opaque? Is there anything else interesting about this sample that you would like to make a note of?



Activity 2: Electrical conductivity

FUN FACT

Some materials let electricity pass through them easily, these materials are known as **electrical conductors**. These materials can be used as a great way to get electricity from one place to another.

Some materials do not allow electricity to pass through them, these materials are known as **electrical insulators**. These materials can be used to help keep people and objects safe from electrical shocks.

In pairs, set up the electrical circuit. To do this you will need 1 battery (also called a cell), one cell holder, 2 red 'push fit' wires, 1 black 'push fit' wire, and a light bulb. Arrange the circuit as shown below.

Touch the free ends of the red wires together. This should complete the circuit and turn on the light bulb as electricity flows from the battery, through the wires and into the bulb. Note that the light bulb will only turn on when a connection is made between the metal parts of the red wires, not the plastic part.

Once you know that your circuit works you can begin to test the materials.

One by one place your material samples on the table and touch either side with one of the free red wires. If the material is conductive and allows electricity to flow though it, the light bulb will turn on. If the material is an insulator the electricity will not flow through it and the light bulb will not turn on.

Write down your results on your Worksheet and test all 11 materials.

Discuss with your partner, where might we use conductors and insulators in our day to day lives? Why are the material properties of conductors and insulators important?

EXTRA FACT

Electricity or 'current' is the flow of electrons. When we have moving electrons, we have a magnetic field. This applies to any charged particles, including the ions in a plasma. 'fusion engineers' can use this knowledge to help make clean and sustainable energy.

Activity 3: Magnetism

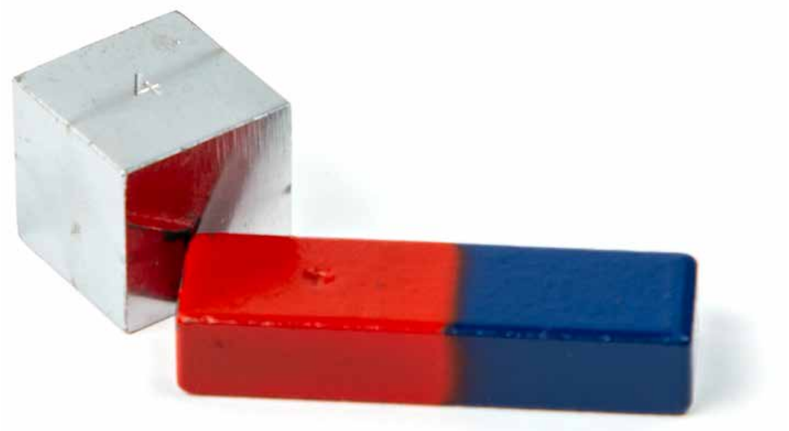
Working with another pair on your table, can you position your magnets with the North poles together, then South poles together, then opposite poles together. Note the attraction and repulsive forces. What happens if you put a pole to the centre of the other magnet?

Now back in your pairs, using the bar magnet from your equipment pack, can you figure out which of the materials in the box are magnetic by holding the magnet near each material, or by touching each material?

Discuss with your partner:

Did you find any unexpected results?

Are all metals magnetic?



Activity 4: Density

FUN FACT

The most dense material on earth is Osmium, which is a rare and very heavy metal. Osmium is most commonly found in South Africa.

All of your materials blocks are the same size, but they have different weights because they are made out of different materials. This is due to the size of the atoms which the material is made of, and how tightly packed together those atoms are.

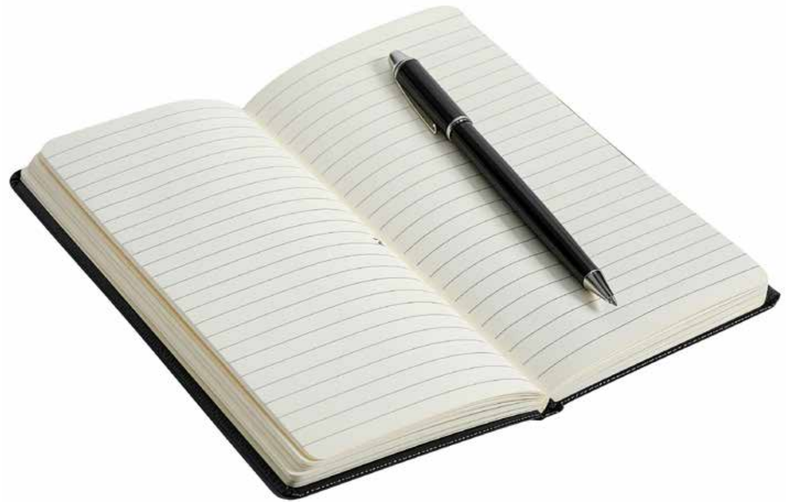
Turn on the weighing scales and weigh each material individually, then write down your results on your worksheet.

TOP TIP: Remember to ‘zero’ your weighing scales, you can do this by pressing the ‘tare’ button while there are no materials on the scales.

Density = Mass ÷ Volume

Activity 5: Material uses

- Make a list of some objects you can see around you.
- Write down what material is used to make each object.
- Explain why that material is used, think about the properties of that material.



Summary

We have learned that the matter inside the sun is not a solid, liquid or gas but a plasma. Solids, liquids and gases are made of atoms or molecules. Plasmas are a higher energy state than solids, liquids and gases, so they are hotter and their particles move around faster.

Different materials have different properties making them useful for specific jobs. The elements that make up a material and the way that those elements are 'packed together' has an impact on the properties of that material.

Metals are conductors but woods and plastics are insulators. This is means that metals allow electrical currents to flow through them. Wood and plastics do not allow for this flow of electricity, meaning that they 'break' any circuit that they are in.

Magnets can attract and repel other magnets and can produce forces without the need for contact. Not all metals are magnetic, iron was the only magnetic material tested during this experiment.

Materials with larger elements and atoms that are closely packed together have a higher density. This means that they weigh more despite being the same size.

Tokamak style fusion energy machines use magnetic confinement, which means large electromagnets use magnetic forces to contain and control hot plasma. By building fusion energy machines out of the best possible materials and by using strong magnets to hold the plasma in place it means that engineers and scientists can use the machines to release energy from plasma that is hotter than the sun!

Appendices

Appendix A

Density cube set can be purchased here:

brecklandscientific.co.uk/material-kits-and-sets/density-cube-set

Other density cube set options are available online through various organisations including:

Phillip Harris, Eisco Labs ad Blades Biological Ltd.

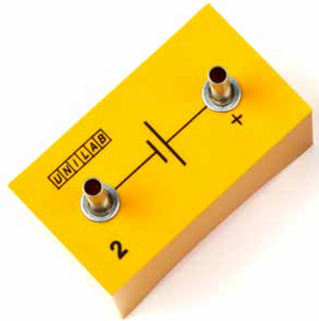
The remaining equipment seen in this document was purchased through:

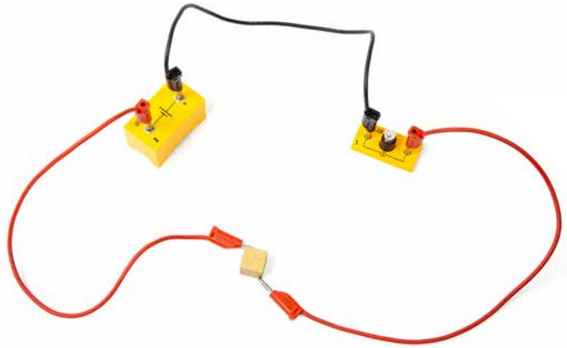
philipharris.co.uk

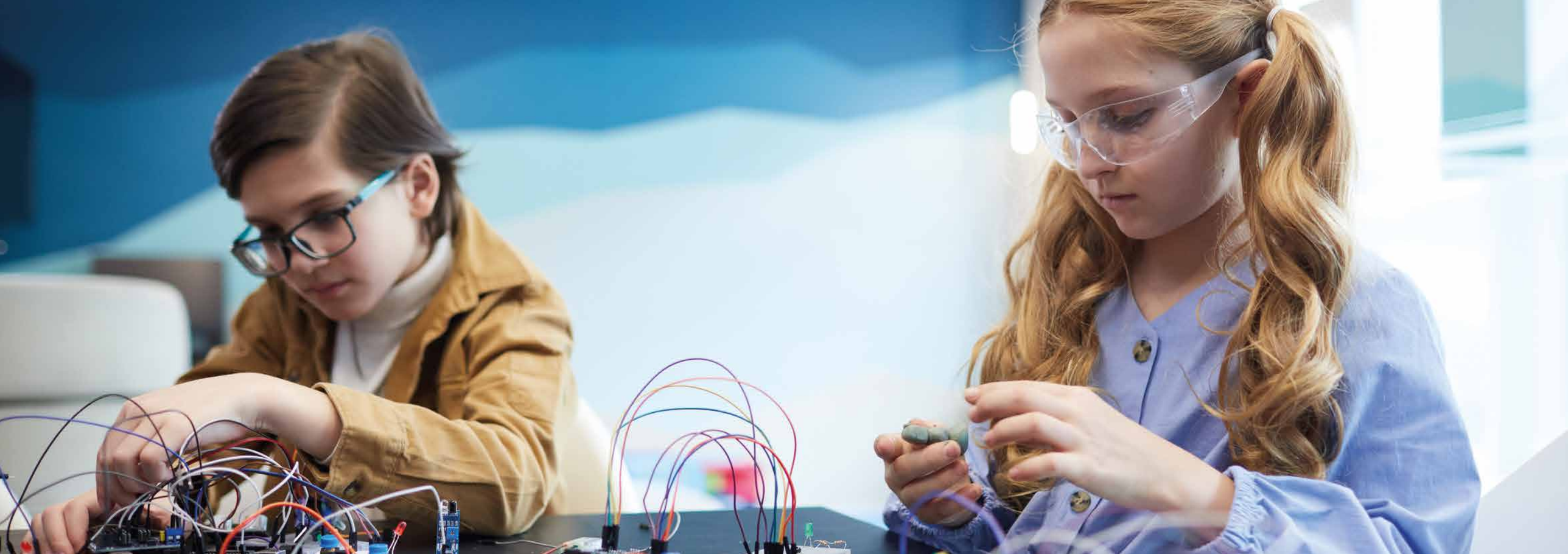
Other suppliers can be found online.

Risk Assessment

DESCRIPTION OF TASK	POTENTIAL HAZARDS	WHAT COULD GO WRONG	WHAT WILL BE DONE TO CONTROL THESE RISKS?
PRE ACTIVITY ASSESSMENT	Lead in the material density block samples could be slightly toxic to handle	Pupils could handle the Lead for long periods of time	Any lead or other potentially harmful materials will be removed from the pack before being handed over to the pupils.
ACTIVITY 1 **INSPECTING AND DESCRIBING SAMPLES**	Small parts	Injury could result from swallowing a test sample	Ensure density blocks are not given to small children or those who may attempt to swallow them.
ACTIVITY 2 **ELECTRICAL CONDUCTIVITY**	Light bulb could get hot Damaged battery used	Burn or mild discomfort. Risk of thermal run away (high heat, possible fire)	Light not to be left on Disposable batteries to be used, not rechargeable batteries. Workshop facilitators to check batteries for damage before and after use.
ACTIVITY 3 **MAGNETISM**	Use of magnets	Pinch injuries	Only provide 1 magnet per working pair. Verbally warn participants that magnets could potentially pinch fingers and to use appropriate caution.
ACTIVITY 4 **DENSITY**	Small parts	Injury could result from swallowing a test sample	Ensure density blocks are not given to small children or those who may attempt to swallow them.
ACTIVITY 5	N/A	—	—







UK Atomic Energy Authority

The UK Atomic Energy Authority's mission is to lead the delivery of sustainable fusion energy and maximise scientific and economic benefit

Find out more
www.gov.uk/ukaea

UKAEA is one of the world's leading fusion research laboratories, where our scientists and engineers are working with partners around the globe to develop fusion as a new source of cleaner energy for tomorrow's power stations. We are at the forefront of delivering fusion energy – a sustainable low carbon energy source that could change the world.

Fusion is based on the same processes that powers the stars. In the face of a changing climate and dwindling fossil fuel reserves, fusion offers the potential for a safe, abundant, low carbon, reliable baseload energy supply.

With our partners from industry and academia we will all support UKAEA's mission through:

- **Commitment**
- **Performance**
- **Openness & transparency**

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