

Objectives

- P14.1** Use a simple kinetic theory model to explain the different states of matter (solids, liquids and gases) in terms of the movement and arrangement of particles.
- P14.2** Recall and use the equation: density (kilograms per cubic metre, kg/m^3) = mass (kilograms, kg) / volume (cubic metres, m^3).
 $\rho = m/V$
- P14.3** *Investigate the densities of solids and liquids.*
- P14.4** Explain the differences in density between the different states of matter in terms of the arrangements of the atoms or molecules.
- P14.5** Describe that when substances melt, freeze, evaporate, boil, condense or sublimate mass is conserved and that these physical changes differ from some chemical changes because the material recovers its original properties if the change is reversed.

Maths requirements

- 1a** Recognise and use expressions in decimal form.
- 1c** Use ratios, fractions and percentages.
- 2a** Use appropriate numbers of significant figures.
- 3a** Understand and use the symbols: =, <, <<, >>, >, ∞ , ~
- 3b** Change the subject of an equation.
- 3c** Substitute numerical values into algebraic equations using appropriate units for physical quantities.
- 3d** Solve simple algebraic equations.
- 5b** Visualise and represent 2D and 3D forms, including two dimensional representations of 3D objects.

Learning outcomes

-  **SP14.1** Describe the arrangements of particles in solids, liquids and gases.
-  **SP14.1** Use the particle model to explain the different properties of solids, liquids and gases.
-  **SP14.2** Recall the formula relating density, mass and volume.
-  **SP14.2** Use the formula relating density, mass and volume.
-  **SP14.4** Use the particle model to explain why solids, liquids and gases have different densities.
-  **SP14.5** Describe what happens to the mass of a substance when it changes state.

Exploring

1. Investigating densities

This practical forms part of the core practical requirement of the specification and is supported by Students' sheet CP6 (Investigating densities) and *SP14a Core Practical – Investigating densities* in the Student Book.

See Students' sheet CP6 (Investigating densities) for a full method for this practical.

Provide students with a range of labelled liquids and solids and ask them to find the densities. The liquids can be reused if students pour them back into the containers.

Support: Ensure students know how to set balances to zero with a beaker on them. Some students may need help using the formula.

Stretch: Ask students to find the density of expanded polystyrene, and ask them to suggest how they would try to find the density of the polystyrene in it (as opposed to the overall density of the polystyrene and air combined). If necessary, suggest that students search the Internet for 'pressure Styrofoam cup', because increased pressure can force most of the air out of such materials.

Safety

Ensure any spills are mopped up right away. Ethanol is flammable, ensure there are no naked flames and the gas supply is turned off.

Expected results

Students calculate the densities of a range of liquids and solids from measurements of mass and volume.

Course resources

Phys Students' sheet CP6

Equipment

100 cm³ beaker, balance, displacement can, measuring cylinder (50 cm³), a range of liquids, a range of solid objects. Suitable liquids include tap water, salty water, cooking oil and ethanol (or white spirit, methylated spirit etc.). Suitable solids include metals, woods and plastics from materials kits, including expanded polystyrene.

2. Density changes

Students heat thermometers and bimetallic strips and observe the volume changes. Worksheet SP14a.2 provides instructions and questions to help students relate their observations to changes in density. The worksheet is split in two so that if time is short groups can do just one of the activities and report back to the class. Alternatively, the two activities can be demonstrated and the questions used as the basis for a class discussion.

Support: Allow students to follow the practical instructions, and then use the questions on the worksheet as the basis for a class discussion. Summarise the key points on the board for students to copy into their notebooks (heating causes an increase in volume; because the mass does not change the density must decrease).

Stretch: Show students a Galileo thermometer (or a picture of one), and ask them to explain how it works. You may need to remind students that objects float when they are less dense than the fluid they are in.

Safety

Hot water from the tap can be used – there is no need for boiling water.

Expected results

Students observe the change in volume of the liquid in a thermometer and the change in shape of a bimetallic strip when heated.

Course resources

Phys Students' sheet CP6

Equipment

beaker of hot water, liquid-in-glass thermometer, Bunsen burner, heat-resistant mat, bimetallic strip
Optional: Galileo thermometer