**Particle Theory – Solids, Liquids and Gases**  
*Lessons 3 and 4*

---

**Solids, Liquids and Gases**

**Essential Knowledge**

1. Build on knowledge of different materials and their properties. Use the diagrams/drama to explain how the particles in solids, liquids and gases are joined and move.

2. Moving particles have energy. When they stop moving, they release energy, in the case of the crystals, this is in the form of heat. This is called an exothermic reaction.

   **Sodium Ethanoate Stalagmite**
   When the solution cools it becomes supersaturated. This means that more of the sodium acetate is dissolved than would be possible under normal conditions. Any kind of shock to the flask will cause the sodium ethanoate to recrystallise. When it is poured onto the seed crystals, it cools and so recrystallises forming the stalagmite.

3. The properties of silly putty are unusual due to the ingredient polydimethylsiloxane (PDMS). This is a viscoelastic liquid silicone, which makes it act as a viscous liquid over a long time, but as an elastic solid over a short time. This explains why it flows like a liquid, but can bounce or break like a solid. As well as being used in toys, the material is used by physiotherapists for rehabilitative therapy of hand injuries. Apollo astronauts also used it to secure their tools in zero-gravity because of its adhesive characteristics.

   **Silly Putty**
   The silly putty has a property known as viscoelasticity. This means that over time it will flow slowly but it also has the property that it can bounce like a ball.

**Common Misconceptions**

- Materials can only have properties of one state of matter.
- Particles of solids have no motion, all particles (in solids, liquids, and gases) move because they have kinetic energy. Particles in solids vibrate about fixed sites. The vibrations are so small we can’t see them.
- Particles possess the same properties as the materials they compose. For example, atoms of copper are “orange and shiny”, gas molecules are transparent, and solid molecules are hard.
- Pliable solids (such as clay) are not solid.

**Termly Scientific Skills Development Focus: Recording and Analysis of Scientific Data and Observations**

- Collecting and presenting scientific observations in a way that can be analysed.
- Creating graphs and charts of the data.
- Analysing data the data obtained from the experiment and determining whether or not it proves or disproves the prediction.

Opportunities should be given throughout the lesson for children to use and develop their knowledge of planning investigations, through questioning and discussions on questions to investigate, making predictions and suggesting dependent and independent variables.

**Cross curricular links**

**Literacy**

- Writing instructions for the demonstration/investigation using imperative verbs.
Particle Theory – Solids, Liquids and Gases

Lessons 3 and 4

- Definitions of scientific vocabulary as part of a class science dictionary/glossary.
- Creative writing around the “magic potion/slime” created.

Numeracy

- Discussion and use of a variety of tables, diagrams.
- Some understanding of large numbers when describing how small atoms and molecules are and expressing these possibly as factors and powers e.g. $1 \times 10^6$.
- Developing accurate measuring skills.
- Improve language related to ration and proportion.

Other Subjects

- Research Sir Isaac Newton, particularly his time spent working at the Royal Mint, when he notoriously chased down counterfeiters ensuring they were hung, drawn and quartered!
- Meet the Greek philosopher, Democritus. We love this guy because he’s the father of the Particle Theory. This is crazy to think about, but over 2,400 years ago Democritus was sitting around Greece thinking about matter, which is anything that has mass and takes up volume.

Prior discussion

Pupils should be able to give some examples of solids liquids and gases and explain that these states of matter are inter-changeable depending on the temperature of the material.

Ask students if they have ever used a rechargeable hand warmer such as those which contain a colourless liquid which turns into a white solid when a metal disc is clicked. Demonstrate one and pass some around for students to feel.

- Demonstrate that the hand warmer can be ‘recharged’ by heating it in boiling water.
- Challenge students to explain what is happening in this situation. You might also like to link this activity to the energy changes in reversible processes.

Remind children of the particles of materials. Extend this by discussing other ways in which we classify things into solids, liquids or gases:

- SOLID: Holds shape, Fixed volume
- LIQUID: Shape of container, Free surface, Fixed volume
- GAS: Shape of container, Volume of container

Use examples:
- If I poured sand into a bottle, what would happen?
- If I poured water into a bottle, what would happen?
- If I poured marbles into a bottle what would happen?
**Teacher Demonstration**

**Fun Demonstration (1) – Sodium Ethanoate Stalagmite**

You will need: gas cartridge and burner, tripod and leg extensions, matches, heatproof mat, gauze, sodium ethanoate, water, petri dish, conical flask/beaker, stirring rod

1. Weigh 125 g of hydrated sodium ethanoate into the beaker and add 12.5 ml of water.
2. Heat the beaker over a low flame and stir until the solution clears completely.
3. Cover the beaker with a paper towel and allow it to cool to room temperature to give a supersaturated solution. *(Steps 1-3 Should be done ahead of time, even the day before to allow time to cool)*

   *If the solution is knocked, the reaction will take place prematurely. If this happens, you will need to reheat the solution.*

4. Remove the paper towel and place a few crystals of sodium ethanoate on it.
5. Pour the supersaturated solution slowly onto the sodium ethanoate crystals. The solution should crystallise immediately on contact with the crystals. It will form a growing ‘stalagmite’ of solid sodium ethanoate as more and more of the solution is poured onto it.

**Demonstration (2) - Silly Putty**

You will need: tripod, silly putty, cd

1. Place a CD on a tripod with the hole centred.
2. Put some silly putty into the hole.
3. Measure the distance from the desk to the silly putty every 5 minutes.

Please see links below for more information (and a little fun!)

http://www.practicalchemistry.org/experiments/sodium-ethanoate-stalagmite,64,EX.html

http://www.youtube.com/watch?v=LiHW2-pHi4I

http://www.youtube.com/watch?v=8IFzcj4wvQ&NR=1

**Possible Questions/ Suggestions for discussion**

Children watch the solution solidify instantly turning to a solid. They may have experience of small crystal sets at home, but this is better and presents a good opportunity to differentiate between liquids and solids.

Were they surprised at how little water was used?

Where have they seen this reaction before? (Frozen?)

You could ask students to grow their own crystals from different salts by tying a seed crystal to a length of cotton thread or very fine fishing line and suspending it in a saturated solution. Good crystals can be obtained from aluminium potassium sulphate (alum), magnesium sulphate, and iron (II) sulphate.

In addition children will handle silly putty, watching the putty change over time and drawing on their knowledge to observe and question and explain this interesting phenomena.

Is it a solid or a liquid?

Why?

**Children’s Investigation**

1. Materials Circus

   Use of a ‘circus of activities’, and in this case the materials circus, is an excellent way to allow pupils to repeatedly apply recent learning through hands on observation and discussion in pairs and groups. Pupils also have to move around the classroom in stages which is a good way of breaking the potential monotony of static seated lessons.

   The investigation used here is very simple but allows pupils to develop the skill of making rapid observations whilst adjusting quantities of substances used with some real precision to detect changes in the properties of the substance.
Demonstrate the apparatus that the students will be using and depending on the class either show or give them some written or verbal instructions on how to carry out the investigation circus. The different materials should be set up around the class in different containers where necessary and the pupils asked to walk around in pairs or threes to study the materials:

- Naming them
- Determining whether they are solids, liquids or gases
- Explaining why they have come to the conclusions they have using verbal, written or graphical explanations and by using particle model diagrams.

2: Investigating a Thixotropic (non-Newtonian) Substance
Pairs will need: Washing up bowl, cornflour/custard powder, water, food colouring
This investigation is a lot of fun, very messy and provides an excellent opportunity for pupils to apply a scientific model and follow instructions very carefully. Food colouring can be added for an even greater effect.

Method: (With sleeves rolled up!)
1. Measure about three tablespoons of the cornflour or custard powder into the plastic bowls
2. Carefully add water, ½ teaspoon at a time, and mix until it can be picked up as a semi crumbly ball and rolled in the hand.
3. With care, add ‘drops’ of water as the pupil applies a little pressure whilst rolling it around between their palms.
4. If the pupil then quickly opens their hands and holds the ball in their palm it should ‘magically’ turn to liquid!

Children can record the volume of water needed to make the thixotropic substance, then use this data to compare with other groups.

Possible Questions/ Suggestions for discussion
Get the class to record their observations and classifications of each material. Once the mess has been cleared away (this should only take a few weeks!) have a short class discussion for pupils to try to explain what they saw using the ‘particle model’.

- Was the thixotropic substance a solid, liquid or a gas?
- What caused the change?
- Which other materials can change state?
- Ask the class if they can work out where clouds come from using particle theory.
- Ask the class to explain why clothes on a washing line dry.
- As a high level extension question, you might like to ask if they can think about how water changes from a vapour into a solid when it snows using the concept of particles and energy flows.

Learning Outcomes
All children should

- Make predictions
- Recall that everything is made of tiny particles called atoms and molecules, and because these particles are small scientists use models to represent them.
- Learn that materials are classified in terms of properties of solids, liquids and gases.
- Generate descriptions of these properties using their knowledge and observations and learn that some materials are difficult to classify.
- Evaluate their own theories in light of their evidence.
- Record evidence in a scientific way.

Some children could

- Specifically identify the variables.
- Extend a scientific model to explain every day phenomena.
- Suggest ways in which the experiment could be of use.
Particle Theory – Solids, Liquids and Gases

Lessons 3 and 4

- Research the life of Democritus - who first used the word Atom – which means that which cannot be divided and conduct his simple but elegant thought experiment using a piece of paper to see how small a piece you can get by cutting it in half continually.

A few children could

- Suggest ways to improve the experiment to obtain more meaningful results
- Explain in detail, using particle theory, why some substances what appear to be solid are in fact liquids.
- Explaining phenomena such as sublimation Eg. in substances like solid air fresheners or solid CO₂.
- Research non-Newtonian fluids.
- Design an experiment to see if there are any other ‘powders’ that work as non-newtonian liquids.
- Very keen students who perhaps have heard of ‘Plasma’ from various space films etc could produce a report on the difference between a plasma and a gas (plus diagrams!)

Plenary/Review including Skills Progression focus: Recording and analysis of scientific data and observations

- Share decisions on classification of materials, and encourage children to debate their findings.
- Through whole class discussion elicit from the pupils what they observed during the investigation.
- Suggest ways in which to record their findings, and go on to present their data in a scientific way.
- What do children think they needed to do to ensure that they would get the same results if they or someone else was to repeat this experiment?
- The class should write on their experiment sheets an agreed definition for the term ‘valid data’.
- There might be an opportunity during the lesson to discuss what kind of graph would be best used to display data from this kind of experiment.

Useful websites

http://www.bbc.co.uk/bitesize/ks2/science/materials/solids_liquids_gases/read/1/
http://www.bbc.co.uk/bitesize/ks3/science/chemical_material_behaviour/particle_model/activity
http://en.wikipedia.org/wiki/Viscoelasticity
https://www.youtube.com/watch?v=3zoTKXXNQIU
https://www.youtube.com/watch?v=sWu9CyDwuFs