Unusual Bonds

Learning Objectives:

- To understand that materials are made up of atoms;
- To understand that both which atoms, and how they are arranged, give a material its properties;
- To name everyday materials and identify them;
- To distinguish between an object and the material it's made of, noting that some are made of more than one material;
- To describe the physical properties of a variety of materials;
- To identify that the shapes of some materials can be changed.

Science Skills:

- Making detailed observations and comparisons, taking note of patterns;
- Exploring and talking about ideas;
- Encountering more abstract scientific ideas and beginning to recognise how these ideas help to understand and predict how the world operates;
- Using equipment and following practical instructions with accuracy and precision;
- Planning adaptions and/or improvements to a practical method;
- Gain new scientific vocabulary.

Resources:

- Pens and paper
- Lolly sticks (at least 20)
- Circular stickers ~ size of a coin (at least 20)
- PowerPoint of images

What you should know before you start - *Slide 1 of Kathleen Lonsdale: Unusual Bonds*

Atoms

Materials are made up of lots of atoms. Atoms are too small to see with our eyes, or even a microscope. There are two things which affect the properties of a material: (1) which atoms it's made of, (2) how those atoms are arranged. Diamond and graphite (in pencils) are both made **only** of carbon atoms, but those carbon atoms are arranged differently, making them different.

Bonds

In a material, atoms are held together by **bonds**. Sometimes these bonds are strong and sometimes they are weak. **Molecules** are made of small numbers of atoms bonded together.

QUICKSTARTER – Properties properly

Compare the materials provided See *Slide 2* of PowerPoint.

- Soil
- Diamond
- Oil
- Plastic
- Pencil

Ask:

- What are the physical properties of these materials?
- Can you change their shape? If so, how?

Group the materials according to physical properties, such as:

- heaviness/density
- state (solid, liquid, gas)
- colour
- flammability
- strength
- shininess

Identify the difference between the objects and the materials they are made of (the pencil is made of wood and graphite, the cork and glass in the oil picture may also be mentioned). All of these materials are made mostly of carbon atoms. It is the different ways that carbon atoms are bonded together into different structures that give them their different physical properties.

Soil: https://en.wikipedia.org/wiki/Soil_regeneration#/media/File:Soil_Survey09_(39041768842).jpg
Diamond: https://en.wikipedia.org/wiki/Diamond_(gemstone)#/media/File:Brillanten.jpg
Oil: https://commons.wikimedia.org/wiki/File:Bottle_of_olive_oil.jpg
Plastic: https://commons.wikimedia.org/wiki/File:Recyclables.JPG
Pencil: https://en.wikipedia.org/wiki/Pencil#/media/File:Pencils_hb.jpg

Kathleen Lonsdale's story [*See photos on Slide 3*]
Listen to the story about Kathleen Lonsdale, make a timeline of her life, draw her in her laboratory, create a costume, or build a piece of her equipment.

In one wet January in 1903, Kathleen Yardley was born in poverty-stricken Ireland. Kathleen was a tenth child, and her parents, who ran a post office, didn't have much money. As such, in the first few years of her life, Kathleen often didn't get enough to eat, and due to malnutrition, she grew up small. When she was just five, her parents did what a lot of Irish people were doing – left. They emigrated to Essex in England, and here Kathleen went to school.

The young Kathleen was inquisitive and studied hard. Not afraid of standing out, she even went to a boys' school where she could study maths and science! Then, at sixteen, she got a scholarship to study maths at the University of London (most people go to university at eighteen). But Kathleen didn't know what she would do with maths, and was terrified of becoming a maths teacher! Her headmistress told her she "could never distinguish herself" in physics, but luckily, Kathleen didn't listen: and switched to physics, getting the highest mark for 10 years.

One of her final examiners was Nobel Prize winner William Bragg, who instantly recognised his own "enthusiastic spirit of enquiry" in Kathleen, and invited her to work for him. He taught her how to use x-rays to find the structures of molecules, and she started working on all the difficult (and controversial) topics!

Kathleen married Thomas Lonsdale, an engineer. He encouraged her to keep working, saying he had "not married to get a free housekeeper"! In 1929, whilst pregnant with her first child, Kathleen solved and published the structure of benzene, proving that it was flat. Whilst she looked after her young children, she made her kitchen table into her office, and worked at home, updating the rather old and cranky "space group" data which crystallographers use to solve structures.

Kathleen and Thomas joined the Quaker movement: Kathleen was from a fundamentalist family, but was uncomfortable with it because it clashed with science. However, when in 1939 WWII hit Britain, Kathleen refused to register for civil duties, because Quakers are pacifists and she would have no part in war: she was sent to Holloway prison for one month.

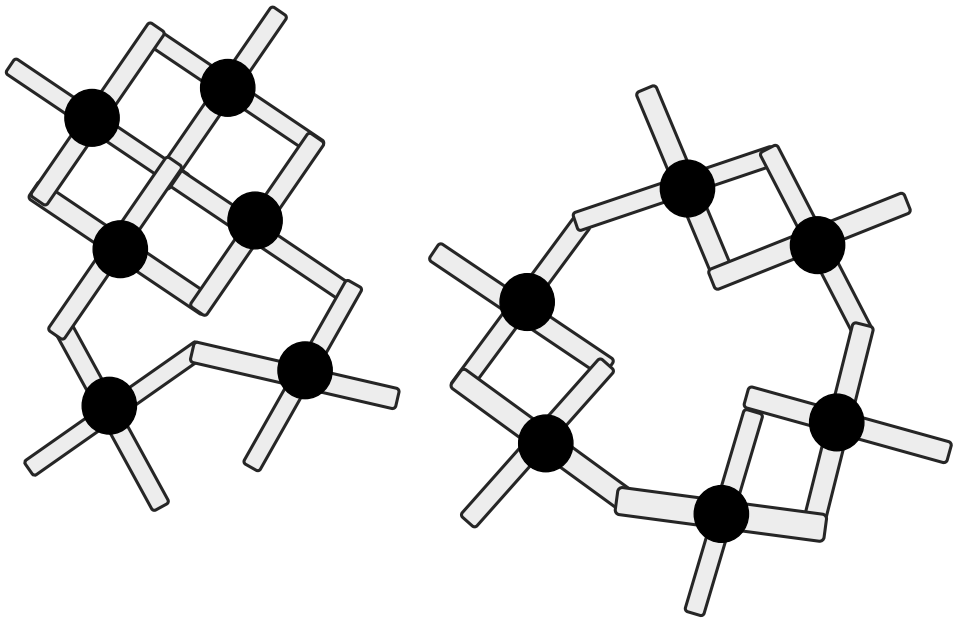
Although daunted, she later reported prison was an "anticlimax"! She was allowed to keep a diary and even got scientific instruments sent in! Once free, Kathleen became an activist for prison reform.

In 1971, aged 68, Kathleen died of cancer.

MAIN TASK – Unusual Bonds

Kathleen Lonsdale identified that the molecule called benzene has unusual bonds. These are what made the molecule flat.
Benzene is made up of 6 carbon atoms (black discs) and 6 hydrogen atoms (ends of sticks).

The pictures below on *Slide 4* show some examples of flat structures that have 6 stick ends showing and use 6 black discs.

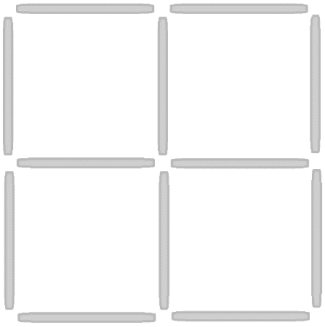


Instructions
1. Working in pairs, use your creativity to rearrange the sticks and discs. How many models can you come up with?
There must be exactly 6 black discs and 6 exposed stick ends.
2. Write a method for others to replicate one of your models.

Wrap up
Ask:

- Plastics are made up of long chains of carbon and hydrogen atoms. Diamond is made of just carbon, but many, many more than 6! A more common model for atoms and bonding is the ball and stick model (see PowerPoint). Can you come up with another way to show atoms bonding together?

EXTENSION ACTIVITY – matchstick maths
Arrange 10 of your lolly sticks in the pattern below and on *Slide 5*.



Now rearrange the sticks to make 3 squares. You must use all the sticks.
Ask:

- What is the smallest number of moves it takes you to go from 4 squares to 3?
- Can you make up a similar challenge for your partner?

REVIEW

ALL: Acknowledge that material properties depend on the way atoms are joined together, not only which atoms they are made of. Can describe the physical properties of a variety of materials. Can tell part of Kathleen Lonsdale's story of discovery.
MOST: Can explain how a molecule is made up of a small number of atoms.
SOME: Can explain what modelling bonds and atoms is.

ANSWERS

3 moves is possible. *See Slide 6*