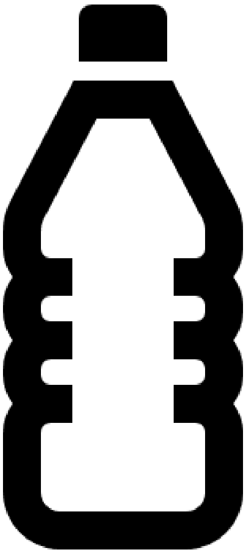
Material Design



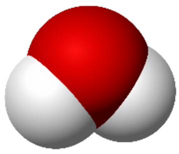
Lesson 1 Small and Long molecules

Have you ever wondered why the ice in your glass melts on a hot day but the glass itself does not, or why the chocolate in your pocket melts but the pen you had in there did not? This is because the chocolate, the glass, the ice and the plastic in the pen all have different melting points. The melting point is the temperature at which a substance changes from solid to liquid. Melting point is measured in ^{o}C, this is the unit.

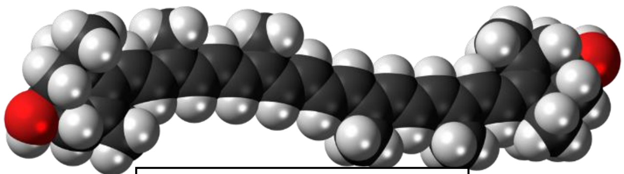
Substance	Melting point (the temperature it changes from a solid to a liquid) ^{o}C
Plastic	160
Chocolate	40-45
Ice	0
Glass	1700

To melt glass, you need to raise it to 1700oC which is a very high temperature indeed.

The difference between the glass and the ice is that when we zoom in on the very small molecules the glass has lots of atoms joined in a row and the ice has very few atoms joined in a row.

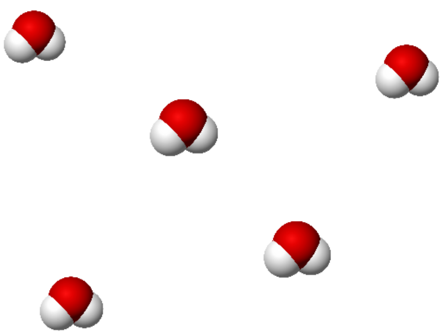


A picture of a water molecule – Short

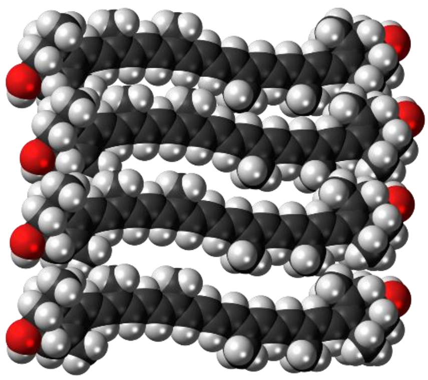


A picture of a molecule in plastic – Long

longer molecules are attracted to each other stronger than short molecules are attracted together. This means they need more heat energy to be separated and therefore a higher temperature to melt. This means that the melting point of a substance is directly linked to how long the molecule is.



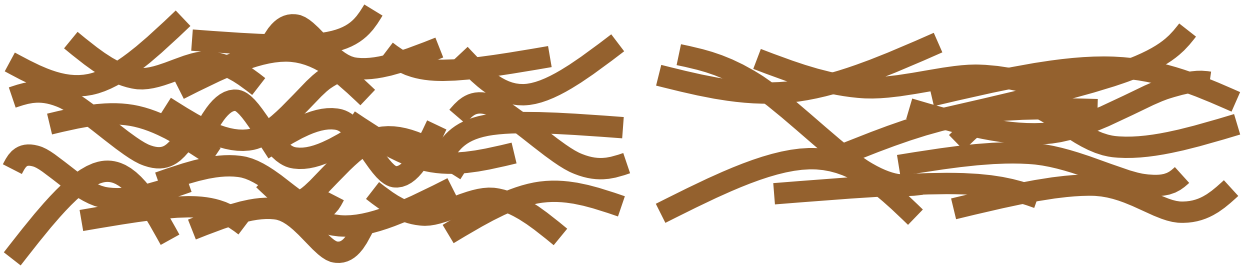
Weak attractions between water molecules – less energy to separate.



Strong attractions between molecules in plastic – more energy to separate.

Independent practice questions

1. What do mean by the term melting point?
2. What are the units for melting point?
3. The temperature of a box is 40°C. There is some chocolate in it, is the chocolate solid or liquid?
4. The temperature of a box is -10°C. There is some ice in it, is the ice solid or liquid?
5. What is the difference between a long molecule and a short molecule?
6. Describe the attraction between molecules in a substance which contains long molecules compared to substances which contain short molecules.
7. What is the melting point of a substances generally directly linked to?
8. Finish the sentences:
   a. The melting point is linked to the length of the molecule and….
   b. The melting point is linked to the length of the molecule because…
   c. The melting point is linked to the length of the molecule but
9. A student says: the ice in my glass melts at room temperature but the glass does not because the attractions between the molecules in ice are strong. Explain why the student is incorrect.
10. The students use different lengths of string to investigate how easy it is for different lengths of molecules to move across each other.



A polymer with longer molecules melts at a high temperature than a polymer made of molecules with shorted molecules.

a. Give one way in which the string model is a **good** representation to explain this.
b. Given one way in which the string model is **not a good** representation.

Lesson 2 Small and Long molecules

Have you ever wondered what makes materials like plastic so strong and flexible? It's all thanks to something called polymers! Let's dive into the world of polymers and uncover the secrets of these amazing molecules.

First off, what exactly is a polymer? Well, imagine a LEGO set. Each LEGO piece is like an atom, and when you snap them together to build something cool, you're making a polymer! In real life, atoms are tiny particles that make up everything around us, like the air we breathe and the water we drink.

Now, here's where it gets interesting. A single polymer molecule can be made up of thousands, or even millions, of these atoms all linked together in a long chain. Just think about it – that's like having a super long train made of LEGO pieces! And just like how different LEGO sets can build different things, different combinations of atoms can create different types of polymers with unique properties.

Imagine two types of LEGO trains: one is a straight line, while the other has branches sticking out. Similarly, polymer molecules can be either linear (straight) or branched (with side branches). Now, let's talk about how these shapes affect the mass of a given volume of polymer.

Picture a box filled with ping pong balls. If you have a bunch of straight-line LEGO trains packed neatly in the box, you can fit a lot of them without any wasted space between them. This means you have a high mass of polymer in that box for the given volume.

But what if those LEGO trains have branches sticking out? Now, they can't pack together as tightly because the branches get in the way. It's like trying to fit a bunch of tree branches into a box – there's going to be more empty space between them. So even though you still have the same number of LEGO trains, the overall mass of polymer in the box for the given volume is lower because of all that extra space.

So, to sum it up, the shape of polymer molecules – whether they're linear or branched – affects how tightly they can pack together in a given space, which in turn affects the mass of polymer you can fit in that space.

Now, why is all of this important? Well, think about all the things around you that are made of plastic – from water bottles to toys to car parts. Understanding polymers helps scientists and engineers design better materials that are stronger, lighter, and more versatile. For example, knowing how to control the shape of polymer molecules can help create plastics that are more flexible or more durable, depending on what they're needed for.

But it's not just about making things. Polymers also play a big role in our environment. Some polymers, like those in biodegradable plastics, can break down into harmless substances over time, which is good for the Earth. Others, like those in single-use plastics, can stick around for hundreds of years, causing pollution and harm to wildlife.

So, by understanding how polymer molecules are built and how their shapes affect their properties, we can make smarter choices about the materials we use and how we use them. Who knew tiny molecules could have such a big impact?

Independent practice

1. What analogy does the explanation use to help understand the concept of polymer molecules?
2. How are polymer molecules formed, and what distinguishes one polymer from another?
3. Explain the difference between linear and branched polymer molecules using the LEGO analogy.
4. How does the shape of polymer molecules affect the mass of a given volume of polymer?
5. Why is understanding polymers important for scientists and engineers?
6. What role do polymers play in the environment, and how can different types of polymers impact the planet differently?
7. Longer Answer Question:

8. Imagine you are a scientist tasked with designing a new type of plastic that needs to be both strong and environmentally friendly. How would you use your understanding of polymer molecules, including their shapes and properties, to create this new material? Provide specific examples and explain the reasoning behind your choices.

Lesson 3 Plasticisers and crosslinks

Hey there, young scientist! Today, we're going to dive into the fascinating world of polymers and explore two important concepts: plasticizers and cross links. These are like the secret ingredients that determine how flexible or strong a polymer can be.

Let's start with plasticizers. Imagine you have a bunch of tiny Lego blocks stuck together to make a big structure. Now, these Lego blocks represent molecules in a polymer. Normally, when you have a lot of these molecules together, the polymer can be stiff, like a hard plastic ruler.

But what if we want our polymer to be softer and more flexible, like a bendy straw? That's where plasticizers come in! Plasticizers are like little helpers that we can add in between the molecules of the polymer. They act like lubricants, making it easier for the molecules to slide past each other.

Think of it this way: if you have a bunch of friends holding hands in a line, it's hard to move around. But if you put some oil on your hands, suddenly you can slide past each other much more easily! That's exactly what plasticizers do to polymer molecules. They make the polymer more flexible by reducing the friction between the molecules.

Now, let's talk about cross links. Cross links are like strong bonds that connect one polymer molecule to another. Imagine you have a bunch of spaghetti noodles in a bowl. If each noodle is separate, you can easily move them around. But if you start connecting some of the noodles with toothpicks, suddenly the noodles become tangled together and it's harder to move them around.

In polymers, these cross links can make the material stronger and more rigid. It's like adding reinforcements to our structure made of Lego blocks. With more cross links, the polymer becomes tougher and less flexible.

So, to sum it up: plasticizers make polymers softer and more flexible by reducing friction between molecules, while cross links make polymers stronger and less flexible by connecting molecules together.

Now, let's see these concepts in action with an example you might be familiar with rubber bands! Rubber bands are made of a polymer called latex. Without any plasticizers or cross links, latex would be stiff and brittle, like a hard eraser. But by adding plasticizers, manufacturers can make latex rubber bands that are stretchy and flexible.

On the other hand, if we add lots of cross links to the latex, it becomes tougher and less stretchy, like the rubber on a car tire. So, depending on how we tweak the number of plasticizers and cross links, we can create different kinds of rubber with different properties.

Isn't it amazing how tiny changes can completely transform the properties of a material? Scientists and engineers use these concepts every day to create all sorts of things, from toys to tires to medical devices. And now, you have a better understanding of how they work!

Keep exploring, young scientist, and remember science is all about asking questions and seeking answers. Who knows what discoveries you might make next!

1. What are plasticizers, and how do they affect the properties of polymers?

   Answer:

2. Explain the analogy used to describe the function of plasticizers in polymers.
3. How does the addition of plasticizers make a polymer softer and more flexible?
4. Give an example of a polymer-based product that benefits from the use of plasticizers and explain why.
5. What happens to the properties of a polymer when it has a high concentration of cross links?
6. Explain in detail how plasticizers work to make polymers softer and more flexible. Include examples and describe the impact of plasticizers on the arrangement of polymer molecules.