

# Telling pure substances from mixtures

Grade 7 science (Year 8 · Class 7) · Lesson

**Quick answer:** A pure substance contains only one kind of particle, while a mixture contains two or more substances that are not chemically joined. Pure substances melt and boil at fixed temperatures, such as 0 °C and 100 °C for water. Mixtures melt and boil over a range, and this helps scientists test for purity.

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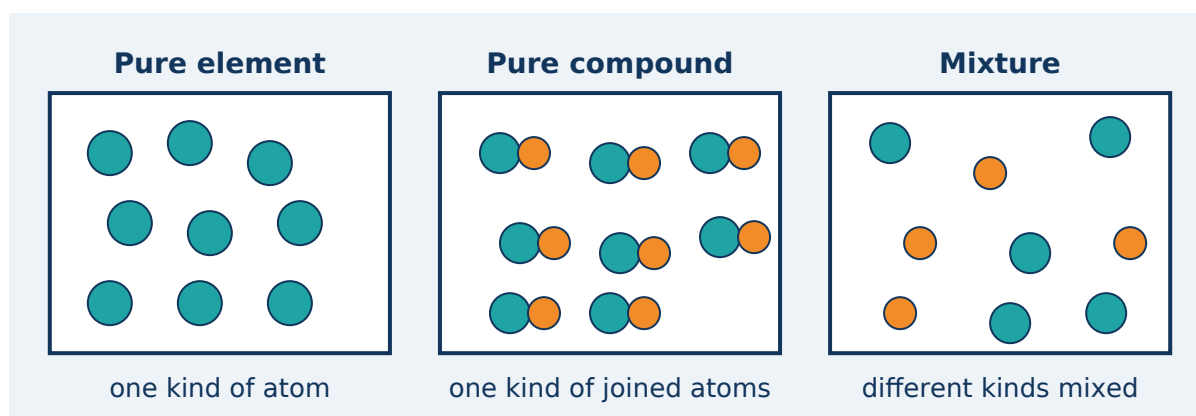
## What is a pure substance?

In everyday talk, "pure" can mean fresh or natural, such as pure orange juice. In science the word is stricter. A **pure substance** contains only one kind of particle, so every bit of it has exactly the same composition and the same properties.

### Definition

A **pure substance** is a material made of only one kind of particle. A **mixture** contains two or more different substances that are not chemically joined to each other.

Distilled water, oxygen, copper and table salt are pure substances. Air, sea water, brass, milk and soil are mixtures. A mixture can be made in any proportion: you can stir a little salt or a lot of salt into water, and it is still salt water.



*Particle pictures of a pure element, a pure compound and a mixture.*

## How can you tell a pure substance from a mixture?

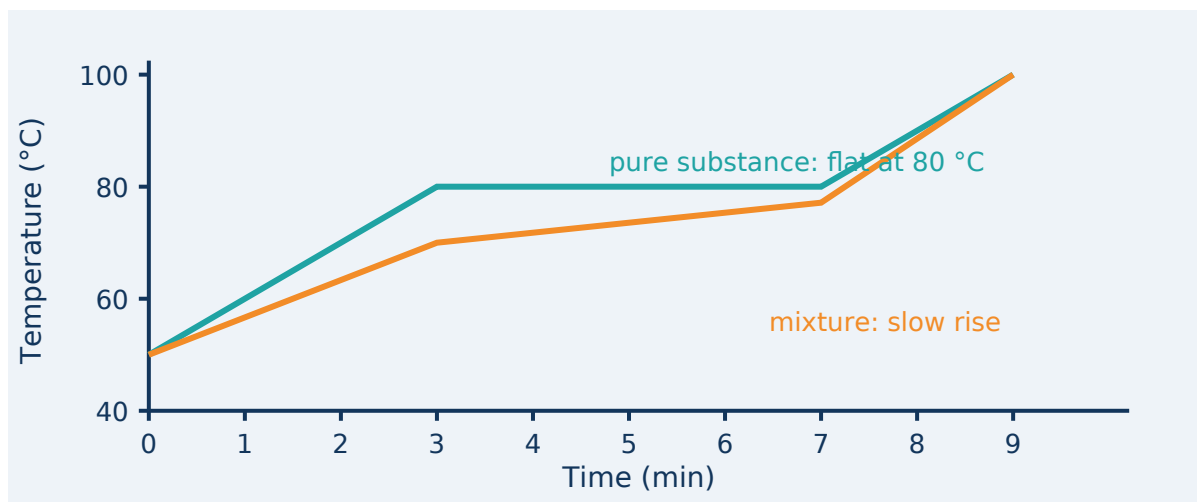
You cannot always tell by looking. Clear tap water and clear distilled water look identical. Scientists use measurable properties, and the best are the melting point and the boiling point.

### Key rule

A pure substance melts and boils at one fixed temperature (at the same pressure). A mixture melts and boils over a range of temperatures, and its melting point is lower than

that of the pure substance.

The graph shows what you observe when you heat a pure solid and an impure sample of the same solid. The pure solid stays at its melting point until all of it has melted. The mixture starts melting at a lower temperature and its temperature keeps rising slowly while it melts.



Heating curves of a pure solid and an impure sample of it.

| Substance    | Melting point (°C) | Boiling point (°C) |
|--------------|--------------------|--------------------|
| Water        | 0                  | 100                |
| Ethanol      | -114               | 78                 |
| Propanone    | -95                | 56                 |
| Lauric acid  | 44                 | 298                |
| Stearic acid | 69                 | 383                |
| Naphthalene  | 80                 | 218                |

Because every pure substance has its own melting and boiling points, these numbers work like a fingerprint. If you measure a sharp melting point, you can look it up in a data table and identify the substance.

### Worked example 1

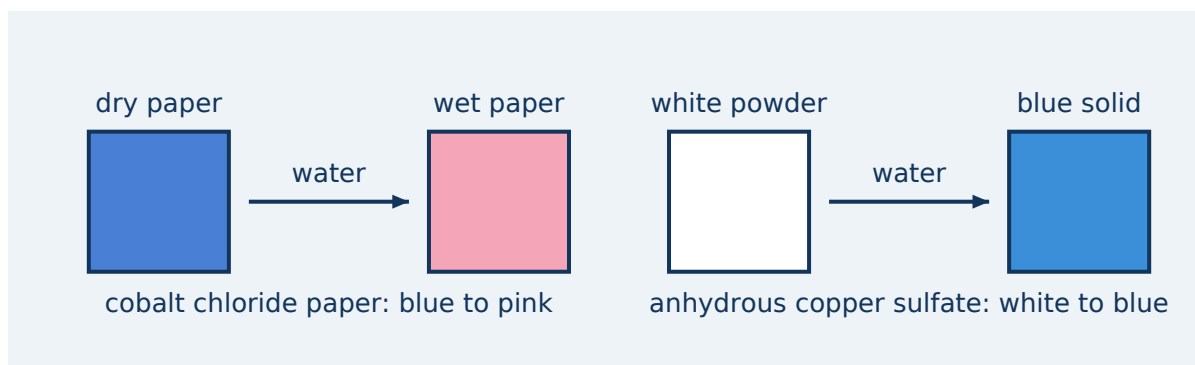
Ravi in Chennai heats a white solid. It starts to melt at 79.5 °C and has all melted at 80.5 °C. **Is it pure? Which substance is it?** The melting range is  $80.5 - 79.5 = 1.0$  °C, which is very narrow, so the solid is pure. The centre value, 80 °C, matches naphthalene in the table. **Answer: a pure sample of naphthalene.**

### Worked example 2

Hana in Leeds tests another sample of the same white solid. It starts melting at 71 °C and is completely liquid at 78 °C. **What does this show?** The melting range is  $78 - 71 = 7$  °C, which is wide, and it begins well below 80 °C. **Answer: the sample is a mixture, or impure naphthalene.**

## How do you test for water?

Pure water freezes at 0 °C and boils at 100 °C at normal air pressure. Water can also be detected with two chemical tests, shown in the figure. Both tests show that water is present, but they cannot show that it is pure. A cup of salt water will turn cobalt chloride paper pink as well.



*Chemical tests that show water is present.*

To prove that a liquid is pure water you must measure its boiling point and its freezing point. Dissolved substances change both: salt water boils above 100 °C and freezes below 0 °C. This is why salt is spread on icy roads in cold countries.

## Is every mixture a bad thing?

No. Many useful materials are mixtures on purpose. Brass is copper mixed with zinc and is harder than copper. Gold jewellery is a mixture of gold and other metals, so a 22-carat ring contains 22 parts of gold in 24 parts of metal. Cooks, builders and engineers mix substances to get exactly the properties they need.

### Common mistake

Do not use "pure" to mean "natural" or "clean". Mineral water from a mountain spring contains dissolved salts, so it is a mixture. Distilled water made in a factory is much closer to a pure substance.

### Lina's tip

When a question mentions a sharp melting or boiling point, think "pure". When it mentions a range or a number that is too low or too high, think "mixture".

### Key points to remember

- A pure substance has only one kind of particle; a mixture has two or more.
- Pure substances melt and boil at fixed temperatures; mixtures over a range.
- Pure water melts at 0 °C and boils at 100 °C at normal pressure.
- Impurities lower the melting point and raise the boiling point.
- Water tests show water is present but not that it is pure.

## Telling pure substances from mixtures: frequently asked questions

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### What is the difference between a pure substance and a mixture?

A pure substance has only one kind of particle and fixed properties. A mixture has two or more substances in any proportion and its properties can change with the amounts.

### Why does a pure substance have a sharp melting point?

All its particles are the same, so they are held by the same strength of attraction and all break free at the same temperature. In a mixture, different particles loosen at different temperatures.

### How does an impurity change the boiling point of water?

Dissolved impurities raise the boiling point above 100 °C and lower the freezing point below 0 °C. The more impurity, the bigger the change.

### Does cobalt chloride paper prove that a liquid is pure water?

No. It turns from blue to pink if any water is present, including in salt water or juice. To prove purity you must measure the boiling point and freezing point.

### Is air a pure substance?

No. Air is a mixture of nitrogen, oxygen, argon, carbon dioxide and other gases. The gases are not chemically joined, and their proportions vary a little from place to place.