

It's Elemental: Pre-Show Study Guide

It's Elemental is a 60-minute chemistry show with ten live experiments, from glow bracelets to fireballs to a giant foam finale. Every reaction starts with an element. Read each section below and answer its questions before you come, so you can spot the science as it happens on stage.

Answer in complete sentences unless a question asks you to fill in a blank.

Section 1: Elements and the periodic table

Everything around you, from your desk to the air you breathe, is made of **elements**. An element is a pure substance made of only one kind of atom. Scientists have found 118 elements, and they are organized on a chart called the **periodic table**.

Each element has a one- or two-letter **symbol**. Some are easy, like O for oxygen and C for carbon. Others come from Latin names, like Na for sodium and K for potassium. Most elements are metals, which sit on the left and middle of the table.

Elements join together to make **molecules**. Water (H₂O) is a molecule of hydrogen and oxygen. Carbon dioxide (CO₂) is a molecule of carbon and oxygen.

Elements you will meet at the show: nitrogen, oxygen, carbon, hydrogen, sodium, potassium, lithium, strontium and copper.

Questions

1. What is an element?
2. How many elements have scientists found?
3. Write the symbol for each element: oxygen ____, carbon ____, hydrogen ____, nitrogen ____, sodium ____, copper ____.
4. What is the difference between an element and a molecule? Give one example of each.
5. Which two elements make up carbon dioxide?

Section 2: Atoms and electrons

An **atom** is the smallest piece of an element. Atoms are far too small to see, even with a regular microscope. Every atom has a center called the **nucleus**, made of **protons** and **neutrons**. Tiny **electrons** move around the nucleus.

The number of protons decides which element an atom is. Every carbon atom has 6 protons, and every oxygen atom has 8.

Electrons sit at different **energy levels**. When an atom is heated, its electrons can jump up to a higher level. When they fall back down, they give off that extra energy as light. Each

element gives off its own color, which is why fireworks can be red, green or blue. You will see this in the Flame Test.

Questions

6. What is an atom?
7. Name the three tiny particles that make up an atom. Which ones are in the nucleus?
8. What decides which element an atom is?
9. What happens to an atom's electrons when it is heated? What do they give off when they fall back down?
10. **Think deeper:** Why might two different metals give off two different colors of light in a flame?

Section 3: Solids, liquids and gases

Matter comes in three main **states**: solid, liquid and gas. In a **solid**, particles are packed tightly and hold their shape. In a **liquid**, they slide past each other. In a **gas**, they spread out and fill any space they are in.

Most solids melt into a liquid before becoming a gas. A few skip the liquid step and turn straight into a gas. This is called **sublimation**. Dry ice, which is frozen carbon dioxide at about $-78.5\text{ }^{\circ}\text{C}$, does this.

Gas particles bump into the walls of their container. How hard they push is called **pressure**. Squeeze more gas into a sealed space and the pressure goes up, until something has to give, like a lid popping off.

Gases can also be heavier or lighter than air. A gas that is **denser** than air, like carbon dioxide, sinks toward the floor.

Air itself is a mix of gases: about 78% nitrogen and 21% oxygen. You can't see it, but it is made of real particles.

Questions

11. Describe how particles behave in a solid, a liquid and a gas.
12. What is sublimation? Name one substance that does it.
13. What happens to the pressure inside a sealed container when more gas is made inside it?
14. Air is about ____% nitrogen and ____% oxygen.
15. **Think deeper:** If you blew a soap bubble filled with carbon dioxide, would it float up or sink? Explain why.

Section 4: Physical and chemical changes

A **physical change** changes how a substance looks or what state it is in, but it is still the same substance. Ice melting into water is a physical change. So is solid dry ice turning into carbon dioxide gas.

A **chemical change**, or **chemical reaction**, makes new substances by rearranging atoms. Baking a cake and rusting metal are chemical changes. You usually can't undo them.

Signs that a chemical reaction is happening:

- Bubbles or gas form
- Light is given off
- The temperature changes (it gets hot or cold)
- The color changes
- A new solid forms

Some reactions get help from a **catalyst**, a substance that speeds up a reaction without being used up. At the show, a catalyst will turn a flask of liquid into a giant column of foam in seconds.

Questions

16. What is the difference between a physical change and a chemical change?

17. List three signs that a chemical reaction is happening.

18. Label each as a physical or chemical change:

Ice melting ____

Wood burning ____

Baking soda and vinegar fizzing ____

Dry ice turning into gas ____

A glow stick lighting up ____

19. What is a catalyst?

20. Think deeper: At the show, watch for the signs of a chemical reaction. Predict which sign you think you will see the most.

Section 5: Fire and combustion

Combustion is the science word for burning. It is a fast chemical reaction between a **fuel** and oxygen that gives off heat and light.

Every fire needs three things, called the **fire triangle**: fuel, oxygen and heat. Take away any one and the fire goes out. That is why firefighters spray water (removing heat) or smother flames with a blanket (removing oxygen).

Most fuels, like wood, gasoline and natural gas, contain carbon and hydrogen. When they burn completely, they make carbon dioxide and water.

How fast something burns depends on how much of it touches oxygen. A log burns slowly, but sawdust blown into the air can burn in a flash, because each tiny piece is surrounded by oxygen. This is called **surface area**.

Questions

21. What is combustion?
22. Name the three parts of the fire triangle.
23. Which two elements are found in most fuels?
24. When a fuel made of carbon and hydrogen burns completely, what two substances does it make?
25. **Think deeper:** Why does a pile of flour barely burn, but a cloud of flour in the air can burst into a fireball?

Section 6: Science safety and show etiquette

Scientists wear **personal protective equipment (PPE)** to stay safe. At the show you will see goggles to protect eyes, a lab coat to protect skin and clothes, and special cryo gloves for handling dry ice, which is cold enough to burn skin.

The fire experiments are **demonstrations only**. They are done by a trained chemist with a fire extinguisher ready. Never try them at home.

Some experiments need **volunteers** from the audience. If you are picked, listen carefully, wear the safety gear you are given and follow every direction. Everyone else can help by counting down, guessing colors and cheering.

Questions

26. What does PPE stand for? Name two pieces of PPE you expect to see at the show.
27. Why does the chemist wear special gloves when handling dry ice?
28. Why should you never try the fire experiments at home?
29. If you are chosen as a volunteer, what are two things you should do?
30. **Think deeper:** Write one question you hope the chemist answers during the show.

Teacher answer guide

Numbers match the student questions. For Think deeper questions, accept any answer that uses the science correctly; the guide lists what a strong answer includes.

Section 1: Elements and the periodic table

1. A pure substance made of only one kind of atom.
2. 118.
3. Oxygen O, carbon C, hydrogen H, nitrogen N, sodium Na, copper Cu.
4. An element has only one kind of atom; a molecule is two or more elements joined together. Examples: oxygen (element), water H₂O (molecule).
5. Carbon and oxygen.

Section 2: Atoms and electrons

6. The smallest piece of an element.
7. Protons, neutrons and electrons. Protons and neutrons are in the nucleus.
8. The number of protons.
9. Heat gives the electrons energy, so they jump to a higher energy level. When they fall back down, they give off the energy as light.
10. **Think deeper:** Each element's electrons sit at different energy levels, so they give off different amounts of energy when they fall, which we see as different colors.

Section 3: Solids, liquids and gases

11. Solid: packed tightly, holds its shape. Liquid: particles slide past each other and take the shape of the container. Gas: particles spread out to fill any space.
12. When a solid turns straight into a gas without melting. Dry ice (frozen carbon dioxide).
13. The pressure goes up.
14. About 78% nitrogen and 21% oxygen.
15. **Think deeper:** It would sink, because carbon dioxide is denser (heavier) than the air around it.

Section 4: Physical and chemical changes

16. A physical change changes how a substance looks or its state but it stays the same substance. A chemical change makes new substances by rearranging atoms.
17. Any three: bubbles or gas form, light is given off, temperature changes, color changes, a new solid forms.

18. a) physical, b) chemical, c) chemical, d) physical, e) chemical.

19. A substance that speeds up a reaction without being used up.

20. **Think deeper:** Any prediction with a reason. Gas forming and light given off are the most common signs in the show.

Section 5: Fire and combustion

21. A fast chemical reaction between a fuel and oxygen that gives off heat and light; burning.

22. Fuel, oxygen and heat.

23. Carbon and hydrogen.

24. Carbon dioxide and water.

25. **Think deeper:** In a cloud, each tiny grain is surrounded by oxygen, giving much more surface area, so it all burns at once. In a pile, only the outside touches oxygen.

Section 6: Science safety and show etiquette

26. Personal protective equipment. Any two: goggles, lab coat, gloves, cryo gloves.

27. Dry ice is about $-78.5\text{ }^{\circ}\text{C}$, cold enough to burn skin.

28. They use fire and flammable chemicals and are done only by a trained chemist with safety equipment, like a fire extinguisher, ready.

29. Any two: listen carefully, wear the safety gear given, follow every direction.

30. **Think deeper:** Answers will vary. Accept any question related to the science in the show.