

14–16 years

The reaction between zinc powder and sulfur



Introduction

When chemical reactions occur, atoms are rearranged to form different substances. The original elements, once combined, have different chemical and physical properties than when they were reactants.

In this demonstration, you will observe an exothermic reaction of two elements, zinc and sulfur, to form the compound zinc sulfide. The two solids are mixed and heated in a test tube (or ignition tube) and changes in their properties can be observed. Careful observations will also reveal that some by-products are formed.



Learning objectives

- Recall the definitions of elements, mixtures and compounds
- Describe the changes that take place during a chemical reaction
- Write chemical equations for the reactions
- Use energy changes to decide whether a reaction is exothermic or endothermic

Zinc and sulfur



Zinc is an essential element – the mineral is required for skin and bone growth, and our bodies use zinc to process food and nutrients.

Zinc ions, Zn^{2+} , are vital components in several different enzymes found in the body.



Sulfur is an essential element. It occurs in the amino acids cysteine and methionine and, therefore, in many proteins. It is a minor constituent of fats, body fluids and skeletal minerals.

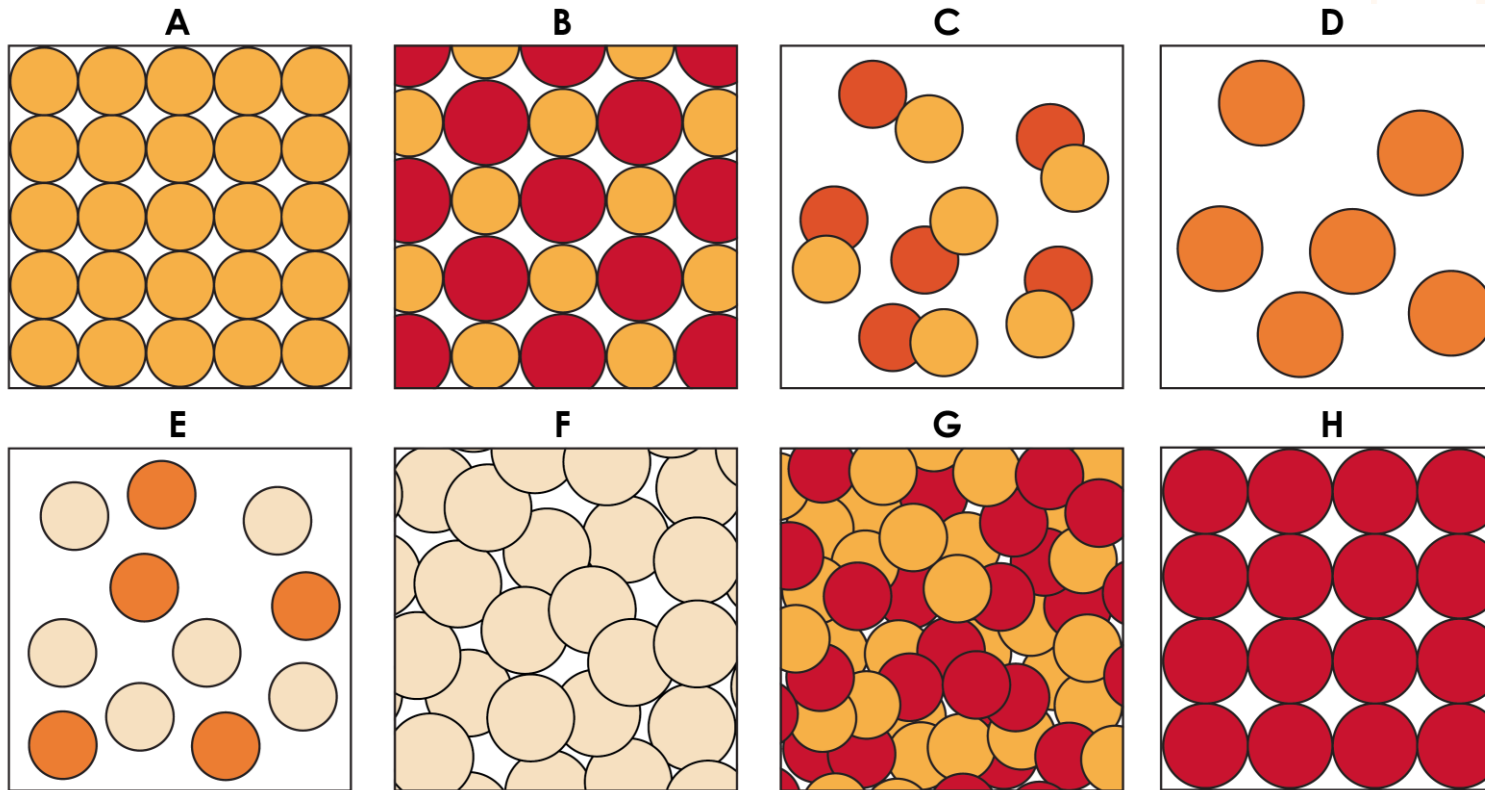


Zinc sulfide is the main form of zinc found in nature. It mainly occurs as the mineral sphalerite. Pure zinc sulphide is white. The ore contains many impurities.



Elements, mixtures and compound

Look at the particle diagrams below and determine which are elements, compounds and mixtures. Explain your answers.



Which particle diagram could represent zinc? Suggest a reason for your answer.

Observations

Watch the teacher demonstration and note down your observations in the table.

| Substance | Symbol | Appearance | Element, mixture or compound? |
|--------------|--------|------------|-------------------------------|
| Zinc | | | |
| Sulfur | | | |
| Zinc sulfide | | | |

Follow-up questions

1. Explain how you know that a chemical reaction has occurred between zinc and sulfur. Refer to descriptions of changes in colour in your answer.
2. In the reaction you observed, zinc (Zn) reacted with sulfur (S) to produce zinc sulfide (ZnS).
 - (a) Write a word equation for this reaction.
 - (b) Write a symbol equation for this reaction. Include state symbols.
3. The reaction between zinc and sulfur is exothermic.
 - (a) Describe the observations that support this statement.
 - (b) Describe the energy changes that take place during the chemical reaction.
 - (c) Explain why the reaction needed to be heated at the start.

Follow-up questions

4. During the reaction between zinc and sulfur, two by-products were formed, zinc oxide, ZnO , and sulfur dioxide, SO_2 .

(a) State the meaning of the term by-product.

(b) Name all the compounds present in the mixture at the end of the main chemical reaction.

(c) Write a symbol equation for the formation of each by-product.

(d) Identify the reactants for each by-product and explain where each reactant came from.

5. The percentage yield of a reaction is calculated using the equation:

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}}$$

Suggest why this reaction has a yield of less than 100%.

Follow-up questions

6. Zinc can be obtained from zinc sulfide by a smelting process.

Step 1 The zinc ore is roasted in air, converting it to zinc oxide.

Step 2 Coke and the roasted ore are fed into the top of the furnace, and air is blasted in at the bottom. The zinc oxide is reduced to zinc by carbon monoxide gas.

Step 3 To prevent the hot zinc from being re-oxidised, it is sprayed with molten lead, forming a mixture. As the mixture cools, the zinc separates out.

- (a) Explain why it is so difficult to extract zinc from zinc sulfide.
- (b) Write an equation to show the process occurring in step 1.
- (c) Write an equation to show the process occurring in step 2.
- (d) Explain why the zinc can be easily separated out in step 3.

Answers

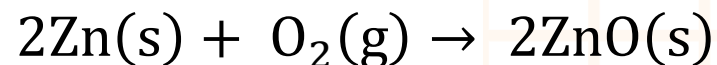
1. Observations during heating: observed a bright light; saw sparks; heard hisses/pops. Observations at the end: a pale-yellow solid substance was left, replacing the pale blue and bright yellow solid mixture.
2. (a) zinc + sulfur \rightarrow zinc sulfide
(b) $\text{Zn(s)} + \text{S(s)} \rightarrow \text{Zn(s)}$
3. (a) observed a bright light; observed sparks; heard hisses/pops.
(b) At the start of the reaction, **energy** was needed to **break** the bonds in the reactants.
The **atoms** rearranged and **energy** was given out as the new bonds **formed**.
During the reaction, **heat** and sound **energy** were given out to the surroundings. Therefore, the reaction was exothermic.
(c) To get the reaction started.

Follow-up questions

4. (a) A product formed during the reaction that is not wanted.

(b) Zinc sulfide. Zinc oxide

(c) zinc + oxygen → zinc oxide



sulfur + oxygen → sulfur dioxide



(d) For zinc oxide – reactants are zinc and oxygen; zinc came from the zinc / sulfur mixture, oxygen came from the air.

For sulfur dioxide – reactants are sulfur and oxygen; zinc came from the zinc / sulfur mixture, oxygen came from the air.

5. By-products are formed during the reaction / Some sulfur dioxide is formed during the reaction / Some zinc oxide is formed during the reaction / Not all the zinc and sulfur atoms end up in the final zinc sulfide product. Therefore, the yield is less than 100%.

Answers

6. (a) Zinc sulfide is a compound. The atoms are held together by strong covalent bonds, so a lot of energy is required to break them.

(b) zinc sulfide + oxygen → zinc oxide + sulfur dioxide
$$2\text{ZnS}(s) + 3\text{O}_2(g) \rightarrow 2\text{ZnO}(s) + 2\text{SO}_2(g)$$

(c) zinc oxide + carbon monoxide → zinc + carbon monoxide
$$\text{ZnO}(s) + \text{CO}(g) \rightarrow \text{Zn}(g) + \text{CO}_2(g)$$

(d) The zinc forms a mixture with lead. The components of a mixture can be easily separated by physical processes as there are no strong chemical bonds to break.