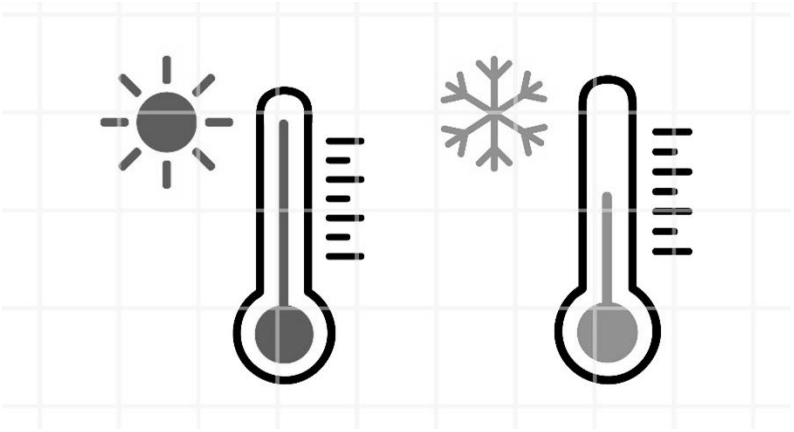
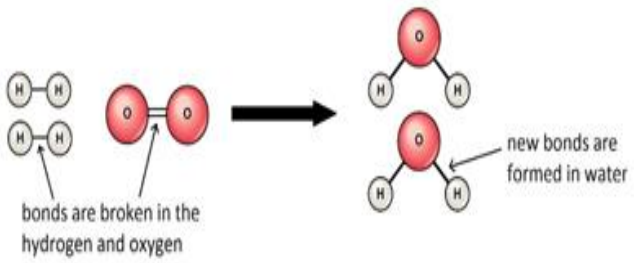
Energy and reactions



L1 Exothermic Reactions

The prefix (ex- or exo-) means out of, away from, outer, external, outside, or exterior. It is derived from the Greek exo meaning "out of" or external. Thermo- , word-forming element of Greek origin meaning "hot, heat, temperature," from Greek thermos "hot, warm," thermē "heat.

Exothermic reactions involve the release of heat energy. In simple terms, these reactions give off heat to the surroundings, making them feel warm. If measured with a thermometer the temperature of a reaction mixture will increase. This process occurs when the energy needed to break bonds in the reactants is less than the energy released when new bonds form in the products.



In real life, exothermic reactions are all around us. An everyday example of an exothermic reaction is the combustion of wood in a fireplace. When wood burns, it reacts with oxygen from the air to produce carbon dioxide (CO_2) and water vapor (H_2O). The energy needed to break the bonds in the wood and the oxygen is less than the energy released when new bonds form in the products. This releases heat and this is why sitting by a cozy fire can make you feel warm.

Wood + Oxygen -> carbon dioxide + water

Energy taken in to break bonds
Less energy

Energy released when making bonds
More energy

In scientific contexts, exothermic reactions play a crucial role in various chemical processes. For instance, the reaction between sodium hydroxide (NaOH) and hydrochloric acid (HCl) is highly exothermic. When these two substances are combined, they react to form sodium chloride (NaCl), water (H_2O), and a significant amount of heat.

Sodium hydroxide + Hydrochloric acid -> sodium chloride + water

Energy taken in to break bonds
Less energy

Energy released when making bonds
More energy

Independent practice. Answer in your books in full sentences.

1. Do exothermic reactions take in or release heat?

2. Correct and rewrite this statement. “Exothermic reactions: The energy needed to break bonds in the reactants is more than the energy released when new bonds form in the products.”

3. Why do bonds need to be broken, and then remade?

4. The temperature before a reaction was 10°C and 8°C after the reaction. Was this reaction exothermic or not. Explain how you know.

5. Kelp is a seaweed. Kelp can be burned to give out energy. Is burning kelp exothermic or not, and explain how you know.

6. Write a symbol equation for the reaction between hydrochloric acid and sodium hydroxide.

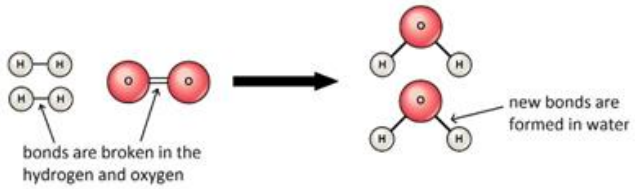
7. A common example of a real-life exothermic reaction is the combustion of natural gas (methane) in a gas stove. The word equation is below.
   Methane + Oxygen → Carbon Dioxide + Water
   Explain why the reaction is exothermic.

8. self-heating cans are based on exothermic reactions. These cans typically contain a separate compartment with chemicals that, when mixed, undergo an exothermic reaction to generate heat.
   One common type of self-heating can uses a reaction between calcium oxide (quicklime) and water. The word equation for this reaction is:
   Calcium oxide + Water →Calcium hydroxide
   Explain why this reaction is exothermic.

L2 Endothermic Reactions

Endo, a prefix from Greek ἔνδον endon meaning "within, inner, absorbing, or containing". Thermo- , word-forming element of Greek origin meaning "hot, heat, temperature," from Greek thermos "hot, warm," thermē "heat.

Endothermic reactions are processes that absorb heat from their surroundings, resulting in a decrease in temperature. In simpler terms, endothermic reactions feel cold because they take in heat to occur. For **endothermic reactions**, the energy needed to break the bonds in the starting molecules is more than the energy released when new bonds are formed in the products.



A real-world example of an endothermic reaction is the process of photosynthesis in plants. In photosynthesis, plants absorb energy from sunlight to convert carbon dioxide (CO_2) and water (H_2O) into glucose ($C_6H_{12}O_6$) and oxygen (O_2). In this process, the energy from sunlight is absorbed to break the bonds in carbon dioxide and water molecules, and then new bonds are formed to create glucose and oxygen. Since the energy absorbed (from sunlight) is greater than the energy released, this reaction is endothermic.

Carbon dioxide +Water → Glucose + Oxygen

Energy taken in to break bonds
More energy

Energy released when making bonds
Less energy

In scientific contexts, another example of an endothermic reaction is the reaction between baking soda (sodium bicarbonate) and vinegar (acetic acid). When these two substances mix, they undergo a chemical reaction that absorbs heat from the surroundings. As a result, the temperature of the mixture decreases, and you may observe bubbles forming as carbon dioxide gas is released. This happens because it takes a lot of energy to break the bonds in the baking soda and vinegar, more than the energy released when the new substances (carbon dioxide, water, and sodium acetate) are formed.

Acetic acid + sodium bicarbonate -> carbon dioxide + water + sodium acetate

Energy taken in to break bonds
More energy

Energy released when making bonds
Less energy

Independent practice

1. Do endothermic reactions absorb or release energy?

2. Do endothermic reactions increase or decrease the temperature of a mixture?

3. Explain the difference between exothermic and endothermic reactions.

4. In a reaction, solid ammonium nitrate dissolves in water, absorbing heat from its surroundings. As a result, the temperature of the solution decreases. Explain if this an endothermic or exothermic reaction.

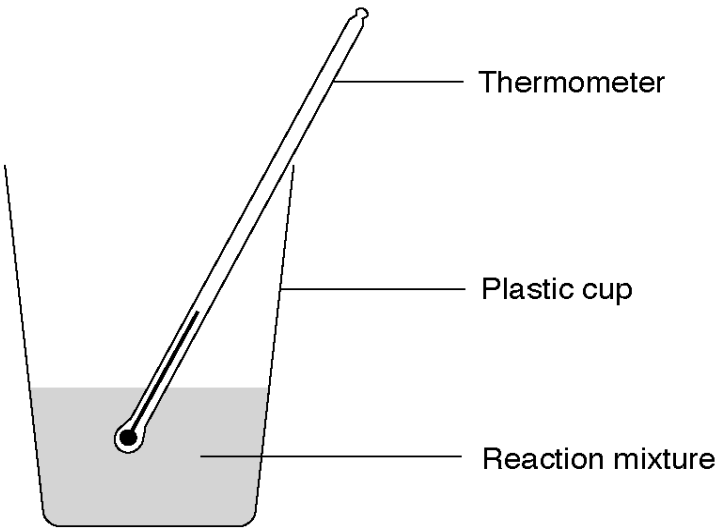
5. Hand warmers and ice packs both use chemical reactions to change temperature. Which type of reaction do each of these products use, and what does this mean in terms of bond breaking and bond making?

6. 150J of energy was used to break the bonds in a reaction, and the starting temperature was 20°C. Suggest how much energy was required to reform the bonds in a reaction where the end temperature was 14°C.

7. Another example of an endothermic reaction involving chemicals is the reaction between citric acid and sodium bicarbonate. The word equation for this reaction is:
   Citric Acid + Sodium Bicarbonate → Sodium Citrate + Carbon Dioxide + Water
   Explain why the reaction is endothermic.

8. Another example of an endothermic reaction is the dissolution of ammonium chloride in water.
   The word equation for this reaction is:
   Ammonium Chloride + Water → Ammonium ions + Chloride ions
   Explain why the reaction is endothermic.

L3 Endothermic and Exothermic reactions



It is relatively straightforward to investigate if a reaction is exothermic or endothermic.

In addition to the equipment on the left a person will also need a measuring cylinder to measure out the required volume of any liquid reactants, and a spatula if there is a solid reactant.

The basic method will be

1. Using a measuring cylinder to measure volume of reactant 1.
2. Place reactant 1 into the plastic cup.
3. Use the thermometer to record the starting temperature.
4. Add reactant 2 to the plastic cup. If a solid using a spatula and stir, if a liquid use a measuring cylinder.
5. Record the maximum or minimum temperature reached using the thermometer.

<u>Variables</u>

- The independent variable is what is changed in the experiment.
- The dependent variable is what is measured in the experiment.
- Control variables are what are kept the same.

<u>Results.</u>

If there is a decrease in temperature the reaction was endothermic.

If there was an increase in temperature the reaction was exothermic.

Independent practice

1. What are the 4/5 pieces of apparatus (equipment) needed for the experiment.
2. What is the measuring cylinder used to measure?
3. Give the independent variable of the investigation.
4. Give the dependent variable of the investigation.
5. Link the use of the measuring cylinder to control variables.
6. Why is a measuring cylinder used rather than a beaker?
7. Why do you need to use the thermometer in two steps?
8. A person found the starting temperature was 20°C and the final temperature was -2°C. What type of reaction was it?
9. State and explain the safety rules to follow give the experiment.
10. An example of a reaction is the reaction between sodium bicarbonate (a solid) and acetic acid (a liquid) Write a method to investigate .if the experiment is exothermic or endothermic.