ScienceCube

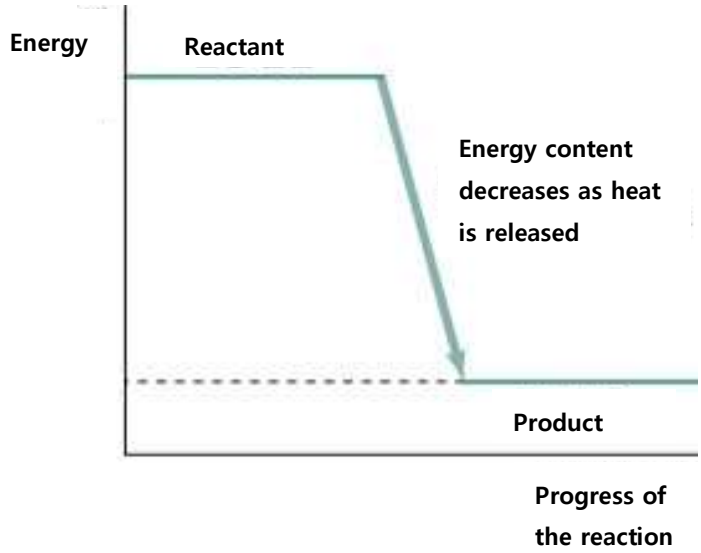
Exothermic Reaction (Making a Hand Warmer)

1. **Learn and explain what an exothermic reaction is.**
2. **Make and explain a hand warmer using the principle of exothermic reactions.**

Fundamental Concept

1. Exothermic Reaction

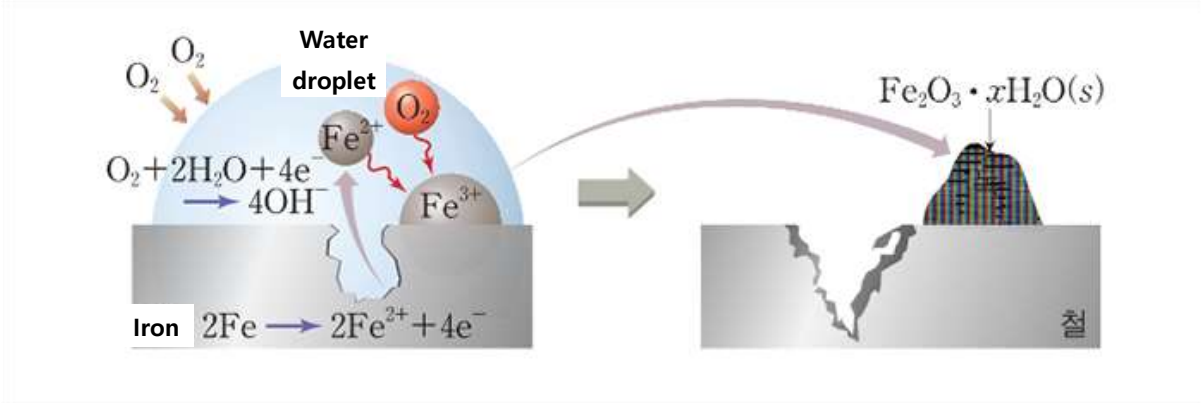
In a chemical reaction, if the reactants contain more energy than the products, the energy of the substances decreases as the reaction proceeds. This decrease in energy is released to the surroundings. Such a reaction is called an exothermic reaction. Generally, during an exothermic reaction, heat is released to the surroundings, raising the temperature, and if the reaction proceeds rapidly, a large amount of heat may be released at once, sometimes causing explosions. Chemical reactions like metal oxidation, fuel combustion, and neutralization reactions, as well as state changes such as gas liquefaction and liquid solidification, are all exothermic reactions.



2. Shakeable Hand Warmer

Powder hand warmers become warm when shaken or kneaded. This principle is due to the oxidation reaction of iron. Iron rusts over time as it combines with oxygen to form iron oxide (rust). This oxidation reaction generates heat, and this principle is utilized in shakeable hand warmers.

Inside the shakeable hand warmer are iron powder, charcoal powder, and a small amount of water. Salt and charcoal powder act as catalysts to accelerate the oxidation of iron. Normally, the oxidation reaction of iron occurs very slowly, so the heat is not noticeable. However, when charcoal powder and salt, which act as catalysts, are added, the iron powder rapidly oxidizes, generating heat.



Oxidation of iron : $Fe \rightarrow Fe^{2+}+2e^-$

$Fe^{2+} \rightarrow Fe^{3+}+e^-$

Reduction of oxygen: $O_2+2H_2O+4e^- \rightarrow 4OH^-$

Formation of red rust: $2Fe^{3+}+6OH^- \rightarrow Fe_2O3 \cdot 3H_2O$(녹)

3. Click hand warmer

When sodium acetate (CH3COONa·3H2O) is heated, it melts, and the melted solution contains a lot of thermal energy. This thermal energy is released when it solidifies again. What role does the snap play? Even when the melted solution is cooled in cold water, it remains in a liquid state instead of solidifying. This solution is called a supersaturated solution, and it is very unstable, so a slight stimulus causes it to solidify all at once. The snap, when bent back and forth, provides this stimulus. When the solution solidifies due to the shock, it releases stored heat all at once, functioning as a hand warmer.

Experiment

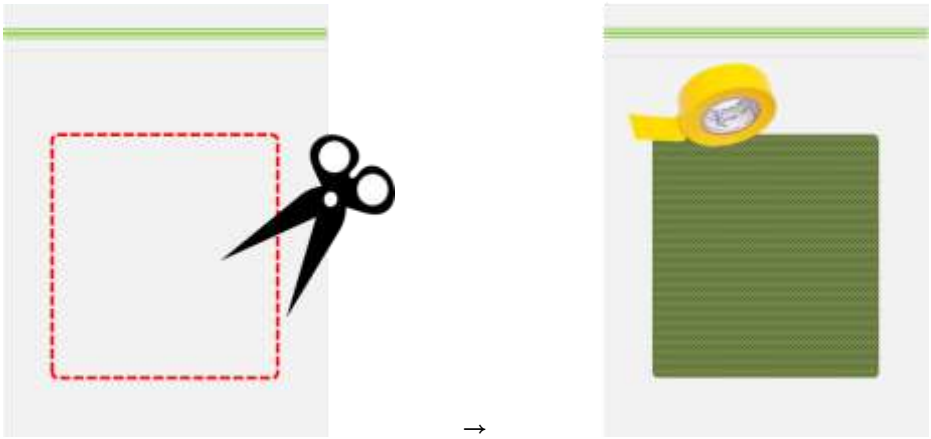
Materials Needed

Interface, Science# program, two temperature sensors, zipper bag (17x10 cm), scissors, non-woven fabric (8x8 cm), tape, iron powder, charcoal powder, salt, water, herbal medicine bag, sodium acetate, metal snap, dropper, heat sealer, 500 mL beaker, alcohol lamp, tripod, lighter, two test tubes, two cork test tube stoppers, two styrofoam cups, dropper

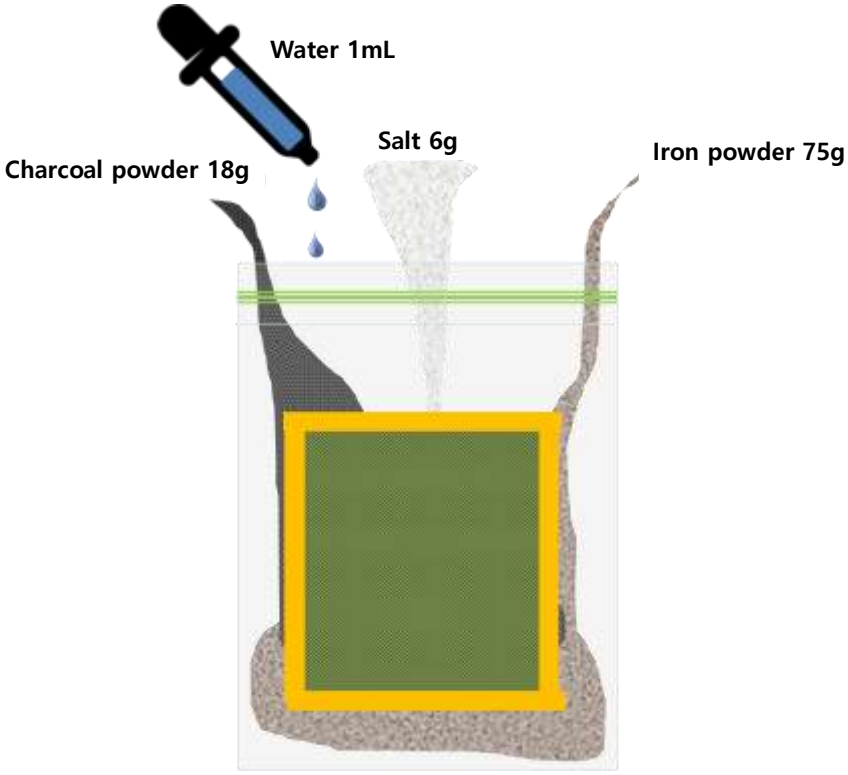
Preparing the Experiment Setup

[Shakeable Hand Warmer]

1. Cut a 7x7 cm square hole in the zipper bag.
2. Attach an 8x8 cm square piece of non-woven fabric to the hole in the zipper bag with tape.



3. Put 75 g of iron powder, 18 g of charcoal powder, 6 g of salt, and 1 mL of water in the zipper bag, seal it, and shake it to complete the shakeable hand warmer.



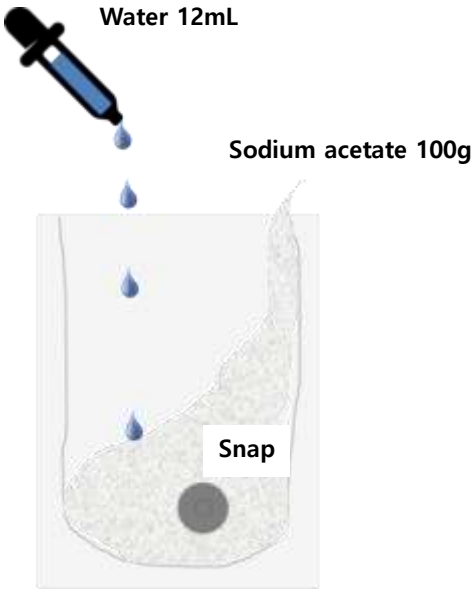
4. Put 10 g of iron powder, 1 g of charcoal powder, 0.5 g of salt, and 0.1 g of water in a test tube, and connect a temperature sensor to the cork stopper so that the sensor touches the powder.

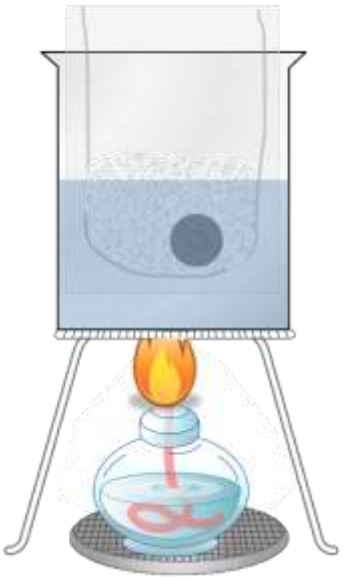
5. Place the test tube with the temperature sensor into a styrofoam cup.

[Liquid Hand Warmer]

1. Put 100 g of sodium acetate and 12 mL of water in a herbal medicine bag along with the snap.

2. Heat the bag in a water bath until the contents are completely melted and transparent.





3. Remove and cool it. If crystals form, reheat to melt them and cool again.

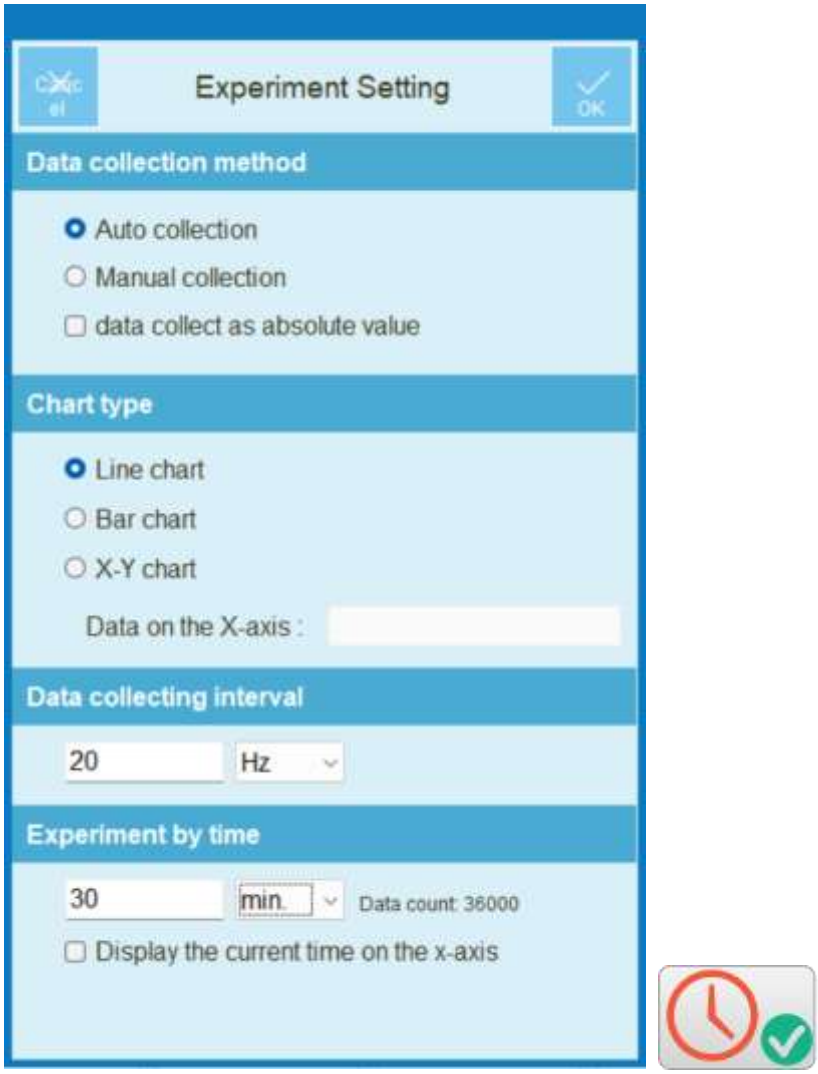
4. Use a dropper to transfer the cooled solution into a test tube in the same amount as the iron powder.

5. Seal the end of the herbal medicine bag with a heat sealer to complete the liquid hand warmer.

6. To activate the liquid hand warmer, snap the snap back and forth to initiate the exothermic reaction, making it warm. The solidified hand warmer can be reused by reheating it in boiling water.

Setting up the Interface

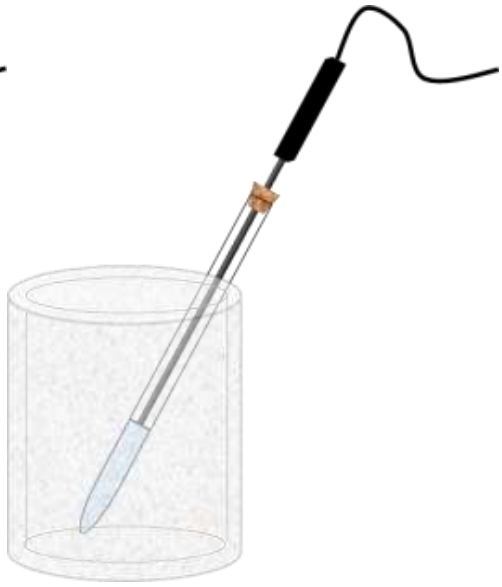
1. Run the Science# program.
2. Connect two temperature sensors to the interface.
3. Press the button to set up the experiment environment or press the button for automatic setup.



Data Collection

1. Press the button  to start data collection
2. Simultaneously shake the liquid hand warmer and the shakeable hand warmer to initiate the exothermic reaction.

[Shakeable Hand Warmer]



[Liquid Hand Warmer]

3. When the exothermic reactions are complete and the temperature returns to room temperature, press the button  to stop data collection.

Data Analysis

Recording Data

1. Take and record photos of the shakeable and liquid hand warmers you made.

2. Create a graph comparing the temperature changes of the two substances in the test tubes.

3. Analyze the temperature change graphs of the shakeable and liquid hand warmers, and

complete the following table.

	Initial Temperature (°C)	Maximum Temperature (°C)
Liquid Hand Warmer		
Shakeable Hand Warmer		

Applying Data

1. Explain the principle of the exothermic reaction in the shakeable hand warmer.

2. Explain the principle of the exothermic reaction in the liquid hand warmer.

Extension Activity

1. Introduce and explain the principle of other methods to make hand warmers aside from the ones described above.