

Cold reactions

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Acknowledgements

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To find out more about the project, and get more resources to help widen participation, visit our Outreach resources hub: rsc.li/3CJX7M3.

Note: all hazard symbols images are © Shutterstock.

Learning objectives

By the end of this session, you will be able to:

- Explain what is meant by 'cold'.
- Describe some practical applications of reactions that give a temperature decrease.

Career link

Consumer products technician

Watch the video job profile on **slide 7** (also available from rsc.li/3HR7C31) to learn about Robert's job. He is a consumer products technician and studies the behaviour of different materials to develop and improve the properties of products, such as cold packs used to treat sports injuries.

Activity 1: cold packs

In this experiment you will investigate which compound is best for a cold pack.

Resources

- Six 50 cm³ beakers
- Spatula
- Thermometer
- Glass rod
- 100 cm³ measuring cylinder
- Stopwatch
- Solids: sodium chloride, sodium hydrogen carbonate, citric acid, calcium chloride, calcium sulfate, ammonium or calcium nitrate

Safety and hazards

Some of the solids you will be using can cause serious eye irritation, skin irritation and may cause respiratory irritation.



Ammonium sulfate may intensify fire as it is an oxidiser.



Wear eye protection and take care when using the compounds.

To do

1. Using the measuring cylinder add 50 cm³ of tap water to a beaker.
2. Measure the initial temperature of the water and record it in the table.
3. Add 5 g of solid and immediately start the timer.
4. Use the marker pen to label the beaker with the name of the solid used.
5. Carefully stir the water using the thermometer to encourage it to dissolve into the water.
6. Measure and record the temperature of the solution every minute for three minutes.
7. Repeat steps 1 to 6 with the other solids if you have been instructed to test all the compounds.
8. If you have made up a citric acid solution or a sodium hydrogen carbonate solution, keep these beakers to one side as you will need them in Activity 2.
9. Pour the solution into the correctly labelled collection beaker for the technician to dispose of later.

Compound	Initial temperature of the water (°C)	Temperature of the solution after 1 minute (°C)	Temperature of the solution after 2 minutes (°C)	Temperature of the solution after 3 minutes (°C)
ammonium nitrate				
sodium chloride				
sodium hydrogen carbonate				
citric acid				
calcium chloride				
calcium sulfate				

To answer

Which of the compounds would be the best to use in a cold pack? Explain your answer.

Activity 2: citric acid and sodium hydrogen carbonate

Citric acid and sodium hydrogen carbonate react together in an endothermic reaction. Follow the steps below to compare how endothermic this reaction is with the reactions investigated in Activity 1.

Resources

- 50 cm³ beaker
- Sodium hydrogen carbonate
- Citric acid 
- Spatula
- Thermometer
- Glass rod
- 100 cm³ measuring cylinder
- Stopwatch

Safety and hazards

Wear eye protection as citric acid causes serious eye irritation, skin irritation and may cause respiratory irritation.

To do

1. Take the solutions of citric acid and sodium hydrogen carbonate you made up in Activity 1.
2. In a new beaker mix equal proportions of the two solutions (25 cm³ and 25 cm³). Record the initial temperature and then take three more measurements at one-minute intervals.
3. Record results and any observations in the table.

Initial temperature of the water (°C)	Temperature of the solution after 1 minute (°C)	Temperature of the solution after 2 minutes (°C)	Temperature of the solution after 3 minutes (°C)
Observations:			

To answer

Is the reaction between citric acid and hydrogen carbonate suitable for use in a cold pack? Explain your answer.

Career link

Flavourist and innovation director

Meet Claire, a flavourist and innovation director. Watch her video job profile on **slide 15** of the PowerPoint, or at rsc.li/40V9mKh, to learn how she applies her chemistry knowledge and understanding to create new flavours, find raw materials and develop technologies.

Activity 3: making ice cream

Resources

- 150 ml of milk
- Two tablespoons of salt
- Crushed ice
- Two zip lock food bags

(If doing this at home you can also add a tablespoon of sugar and flavouring.)

To do

1. Crush the ice and put it in a food bag.
2. Add the milk to the second bag and seal securely.
3. Add the salt to the ice and put the sealed bag of milk into the bag of ice.
4. Seal the outer bag and shake.
5. Keep shaking for 10 minutes.
6. You can't eat this today – but try this method at home with added sugar and flavourings.

To try at home

Can you think of any ideas that will make the ice cream taste nicer? How about adding chopped strawberries or using high fat 'gold top' milk?

Does it also work with plant-based milk?

Demonstration: glow sticks

Answer the following questions while watching the glow sticks demonstration.

(a) How did the temperature of the water affect the brightness of the glow stick?

(b) What happened to the brightness of the glow stick when it was moved between the different temperatures of water?
