Cold reactions

Download the teacher notes,
student workbook and technician notes
that accompany this resource at
rsc.li/3aJIqPc.

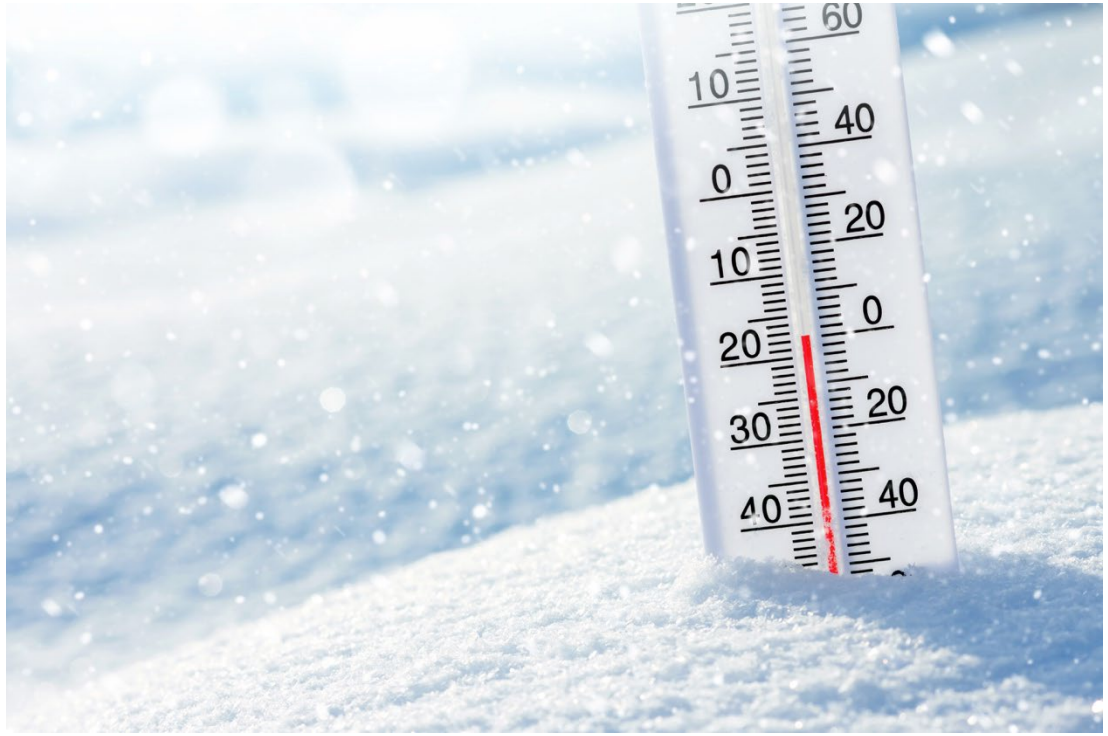
ROYAL SOCIETY OF CHEMISTRY

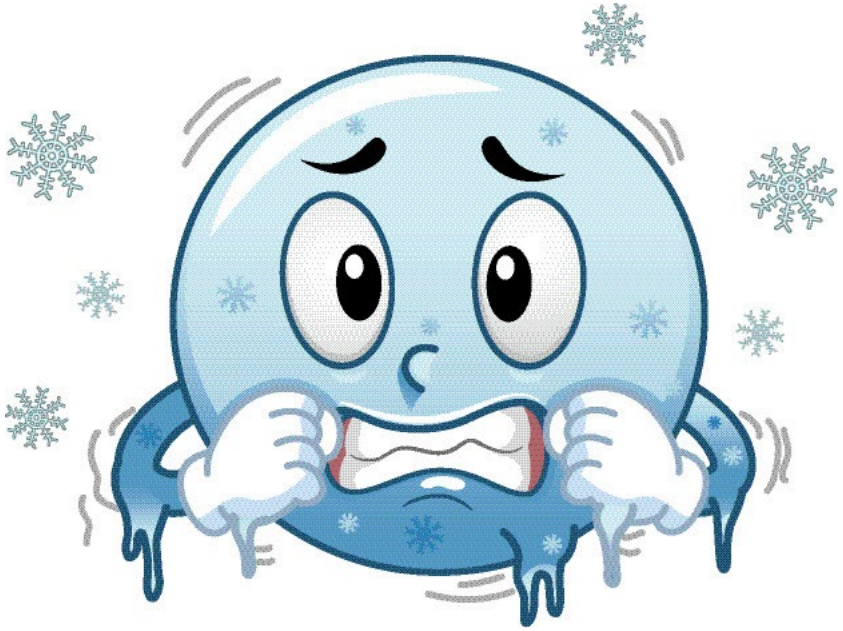
Learning objectives

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.

What is cold?





Put these in order of coldest to hottest

The surface of the moon

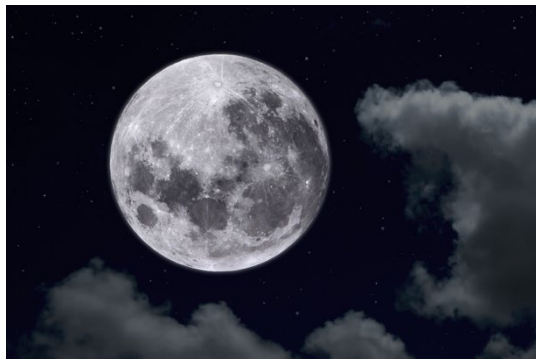
Liquid nitrogen

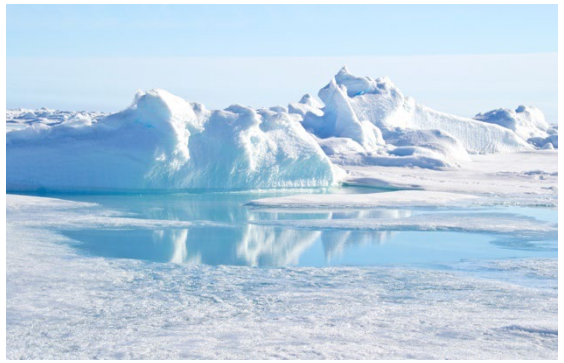
The North Pole during the day

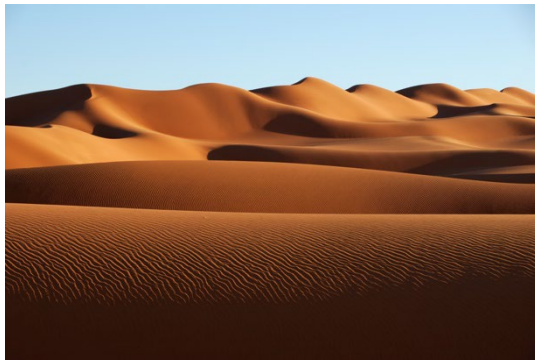
The Sahara desert at night

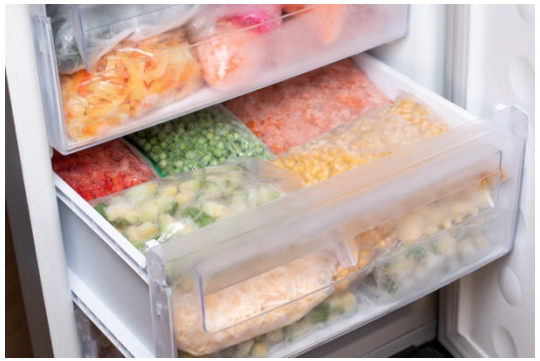
A domestic freezer

The bottom of the ocean









Order of coldest to hottest answers

Liquid nitrogen: −196°C

The surface of the moon: −153°C (in the shade)

A domestic freezer: −18°C

The North Pole during the day: 0°C

The bottom of the ocean: 3°C

The Sahara desert at night: 15°C

What makes something cold?

We perceive something to be cold if its temperature is lower than the temperature being detected by our skin's temperature receptors.

You cannot create 'cold'. Cold is the absence of thermal energy.

An **endothermic** chemical reaction is one that takes in thermal energy from its surroundings.

Very few endothermic reactions are spontaneous. Most require additional energy in the form of heat.

Many chemical reactions used in cooking are endothermic.

Career link

Gases and cold

The expansion of gases is endothermic.
Reactions that produce gases can also be endothermic.

Meet Robert, a consumer products technician, who studies the behaviour of different materials in order to develop and improve the properties of products, such as cold packs used to treat sports injuries.

Activity 1

Cold pack

See student workbook

Activity 1

Cold packs

What do we use cold packs for?

Cold packs work when the compound inside them mixes with, and dissolves in, water in an endothermic reaction.

This endothermic reaction reduces the temperature of the water inside the cold pack, creating a cooling effect that can help to reduce swelling and pain.

You are going to investigate which one of the six compounds would be best to use in a cooling pack.

Cold packs results

Some compounds, such as sodium chloride, will have almost no effect on the temperature change.

Ammonium nitrate should give a significant temperature decrease as this is used in commercial cold packs.

Calcium sulfate is also known as plaster of Paris. This reaction is exothermic (meaning it gives out thermal energy) and the calcium sulfate may start to solidify in the beaker of water.

Activity 2

Citric acid and sodium hydrogen carbonate

See student workbook

Activity 2

Citric acid and sodium hydrogen carbonate

In this activity, you will mix solutions of citric acid and sodium hydrogen carbonate and measure the temperature of the resultant solution over three minutes.

Record your measurements and answer the questions.

As you mix the two solutions, consider why the reaction can’t be used in cold packs.

Citric acid and sodium hydrogen carbonate answers

Although the reaction between citric acid and sodium hydrogen carbonate is endothermic, this combination of solutions would not be suitable for use in a cold pack as the reaction produces carbon dioxide gas.

sodium hydrogen carbonate + citric acid → sodium citrate + water + carbon dioxide

$$3NaHCO_3 + C_6H_8O_7 \rightarrow Na_3C_6H_5O_7 + 3H_2O + 3CO_2$$

Activity 3

Making ice cream

See student workbook

Career link

Flavourist and innovation director

Meet Claire, a flavourist and innovation director, who applies her chemistry knowledge and understanding to create new flavours, find raw materials and develop technologies.

Making ice cream

Resources needed:

150 ml of milk, two tablespoons of salt, crushed ice and two zip lock food bags

Step 1: Crush the ice and put it into a food bag.

Step 2: Add the milk to the second bag and seal securely.

Step 3: Add the salt to the ice and put the sealed bag of milk into the bag of ice.

Step 4: Seal the outer bag and shake.

Step 5: Keep shaking for 10 minutes.

Step 6: You can’t eat this today – but try this method at home with added sugar and flavourings.

Making ice cream answers

Adding salt to ice lowers the melting point of ice to around −5°C.

This encourages the ice to melt, forming a very cold slush, which is cold enough to freeze milk and make ice cream.

Demonstration

Glow sticks

See student workbook

Demonstration

Glow sticks

(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?

Demonstration

Glow sticks answers

(a) The glow sticks shine most brightly in the hot water and least brightly in the ice and salt water.

(b) The glow sticks shine more brightly when moved into hotter water and less brightly when moved into colder water.

Targeted temperature management

Certain kinds of surgery can be done at low temperatures.

There is a much higher chance of success if iced water is pumped round the heart before surgery.

In 1999, Anna Bågenholm survived for three hours with a stopped heart when she fell into a freezing river in the mountains.

If you cool down too fast, however, you risk frostbite, hypothermia and death (so don’t try this at home).

Challenge – cryonics take away task

Cryonics is the process of freezing someone so that they can be revived in the future.

Science fact or science fiction? Do some research on the internet and decide for yourself.

Acknowledgements

This resource was originally developed by the University of Reading to support outreach work delivered as part of the Chemistry for All project.

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