

Chapter

5

Thermochemistry

What is thermochemistry?

What are endothermic and exothermic reactions?

What is the importance of the concept of endothermic and exothermic reactions in daily life?



Let's study

- Endothermic and exothermic reactions

Science Gallery



Every chemical reaction is followed by a change in the form of energy. When chemical reactions occur, chemical energy stored in the reactants is converted to heat energy and released into the surroundings.

Thermochemistry is the study of heat changes when chemical reactions occur. There are many applications of thermochemistry in our daily life which include instant hot packs and instant cold packs as shown in the photographs below.

Instant hot packs are used to release heat into the surroundings. The heat released by instant hot packs can relieve muscle cramp and increase the size of lumen in the blood capillaries so that the rate of blood circulation through these capillaries is increased.



Instant cold packs are used to absorb heat from the surroundings. The heat absorbed by instant cold packs can reduce the swelling of wounds, get rid of heat from inflamed tissues or body organs and reduce the size of lumen in the blood capillaries so that the rate of blood circulation through these capillaries is reduced and this helps to stop bleeding.

Keywords

- ◆ Thermochemistry
- ◆ Endothermic reaction
- ◆ Exothermic reaction
- ◆ Thermal equilibrium
- ◆ Heat
- ◆ Temperature

5.1

Endothermic and Exothermic Reactions



When sodium is added to water, the chemical reaction that occurs is shown in Photograph 5.1.

Name three forms of energy that are released in this chemical reaction.

What form of energy is released or absorbed in most chemical reactions?



Photograph 5.1 Reaction between sodium and water

Chemical reactions can be divided into two types based on the heat change that occurs during the reactions. These are the **exothermic reactions** and **endothermic reactions**.

i SCIENCE INFO

The prefix 'exo' originates from the Greek word which means 'outside' while the suffix 'thermic' originates from the Greek word which means 'heat'. The prefix 'endo' originates from the Greek word which means 'inside'.



Sir, how can we identify whether the reaction shown in Photograph 5.1 is an exothermic or endothermic reaction?

That's easy. We only need to detect the change in temperature of the water in the container. If the water in the container becomes hot, the chemical reaction is an exothermic reaction. If the water in the container becomes cold, the chemical reaction is an endothermic reaction.



Now, I would like to ask a question. Name **one** measuring device that is suitable for determining exothermic and endothermic reactions. Then, explain your answer.

A **thermometer**, sir. A rise in the reading of the thermometer shows that heat is released into the surroundings. This is an exothermic reaction. On the contrary, a drop in the reading of the thermometer shows that heat is absorbed from the surroundings. This is an endothermic reaction.

Very good! Let's carry out Experiment 5.1 to compare and contrast the exothermic and endothermic reactions.

Alright, sir.

i SCIENCE INFO

Recall the relationship between temperature and heat, and the concept of thermal equilibrium which you have learnt in Form 2.

Experiment 5.1

Aim

Compare and contrast the exothermic and endothermic reactions

Problem statement

What are the similarities and differences between the exothermic and endothermic reactions?

Hypothesis

An exothermic reaction is a chemical reaction that releases heat into the surroundings while an endothermic reaction is a chemical reaction that absorbs heat from the surroundings.

5.1.2

5.1.3

Variables

- (a) manipulated variable: Type of chemical substance
- (b) responding variable : Final temperature reading
- (c) constant variable : Volume of water

Materials

Sodium hydrogen carbonate powder, sodium hydroxide, ammonium chloride, 0.1M sodium hydroxide solution and 0.1M hydrochloric acid

Apparatus

Polystyrene cup, thermometer, spatula and measuring cylinder

Procedure

1. Measure and pour 50 ml of water into a polystyrene cup.
2. Leave the water in the polystyrene cup for 2 minutes.
3. Record the initial temperature reading of the water in the given table.
4. Add two spatulas of sodium hydroxide into the polystyrene cup and stir the mixture until all the sodium hydroxide dissolves in the water as shown in Figure 5.1.

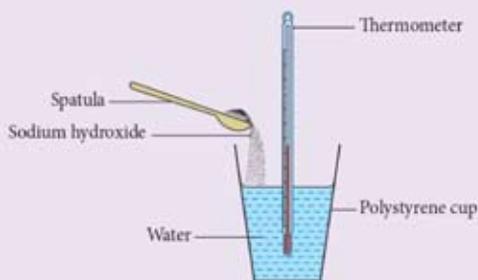


Figure 5.1

5. Record the maximum or minimum temperature in the table.
6. Repeat steps 1 to 5 by replacing sodium hydroxide with ammonium chloride.
7. Measure and pour 25 ml of hydrochloric acid into a polystyrene cup.
8. Leave the acid in the polystyrene cup for 2 minutes.
9. Record the initial temperature of the acid in the given table.
10. Measure and pour 25 ml of sodium hydroxide solution into the polystyrene cup and stir the mixture as shown in Figure 5.2.

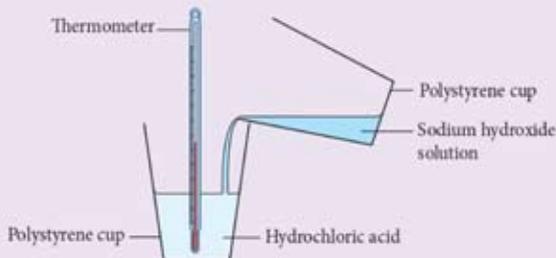


Figure 5.2

- Record the maximum or minimum temperature in the table.
- Repeat steps 7 to 11 by replacing sodium hydroxide solution with 2 spatulas of sodium hydrogen carbonate powder.

Observations

Reactants	Sodium hydroxide and water	Ammonium chloride salt and water	Hydrochloric acid and sodium hydroxide solution	Hydrochloric acid and sodium hydrogen carbonate
Temperature before reaction (°C)				
Maximum or minimum temperature during reaction (°C)				
Type of reaction				

Conclusion

Is the hypothesis of the experiment accepted? What is the conclusion of this experiment?

Questions

- What is the operational definition for:
 - the release of heat in this experiment?
 - the absorption of heat in this experiment?
- What happens when the temperature shown on the thermometer is at maximum or minimum?
 - Explain your answer to question 2(a).
- State the criteria used in this experiment to classify the reaction as:
 - exothermic
 - endothermic
- List the exothermic reactions in this experiment.
- List the endothermic reactions in this experiment.
- How can the accuracy of the maximum or minimum temperature be increased?
 - Explain your answer to question 6(a).

Examples of Exothermic and Endothermic Reactions in Daily Life

Examples of exothermic and endothermic reactions in daily life are shown in Photograph 5.2.



Fireworks display



Photosynthesis



Cake baking



Respiration

Photograph 5.2 Examples of exothermic and endothermic reactions

Based on Photograph 5.2:

- which are exothermic reactions?
- which are endothermic reactions?

Designing Materials Using the Concept of Exothermic and Endothermic Reactions to Solve Problems in Daily Life

Carry out Activity 5.1 to design materials using the concept of exothermic and endothermic reactions to solve problems in daily life.

Activity 5.1

To study engineering designs to solve problems in daily life

Instructions

1. Work in groups.
2. Gather information on the engineering design process to:
 - (a) produce materials to relieve muscle cramp

- (b) produce an emergency lamp when there is a power failure

- (c) design a container that can maintain high or low temperature

3. Write the information and research results obtained by your group in the form of a folio.

21st Century Skills

- ICS, CPS, STEM
- Project-based learning activity

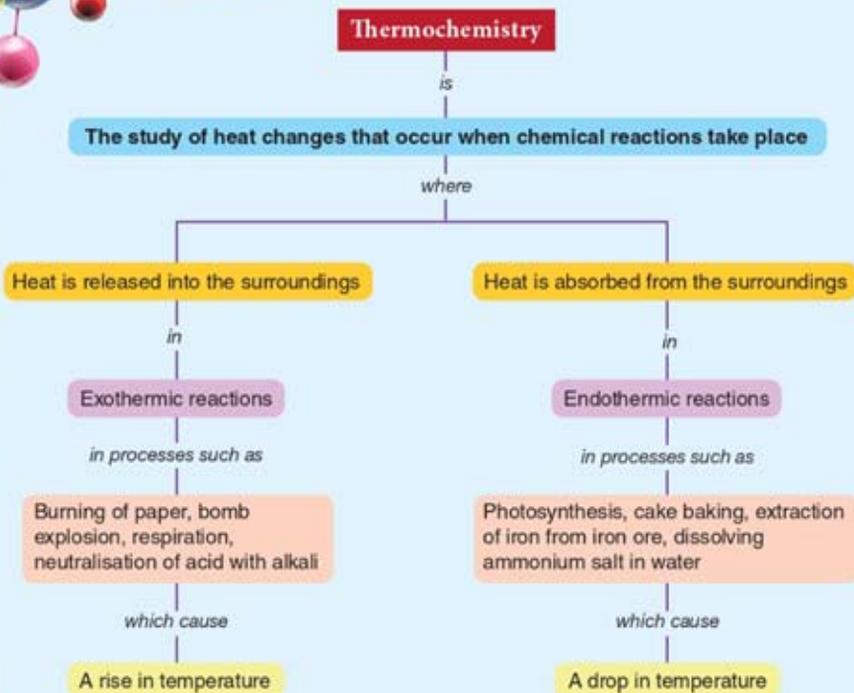


Formative Practice 5.1

1. Define the following types of chemical reactions:
 - (a) Endothermic reaction
 - (b) Exothermic reaction
2. What is thermochemistry?
3. Why does our body temperature increase when performing vigorous physical activities?
4. (a) Name **one** example of a global phenomenon caused by exothermic reaction.
(b) Give **one** solution to the phenomenon mentioned in question 4(a).
5. (a) Name the reaction produced by materials to relieve muscle cramp.
(b) Explain your answer.



Summary




Self-reflection

After studying this chapter, you are able to:

5.1 Endothermic and Exothermic Reactions

- Define endothermic and exothermic reactions.
- Relate heat absorbed or released in a chemical reaction to endothermic and exothermic reactions.
- Carry out an experiment to compare and contrast endothermic and exothermic reactions.
- Explain with examples exothermic and endothermic reactions.
- Design materials using the concept of exothermic and endothermic processes to solve problems in life.


Summative Practice 5

Answer the following questions:

1. There are two types of reactions: exothermic reaction and endothermic reaction. Match the examples of processes with the correct type of reaction.

(a) Burning of petrol

(b) Photosynthesis

(c) Respiration

(d) Making bread

(e) Neutralisation

(f) Rusting of iron

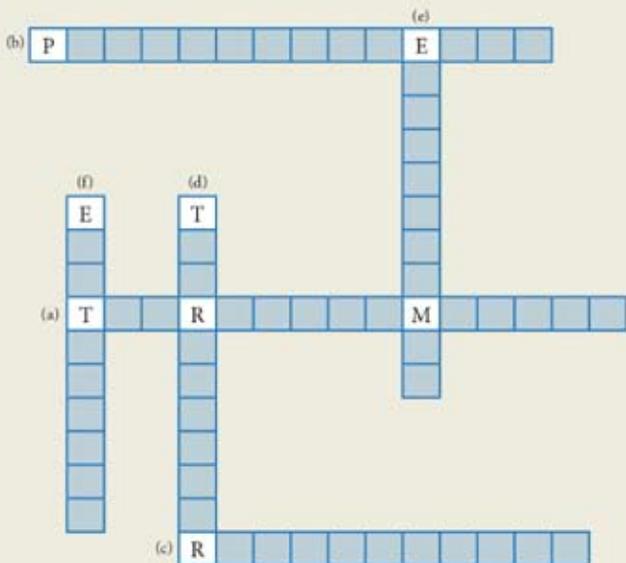
Exothermic reaction

Endothermic reaction

2. Underline the **correct** answers.

- (a) The burning of a candle is an exothermic reaction because heat is (released/absorbed).
- (b) Exothermic reaction in the body (increases/decreases) the body temperature.
- (c) Exothermic reaction is applied in instant (cold/hot) packs.
- (d) Baking a cake is not an exothermic reaction because heat is (released/absorbed).

3. Solve the crossword puzzle below.



Across

- (a) Study of heat change when chemical reactions take place.
- (b) Endothermic reaction that occurs in plants.
- (c) Exothermic reaction that occurs in animals.

Down

- (d) A device that measures change in temperature during exothermic and endothermic reactions.
- (e) Chemical reaction that absorbs heat from the surroundings.
- (f) Chemical reaction that releases heat into the surroundings.

4. Figure 1 shows an apparatus set up to heat calcium carbonate.

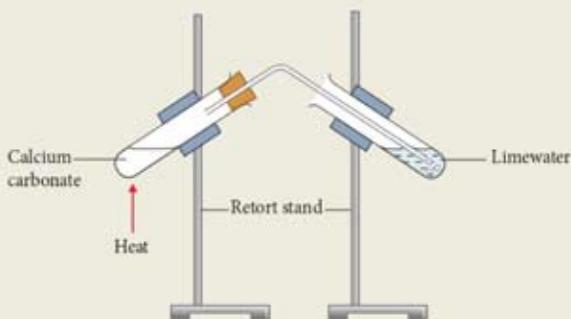


Figure 1

Is the heating of calcium carbonate an exothermic reaction or an endothermic reaction? Explain your answer.

- Differentiate the reaction between hydrochloric acid and sodium carbonate, and the reaction between hydrochloric acid and sodium hydrogen carbonate.
- How can the effects of global warming be reduced by the replanting of trees? 🌳
- (a) Figure 2 shows a thermite reaction, that is the heating of iron(II) oxide, aluminium powder and magnesium tape.



Figure 2

Is a thermite reaction an exothermic reaction or endothermic reaction? Explain your answer. 🌳

- (b) Figure 3 shows an application of a thermite reaction.



Figure 3

Describe the application of thermite reaction in Figure 3. 🌳

Focus on HOTS

8. Figure 4 shows an instant hot pack and an instant cold pack used in hospitals to relieve muscle cramps and reduce the swelling of wounds.

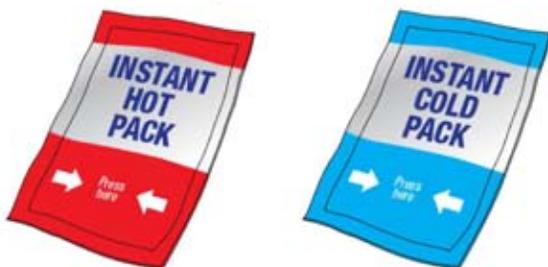


Figure 4

Using your creativity, modify and make an instant hot pack and an instant cold pack using the following materials. Explain. 🍷

