

14C Types of Chemical Reactions

Can we measure the heat released/energy absorbed by instant hot and cold packs?

All chemical reactions are either exothermic (release energy) or endothermic (absorb energy). However, some physical processes such as dissolution (dissolving) can also release/absorb energy. This is the basis for commercially available instant hot packs and cold packs. Most hot and cold packs work by breaking a membrane that separates a solid and water. Once the membrane is broken, the solid dissolves in the water. Depending on the nature of the compound, heat is either released (hot pack) or absorbed (cold pack) during the process. In this investigation, you will examine the temperature changes of hot and cold packs and determine the energy absorbed or released during the chemical reactions that take place.

Materials

- 2 foam cups
- Temperature probe
- Data Collector
- Safety goggles
- Lab apron
- Water
- Calcium chloride (from an instant hot pack or ice melt)
- Ammonium nitrate (from an instant cold pack)
- Electronic scale (or triple-beam balance)
- 100 mL graduated cylinder



WARNING — This lab contains chemicals that may be harmful if misused. Read cautions on individual containers carefully. Not to be used by children except under adult supervision.

1 Stop and think

Calcium chloride is used to melt ice on winter roads. Would that process be exothermic or endothermic? Why?

2 Doing the experiment

Part A: Hot Pack - Record all measurements in Table 1.

1. Use a graduated cylinder to measure 50 mL of water. Record the mass of the water in Table 1 (HINT: 1 mL of water = 1g).
2. Pour the water into 2 nested foam cups and place the temperature probe into the water.
3. Use a balance to measure out about 10 g of calcium chloride (CaCl_2). Record the mass of the CaCl_2 in Table 1.
4. Select new experiment on the Data Collector and press Go. Wait for the temperature of the water to stabilize and record that temperature in Table 1 (initial temperature).
5. Pour the CaCl_2 into the water and stir with the temperature probe.
6. Watch the graph and the temperature reading as the reaction proceeds.

- Watch for the highest temperature reading before the temperature starts to go down again. Record that temperature in Table 1 (final temperature).
- Pour the solution down the drain and then rinse and dry your foam cups.

Mass of water (g)	Mass of CaCl_2 (g)	Initial temp. ($^{\circ}\text{C}$)	Final temp. ($^{\circ}\text{C}$)

Part B: Cold Pack

- Use a graduated cylinder to measure 50 mL of water. Record the mass of the water in Table 2 (HINT: 1 mL of water = 1g).
- Pour the water into 2 nested foam cups and place the temperature probe into the water.
- Use a balance to measure out about 10 g of ammonium nitrate (NH_4NO_3). Record the mass of the NH_4NO_3 in Table 2.
- Select new experiment on the Data Collector and press Go. Wait for the temperature of the water to stabilize and record that temperature in Table 2 (initial temperature).
- Pour the NH_4NO_3 into the water and stir with the temperature probe.
- Watch the graph and the temperature reading as the reaction proceeds.
- Watch for the lowest temperature reading. Record that temperature in Table 2 (final temperature).
- Pour the solution down the drain and then rinse and dry your foam cups.

Mass of water (g)	Mass of NH_4NO_3 (g)	Initial temp. ($^{\circ}\text{C}$)	Final temp. ($^{\circ}\text{C}$)

3 Analyzing the Data

- Calculate the temperature change of the CaCl_2 and water reaction.
- Calculate the heat gained by the solution using the equation below: Assume the specific heat of the solution is equal to the specific heat of water. The specific heat of water is

4.184 J/g °C.

HEAT EQUATION

$$E = mC_p (T_2 - T_1)$$

Where: E = heat lost or gained

m = mass of solution in the calorimeter

C_p = specific heat of substance

$T_2 - T_1$ = change in temperature (also referred to as ΔT)

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- c. Calculate the amount of energy (in Joules) released per gram of CaCl_2 . Remember: Q is the opposite sign of the value you calculate.

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- d. Calculate the temperature change of the NH_4NO_3 reaction.

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- e. Calculate the heat lost by the solution using the heat equation: Assume the specific heat of the solution is equal to the specific heat of water.

Where: E = heat lost or gained

m = mass of solution in the calorimeter

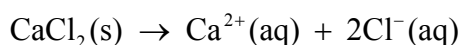
C_p = specific heat of substance

$T_2 - T_1$ = change in temperature (also referred to as ΔT)

- f. Calculate the amount of energy (in Joules) absorbed per gram of NH_4NO_3 . Remember: Q is the opposite sign of the value you calculate.
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4 Thinking about what you observed

- a. Look at the reactions below. Place the energy value on the appropriate side of the two equations.



- b. When CaCl_2 dissolves in water the true value for $E = -747 \text{ J/g}$. When NH_4NO_3 dissolves in water the true value for $E = 326 \text{ J/g}$. Compare your experimental values by calculating the percent error for each reaction.
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- c. Describe why your skin feels cool when a cold pack is applied and warm when a hot pack is applied.
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