Name Key Date _____ Class _____ 38 pts Total

12–1 Apply

Exothermic vs. Endothermic Changes

Cheryl was asked to classify some chemical reactions as either endothermic or exothermic. She added 5.0 g of five different solids to 20 mL of water and monitored the temperature change until all of the solid had dissolved. The results of the experiment are shown in the table below.

Solid	Beginning water temperature (°C)	Final water temperature (°C)	Change in water temperature (°C)
NH_4NO_3	25.4	22.1	–3.3
$CaCl_2$	25.4	28.9	+3.5
LiCl	25.4	23.9	–1.5
NaCl	25.4	25.1	–0.3
NaOH	25.4	29.5	+4.1

Questions

1. List the solids that underwent exothermic reactions in solution and those that underwent endothermic reactions.

   A list of rxns:
   Exothermic = $CaCl_2$, NaOH
   Endothermic = NH_4NO_3, LiCl, NaCl

2. How could you determine which solid releases the greatest amount of heat per mole?

   Compare the temp change produced by an identical # of moles of each solid dissolving in an identical amount of water.

3. The equation for NaOH dissolving in water is $NaOH(s) \rightarrow Na^+(aq) + OH^-(aq)$. Rewrite this equation to include the word "energy" in its appropriate location.

   $NaOH(s) \rightarrow Na^+(aq) + OH^-(aq) + Energy\ (heat)$

4. Explain what happens to the energy that "disappears" from the water in an endothermic reaction.

   The energy is absorbed by the reactants and becomes stored in the chemical bonds of the products.

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12–1 Enrich

The Cold Facts About Hot and Cold Packs

Have you ever needed to soothe a strained back with a hot pad or reduce a swelling with a cold pack? These easy-to-use hot and cold packs contain chemicals that undergo exothermic or endothermic reactions. Exactly how these reactions produce their healing effects is easy to explain chemically.

Most chemical reactions give off heat. Consider, for example, the burning of a match. The chemicals on the head of the match store energy in their chemical bonds. When you strike the match, the original chemical bonds are broken and new bonds are formed, releasing the stored energy as heat. This is an example of an exothermic reaction that occurs very rapidly. Hot packs involve exothermic reactions that occur more slowly and at lower temperatures. Hot packs are designed to allow a controlled reaction to occur on demand.

A hot pack has an outer plastic covering and an inner paper bag with small pores or holes. In some packs, the paper bag contains a mixture of powdered iron, table salt, activated charcoal, and sawdust. These ingredients have been slightly moistened with water. When oxygen is added, a chemical reaction occurs. The user supplies the oxygen when he or she removes the plastic covering and shakes the bag. When oxygen comes in contact with the powdered iron, the powdered iron begins to rust, or oxidize, very rapidly. As you probably know, iron usually rusts more slowly, for example, when a hammer is left out in the rain. In a hot pack, however, oxygen and iron mix very quickly, resulting in very rapid rusting and noticeable heat. The exothermic reaction releases heat, which can then be absorbed by your sore back.

Cold packs, on the other hand, are designed to make use of an endothermic chemical reaction to produce a low temperature. One type of cold pack consists of two sealed bags, one inside the other. The outer bag is made of a thick plastic and contains ammonium nitrate, a white powdered salt. The inner plastic bag is much thinner and contains water. A firm blow to the cold pack will break the inner bag and release the water. The ammonium salt then dissolves in the water and the resulting solution becomes very cold. The endothermic reaction must absorb energy from the environment. A cold pack placed on your skin will absorb thermal energy from your skin, making your skin feel cooler.

Chemical hot and cold packs can be used to provide quick and effective first-aid treatment. The reactions, however, are only temporary and the packs cannot be used again.

Critical Thinking

1. Both the hot pack and cold pack require the user to input energy to begin the initial reaction. How is this energy provided in each case? (*Making comparisons*)
2. Explain why a cold pack becomes colder as it absorbs heat from your skin. (*Applying concepts*)

1) Shaking the hot pack causes oxygen to mix with the contents of the bag and begin the rxn. Hitting the cold pack breaks the seal, mixes the reactants, and initiates the rxn.

2) The heat from your skin is absorbed by the reactants and allows the reaction to proceed, which ultimately results in a decrease in temperature.

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12–1 Review and Reinforcement

Chemical Reactions That Involve Heat

On the line at the left, write the letter of the definition that best matches each term.

C	1. heat	a.	reactions that release heat
d	2. thermochemistry	b.	the SI unit of energy and heat
a	3. exothermic reactions	c.	the energy that is transferred from one object to another
f	4. endothermic reactions	d.	the study of the changes in heat in chemical reactions
b	5. joule	e.	example of an exothermic reaction
e	6. combustion	f.	reactions that absorb heat

If the statement is true, write "true." If it is false, change the underlined word or words to make the statement true. Write your answer on the line provided.

True 7. It is energy that maintains your body temperature close to 37°C.

Bond formation 8. Bond breaking in chemical reactions releases energy.

different temps. 9. Heat is transferred between two objects that are at the same temperature.

Endothermic 10. An exothermic reaction absorbs heat from the environment.

True 11. All combustion reactions are exothermic.

left 12. If a reaction is endothermic, the amount of heat appears on the right side of the arrow in the balanced equation.

True 13. Energy can be stored in the chemical bonds of a substance.

Answer each of the following questions in the space provided.

14. Provide two examples from daily life that demonstrate how heat is transferred from one object to another.

Possibilities: hot tea warming a spoon, ice makes hands feel cold, log burning warms a room.

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12–1 *Review and Reinforcement (continued)*

15. Why is the joule, the SI unit of energy, also the appropriate unit for measuring heat?

Heat and energy are related. Energy can be transfered in the form of heat.

16. Provide an analogy that explains why bond breaking requires energy.

Possible analogy: Red Rover

Red Rover

model kit, break it apart
Stand on chair, fall out of chair
things tend to go towards Stability.

17. When ammonium chloride dissolves in a beaker of water, the beaker becomes cold to the touch. Explain this phenomenon.

Endothermic. Heat is absorbed from the beaker by the reactants, and this heat transfer causes the temp of the beaker to drop.

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12–2 Review and Reinforcement

Heat and Enthalpy Changes

Complete each of the following sentences by filling in the appropriate word or phrase from the list below.

less	endothermic	change
moles	exothermic	pressure
energy	standard enthalpy change	enthalpy

1. The heat absorbed or released in a reaction depends on a quantity called enthalpy.
2. The enthalpy of a substance is similar to, but not exactly the same as, the energy of a substance.
3. The symbol ΔH literally means a change in enthalpy.
4. The ΔH for a(n) endothermic reaction always has a positive sign.
5. In an exothermic reaction, $H_{products}$ will always be less than $H_{reactants}$.
6. Conditions such as temperature, pressure, and the physical states of the substances in a reaction can affect ΔH.
7. The enthalpy change measured at 1 atm and 25°C, when the reactants and products are in their standard states, is called a Std. enthalpy change.
8. You must know the number of moles of reactants involved in a reaction to calculate ΔH.

Answer each of the following questions in the space provided.

9. How is the enthalpy of a substance related to the energy of a substance?

The enthalpy of a substance is its energy plus a small term having to do with the pressure and volume of the substance. (or Work)

Q $\Delta H < Q_{work}$

10. If you were given $\Delta H°$ of a reaction, could you determine whether the reaction was exothermic or endothermic? Explain your answer.

Yes, a (+) $\Delta H°$ would indicate an endothermic rxn while a (-) $\Delta H°$ would indicate an exothermic rxn.

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12–2 *Review and Reinforcement (continued)*

11. Compare the enthalpy of the reactants and the products in both exothermic and endothermic reactions.

The enthalpy of the products is lower than that of the reactants in an exothermic rxn. The enthalpy of the products is greater than that of the reactants in an endothermic rxn.

exo

endo

12. What is meant by the standard state of an element?

The standard state is the most stable form of an element under standard conditions.

Solve each of the following problems as directed. Show all your work.

13. Calculate the amount of heat released by the combustion of 1.75 mol of benzene (C_6H_6).

$$2C_6H_6 + 15O_2 \rightarrow 12CO_2 + 6H_2O \qquad \Delta H^\circ = -98.0 \text{ kJ}$$

$$\left(\frac{1.75 \text{ mol } C_6H_6}{1}\right)\left(\frac{-98.0 \text{ kJ}}{2 \text{ mol } C_6H_6}\right) = -85.75 \text{ kJ}$$

14. How much heat is transferred when 100.0 g of calcium oxide (CaO) reacts with carbon according to the equation below? Is this reaction endothermic or exothermic?

$$CaO + 3C \rightarrow CaC_2 + CO \qquad \Delta H^\circ = +464.8 \text{ kJ}$$

$$\left(\frac{100.0 \text{ g CaO}}{1}\right)\left(\frac{1 \text{ mol}}{56 \text{ g CaO}}\right)\left(\frac{464.8 \text{ kJ}}{1 \text{ mol}}\right) = 830 \text{ kJ}$$

15. Ammonium dichromate decomposes in a vigorous reaction when it is heated. Calculate the heat transferred for the decomposition of 53.0 g of ammonium dichromate according to the following equation.

$$(NH_4)_2Cr_2O_7 \rightarrow N_2 + 4H_2O + Cr_2O_3 \qquad \Delta H^\circ = -315 \text{ kJ}$$

$$\left(\frac{53.0 \text{ g } (NH_4)_2Cr_2O_7}{1}\right)\left(\frac{1 \text{ mol}}{252 \text{ g } (NH_4)_2Cr_2O_7}\right)\left(\frac{-315 \text{ kJ}}{1 \text{ mol}}\right) = -66.25 \text{ kJ}$$