

# Thermochemistry Notes

Heat changes that occur during a chemical reaction

# What is Thermochemistry?

- The study of heat changes in chemical reactions and physical states.
  - Law of Conservation of Energy
  - Calorimetry
  - Temperature
  - Heat
  - Heat Capacity
  - Specific Heat

# Energy

- The capacity for doing work or supplying heat
- Energy is weightless, colorless, and odorless
- Energy that is stored in the bonds of chemical substances is called **chemical potential energy**. (Example: gasoline)

# Forms of Energy

- Potential
  - stored energy
- Kinetic
  - Energy of motion
- Work
  - energy used in a process
- **Enthalpy**
  - Heat energy lost or gained in a process

# What is work and heat?

- **Work** = when a force is used to move an object
- **Heat** = energy that is transferred from one object to another, because of a temperature difference. ( $q$ )
  - Heat flows from warm to cold until equilibrium is reached

When describing the flow of heat:

- Heat flow into a system is an endothermic process (+q)
- Heat flow out of a system is an exothermic process (-q)

(Calorimeter—an instrument that measures heat changes in a closed system)

# What is a calorie?

The quantity of heat required to raise 1 gram of water 1 °C.

The SI unit of measurement for heat is the joule.

1 joule = 0.2390 calories

1 Calorie = 4.184 joules

1 Calorie = 1000 calories

- The amount of heat needed to raise 1 g of a substance 1 °C.
- Table 1 pg 533
- Heat capacity depends upon the mass and the composition of the object.

## Specific Heat Capacity (Specific Heat)



# Examples

Water has the highest specific heat capacity. It absorbs a lot of heat before finally increasing temperature.

Metals have the lowest specific heat capacity. A small amount of absorbed energy immediately changes temperature

There is a calculation that can be performed to determine the specific heat of an object.

$$q = C \times m \times \Delta T$$

C = Specific Heat (J/g°C or cal/g°C)

q = heat (J or cal)

m = mass (g)

$\Delta T = T_{\text{final}} - T_{\text{initial}}$  (°C)

# Sample Problems

## Reminder:

For a phase change use  $\rightarrow Q = m\Delta H$

Non-phase change use  $\rightarrow q = C \times m \times \Delta T$

When 435 J of heat is added to 3.4 grams of olive oil at 21°C, the temperature increases to 85°C. What is the specific heat of olive oil?

$$C = ?$$

$$q = 435 \text{ J}$$

$$m = 3.4 \text{ g}$$

$$\Delta T = T_{\text{final}} - T_{\text{initial}} = 85^\circ\text{C} - 21^\circ\text{C} = 64^\circ\text{C}$$

$$q = C \times m \times \Delta T$$

$$C = ?$$

$$q = 435 \text{ J}$$

$$m = 3.4 \text{ g}$$

$$\Delta T = T_{\text{final}} - T_{\text{initial}} = 85^{\circ}\text{C} - 21^{\circ}\text{C} = 64^{\circ}\text{C}$$

$$q = C \times m \times \Delta T$$

Solve for C

$$C = q / (m \times \Delta T)$$

$$C = 435 \text{ J} / (3.4 \text{ g} \times 64^{\circ}\text{C}) = \underline{2.0 \text{ J/g}^{\circ}\text{C}}$$

- Heat flow out of a system is an exothermic process (-q)
- Heat flow into a system is an endothermic process (+q)

$$q = (0.14 \text{ J/g}^\circ\text{C})(250.0 \text{ g})(52 \text{ }^\circ\text{C}) = \underline{1800 \text{ J}}$$

**Positive = Endothermic**

**Remember...**

# Enthalpy

- H=Heat of substance at a constant pressure

$$q = \Delta H = C \times m \times \Delta T$$

$$\Delta H = \text{enthalpy}$$

C = Specific Heat (J/g°C or cal/g°C)

q = heat (J or cal)

m = mass (g)

$\Delta T = T_{\text{final}} - T_{\text{initial}}$  (°C)

# Enthalpy

+  $\Delta H$  = endothermic rxn

-  $\Delta H$  = exothermic rxn



# Enthalpy of Reaction

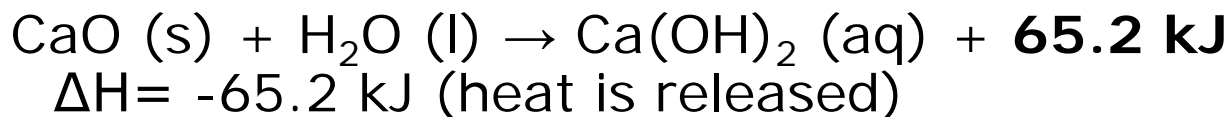
- The quantity of energy transferred as heat during a chemical reaction.
  - $\Delta H = H_{\text{products}} - H_{\text{reactants}}$

# Thermochemical Reactions

$$\Delta H = H_{\text{products}} - H_{\text{reactants}}$$

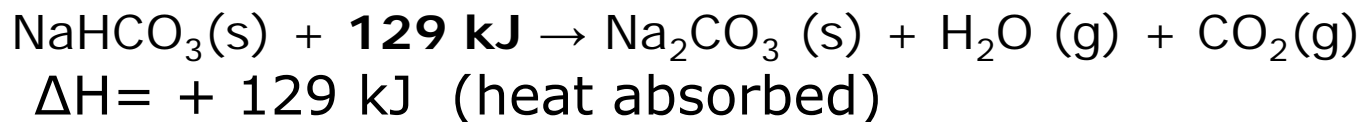
- Heat of Reaction – the heat required or released in a reaction (coefficients are mole quantities)

## Exothermic Reaction

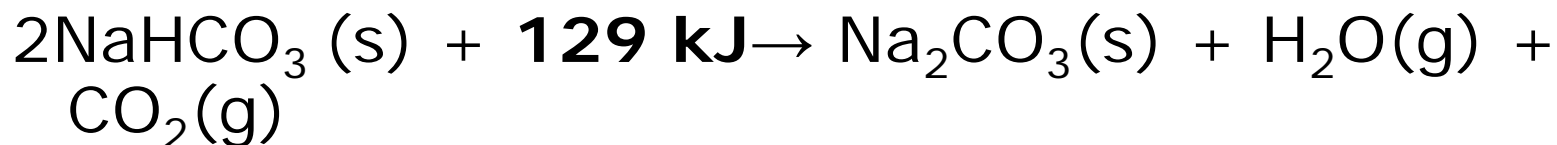


See graph page 536

## Endothermic Reaction



## Practice



1) Calculate the  $\Delta H$  of the reaction.

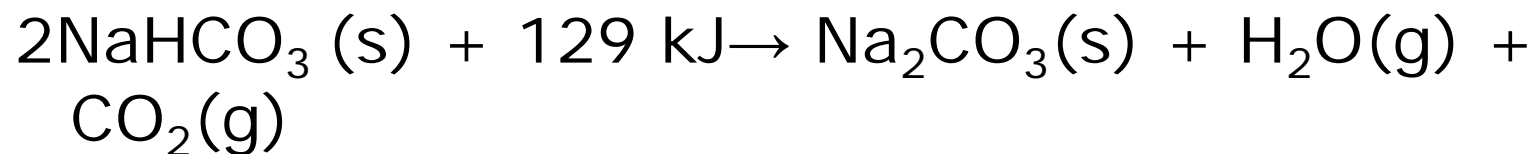
$$\Delta H = H_{\text{reactants}} - H_{\text{products}}$$

$$\Delta H = 129 \text{ kJ} - 0 \text{ kJ} = + 129 \text{ kJ}$$

2) Calculate the kJ of heat required to decompose 2.24 mol  $\text{NaHCO}_3(\text{s})$ .

$$2.24 \text{ mol NaHCO}_3 \times \frac{(+ 129 \text{ kJ})}{2 \text{ mol NaHCO}_3} = 144 \text{ kJ}$$

## More Practice



3) How much energy is absorbed when 25g of  $\text{NaHCO}_3$  decomposes?

$$25\text{g NaHCO}_3 \times \frac{1 \text{ mol NaHCO}_3}{84\text{g NaHCO}_3} \times \frac{129 \text{ kJ}}{2 \text{ mol NaHCO}_3} = 19.2 \text{ kJ}$$