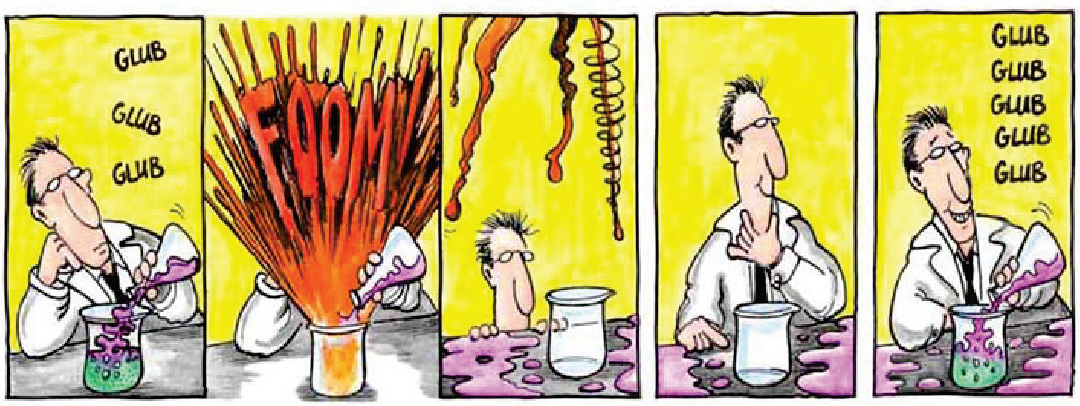
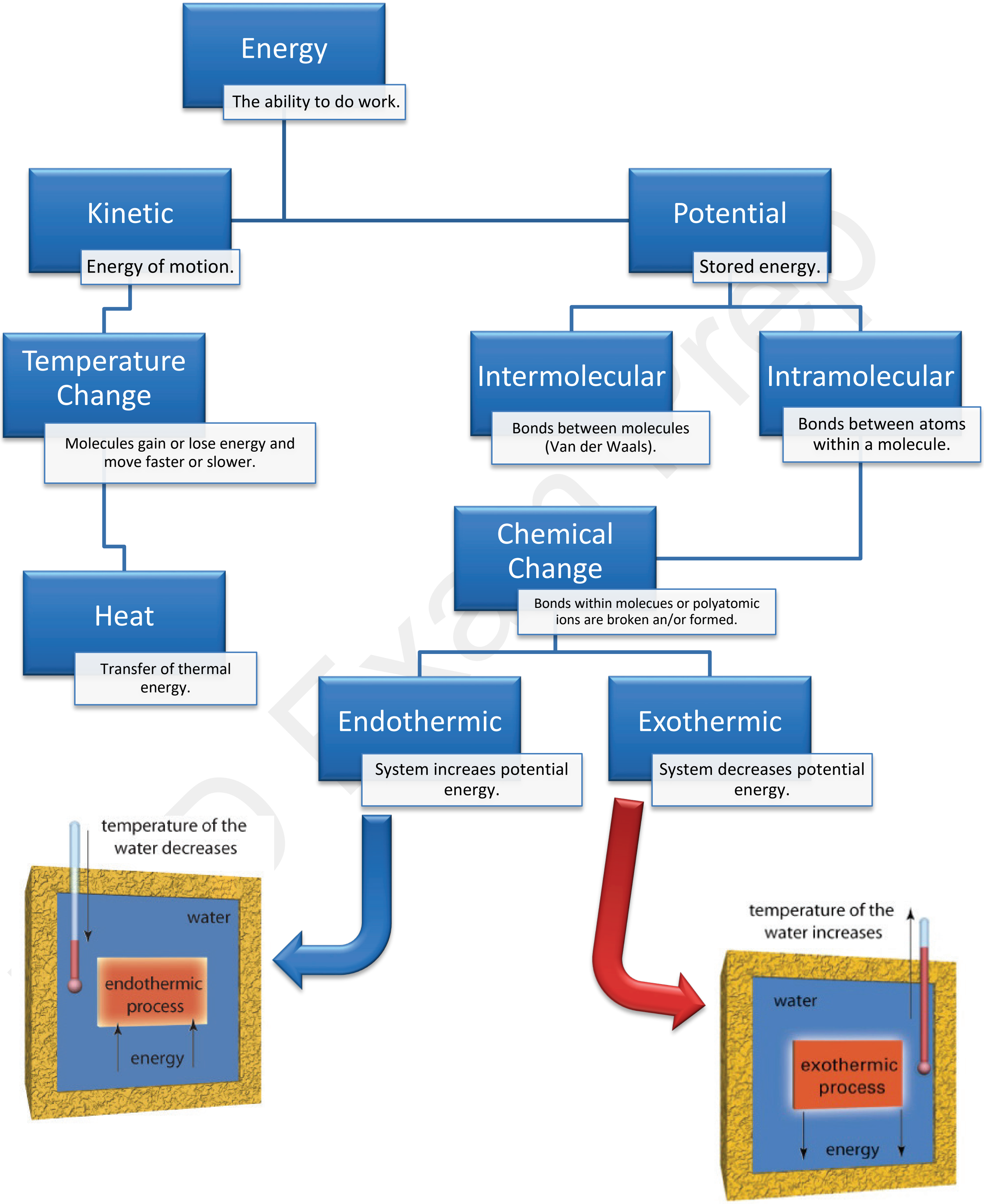
Chemistry 30

Unit A

Thermochemical Changes




Energy
The ability to do work.
Kinetic
Energy of motion.
Potential
Stored energy.
Temperature Change
Molecules gain or lose energy and move faster or slower.
Intermolecular
Bonds between molecules (Van der Waals).
Intramolecular
Bonds between atoms within a molecule.
Chemical Change
Bonds within molecues or polyatomic ions are broken an/or formed.
Heat
Transfer of thermal energy.
Endothermic
System increaes potential energy.
Exothermic
System decreaes potential energy.
temperature of the water decreases
water
endothermic process
energy
temperature of the water increases
water
exothermic process
energy

Heat Transfer and Calorimetry

- **Thermal energy** – the kinetic energy (E_k) of the entities of a substance. Thermal energy increases with temperature.

$$Q = mc\Delta t$$

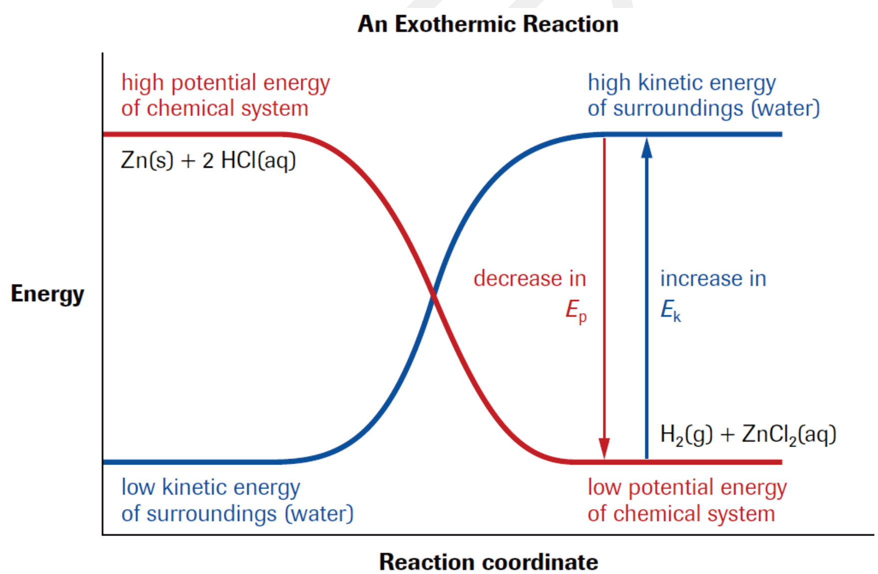
- **Temperature** – a measure of the average kinetic energy of the entities of a substance
- **Heat** – thermal energy <u>transferred</u> between systems. Heat is *not* possessed by a system.
- **Chemical potential energy** (E_p) – energy stored in chemical bonds
- **Enthalpy** (H) – the total kinetic and potential energy in a chemical system
- **Change in enthalpy** ($\Delta_r H$) – difference in enthalpy (assume the difference in chemical potential energy) between the products and reactants. THE TEMPERATURE OF THE SYSTEM DOES NOT CHANGE!

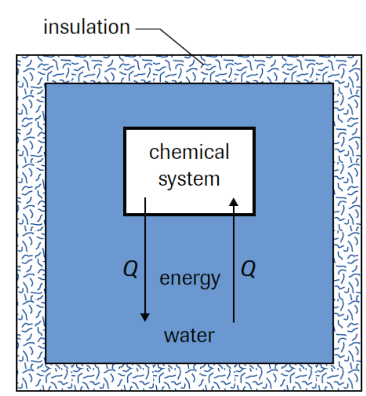
$$\Delta_r H = H_{products} - H_{reactants}$$

- **Molar change in enthalpy** ($\Delta_r H_m$) – change in energy per mole of a substance undergoing a specific reaction

$$\Delta_r H = n\ \Delta_r H_m$$

Subscript	Meaning
r	any reaction specified
c	complete combustion
f	formation
d	decomposition
sol	solution
dil	dilution





Example 1

Methylpropane, $C_4H_{10}(g)$, is used as a lighter fluid. When 1.80 g of methylpropane is burned in a calorimeter, the temperature of 2.60 kg of water changed from 20.0 °C to 29.7 °C.

a) Calculate the amount of thermal energy absorbed by the water.

b) Determine the enthalpy change for the combustion of 1.80 g of methylpropane.

c) Determine the molar enthalpy of combustion for methylpropane.

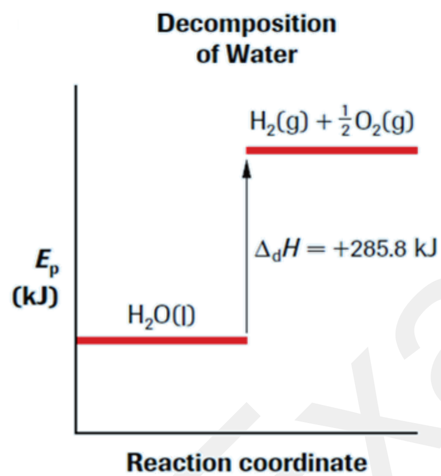
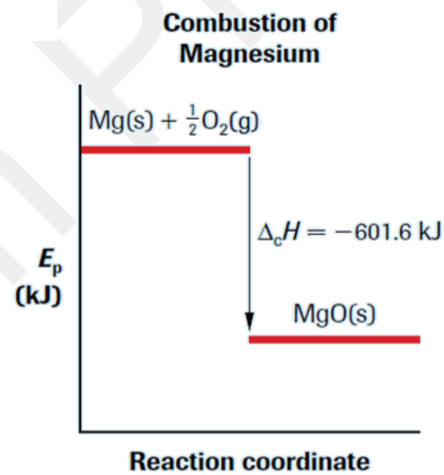
Example 2

A student is asked to prepare a 50.0 mL solution of ammonium nitrate. If the molar enthalpy of solution of ammonium nitrate is +25.0 kJ/mol, determine the mass of ammonium nitrate that should be dissolved to decrease the temperature of the water by 7.55 ˚C?

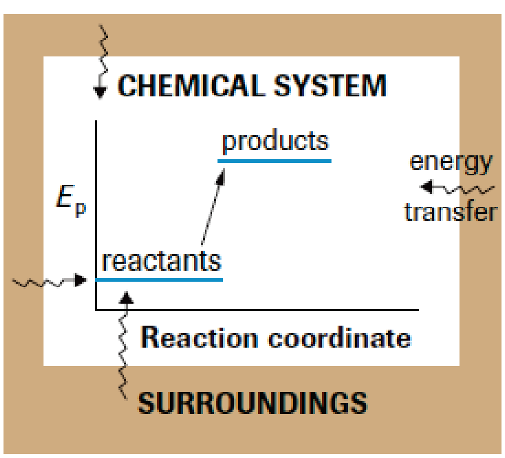
Example 3

150 mL of 0.200 mol/L HCl(aq) is added to 150 mL of 0.200 mol/L NaOH(aq). If the initial temperature of both solutions is 25.0ºC and the final temperature of the mixture after the reaction was complete was 27.1ºC, determine the molar enthalpy of neutralization for HCl(aq).

Four Ways of Communicating Enthalpy Changes

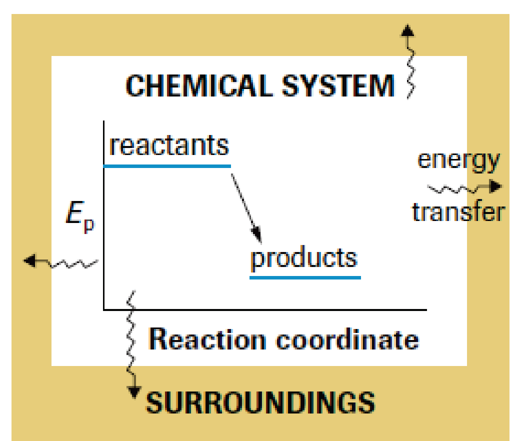
		ENDOTHERMIC Decomposition of Water	**EXOTHERMIC** Combustion of Magnesium
1)	Molar Enthalpy	$\Delta_d H_m = +285.8$ kJ/mol	$\Delta_c H_m = -601.6$ kJ/mol
2)	Enthalpy Change	$H_2O(l) \rightarrow H_2(g) + \frac{1}{2}O_2(g) \quad \Delta_d H^\circ = +285.8$ kJ	$Mg(s) + \frac{1}{2}O_2(g) \rightarrow MgO(s) \quad \Delta_c H^\circ = -601.6$ kJ
3)	Term in a Balanced Equation	$H_2O(l) + 285.8 \text{ kJ} \rightarrow H_2(g) + \frac{1}{2}O_2(g)$	$Mg(s) + \frac{1}{2}O_2(g) \rightarrow MgO(s) + 601.6 \text{ kJ}$
4)	Chemical Potential Energy Diagram		

Endothermic Reaction



Surroundings are cooled as chemical system absorbs energy.

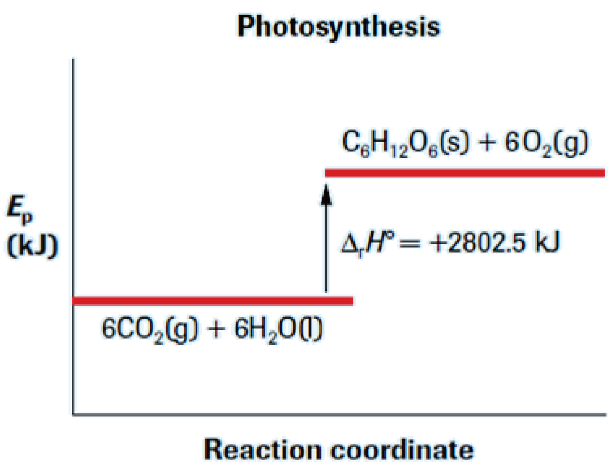
Exothermic Reaction

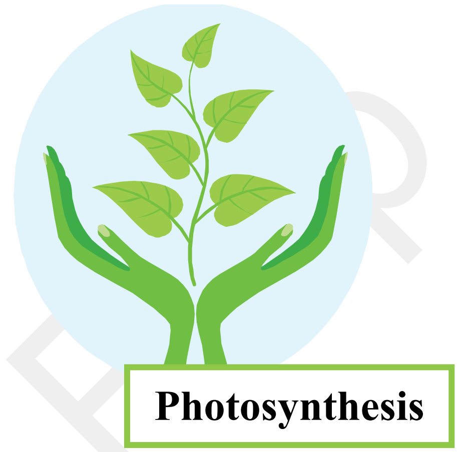


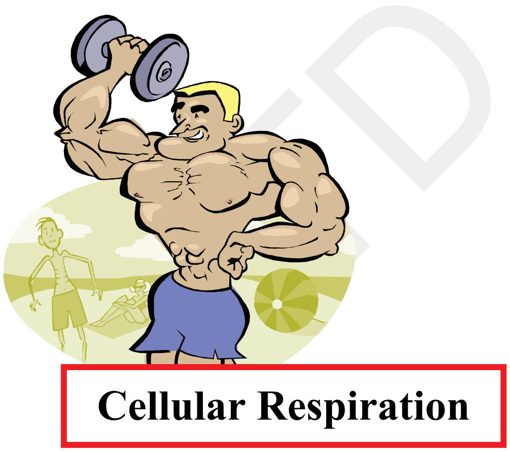
Surroundings are warmed as chemical system releases energy.

The Sun is a Major Source of Stored Chemical Energy on Earth

1. The standard molar enthalpy for photosynthesis of glucose:
   $\Delta_r H°_{m\,C_6H_{12}O_6} = +2802.5$ kJ/mol
2. $6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(s) + 6O_2(g) \quad \Delta_r H° = +2802.5$ kJ
3. $6CO_2(g) + 6H_2O(l) + 2802.5 \text{ kJ} \rightarrow C_6H_{12}O_6(s) + 6O_2(g)$
4. Potential energy diagram for photosynthesis:







1. The standard molar enthalpy for cellular respiration of glucose:
   $\Delta_r H_m°_{\,C_6H_{12}O_6} = -2802.5$ kJ/mol
2. $C_6H_{12}O_6(g) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l) \quad \Delta_r H° = -2802.5$ kJ
3. $C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l) + 2802.5$ kJ
4. Potential energy diagram for cellular respiration: