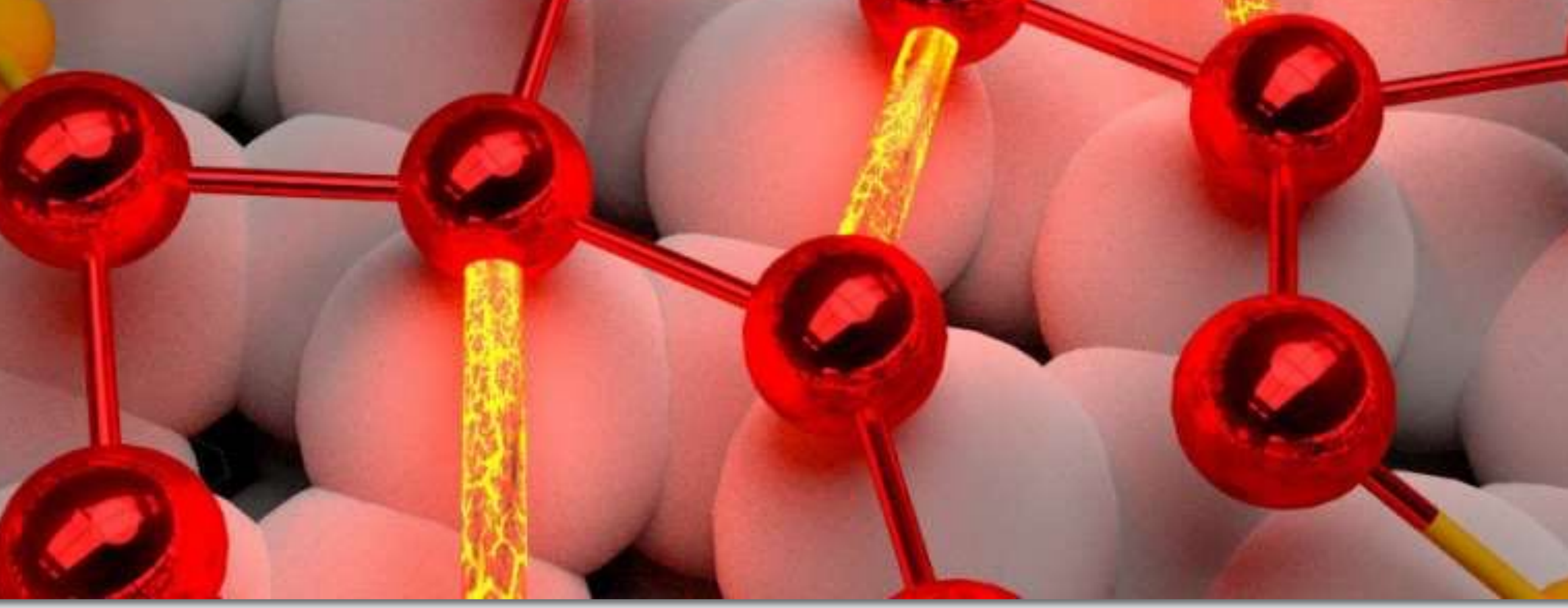
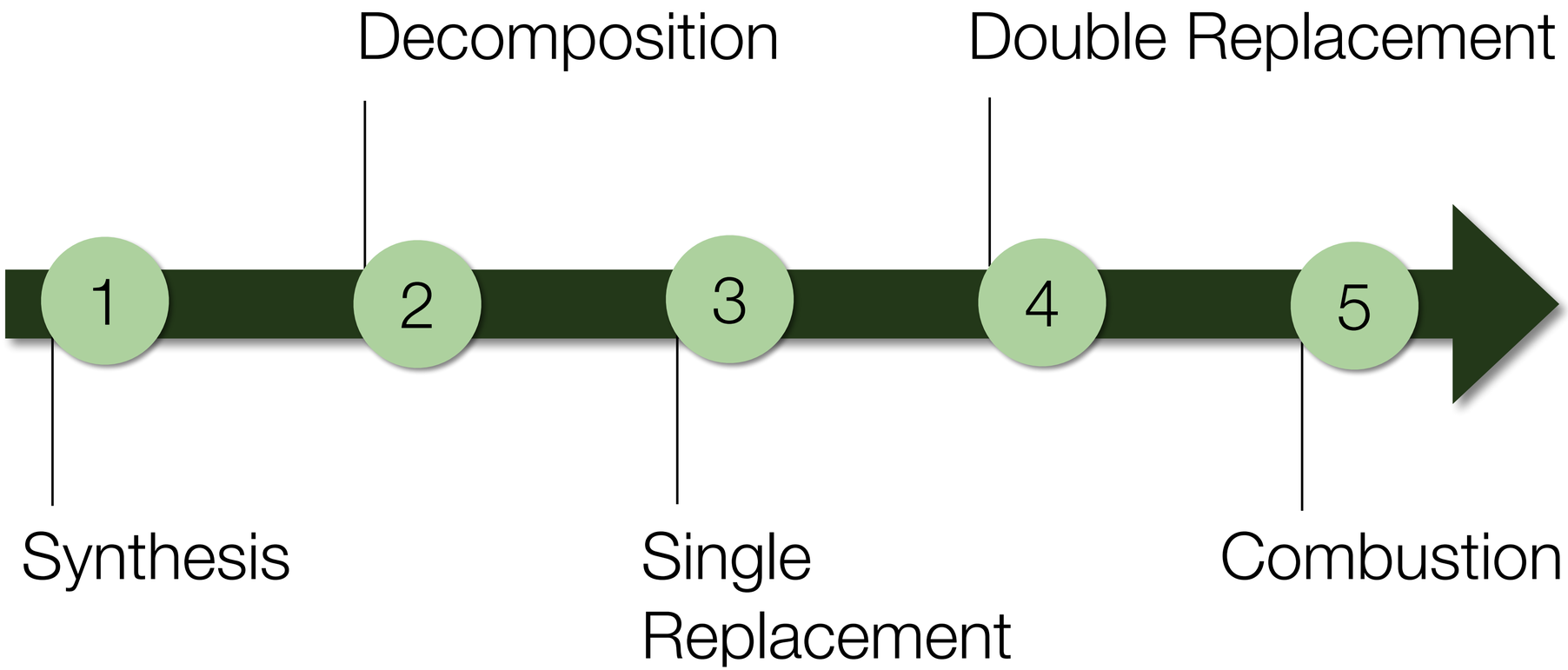


Changes & Chemical Reactions

Unit 5

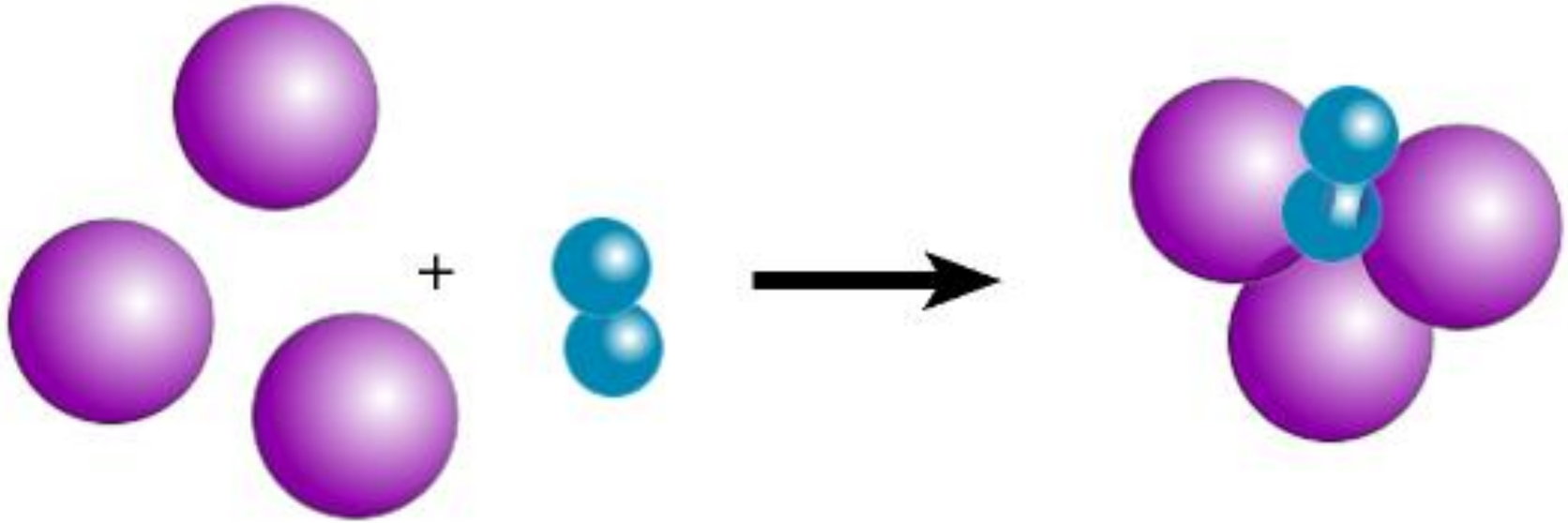
5 Types of Chemical Reactions

Topic 1



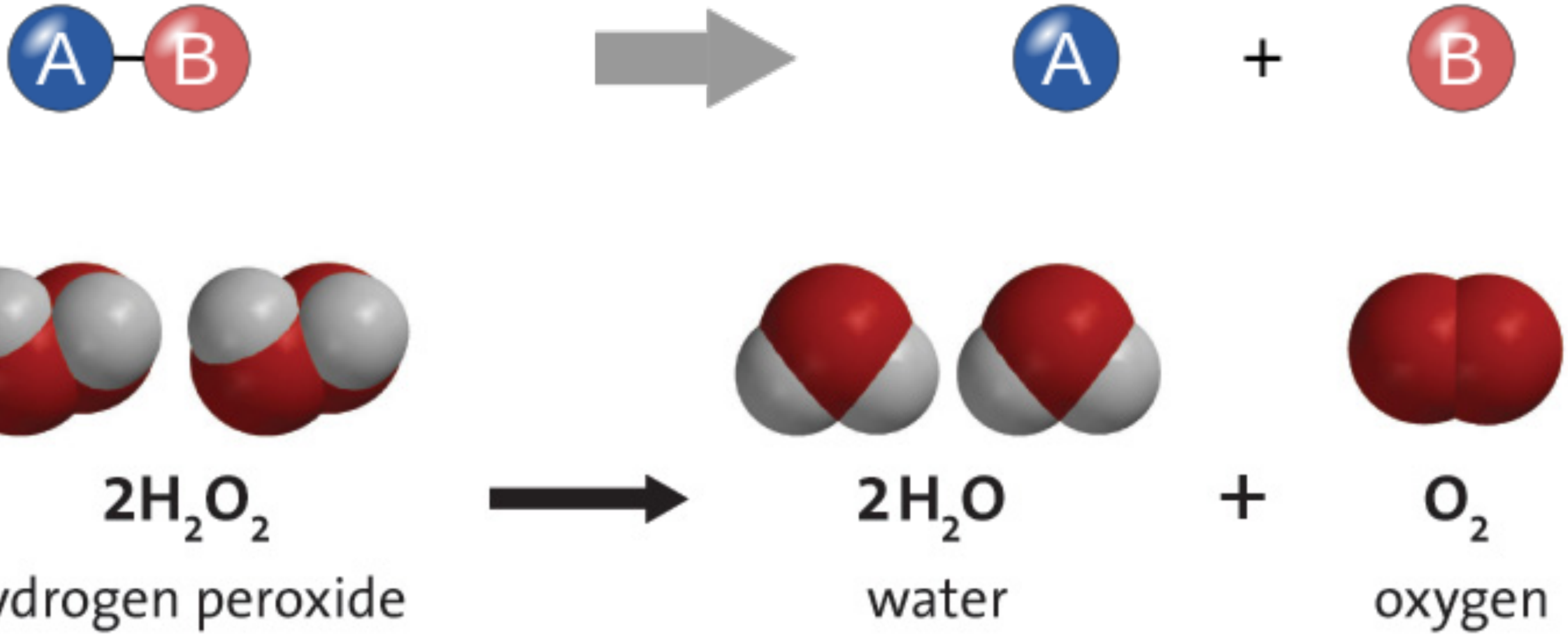
Synthesis

$2H_2 + O_2 \rightarrow 2H_2O$



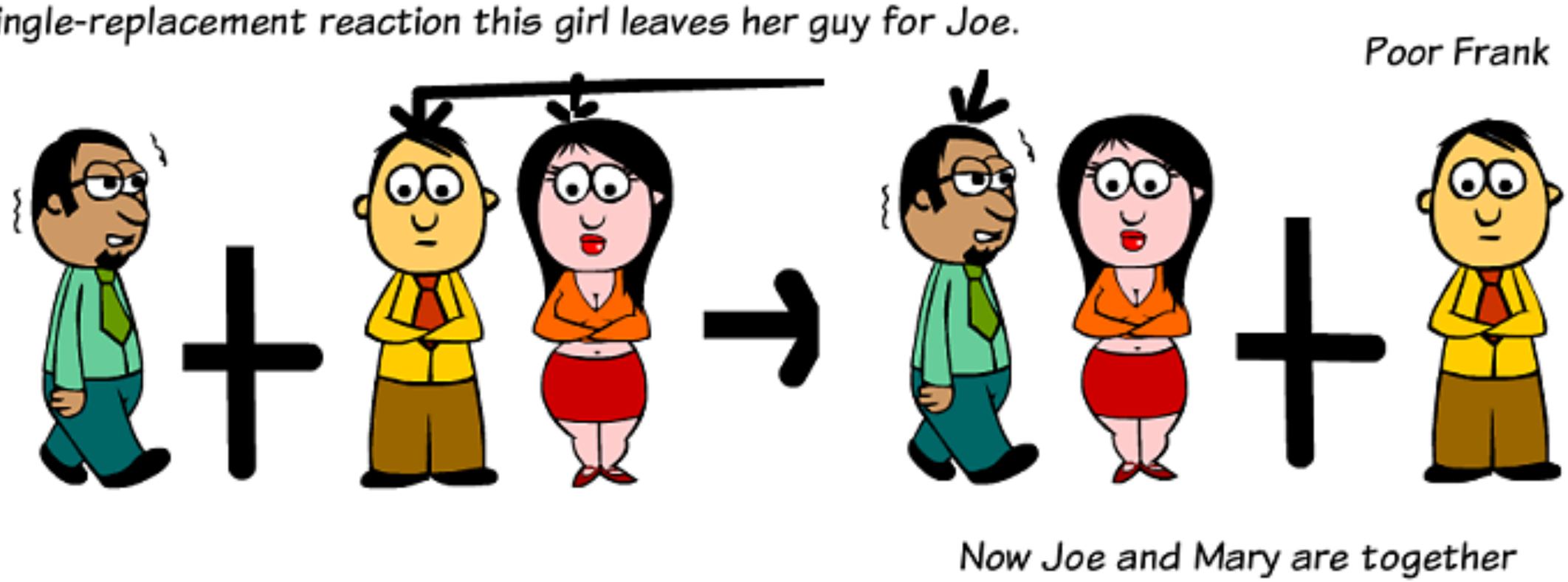
Decomposition

$2NH_3 \rightarrow N_2 + 3H_2$



Single Replacement

$CaCl_2 + 2Li \rightarrow 2LiCl + Ca$



Double Replacement

NaCl

+

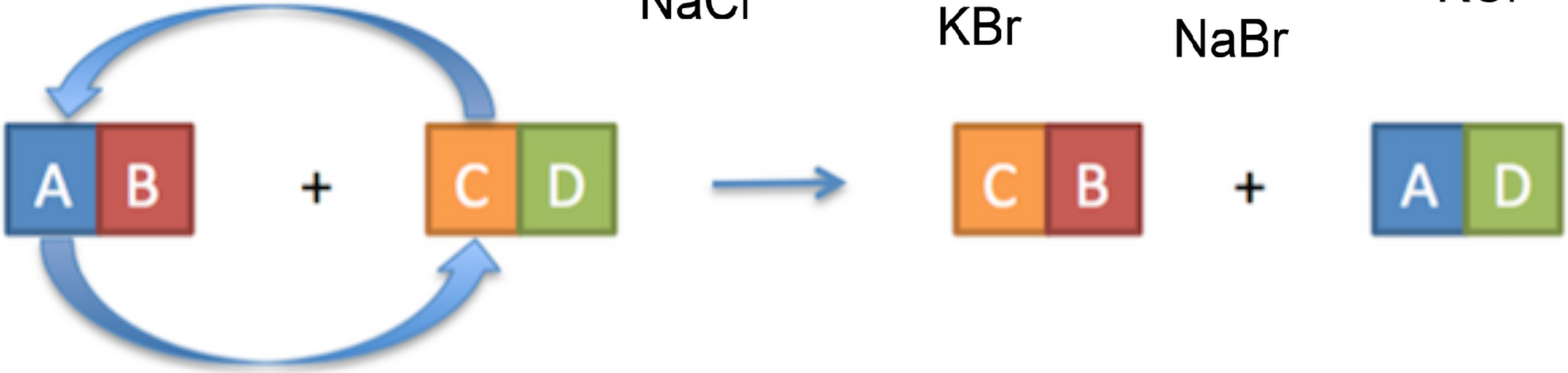
KBr

-->

NaBr

+

KCl

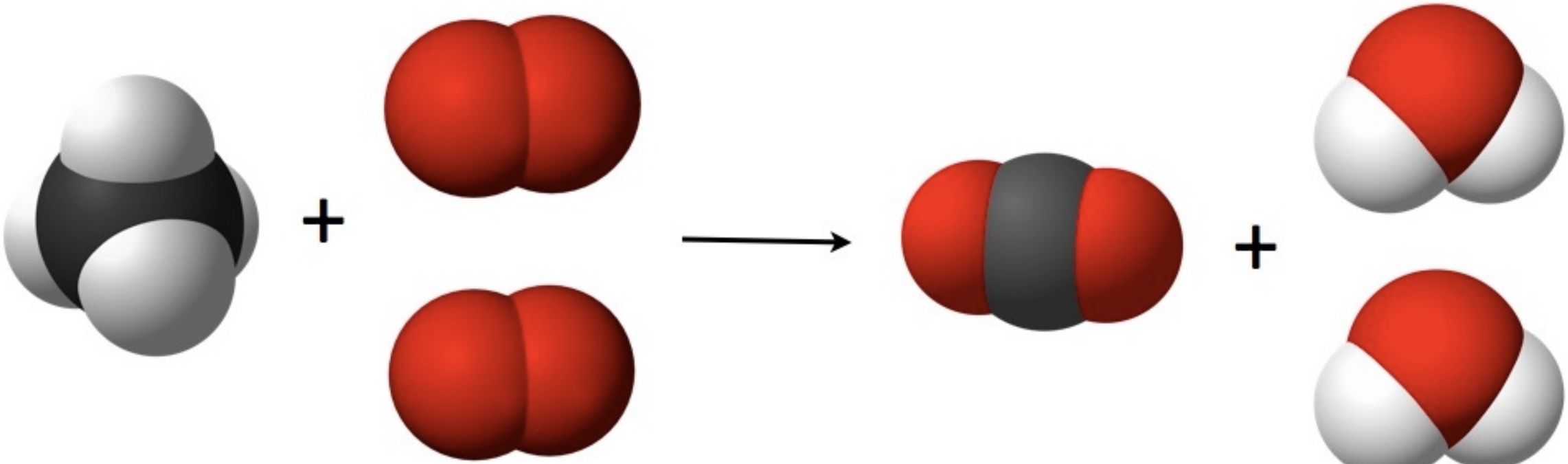


A and C are Cations (Positive Ions)

B and D are Anions (Negative Ions)

Combustion

hydrocarbon + oxygen → carbon dioxide + water



$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

Describe each of the following reactions:

Decomposition
Synthesis
Single Replacement
Double Replacement

A reaction occurs in which only one reactant is present. Decomp

A metal reacts with an acid SR

Magnesium burns Synthesis

Two salt solutions react with each other. DR

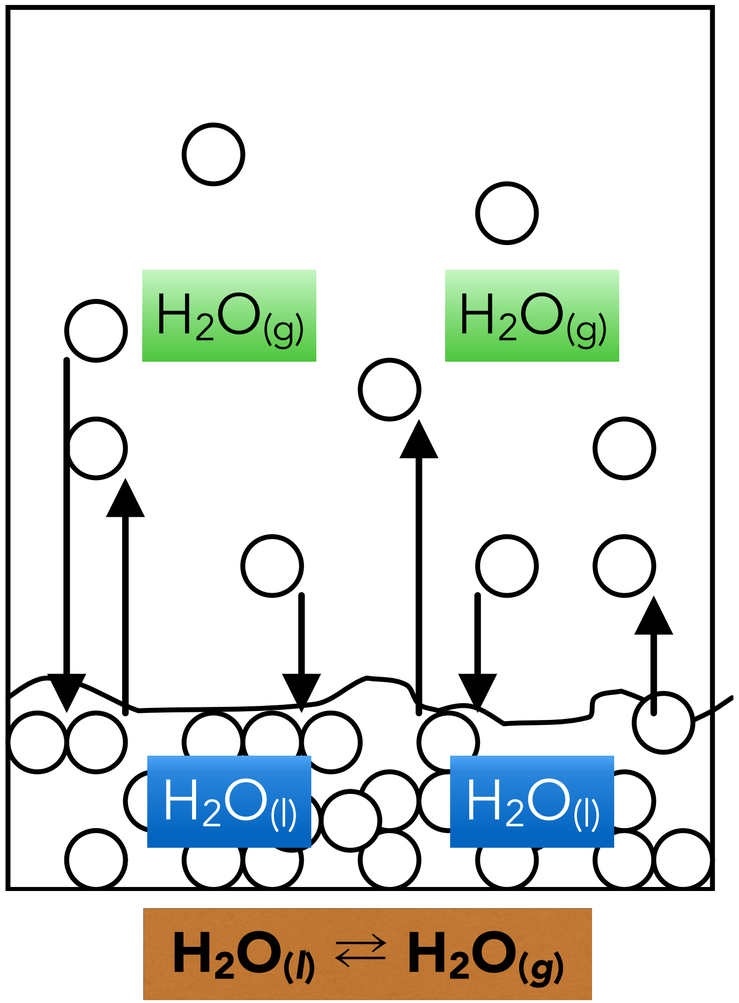
Two elements unite to form a compound. Synthesis

A compound breaks down. Decomp

$HCl + NaOH \rightarrow NaCl + H_2O$ DR

Equilibrium & Collision Theory

Topic 2



- Forward and Backward process *rates* are the SAME

- In this example we have a physical change, but equilibrium can occur for chemical changes, too.

In order for equilibrium to occur…

The **rate** of the forward reaction must be equal to the **rate** of the reverse reaction.

Conditions for Equilibrium

Reversible

- Burning wood can never be in equilibrium..

Closed System

- If a gas is produced and flies away, it's not present to go back!

Amounts of P & R

- Do not change!!

Collision Theory

Collision Theory

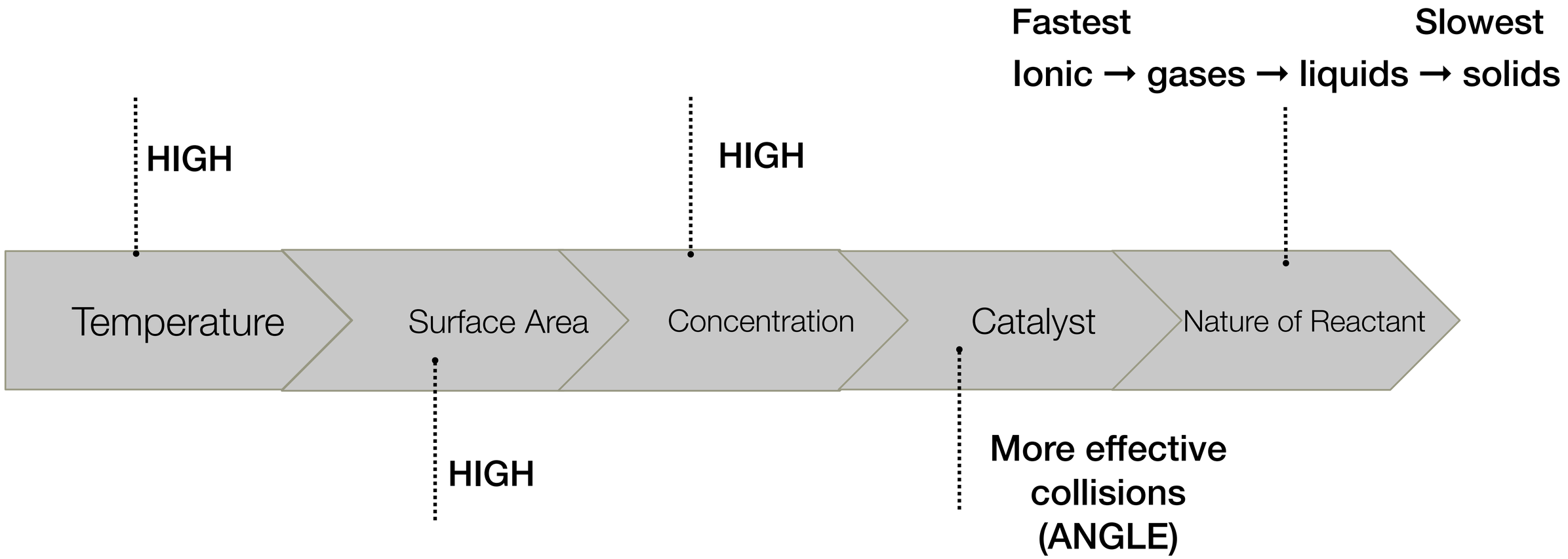
Reactions require <u>effective collisions</u>!

More Collisions	Fewer Collisions
• Faster reactions • Increased reaction rate • Decreased reaction time	• Slower reactions • Decreased reaction rate • Increased reaction time

<u>Other Factors</u>

- Frequency of collisions
- How hard they hit
- Angle of impact

Factors Affecting Reaction Rate



Regents Practice

1. An increase in temperature increases the rate of chemical reactions. This is primarily because the

(1) concentration of the reactants increases
(2) number of effective collisions increases
(3) activation energy increases
(4) average kinetic energy decreases

2. An increase in temperature increases the rate of a chemical reaction because the

(1) activation energy increases
(2) activation energy decreases
(3) number of molecular collisions increases
(4) number of molecular collisions decreases

3. A chemical reaction has reached equilibrium when
(1) the reverse reaction begins
(2) the forward reaction ceases
(3) the concentration of the reactants and products become equal
(4) the concentrations of the reactants and products become constant

Changes in Oxidation State

Topic 3

How does a car rust?

$$2Fe + O_2 \rightarrow 2FeO$$

$$4Fe + 3O_2 \rightarrow 2Fe_2O_3$$

What you don't see happening here is a TRANSFER of electrons … from Iron to Oxygen.

This is a *chemical change*.

Remember

Metals

- *Lose* electrons
- form positive ions
- Ions are SMALLER than the atom

Non-Metals

- *Gain* electrons
- form negative ions
- Ions are BIGGER than the atom

Oxidation vs. Reduction

Oxidation

- *Losing* electrons

$Na \rightarrow Na^{+} + 1e^{-}$

Reduction

- *Gaining* electrons

$Cu^{2+} + 2e^{-} \rightarrow Cu$

Rules for Assigning Oxidation #’s

1. A ‘free element’ = oxidation # of 0.

Br_2, each Br = 0

Ca = 0

Na = 0

Ne = 0

S_8, each S = 0

O_2, each O = 0

Take out your Periodic Table of Elements!!

2. Your periodic chart can tell you the oxidation number (same as the charge) for most elements when they are in compounds.

In compounds:

A. Group 1 alkali metals are +1

B. Group 2 alkaline earth metals are +2

C. F is always -1

D. H is almost always +1

Exception: Metal hydrides. In NaH, H = -1

In CaH_2, H = -1

E. O is almost always -2

Exception: In peroxides (See Table E). In Na_2O_2, O = -1

In OF_2, O = +2

F. Group 17 halogens (Cl, Br, I) are usually -1, but *can* be +1, +3, +5, +7.

3. In neutral compounds, charges must add up to 0.

4. In polyatomic ions (like SO_4^{2-}, NO_3^{1-}, NH_4^{1+}, etc.), charges must add up to the charge on the ion.

5. Some elements can have several possible oxidation states. For these, you need to calculate the oxidation state (charge) in each case.

Some Examples

Find the Oxidation state of each element:

CO_2

H_2

Na_2S

K_2SO_4

$LiClO_4$

Red-Ox Reactions (Summary)

1. Assign all oxidation numbers.

2. Have the numbers changed?
   (a) If ‘yes’ = redox
   (b) If ‘no’ = NOT redox

3. Who gained (reduction) and who lost (oxidation)

$$2Na + Cl_2 \rightarrow 2NaCl$$

Regents Practice

What is the oxidation state of nitrogen in the compound NH_4Br?

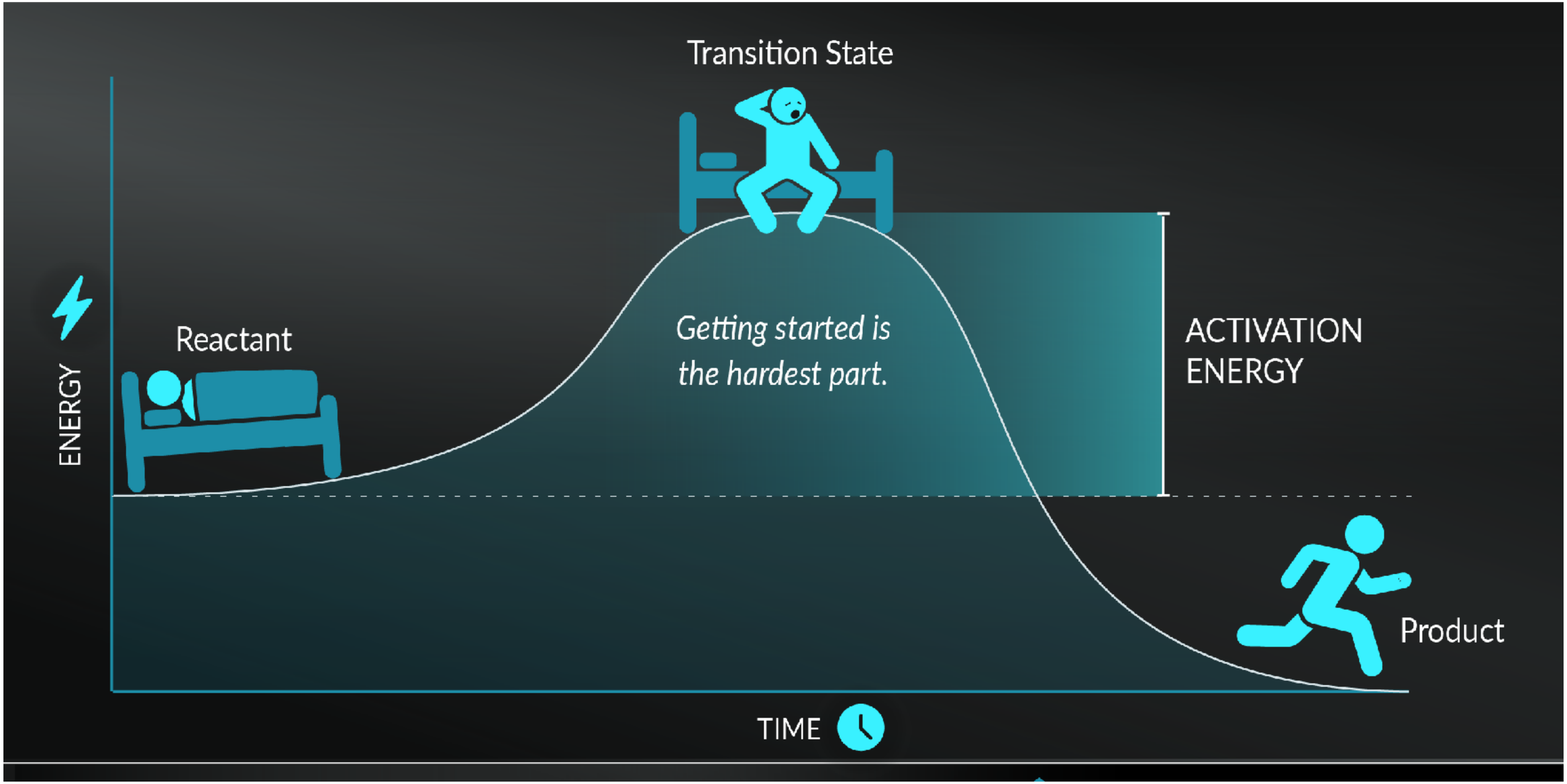
(1) –1
(2) +2
(3) –3
(4) +4

Potential Energy & Enthalpy

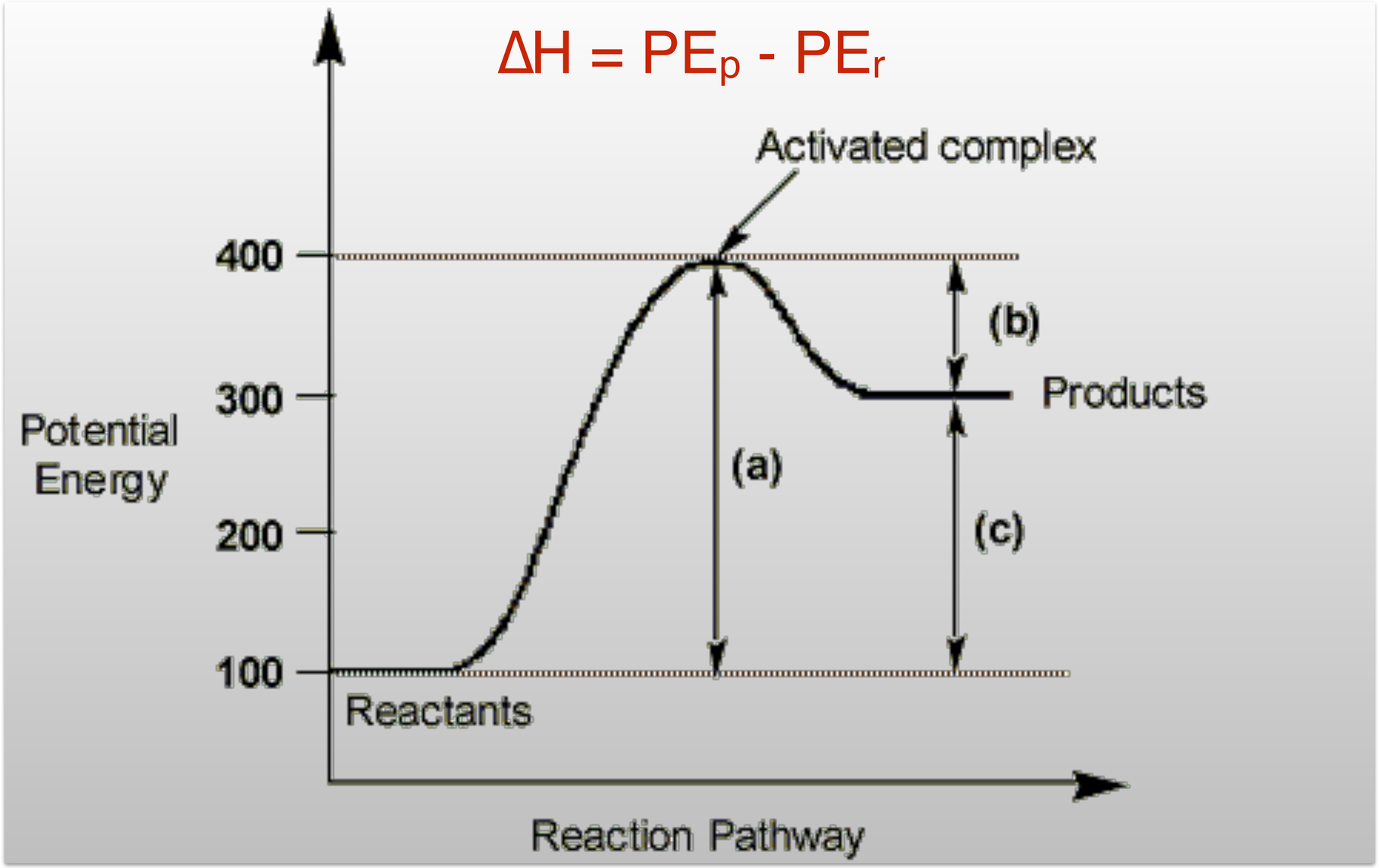
Topic 4

POTENTIAL ENERGY DIAGRAM

- The minimum energy needed is the **activation energy** (E_a).



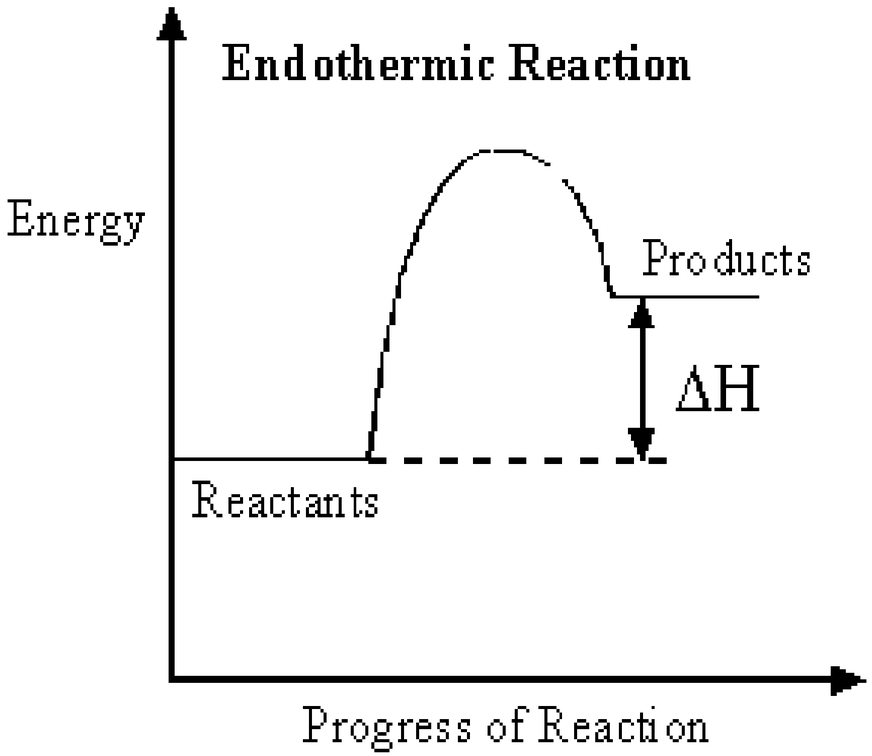
Potential Energy Diagrams



Endothermic vs. Exothermic

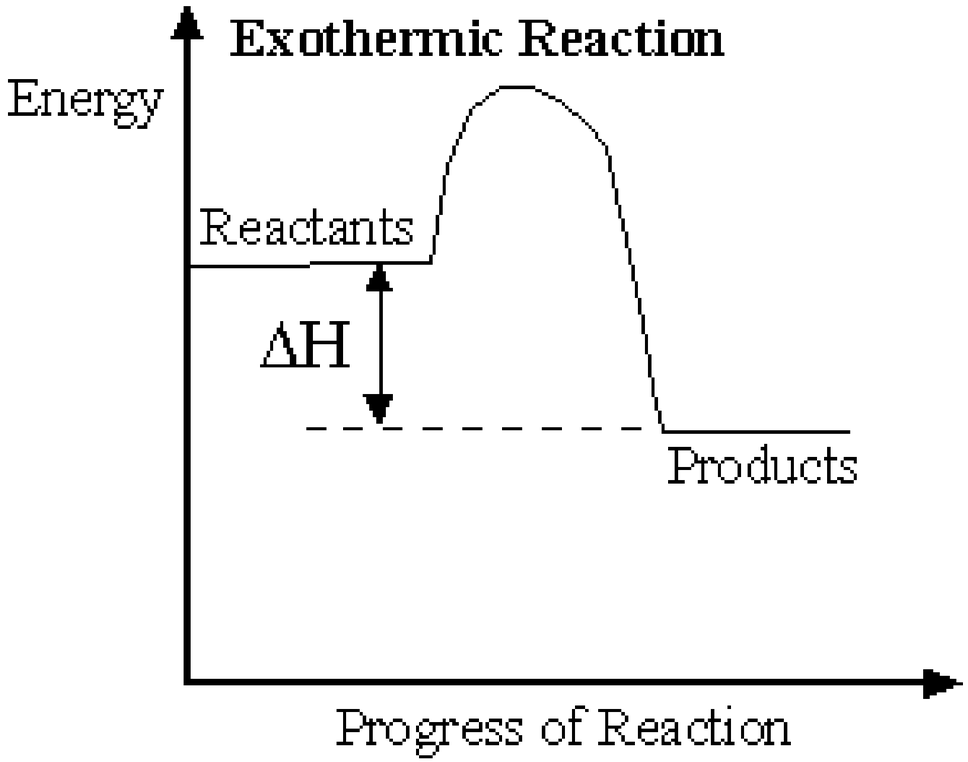
Reaction 1:

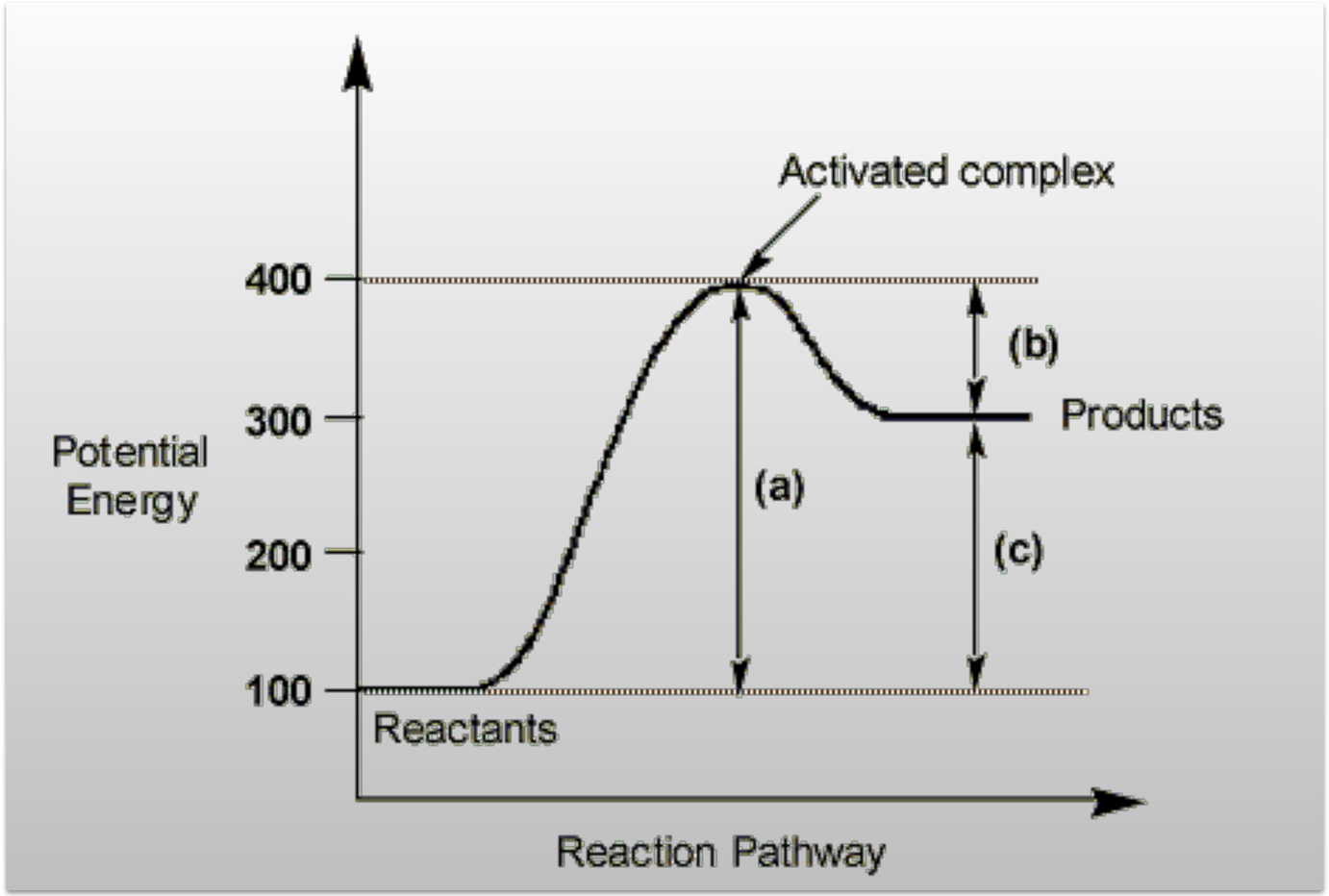
A + B + **heat** → C + D



Reaction 2:

E + F → G + H + **heat**





A POTENTIAL ENERGY diagram will include:

1) **PE of the reactants (PER)**
2) **PE of the products (PEP)**
3) **Activation energy (E_a)**
4) **Change in the PE (Heat of Reaction = ΔH = PEP – PER)**
5) **PE of the activated complex**

*****Draw these in on the diagrams above!!*****

Enthalpy of a Physical Change

- Heat changes when making a solution!
- The *heat of solution*: amount of heat required or produced when 1 mole of a material is dissolved in water.
- ΔH is **negative** = *exothermic* (heat is given off)
- ΔH is **positive** = *endothermic* (heat is absorbed, solution gets cold)
- Look at the last 6 equations on Table I. Each of these describes the solution of an ionic compound.
- ***YOU TRY***: Draw and label a PE Diagram for dissolving NaCl.

Enthalpy of a Chemical Change

- Look at the top half of Table I. These are ***chemical*** changes.
- Draw and label a PE Diagram for a reaction between gasoline (C_8H_{18}) and oxygen:

The purpose of the catalyst in a reaction is to

(1) change the activation energy required of the reaction
(2) provide the energy necessary to start the reaction
(3) increase the amount of product formed
(4) decrease the amount of reactants used

Kinetic Energy & Entropy

Topic 5

Think about what your bedroom looks like right now …

What is Entropy?

- Entropy = a measure of disorder in a system.
  - Nature prefers disorder.
  - Solids are more ordered than liquids and gases.
  - If more gas exists when the change is complete then there is more disorder in the system = increase in entropy.
  - A solution (aq) is more disordered than a solid or a liquid.

How can Entropy be Increased?

1. Changing from Solid to liquid, liquid to aqueous, or liquid to gas
2. More particles (i.e. more moles)
3. Increase temperature

How can Entropy be Increased?

$$4Al_{(s)} + 3O_{2(g)} \rightarrow 2Al_2O_{3(s)}$$

Entropy ***decreases*** because we are going from a gas to a solid.

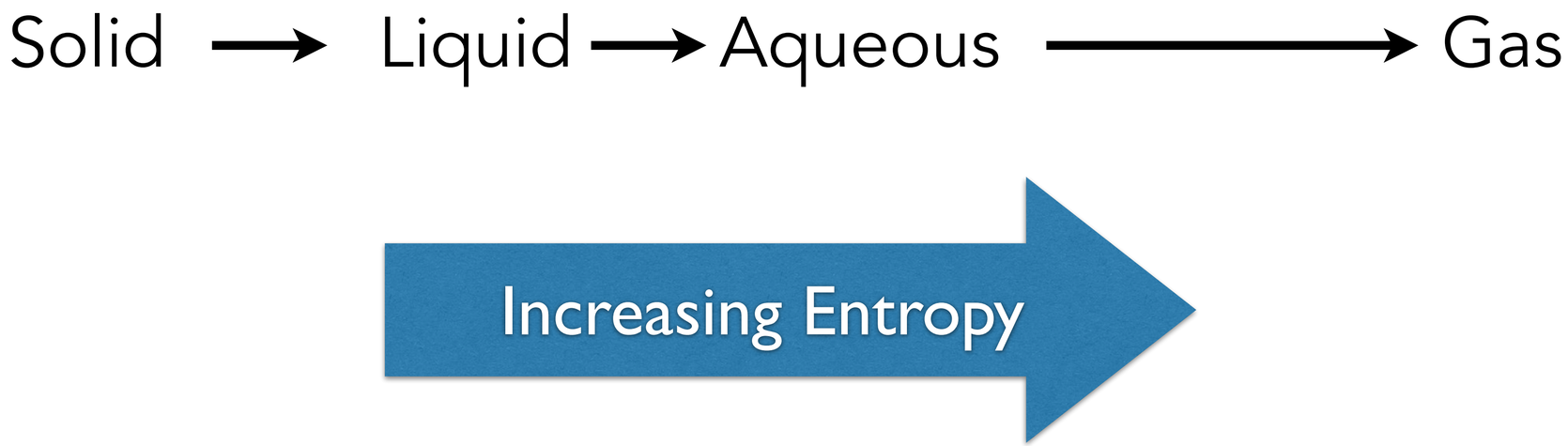
$$Cu_{(s)} + 2HNO_{3(aq)} \rightarrow CuNO_{3(aq)} + NO_{2(g)} + H_2O_{(l)}$$

Entropy ***increases*** because we are going from a solid to aq/g/l

$$N_{2(g)} + \underbrace{3H_{2(g)}}_{4 \text{ moles}} \rightarrow \underbrace{2NH_{3(g)}}_{2 \text{ moles}}$$

Entropy ***decreases*** because we have fewer particles.

Finally!



Regents Practice

The entropy of a sample of CO_2 increases as the CO_2 changes from

(1) gas to liquid
(2) gas to solid
(3) liquid to solid
(4) solid to gas

Use the Reaction below to solve the following problem:

$$2NaHCO3(s) + heat \rightarrow Na2CO3(s) + H2O(g) + CO2(g)$$

State evidence that indicates the entropy of the products is greater than the entropy of the reactants. [1]

Reactants - all solid

Products - some gases

Unit Essentials

Use to Prepare Test Study Guides

Topic 1 - Review

ESSENTIALS: Know, Understand, and Be Able To…

- ❑ The three phases of matter (solids, liquids and gases) have different properties.
- ❑ Distinguish between chemical and physical changes.
- ❑ In all chemical reactions there is a conservation of mass.
- ❑ A balanced chemical equation represents a conservation of atoms.
- ❑ The coefficients in a balanced chemical equation can be used to determine mole ratios in the reaction.
- ❑ A chemical change results in the formation of different particles with changed properties.
- ❑ Balance equations, given the formulas of reactants and products.
- ❑ Calculate simple mole-mole stoichiometry problems, given a balanced equation.
- ❑ A chemical change results in the formation of different particles with changed properties.
- ❑ Types of chemical reactions (changes) include synthesis, decomposition, single replacement, double replacement, and combustion.
- ❑ Identify types of chemical reactions

Text References: p. *42 & 46-47, p. 330-336*

Topic 2 - Changes in Rate & Equilibrium

ESSENTIALS: Know, Understand, and Be Able To…

- ❑ The rate of the chemical reaction depends upon several factors: temperature, concentration, nature of reactants, surface area, and the presence of a catalyst.
- ❑ Some chemical and physical changes can reach equilibrium.
- ❑ At equilibrium the rate of forward reaction equals the rate of reverse reaction. The measurable quantities of reactants and products remain constant at equilibrium.
- ❑ Use collision theory to explain how various factors, such as temperature, surface area, and concentration, influence the rate of reaction.
- ❑ Describe:
  a. the conditions that must occur to put a process into a state of equilibrium.
  b. the rates of opposing processes in an equilibrium system.
  c. the concentration of particles in an equilibrium condition.
- ❑ Identify an example of physical equilibria (such as phase equilibrium) and correlate to a heating curve and/or Table H

Text References: p. *542-547, 392, & 549-551*

Topic 3 - Changes in Oxidation State

<u>ESSENTIALS:</u> Know, Understand, and Be Able To…

- ❑ In all reactions there is a conservation of electrical charge (valence electrons move between atoms, but are not created or destroyed).
- ❑ Oxidation numbers (charges) can be assigned to atoms and ions.
- ❑ An "oxidation/reduction reaction" is one that involves the transfer of electrons between substances. Some, but not all, chemical changes are "redox" reactions.
- ❑ When elements undergo changes in oxidation numbers (charges), this indicates that oxidation and reduction have occurred.
- ❑ Gaining electrons in a chemical reaction is called "reduction" (GER).
- ❑ Losing electrons in a chemical reaction is called "oxidation" (LEO).
- ❑ Assign oxidation numbers to all atoms in a chemical reaction, using the Periodic Table.
- ❑ Determine whether or not a reaction is a redox one.
- ❑ Identify the species that has lost electrons and been oxidized.
- ❑ Identify the species that has gained electrons and been reduced.

Text References: *p. 639 – 647*

Topic 4 - Potential Energy & Enthalpy

<u>ESSENTIALS:</u> Know, Understand, and Be Able To…

- ❑ In all chemical reactions there is a conservation of energy.
- ❑ Systems in nature tend to undergo changes that lower the potential energy (bond energy), in other words, are exothermic.
- ❑ One important physical change is dissolving materials in water. This process is either exo- or endothermic.
- ❑ When the attraction between ions is greater than the attraction of ions for water, an ionic compound does not dissolve. It is said to be insoluble.
- ❑ Potential energy released or absorbed by a chemical reaction can be represented by a potential energy diagram.
- ❑ Distinguish between endothermic and exothermic reactions, using energy terms in a reaction equation or using potential energy diagrams.
- ❑ Read and interpret potential energy diagrams: PE reactants, PE products, activation energy (with or without a catalyst), heat of reaction (ΔH).

Text References: *p. 511, 514-515*

Topic 5 - Kinetic Energy & Entropy

<u>ESSENTIALS:</u> Know, Understand, and Be Able To…

- ❑ Systems in nature tend to undergo changes that lower the potential energy (bond energy), in other words, are exothermic.
- ❑ Since most reactions are exothermic, heat is being released. This has the effect of speeding up the particles in the system, or in other words, increasing the kinetic energy.
- ❑ Entropy is a measure of the kinetic energy of the particles in the system. Systems at higher temperatures have more entropy.
- ❑ Systems with greater entropy contain particles with more disorder. Gas particles have more entropy than liquids or solids.
- ❑ Systems in nature tend to go to a higher entropy state.
- ❑ Compare the entropy of phases of matter.
- ❑ Predict whether entropy increases or decreases for a chemical reaction or a physical change.

Text References: *p. 570*