TOPIC 8.1

Collision Theory

What needs to happen for a reaction to occur?

Chemical changes create new substances from old ones. To do that, old bonds need to get broken and new bonds need to get formed.

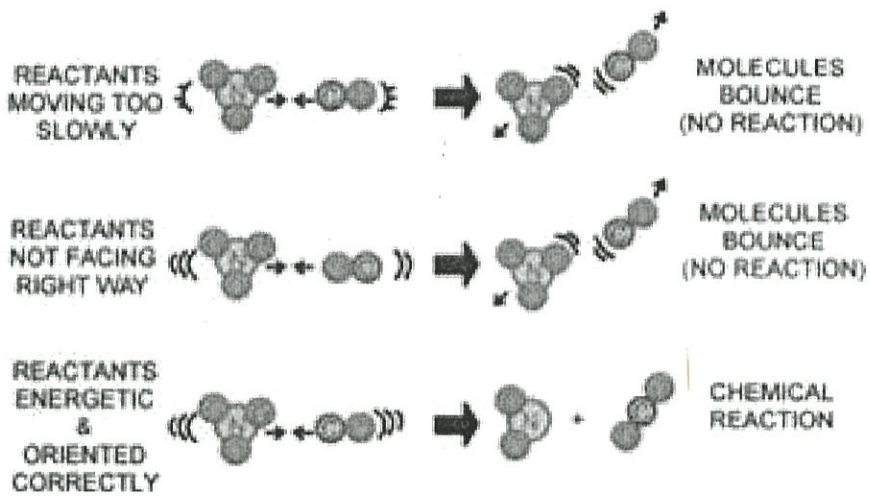
Breaking bonds absorbs/requires **energy; making bonds** releases **energy**

When we thought about chemical bonding, we looked at how electrons move when bonds are made:

Sharing electrons: covalent bond
Transferring electrons: ionic bond
"Sea" of electrons: metallic bond

However, all this electron movement doesn't take place automatically—the setup needs to be right.

Collision theory: particles must collide with the right amount of energy and proper orientation



not enough energy

not proper orientation

just right!

TOPIC 8.2

Factors that Affect Rate of Reaction

How can we speed up reactions?

We will use this video: https://youtu.be/OttRV5ykP7A to fill in the following table.

What do I need to do to speed up a chemical reaction?	Why does this work?	How does the new hypothetical school design change to increase the chances of getting a date to the dance?
1. Shrink container or increase concentration	increases the # of effective collisions	hallways get smaller
2. Increase number of particles	increases the # of effective collisions	population of school increases
3. Speed up particles by adding heat	particles collide more often and with greater force	bell time is cut in half
4. Break up clumps into individual particles (increase surface area)	particles collide more often	no more traveling in packs
5. Add a catalyst	-lowers the activation energy (energy required to start a reaction) -ensures proper orientation	introduce a "matchmaker"

The more effective collisions,

the higher [illegible] / faster the reaction rate.

TOPIC 8.3

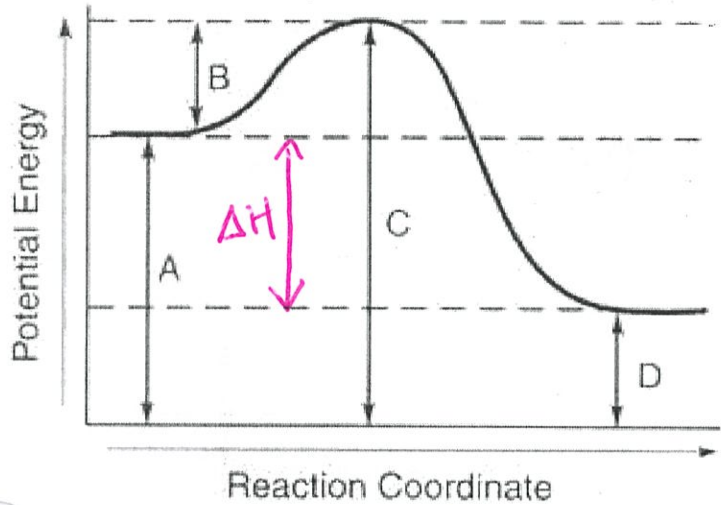
Potential Energy Diagrams

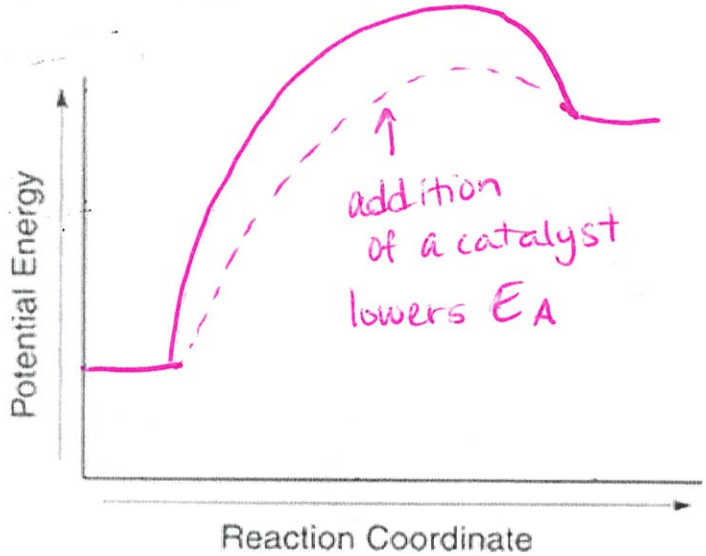
How can we model graphically reaction rates?

As chemical reactions take place, the changes that occur are the result of breaking old bonds and forming new ones. We already know a bit about that:

Breaking bonds absorbs **energy; making bonds** releases **energy**

The type of energy associated with chemical bonds is potential energy. One of the more useful graphs in chemistry tracks the changes in the potential energy of a chemical system as a reaction takes place:





EXOTHERMIC

PER: potential energy of reactants (A)

PEP: potential energy of products (D)

ΔH (PEP-PER): heat of reaction (D-A)

E_A: activation energy (B)

Task: Draw and label the PE diagram of an endothermic reaction. Add a dotted line on the diagram to show the effect of adding a catalyst to the reaction.

Endothermic: energy (heat) is added, so... PEP > PER

Catalysts speed up reactions without affecting the reactants or products themselves. Therefore, they work by lowering the E_A.

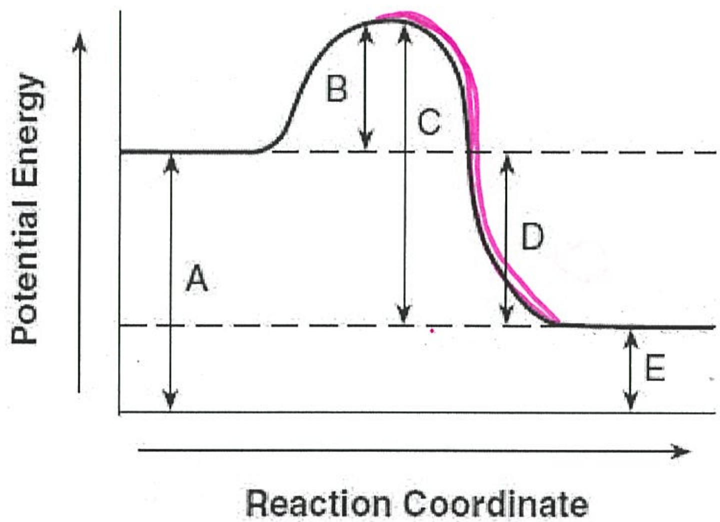
TOPIC 8.4

Reaction Reversibility

Can chemical changes be reversed?

Imagine a PE diagram as a very simple roller coaster; now imagine riding it in reverse. It takes a bit of engineering prowess and some energy to make it happen, but it can be done.

The same thing is true of chemical reactions. Just as physical changes are reversible (you can melt some ice, and then freeze it again), many chemical changes are reversible:



The reaction shown is exo thermic
Endo or exo?

If the reaction is running in the *forward* direction (reactants → products), the activation energy is represented by letter B

If the reaction is reversible and is running in the *reverse/backwards* direction (products → reactants), the activation energy would be represented by C

How do we represent all that chemically? We're going to need a new arrow: ⇄

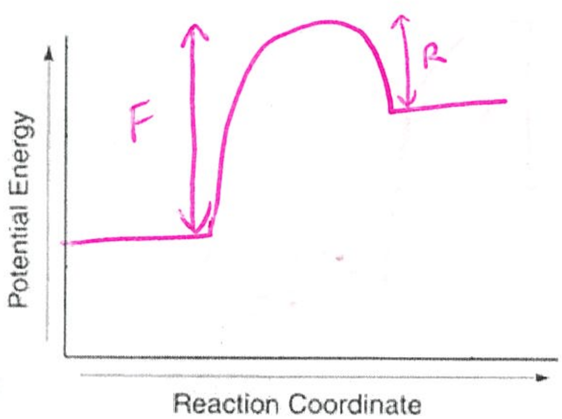
$Na_2CO_3 + CaCl_2 \rightleftarrows 2NaCl + CaCO_3$

Forward reaction: $Na_2CO_3 + CaCl_2 \rightarrow 2NaCl + CaCO_3$

Reverse reaction: $2NaCl + CaCO_3 \rightarrow Na_2CO_3 + CaCl_2$

An endothermic reaction is reversible.

1. *Draw a possible PE diagram to represent the change.*
2. *Compare the activation energy of the forward and reverse reactions*



Activation energy of the forward reaction is greater than the reverse.

TOPIC 8.5

Table I: Heat of Reaction

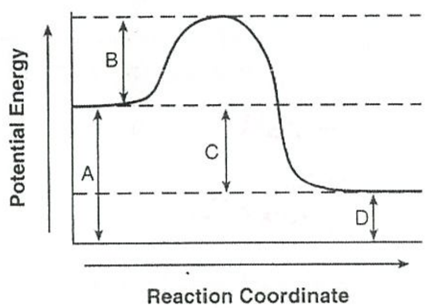
How can we manipulate how much heat is absorbed or released?

Potential energy diagrams provide a nice way of showing whether a reaction is endothermic or exothermic. ?emember that we can also...

1. **FEEL whether a change is endo- or exothermic**

2. **LOOK UP whether a change is endo- or exothermic on Table** I

Choose a chemical reaction (not a physical change!) from Table I that could be described by this PE diagram: exothermic ($-\Delta H$)



This PE diagram could represent:

$2\,CO(g) + O_2(g) \rightarrow 2\,CO_2(g) + 566$

Which letter represents the potential energy contained in the reactant molecules? A

Which letter represents the potential energy contained in the product molecules? D

Which letter represents the activation energy of the reaction? B

Which letter represents the heat of reaction? C

What is the quantity of heat released when 1 mole(s) of product is made? 283 kJ

What is the quantity of heat released when 5 moles of product are made? 1415 kJ

$\frac{2}{5} = \frac{566}{x}$ $\quad \frac{2x}{2} = \frac{2830}{2}$

TOPIC 8.6

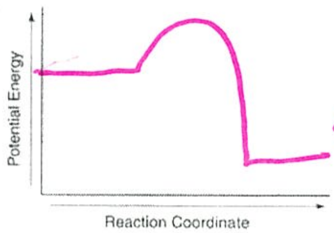
Entropy

Does "nature" have a preference for the direction a reaction proceeds?

If many reactions can be reversed, what motivates a chemical reaction to try to proceed at all? Laziness, potentially. The "goal" of a reaction system is to get its products to be less prone to change. That goal has 2 components:

1. **Energy: Create products with low potential energy ("lazy")**

From an energy perspective, explain why exothermic reactions tend to be more favorable than endothermic ones. State evidence from a PE diagram to support your answer.



products have lower PE

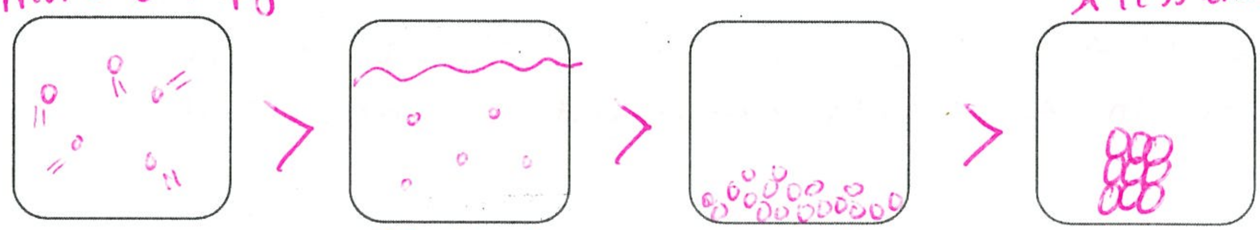
2. **Entropy: Create highly disordered ("messy") product particles**

What makes particles "messy"?

when they're far apart, moving randomly

Entropy: a measure of disorder

*more entropy   *less entropy



gas > aqueous > liquid > solid

Systems in nature tend to undergo changes toward

low energy and high entropy

These changes tend to be spontaneous *: happening naturally over time at a particular temperature and pressure*

TOPIC 8.7

Dynamic Equilibrium

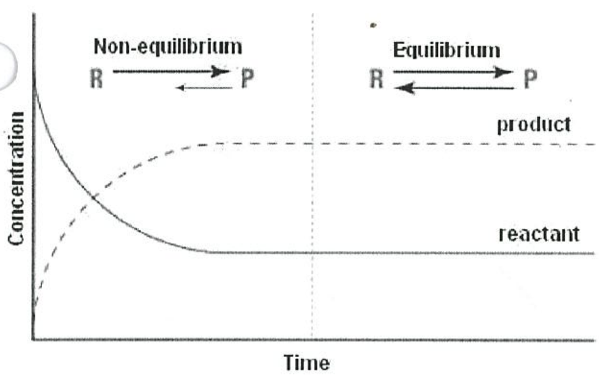
How can we describe a chemical reaction that moves forwards and backwards?

All reversible changes eventually reach a "balanced" state called equilibrium.

Equilibrium in chemistry has to do with finding balance. Forward and reverse reactions will battle it out until, eventually, both reactions are happening at the same speed and no overall change is seen.

When in **dynamic equilibrium**, the rate of the **forward reaction** EQUALS the rate of the **reverse reaction.** The concentration of the reactants and products are CONSTANT.

"equal exchange, constant concentration"

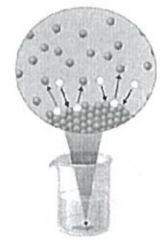


What's happening in the graph to the left?

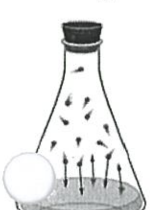
Concentration of products increase until equilibrium is reached, then remains steady. [reactants] ↓ until equilibrium is reached

Dissolving is a reversible change, can it reach dynamic equilibrium?
Sure. A saturated solution maintains a constant concentration of dissolved solute through an equal exchange rate of dissolved and undissolved particles. It's called...

Solution equilibrium


Saturated solution

Boiling/melting are reversible changes, can they reach dynamic equilibrium?



Sure. Just hold the substance at constant temperature in a **closed** container and you'll have constant amounts of liquid and gas (or solid and liquid) with an equal exchange rate between the two. It's called...

Phase equilibrium

TOPIC 8.8

Le Chatelier's Principle

What happens when a stress is applied to a chemical equilibrium?

[ ] = concentration

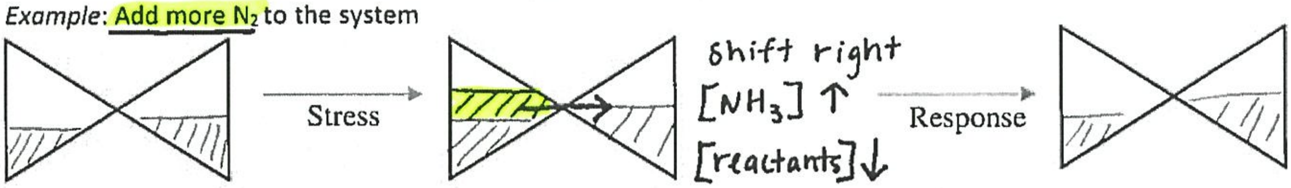
"When a stress is applied to a system, the reaction will try to shift in a direction that will relieve the stress!"

Stress 1: CONCENTRATION OF REACTANTS/PRODUCTS

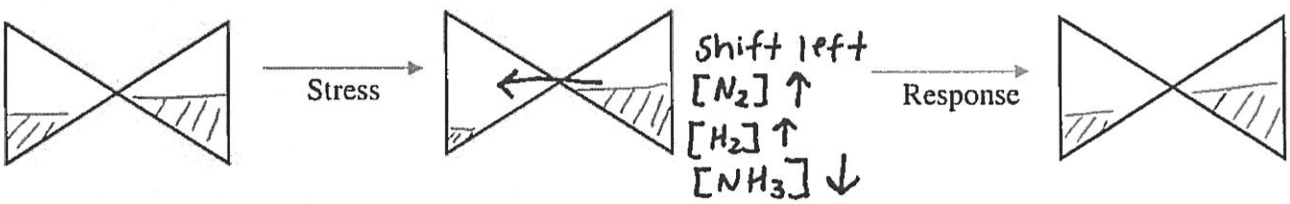
Rate of reaction trend: *Increasing the concentration of a substance* increases *its rate of reaction.*

$$N_2(g) + 3H_2(g) \rightleftarrows 2NH_3(g)$$

Example: Add more N_2 to the system



Example: Remove H_2 from the system

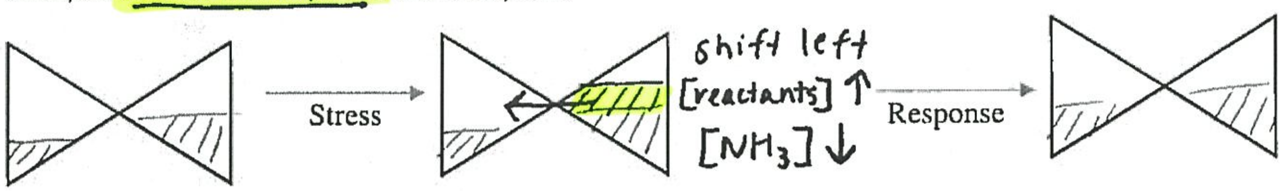


Stress 2: ("concentration of") TEMPERATURE/HEAT ENERGY

Rate of reaction trend: *Increasing the temperature of a system* increases *the rate of reaction.*

$$N_2(g) + 3H_2(g) \rightleftarrows 2NH_3(g) + \text{energy}$$

Example: Increase the temperature of the system

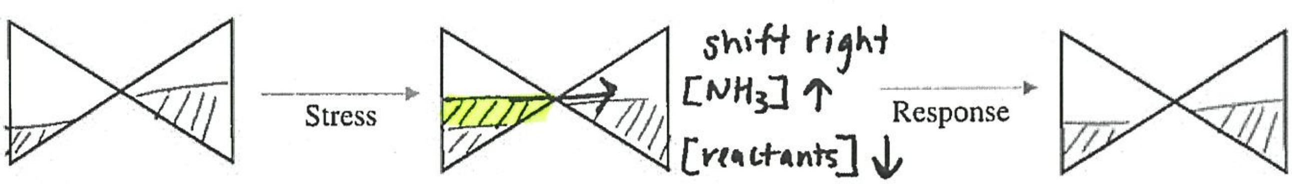


Stress 3: ("concentration of") PRESSURE OF GAS

Rate of reaction trend: *Increasing the pressure on a gas* increases *the rate of reaction.*

$$\text{pressure} + N_2(g) + 3H_2(g) \rightleftarrows 2NH_3(g)$$

Example: Increase the pressure on the system



BTW → Catalyst - Increases the forward and reverse rates equally, so there will be NO shift in the system!
↳ No affect on equilibrium!

TOPIC 8.9

Conservation in Chemical Change

What stays the same over the course of a chemical reaction?

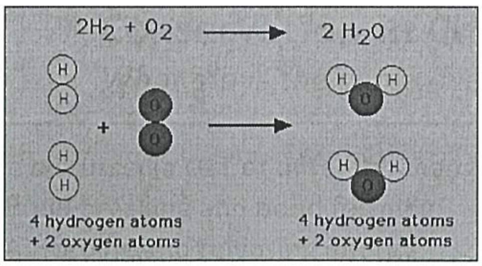
We have discussed a LOT of different changes that take place when chemical reactions occur:

- Bond breaking and bond forming
- Absorbing and releasing energy
- Increasing (or decreasing) entropy
- Forward and reverse rates
- Concentrations of reactants and products...

You get the point. But even as so many things change, THREE things always remain constant (are conserved):

1. Mass

How did we show it?

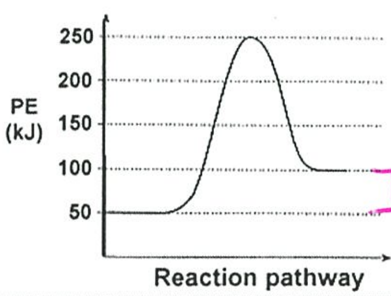


2 moles	1 mole	2 moles
$2H_2$ +	$1O_2 \longrightarrow$	$2H_2O$
4 grams	32 grams	36 grams

balancing chemical equations

2. Energy

How did we show it?



energy absorbed from surroundings

$\Delta H = 50 kJ$

3. Charge

How did we show it?

$$\overset{0}{4Al} + \overset{0}{3O_2} \longrightarrow 2Al_2O_3$$

+3 +3 / −2 −2 −2

writing ionic formulas

0 = 0 ✓