Kinetics III/Collision Theory

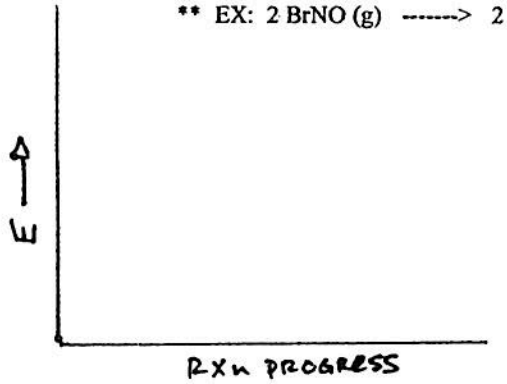
AP Chemistry

A. Return to COLLISION THEORY:

1. The rate of a reaction is _____ proportional to the number of EFFECTIVE or product-forming molecular collisions per second.

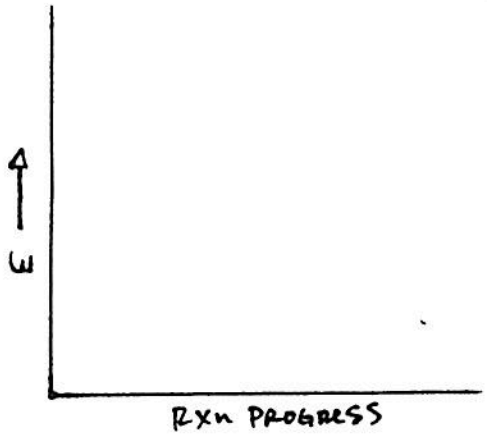
2. Are ALL collisions product forming? NO!!! On average, at room temp and 1 atm, $1x10^{27}$ collisions take place in a 1 mL volume every second. That's A LOT. If EVERY one of these collisions lead to product, then most reactions would be complete almost instantaneously which is not the case. Just colliding isn't enough....collisions have to be of a MINIMUM KINETIC ENERGY so as to break some bonds and initiate a chemical reaction.

3. ACTIVATION ENERGY (E_a) - the minimum amount of energy required to initiate a chemical reaction.
   ** EX: 2 BrNO (g) -------> 2 NO (g) + Br_2 (g)



At the top of the hill is the _____. This is where the molecules collide to form an "activated complex", a temporary and _____ species formed somewhere between bond-breaking and bond-forming.

Notice the decomposition of BrNO (g) is an _____ process, the products are _____ stable (have stronger bonds) than the reactants and energy is _____. How would the energy diagram of an endothermic reaction compare?



Different reactions have different energy barriers that must be overcome depending on how much energy is needed to break the initial bonds. The stronger the bonds, the _____ the activation energy, E_a.

EX: The burning of methane is oxygen is a highly EXOTHERMIC reaction. Yet, a mixture of methane and oxygen gas can kept indefinitely without any apparent change. Explain and illustrate using an energy diagram.

B. Explain how the following factors that affect the RATE of a rxn on a molecular level....in terms of collisions with enough energy to overcome activation energy:

Which of these factors also affect k, the rate constant? Remember our expression for k. $k = \frac{\text{rate}}{[A]}$

a. Concentration (applies mostly to liquids and gases)

_____ Change k?

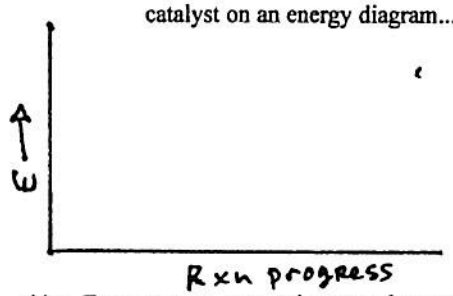
b. Increase in surface area (applies mostly to solids)

_____ Change k?

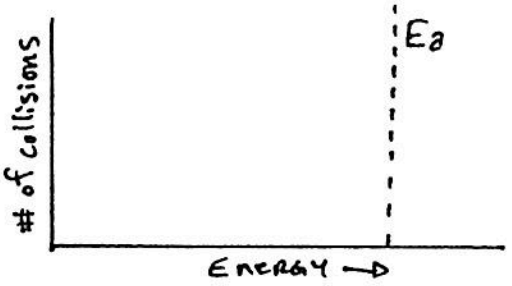
c. Nature of the reactant

_____ Change k?

d. A Catalysis - A substance that speeds up a reaction without being consumed itself. How does a catalyst work? A catalyst provides a new pathway for the reaction to occur, one that has a LOWER E_a. Illustrate the effects of a catalyst on an energy diagram....



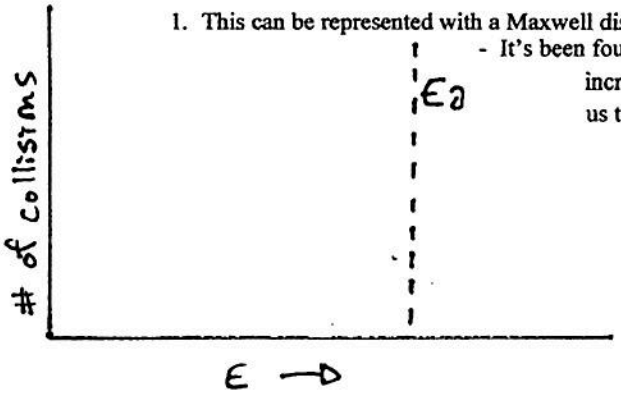
_____ Change k?



**e. Temperature - as you increase the temp, you increase the number of particles with enough kinetic energy to overcome the activation energy of the reaction, which _____ the rate of reaction.

_____ Change k?

1. This can be represented with a Maxwell distribution curve:



- It's been found that the # of collisions with enough K.E. to overcome the E_a increases EXPONENTIALLY with an increase in temperature. This leads us to the Arrhenius equation: $k = Ae^{-E_a/RT}$

EX: Consider this reaction: $H_2\,(g) + I_2\,(g) \dashrightarrow 2\,HI\,(g)$

When this reaction takes place in a sealed isothermal container, the rate law for this reaction is Rate = $k[H_2][I_2]$. If an *additional* mole of H_2 gas is added to this reaction chamber, what do you predict would happen to the rate of the rxn? k ? EXPLAIN.