I5-I8
(pg 12-25)

Chemistry 12
Reaction Kinetics II

Name:
Date:
Block:

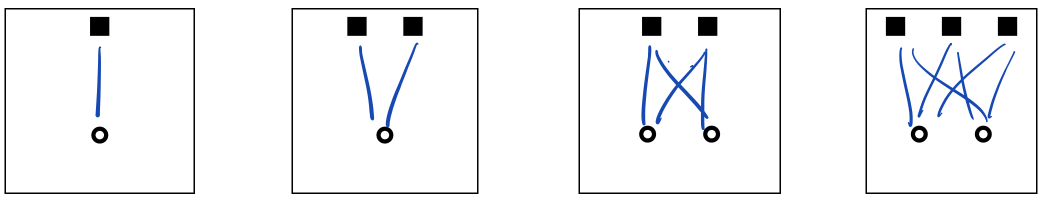
1. **Collision Theory**
2. **Activation Energy**
3. **Potential Energy Diagrams**

Collision Theory (Kinetic Molecular Theory)

- In order for two molecules to react, they must Collide with each other.
- When they collide they transfer energy among themselves.

Consider a hypothetical reaction between two gas particles, A and B, to form AB according to the reaction:

$$A_{(g)} + B_{(g)} \rightarrow AB_{(g)}$$



Total possible collisions: 1 | 2 | 4 | 6

The rate of reaction is directly proportional to the product of the concentrations of the reactants.

- When two variables are directly proportional to one another, there is a constant that relates the two, called a proportionality constant, represented by the letter *k.*
- Rate Law:

Reaction rate = $k[A]^x[B]^y$

- The proportionality constant is called a rate-constant. Each reaction has its own unique rate law and its own unique rate constant.
- **For many reactions, x and y are equal to 1, and are called reactant orders. We will only be dealing with reactions with an order of 1.**

1. Assume a reaction occurs by this rate law: rate = k[A]. How would the rate be affected by each of the following changes in concentration?
   a) [A] is doubled.

   Rate is also doubled

   b) [A] is halved.

   Rate is halved

2. Assume a gaseous reaction occurs by this rate law: rate = k[A][B]. How would the rate be affected if the volume of the container were halved?

   [A] is doubled
   [B] is also doubled

   Rate x4

3. We also know that **temperature** changes the rate.
    a) Considering the rate law, rate = k[A], how is the rate of a reaction affected by increasing temperature?

rate will ↑

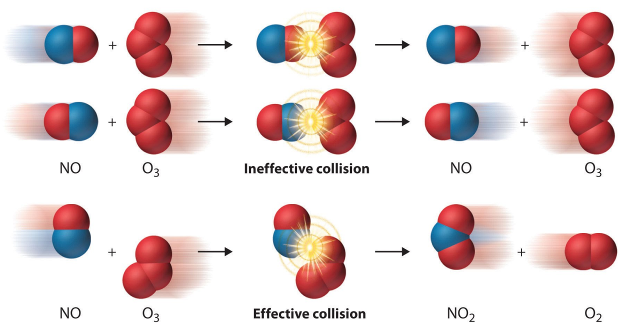
    b) What part of the rate law must be affected by changing temperature?

Temperature is in "k" - the proportionality constant
↳ we know this b/c it's not in [A]

Activation Energy (E_a)

Most collisions are not "successful" and do not result in a reaction.

A **successful collision** requires the following:
1. Favourable geometry
2. Sufficient energy to break chemical bonds



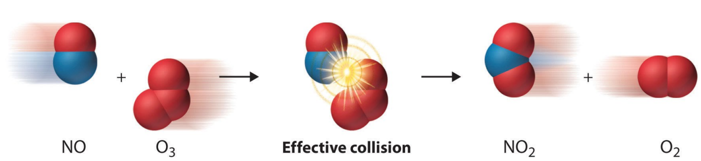
Which of the following reaction is fastest?

a. $H_{2(g)} + I_{2(g)} \rightarrow 2HI_{(g)}$
b. $Ag^+_{(aq)} + I^-_{(aq)} \rightarrow AgI_{(s)}$
c. $C_6H_{12}O_{6\,(s)} + 6\ O_{2(g)} \rightarrow 6\ CO_{2(g)} + 6\ H_2O_{(g)}$
d. $5C_2O_4^{2-}{}_{(aq)} + 2MnO_4^{2-}{}_{(aq)} + 16H^+_{(aq)} \rightarrow 10CO_{2(g)} + 2Mn^{2+}{}_{(aq)} + 8H_2O_{(l)}$

↑ more energy needed to break original bonds

Activation Energy: The minimum kinetic energy that the reacting species must have in order to react

- Must overcome:
    - Repulsive forces between electron clouds of the reacting molecules
    - Weaken or break bonds



Transition State Theory:

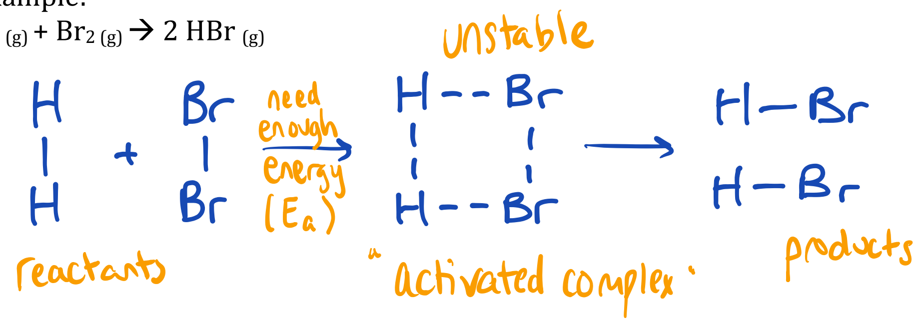
When molecules have enough kinetic energy to react collide, their electron clouds initially repel one another to form an unstable transitory configuration of atoms. " activated complex "

- Because they have sufficient kinetic energy to overcome this, the unstable complex will form the desired products.

Bond *breaking* requires energy __input___, **while bond *forming* results in energy** __release___.

Example:

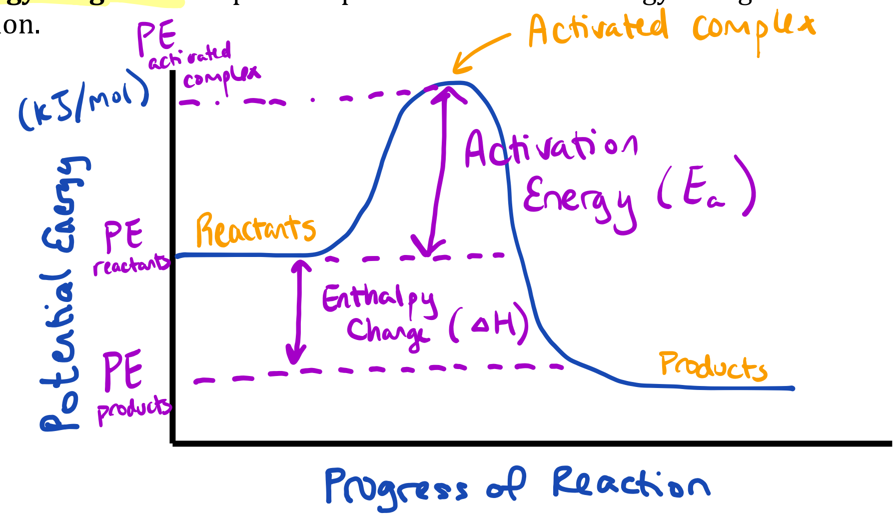
$H_{2\,(g)} + Br_{2\,(g)} \rightarrow 2\,HBr_{\,(g)}$



Potential Energy Diagrams

As bonds are broken/formed, there is energy gained and lost. The total energy in the system depending on the position of the particles is called the __potential___ energy. As bonds are broken and formed, the change in the total energy is represented as a Potential Energy Diagram.

Potential Energy Diagrams: Graphical representation of the energy changes that take place during a chemical reaction.



The activation energy, Ea, is the difference between the potential energy of the activated complex and the potential energy of the reactant molecules.

- It represents the amount of energy the reactant molecules must gain to form an activated complex.

$$\boxed{E_a = PE_{AC} - PE_R}$$

always (+)

The enthalpy change (ΔH) is the difference between the total potential energy of the products and the total potential energy of the reactants.

$$\boxed{\Delta H = PE_P - PE_R}$$

(+) endothermic

(−) exothermic

Calorimetry – the science of measuring the change in heat associated with a chemical reaction

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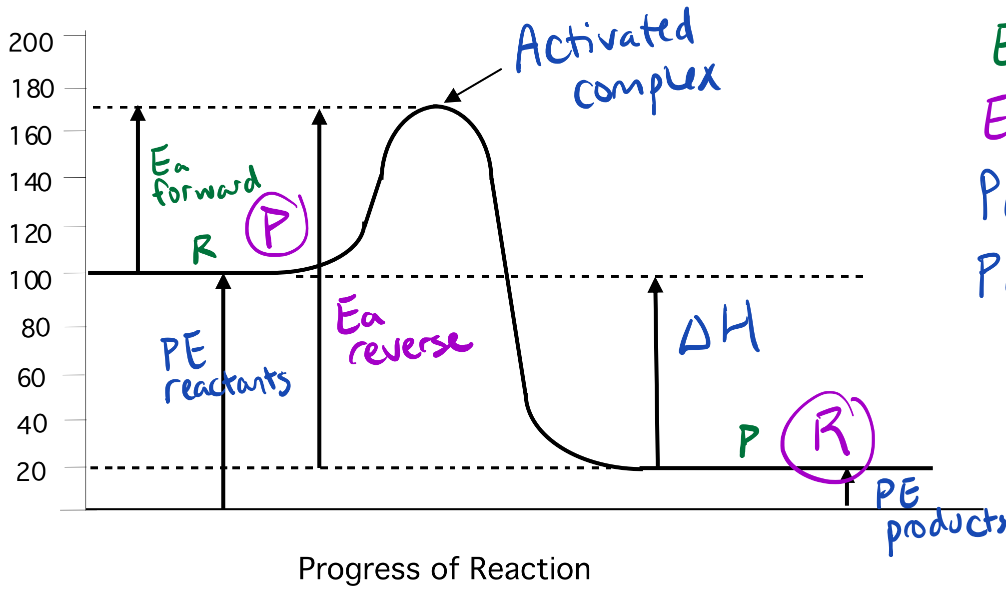
1. Label each arrow in the following diagram:

ΔH
Activated complex
E_a forward
E_a reverse
PE reactants
PE products



2. Consider the following graph on the right.

a) What is the potential energy of the activated complex?

45 kJ/mol

b) What is the activation energy of the reaction? $E_a = PE_{AC} - PE_R$

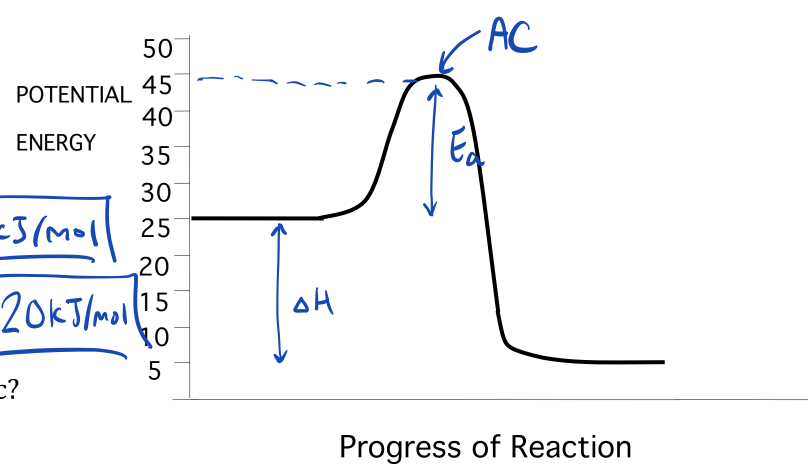
$= 45 - 25 = \boxed{20\text{ kJ/mol}}$

c) What is the ΔH for this reaction?

$\Delta H = PE_P - PE_R = 5 - 25 = \boxed{-20\text{ kJ/mol}}$

d) Is the reaction endothermic or exothermic?

exothermic



Many chemical reactions are **reversible** under certain conditions.

The first potential energy diagram could be read in reverse to give the same measurements provided by the second diagram.

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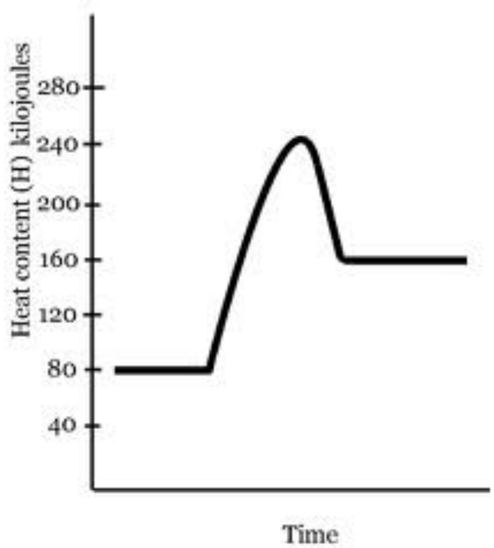
3. Answer the following questions about this potential energy diagram:



a) Give ΔH for the forward reaction. Is this reaction exothermic or endothermic?

$\Delta H = 160 - 80$

$= 80\ kJ/mol$ endothermic

b) Give ΔH for the reverse reaction. Is this reaction exothermic or endothermic?

$\Delta H = 80 - 160$

$= -80\ kJ/mol$ exothermic

c) Give E_a for the forward reaction.

$E_a = 240 - 80$

$= 160\ kJ/mol$

d) Give E_a for the reverse reaction.

$E_a = 240 - 160$

$= 80\ kJ/mol$

which requires a lower E_a?

e) Which is faster, the forward or reverse rate?

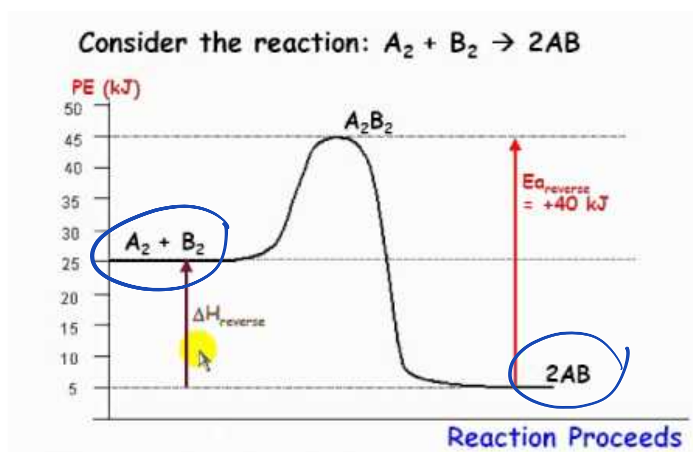
reverse

f) Give the potential energy for the activated complex. How does this value compare for the forward and reverse reactions?

$PE_{AC} = 240\ kJ/mol$

This is the same for both the forward & reverse

4. Consider the graph and equation on the right:



a) What species represents the transition state? (Activated complex)

A_2B_2

b) Which is faster, the forward or reverse rate?

forward

c) Circle the specie(s) that has the *strongest* bonds:

$A_2 + B_2$ OR AB

d) Explain your answer to the question above. AB has a higher activation energy

↳ requires more energy to break its strong bonds.

Hebden Workbook: Pg. 23 #34, 37 Pg. 25 #41-45

Potential Energy Diagrams Worksheet