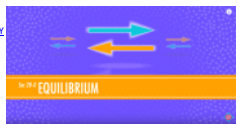
I) General Characteristics Of Equilibrium

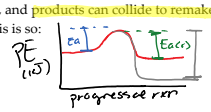
https://www.youtube.com/watch?v=g5wNg_dKsYY

October 14, 2017 5:40 PM

https://www.youtube.com/watch?v=wID_ImYQAgQ



Theoretically, all chemical reactions can be reversible, meaning reactants can collide to make products, and products can collide to remake reactants. Using a typical PE curve, explain why this is so:

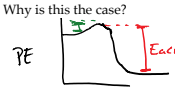


- if the reactant collisions can attain FWD Ea, products will form.
- if the products can attain Ea(r), then reactants will re-form

Some chemical reactions are **spontaneously** reversible. What does this mean?

Both the FWD and reverse Ea are attainable.
This is the case if both the FWD and RVS Ea are LOW.

Though every reaction is theoretically reversible, some reactions cannot be reversed.
Why is this the case?



FWD Ea small and easily attained.
BUT... reverse Ea(r) is too high to be achieved.
Too much energy required.

Some reactions that are not spontaneously reversible can become reversible by manipulating conditions, such as raising the temperature, or supplying electricity. Thus, the reverse E_a becomes attainable due to the extra energy supplied to the system. For example, certain batteries can be recharged (the reverse of discharging) by plugging them in.

In this unit, we will study reversible reactions. An example of a spontaneously reversible reaction:

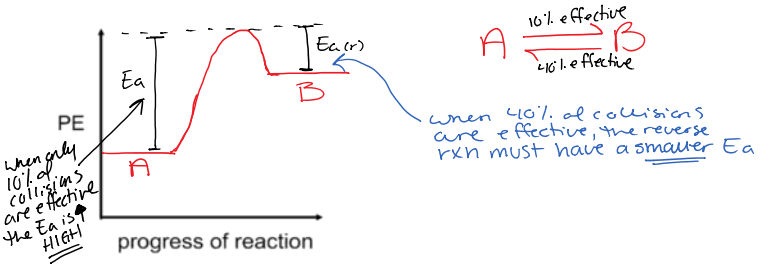
$N_2O_{4(g)}$ + energy $\Leftrightarrow$ $2NO_{2(g)}$ or $\rightleftharpoons$

A 'double arrow' is used to show that the reaction is occurring in both directions.
Why would this reaction only occur in a 'closed' system?

Because the substances are in the gas phase. In an open system, particles 'escape' and collisions are very unlikely.

The following quantitative example will be used to show what inevitably occurs when a reversible reaction is left undisturbed.
Suppose our reaction is:

A $\Leftrightarrow$ B ΔH = positive (+) endothermic



A ⇌ B
10% effective
40% effective

Sketch a PE curve:

The reaction begins with 500 particles of A and 0 particles of B. 10% of the 'A' collisions are effective whereas ~~40% of the~~ 'B' collisions are effective. How is this consistent with the PE curve?

Complete the table and think about what is developing.

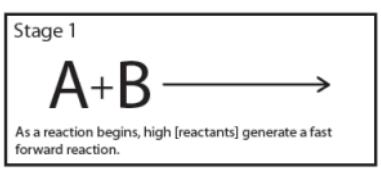
Molecules of A	A molecs reacting	A molecs produced	Molecules of B	B molecs reacting	B molecs produced
start 500	50	0	0	0	50
450	45	20	50	20	45
425	43	30	75	30	43
412	41	35	88	35	41
406	41	38	94	38	41
403	40	39	97	39	40
402	40	39	98	39	40
401	40	39	99	39	40
400	40	40	100	40	40
400	40	40	100	40	40
* 400	40	40	100	40	40 *
	⋮ etc.				

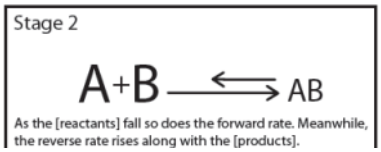
10% effective collisions
40% eff. collisions.
50 molec. of B prod. when 10% collisions of A are effective
45 A ⇌ 20 B
rate = ΔQ/Δt = ?
FWD rate decreases
A ⇌ B
Reverse rate increases
..... until they reach equilibrium (same rates)

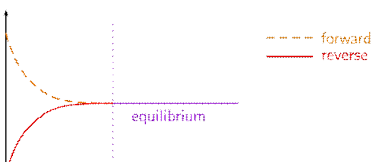
Things to Consider:

1. The amount of 'A particles reacting' can be likened to the forward reaction rate, and the amount of 'B particles reacting' can be likened to the reverse reaction rate.
2. Think about how the forward and reverse rates are changing as the reaction proceeds and why this is the case. Also think about how the amount of 'Particles of A' are changing compared to the 'Particles of B', and how this is affecting the reaction rates.
3. What role does the % of effective collisions play in the system (10% for forward vs. 40% for reverse).
4. Can you explain the system at the end of the experiment?

Note any observations and thoughts from what has developed during the reaction:







Conclusions:
If a reversible system is left undisturbed, eventually the forward and reverse rates will become equal
At this point, the reaction has attained EQUILIBRIUM.
The amount, or concentrations, of both reactants and products have become constant (but not equal due to the different % of effective collisions for the fwd and rvs reactions.

Draw a graph that depicts the change in A particles and the change in B particles as the reversible reaction proceeds.

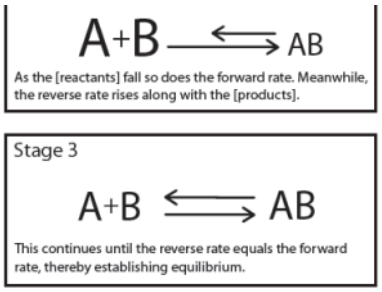


Figure 2.1.2 *Diagrammatic representation of chemical equilibrium being established*

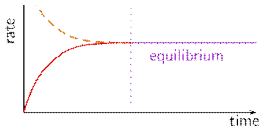


Figure 2.1.3 shows equilibrium being achieved at about $t = 7$ s when the reactant and product concentrations become constant. It is important to note that the concentrations of reactants are not equal to the concentration of products at equilibrium. Only the forward and reverse reaction *rates* are equal.

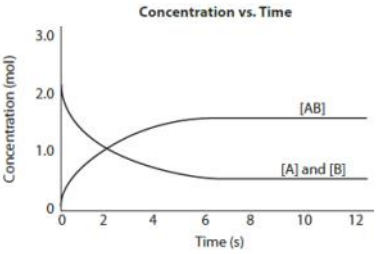
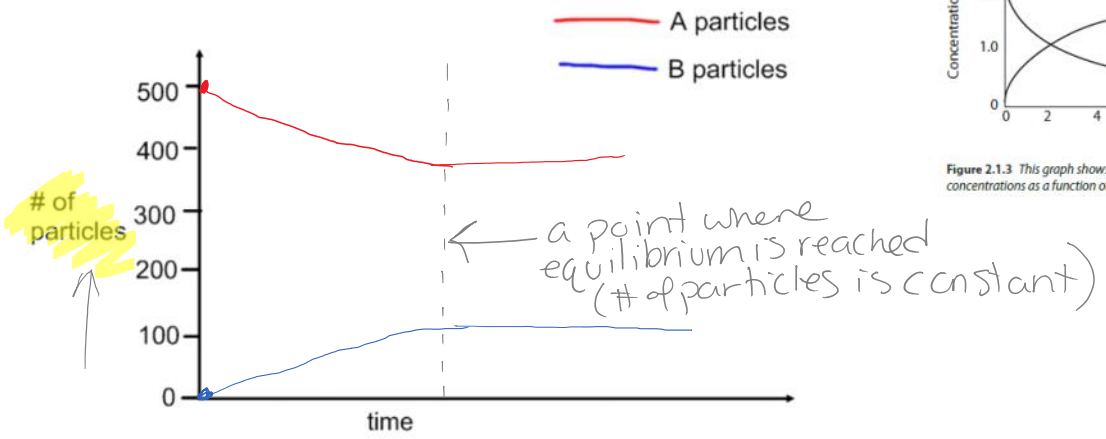
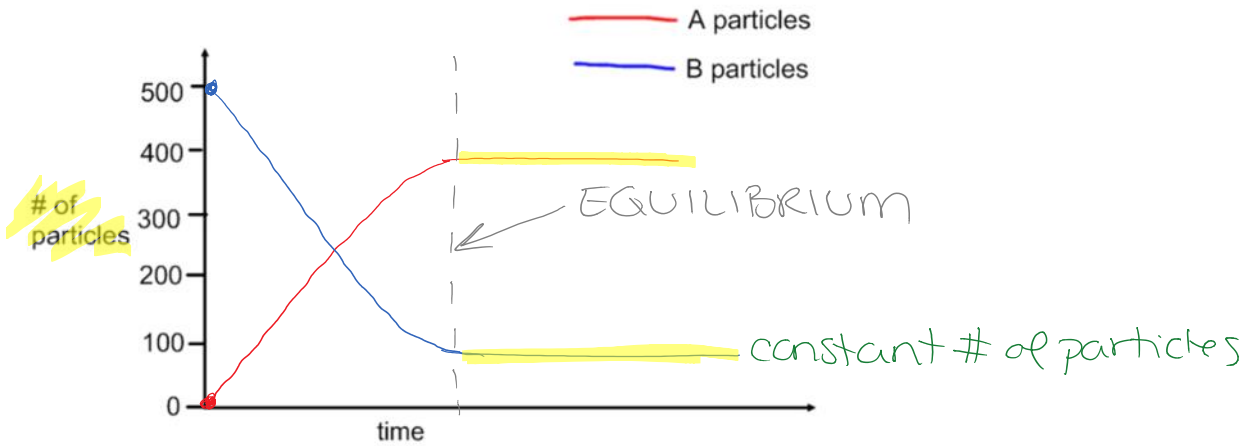


Figure 2.1.3 *This graph shows what happens with reactant and product concentrations as a function of time as equilibrium is established.*



Draw a dashed vertical line to indicate where equilibrium was attained.

What is you start with 500 particles of B and 0 particles of A?



Draw a dashed vertical line to indicate where equilibrium was attained.

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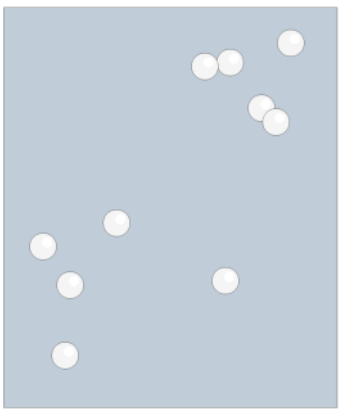
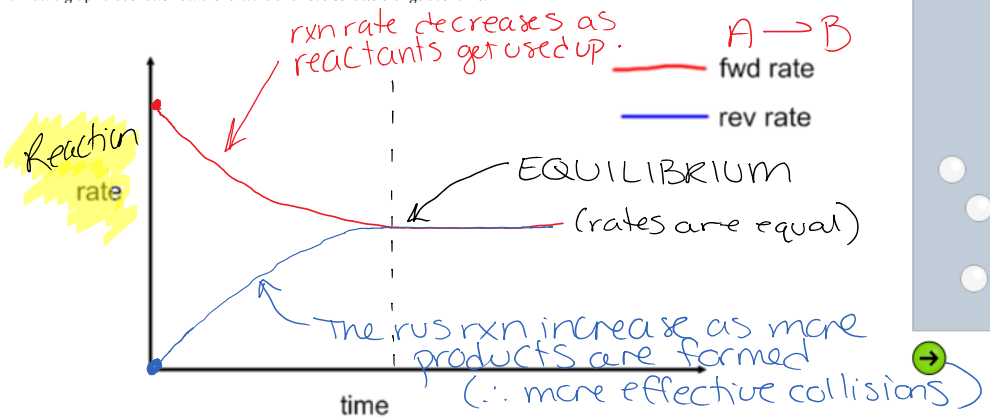


Back to the original system we studied with a start of 500 particles of A and 0 particles of B. Draw a graph that shows how the forward and reverse rates change over time.



Draw a dashed vertical line to indicate where equilibrium was attained.

Equilibria (plural for equilibrium) are dynamic. What does this mean? Even though reactant and product concentrations are constant, both the fwd and rvs reactions continue to occur... but the rates are equal.
What do you see when you look at an equilibrium system at the macroscopic level (with the naked eye)?

Equilibria (plural for equilibrium) are **dynamic**. What does this mean? Even though reactant and product concentrations are constant, both the FWD and RVS reactions continue to occur... but the rates are equal.

What do you see when you look at an equilibrium system at the macroscopic level (with the naked eye)?

The system 'appears static'

BUT we know that microscopic changes are happening because the FWD and RVS reactions are occuring simultaneously. (very small, immeasureable differences)

Here are some general characteristics of any equilibrium system:

1. Forward and reverse rates are EQUAL.
2. Concentrations are constant.
3. Macroscopic properties are constant (static)
4. Equilibrium can be attained from either direction.
5. If gases are involved, you must have a closed system.
6. Temperature must be constant. "@ STP"

Assignment 1:

1. Explain the process of how equilibrium is attained. Use the reaction $2HI \Leftrightarrow H_2 + I_2$ and suppose you start with only HI. To get you started:

There are initially many HI collisions, causing an initial large forward rate. Since there are no H_2 and I_2 molecules, the initial reverse rate is zero. However, as HI molecules continue to collide, …

2. Consider the following:

I. forward and reverse rates are equal
II. macroscopic properties are constant
III. can be achieved from either direction
IV. concentrations of reactants and products are equal

Which of the above are true for all equilibrium systems?

A. I and II only
B. I and IV only
C. I, II, and III only
D. II, III, and IV only

3. Consider the following equilibrium:

$N_{2(g)} + 2O_{2(g)} \Leftrightarrow 2NO_{2(g)}$

Equal moles of N_2 and O_2 are added, under certain conditions, to a closed container. Which of the following describes the net change in the reverse reaction as the system proceeds toward equilibrium?

	Rate of Reverse Reaction	**[NO_2]**
A.	increases	increases
B.	decreases	increases
C.	increases	decreases
D.	decreases	decreases

4. In Hebden, read the bottom of p.38, the top of p.39, the first half of p.40, and the bottom of p.41. Then do (on p.40 & 41) #6bcde and #7bcd