<u>Chemistry</u>
<u>Do It Yourself Equilibrium Notes</u>

Read this text and then fill in the blanks in pages 71 to 73 in your booklet. Finally do p74 for homework.

I hate being absent, but it is inevitable; I have to validate a final exam. Let's make the best of things by not wasting the period and by using the opportunity to learn something directly from the combination of text and thinking, a skill that will be indispensible in the real world and in college and university when you're bound to get at least a couple of professors who cover material too quickly, sporadically and/or with an accent thicker than peanut butter.

Let's start by describing what chemical equilibrium is not. **It's not irreversible.** The extreme irreversible reaction is a one way affair, like burning a book. There is no way in the universe that the ashes and gases produced by combustion will reorganize themselves into loose leaf, ink, and symbols that were in the original. That's because combustion is an extreme case of irreversibility; in reacting they not only released heat but also created a more chaotic molecular state. Other irreversible reactions include neutralizations between strong acids and strong bases. In an everyday sense there's aging, growth and digestion. Think of more and list them here...
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Chemical equilibrium is also **not a steady state**. An *open* system can be in a steady state if the input rate of a substance equals the output rate. An open system is one that loses a substance from one "opening" and then gets that same substance back from another source. For instance if our school population is at steady state, it implies that our population is not changing from one year to the next even though we lose graduates, movers and trouble makers. That's because at steady state the number of new grade 7's and people switching into our school per year (input rate) matches the annual number leaving (output rate). The amount of water in a waterfall is at steady state, assuming that the river feeding it has a constant volume.

How could you create a simple steady state with a glass of water and a faucet? No, you don't have to drill a hole in it! …..think. You just have to fill it to the top and then let more water flow into it. The overflow will be equal to the input rate from the faucet, and the glass will have a steady amount of water.

A more technical example is the case of the nitrogen cycle we studied last year. The input rate: the combination of denitrification of nitrates in the soil (conversion to nitrogen gas in the atmosphere) equals the output rate or the amount of nitrogen that is being converted into nitrates by biological fixation and fertilizer production. So the amount of nitrogen in the air is held at a steady concentration.

So what is **chemical equilibrium**? Equilibrium is a reversible reaction occurring in a **closed** system. Once a reaction attains equilibrium, the *rate of the forward reaction equals the rate of the reverse reaction*. At the macroscopic level (to the visible eye), the reaction seems to have stopped, but at the molecular level it continues in both directions.

A simple example would be a small amount of water in a sealed container within a warm room. It will be at equilibrium if the rate of evaporation equals the rate of condensation. We don't have to have equal amounts of liquid and gas; it's the rates that are equal. It's not irreversible because the liquid water doesn't eventually disappear. In fact it seems as though nothing's going on because the amount of liquid or gas does not change.

$$H_2O_{(l)} \leftrightharpoons H_2O_{(g)}$$

Notice the symbol for equilibrium: $\leftrightharpoons$ The arrows point in different directions to denote the forward and reverse reactions.

<u>Example 1</u> $2\ NO_{2\ (g)} \leftrightharpoons N_2O_{4(g)}$

Macroscopic observations:

Initially, we have no N_2O_4 (invisible) and 2 moles/L of NO_2. (red- brown gas). With time, the brown colour fades. While these changes are occurring, we have not yet reached equilibrium.

When equilibrium is reached, the brown colour stops fading, and the concentrations of the two gases remain constant.

But the system is not really dead. It's as if people are stapling papers together but at the same rate others are unstapling them.

Microscopically, or mor e precisely at the molecular level, each time a pair of NO_2 molecules "staple themselves", an N_2O_4 splits up at the same rate.

Example 2 A large crystal of iodine is dropped into CCl_4.
a) Describe what you would see before equilibrium is reached and after equilibrium is attained.

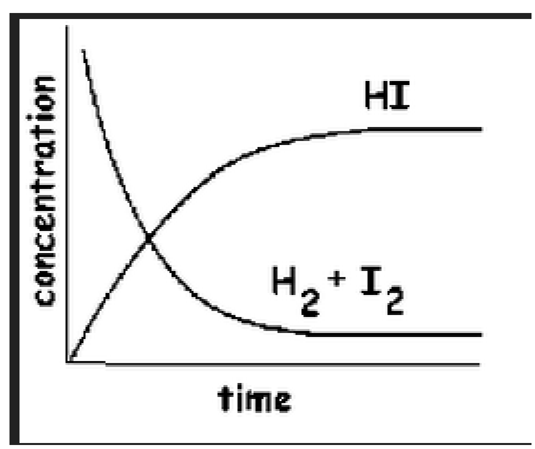
Before equilibrium is reached, part of the crystal would dissolve in carbon tetrachloride, which would render the solution progressively more purple. Then there would not be enough solvent to dissolve any more, and it *would appear* to stop dissolving. Now we have equilibrium

b) Explain what occurs at the molecular level once equilibrium is established.

Each time a molecule of iodine dissolves there will be one already in solution that will stick to the solid iodine at the same rate.

$$I_{2(s)} \leftrightarrows I_{2\ (CCl4)}$$

Example 3 When is equilibrium attained?



Not where the lines cross! Equilibium is not about equal concentrations but about *equal rates*. So the rate or how concentration changes with time is really the slope. On the graph the only time the slopes are equal is when they're both equal to zero.

When they are equal to zero, nothing is changing on the visible level, so we have equilibrium.

See next page..

So equilibrium starts at the point in time where the vertical line intersects the x axis.