LIQUIFICATION OF GASES

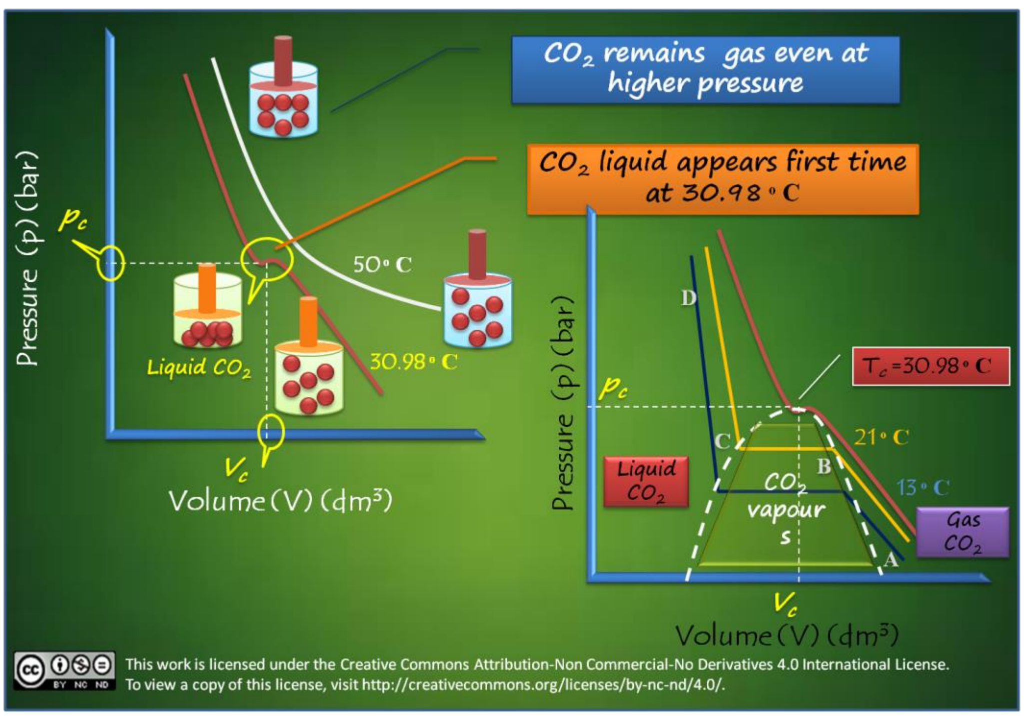
We all are familiar with the different phases of matter viz. gas, liquid and solid. You have learned that the basic difference between these phases is the strength of inter-molecular attraction between their molecules. By changing the strength of inter-molecular attraction between molecules of any phase we can transform it to another phase. In this post we will learn how we can transform gas into liquid phase and see how the knowledge of gases and their laws helps us to make this transition.

When one phase transforms into another phase, one intermediate phase occurs during this transition which is present in between these two phases or you can say that this third phase is a bridge between two different phases. In the transition of gas into liquid, vapour is the intermediate phase.

What are the key changes we have to make in the molecules of gas phase to convert it into liquid phase? We have to bring them closer so they are held together by intermolecular attraction, in order to do it we have to reduce the volume. If we apply pressure we can reduce the volume of gas. Furthermore, we need to reduce temperature to slow down the speed of molecules. That means we need to find that particular temperature, pressure and volume in which we can liquefy real gas, and here Boyle's law helps us.

In the last post you have learned that, real gases follow ideal behaviour and obey Boyle's law at higher temperature. You have seen in the graph of pV vs p where a straight line was obtained for ideal gas, which means that its volume cannot be reduced even on applying high pressure or in other words ideal gas cannot be liquefied. On the other hand, when we reduce the temperature of real gases, they deviated from the Boyle's law. The highest temperature at which a real gas shows deviation from ideal behaviour for the first time is the temperature at which we can liquefy a real gas. This is known as critical temperature (T_c). And corresponding pressure and volume are known as critical pressure (p_c) and critical volume (V_c).

Let's take an example of CO_2 gas. At higher temperature range from 50 °C to 31 °C when pressure is applied it shows perfectly Ideal behaviour as expected by Boyle's law (to learn more visit DoReal Gases Behave Ideally?). When we reduce the temperature just a bit more to 30.98 °C it shows deviation from Boyle's law on applying pressure. In the graph this deviation is clearly recognised by a sudden change in curve. At this point we get liquid CO_2 for the first time. This temperature 30.98 °C is the critical temperature (T_c) of CO_2 gas. At this temperature on applying pressure CO_2 gas gets compressed and transforms into liquid CO_2.



What happens if we further reduce the temperature? CO_2 gas shows different behaviour on applying pressure at temperature below 30.98 ^{o}C.

- On compressing, initially CO_2 gas remains gas till point ‘B’
- On applying still more pressure it shows deviation from Boyle's law and a little liquid CO_2 appears
- On further compression the pressure remains constant for a period (point ‘B’ to ‘C’) and we get a plateau for this phase. In this region we get vapour CO_2 that means a state in which liquid and gas coexist.
- If we further compress it, a steep rise in pressure is observed (point ‘C’ to ‘D’). As the plateau ends we start getting liquid CO_2.

All real gases show similar behaviour as CO_2. CO_2 gas represents all real gases. But every gas has a particular set of critical constants.

So what you have learnt in this post? At critical temperature (T_c) you can liquefy a gas directly into liquid phase. It means that you can skip transition phase. But if you carry out liquification at a temperature lower than critical temperature, you will get the transition phase region or two phase portion in which gas and liquid coexist.

Source : http://chemistrynotmystery.blogspot.in/2014/11/liquification-of-gases.html