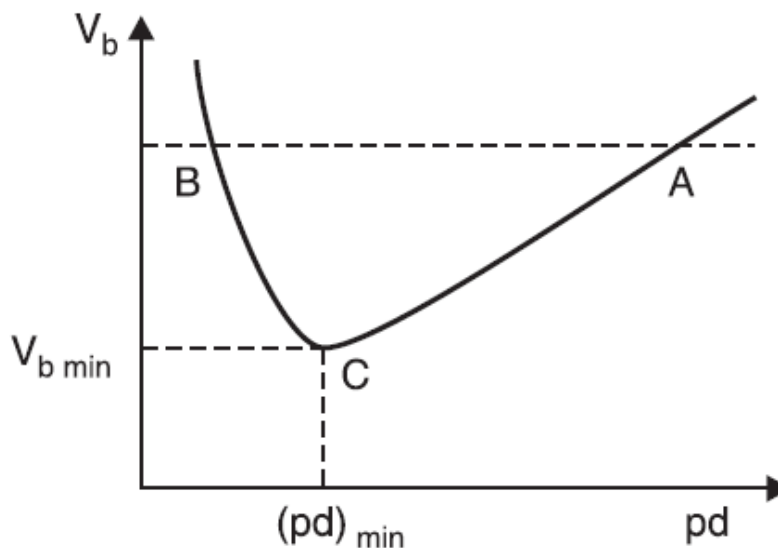


## Paschen's Law

In order to understand the breakdown characteristics of gas or air at different pressure, here are few important points to remember.

1. Volume of chamber with electrodes remaining the same, low pressure means less dense air or gas with atoms and molecules far apart from each other.
2. Volume of chamber with electrodes remaining the same, high pressure means more dense air or gas with atoms and molecules closer to each other or more confined.
3. Electrons emitted from cathode (field emission) are only possible under high electric field. These are field emitted electrons.
4. Those electrons already present in the gap due to cosmic radiations etc are the primary electrons.
5. Mean free path is the distance travelled by electron in electric field before collision in which it gains kinetic energy.
6. Collision transfers energy to the atom.
7. Collision-ionization results in production of electrons.
8. Gap current refers to the electrons motion that depends on the number of electrons and the speed of electrons.
9. Space charge means the positive ions created in the gap (space between two electrodes).

Consider the behavior of air in Townsend experiment at different pressure as according to the graph shown in Figure (1) with A, B and C points.



**Figure (1)**

According to Paschen, the breakdown depends on the gas (air) pressure that gives unique characteristics as shown in Figure (1). The point C is Paschen's minimum point at which the gas

pressure is such that the breakdown takes place at minimum value. Remember this is not necessary the STP point. With increasing the pressure beyond Paschen minimum point, the atoms and molecules become densely packed. Thus the mean free path for electrons is reduced so that the chances of collision-ionization are less. However, when the voltage or electric field increases, the electrons gain sufficient energy in reduced mean free path to ionize atom to cause avalanche and thus breakdown. Moreover at high fields, electrons start emitting from cathode which further produces ionization. This can only happen under high electric field or higher voltages (point A on the characteristics).

On the other hand when the gas or air pressure is less compared to Paschen's minimum point, the atoms and molecules are placed far apart and electrons on their way to anode may miss collision. Thus the chances of collision-ionization are less even with the greater mean free path. However, if field or voltage is high enough to cause field emission from cathode, the number of electrons increases (primary plus those introduced by field emission process) then the chances of hitting the atoms is greater and so electron multiplication and avalanche formation stands greater chances. This means that to cause breakdown, the voltage must be increased (point B on the characteristics).