

3.3 Collisions of electrons with atoms (2)

AS16

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Excitation

In the gas-filled accelerating tube described on Revision Card AS15, many electrons will collide with gas atoms without ionizing them because they are not travelling fast enough. What happens to these electrons?

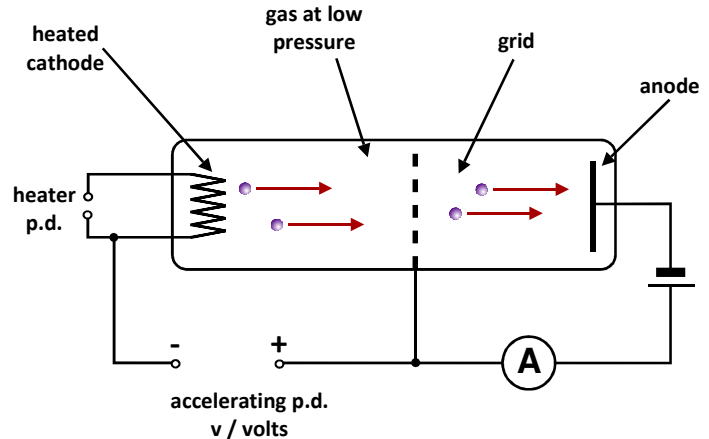
The answer is that most will suffer perfectly elastic collisions with the gas atoms and be deflected without losing any kinetic energy. However, if an electron happens to have a

Kinetic energy exactly equal to the energy that one of the atomic electrons needs to climb to a higher energy level, the colliding electron will suffer a completely inelastic collision with the atom and give up all of its kinetic energy to the atomic electron.

Measuring Excitation Energies

In the modified gas-filled tube shown above, electrons are accelerated from the cathode to the grid, then continue on to the anode, which is kept at a slight negative potential with respect to the grid, so that the electrons are travelling slightly “uphill”.

As the accelerating p.d. is increased, electrons gain more and more kinetic energy, but they suffer perfectly elastic collisions with the gas atoms and travel on to the anode. When their kinetic energy is exactly equal to the energy needed by electrons in the gas atoms to move up to a higher energy



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Level, the accelerated electrons give up all their energy to the gas atoms they collide with and no longer reach the anode. This is seen as a drop in the ammeter reading. The kinetic energy of the accelerated electrons is now equal to the first excitation energy of the atom.

$$\textit{Excitation energy} = e \times V \textit{ joules}$$

As the accelerating p.d. is increased further, the current read by the ammeter rises again until the next excitation energy is reached, when there is again a steep fall. Several such falls can be observed, each one corresponding to the jump between a pair of electron energy levels in the gas atoms.

Why is energy needed by atomic electrons to move up to higher energy levels?

The electrons are moving further away from the nucleus and require energy to do work against the attractive force of the positive charge on the nucleus.