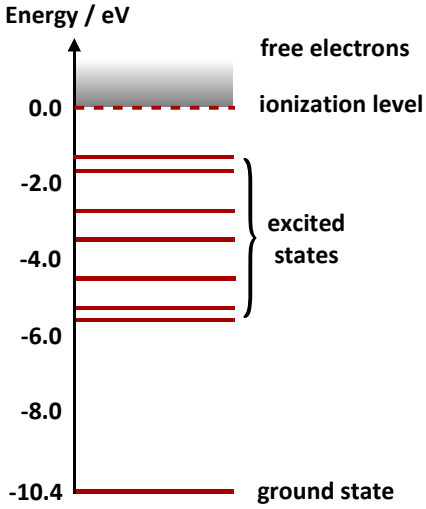
3.4 Energy Levels in Atoms

Electrons in Atoms

- Unlike free electrons, those trapped in atoms can only have certain energies.
- A handy model is to think of them orbiting the nucleus in energy levels which chemists call "shells". (It is ***not*** an accurate picture, however! Electrons are not simple particles and it would be impossible for them to orbit like little planets.
- Electrons can exist in one orbit or another but never between orbits.
- Atoms can only take in energy in the amounts needed to push electrons from one energy level to a higher one. They also emit energy only in the amounts corresponding to the energy lost by an electron as it falls from higher to lower levels.



- The lowest energy state of an atom is its **ground state**. Any states of higher energy are called **excited states**.
- The diagram above shows the energy levels of a mercury atom. Note that free electrons are said to have zero energy and all bound electrons have energies of less than this. Hence, all the energy level values are negative. (The energy referred to is actually the electrical potential energy due to the electrostatic force between the electron and the nucleus.

Gas Discharge

- The most stable state for an atom is one in which all the electrons are in the lowest energy states. (This does ***not*** mean that all are in the ground state, since only certain numbers can

occupy each level. The maximum on the lowest level, for example, is two).

- When an electric current is passed through a gas at low pressure, (see card AS16), collisions between free electrons and gas atoms can knock atomic electrons up to higher levels.
- These excited atoms are not stable and the electrons fall back down again to their original levels, giving out their energy as photons of electromagnetic radiation – sometimes light. Gas discharge tubes, therefore, glow when a current is passed through them.
- The energy of the emitted photon is just equal to the energy lost by the electron falling from a higher level of energy E_1 to a lower level E_2.

$$photon\ energy = hf = E_1 - E_2$$

- When electrons fall back down, there are often several ways they can do this. They may do it in one big jump, straight back to their original level, or they may fall back in several smaller jumps, via the levels in between.
- The bigger the drop, the higher the frequency (and the shorter the wavelength) of the resulting photon.