Unit 1
Particles, Quantum Phenomena and Electricity

3.5 Energy Levels and Spectra

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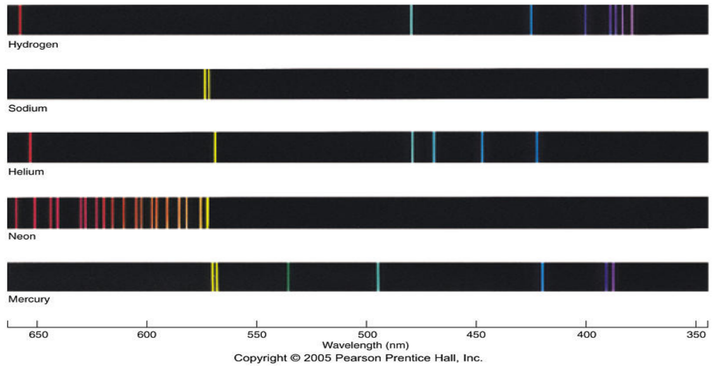
3.5 Energy Levels and Spectra

Line Emission Spectra

- A low pressure gas can be made to glow when a current is passed through it.
- The spectrum of radiation emitted by the gas consists of discrete lines. Each line represents a particular wavelength or photon energy.
- These photons are emitted when electrons, which have been excited by collision with electrons carrying the current through the gas, fall back to their original energy levels.



Line emission spectra of some common elements

- Because the energy levels are unique to the gas atoms, no two line spectra are the same. The spectrum is a "fingerprint" of the element. Astronomers can tell which gases are burning in stars, for example, by analysing the line spectra of the light they emit.
- The energy of an emitted photon is equal to the energy lost by the electrons falling down from a higher energy level E1 to a lower one E2:

$$\text{photon energy } hf = E_1 - E_2$$

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3.6 Wave-Particle Duality

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Consider the following experiments you have seen:

1. Water waves in a ripple tank spread out after passing through a gap between two barriers. This is diffraction. The amount of diffraction is greatest when the size of the aperture is of the order of the wavelength. This is a wave property.
2. Laser light passed through a fine slit produces the same diffraction pattern on a screen beyond the slit. Light exhibits wave properties.
3. Microwaves also exhibit diffraction. Electromagnetic radiation in general exhibits wave properties.
4. The laser diffraction pattern in 2 above can be detected using a photoelectric detector but the photoelectric effect **cannot** be explained by the theory that light is a wave motion.
5. Electrons can be deflected by magnetic and electric fields, behaving just like particles but, when they are passed between the planes of atoms in a graphite crystal, they produce a diffraction pattern on a fluorescent screen.

Clearly, the inference from this evidence is that the distinction between "particles" and "waves" is not as clear as we once thought. In 1923, Louis de Broglie suggested that matter particles have a wavelike nature and related the particle property of **momentum (p)** to the so-called de Broglie wavelength (λ) by the equation:

$$p = \frac{h}{\lambda}$$

The momentum, p, is mass x velocity ($p = mv$)