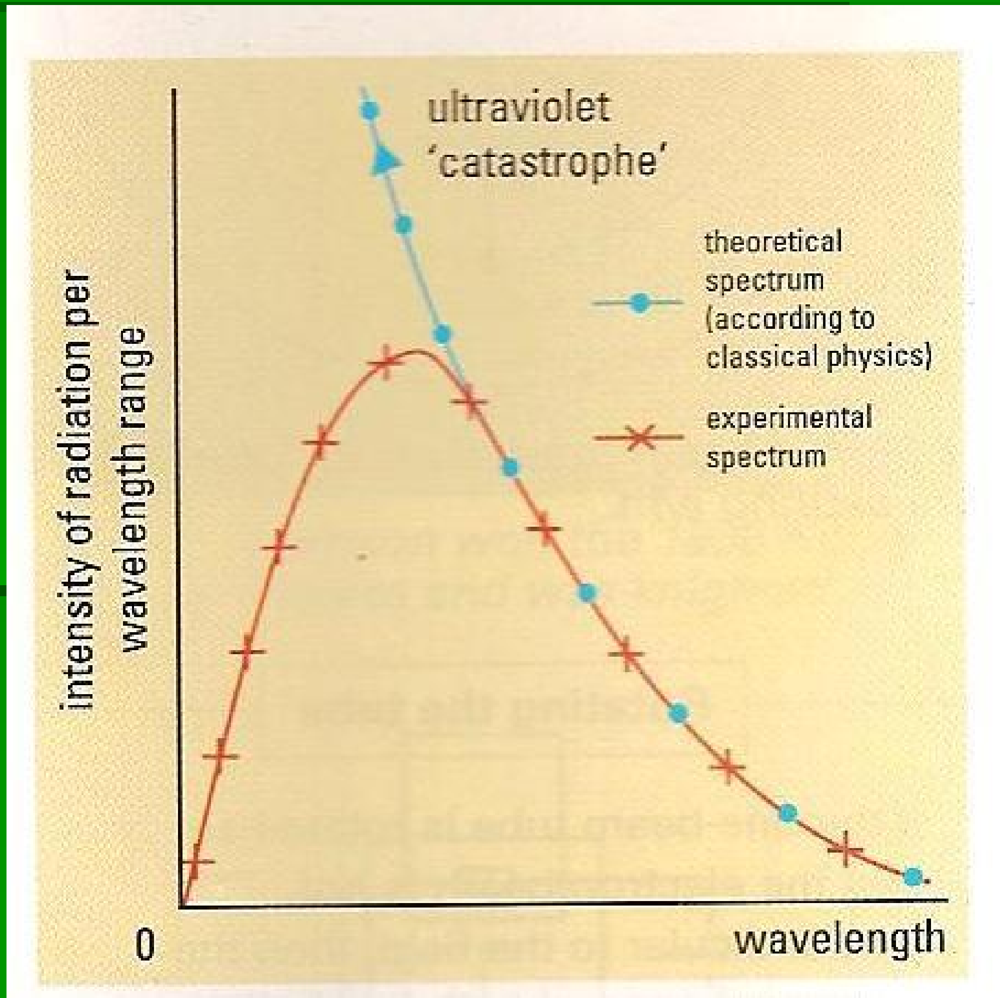
Modern physics

1.1Quanta

Black body radiation

- All hot bodies radiate – an ideal radiator – **black body**
- Ultraviolet catastrophe



In 1900 – Max Planck (a German physicist) – assumed that the oscillators that emit radiation can only have **discrete energies**. Each oscillator can have zero energy or some multiple of a fixed amount (quantum) which depends on the frequency f of oscillation according to the formula

$$E = nhf,$$

where n – is an integer (0, 1, 2, ...)

h – Planck constant ($h = 6.626 \times 10^{-34}$ Js)

- Shorter waveletghts correspond to higher frequencies – oscillators in this part of spectrum need a lot more energy to get into even the first vibration state than those emitting radiation at a longer wavelength (lower frequency).
- If energy is quantized, intensity of the spectrum at high frequencies drops down rapidly to zero.

•Conclusion – electromagnetic radiation is emitted in discrete energy packets or quanta.

The photoelectric effect

•Light falling on some metal surfaces could eject electrons from them – photoelectric effect.

•Ejection of electrons should depend only on the intensity of the incident light and not on its frequency and only if enough enegry is delivered close to electrons on the surface. - Neither of these expectations was borne out in practice.

Laws of photoelectricity:

- For any metal, electrons are only emitted if the frequency of the incident light is above some threshold value f_0. (So weak ultraviolet can emit electrons from zinc, whereas very intense infrared cannot, even though it is delivering far more energy per second to each unit area of the zinc surface.)

- The threshold frequency depends on the metal and is usually lower for more reactive elements (so electrons are emited from potassium more readily than from zinc, and from zinc more readily than from copper).

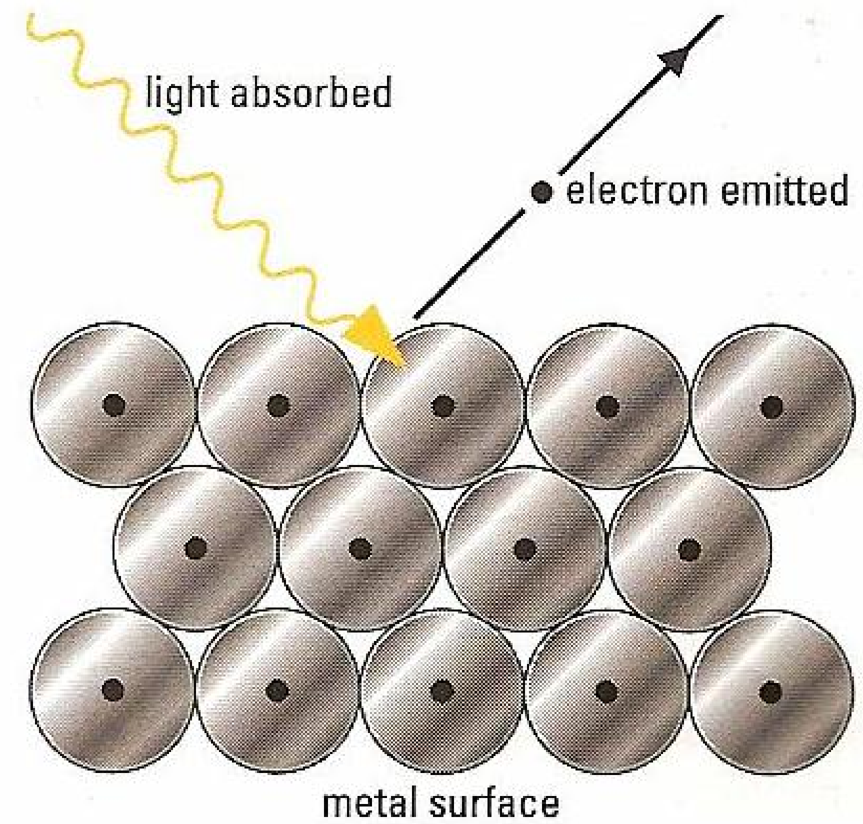
- The maximum kinetic energy of the ejected electrons depends only on the frequency of the incident radiation and is proportional to the difference between the light frequency and the threshold frequency: $KE_{max} \sim (f - f_0)$

Photon (E = hf):

•photons are invisible – photon energy is proportional to frequency – electrons are only ejected with light above a certain threshold frequenncy. Increasing intesity does not affect the energy of individual photons, only the number arriving per second

•the minimum energy required to free an electron from the surface depends on the metal

•the maximum kinetic energy of ejected electrons can be no greater than the difference between the photon energy and the threshold energy



The photoelectric effect. If light of high enough frequency falls onto a metal surface, it can eject electrons.