Notes page #21

Photons.

When light interacts in matter it does not behave as a wave would. Instead it interacts as a particle.

Evidence of photons

Low intensity light source

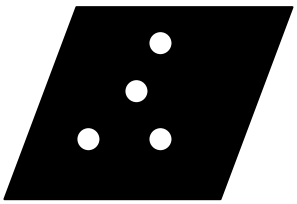


Image forms one "dot" at a time

Photons are bundles with energy and momentum

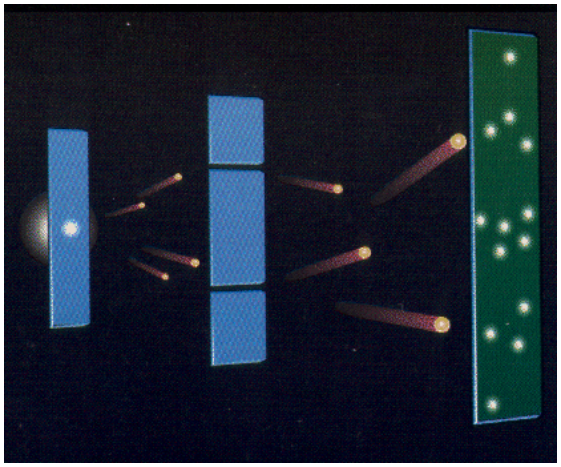
$E = hf$ where E is the energy carried by the photon, h is Planck's constant and f is the frequency of the light (yes we're using wave terms to describe particles – contrary isn't it?)

$h = 6.63 \times 10^{-34}$

$\rho = \frac{h}{\lambda}$ where p is the momentum of the photons, h is planck's constant and λ is the wavelength of the photon (or at least of the light the photon is a part of).

Find the energy and momentum of a typical blue light $\left(\lambda = 7 \times 10^{-6}\, m\right)$

And a radio wave ($f = 2 \times 10^{8}\, Hz$)



Two slit interference pattern (photon explanation)

What will the pattern look like over time?

The photo-electric effect: When light of sufficiently high frequency is incident on matter, it may be absorbed by the matter, from which electrons are then emitted. This is called the 'photoelectric effect'.

This phenomenon invalidates light as a wave
Reasons:

The intensity of the incident light affects the number, but not the energy, of emitted electrons.

The minimum frequency f_o at which electrons are emitted varies with the type of material, and is called the 'threshold frequency'. No electrons are emitted before the threshold frequency is reached. After that increasing the frequency does not increase the number of electrons released instead it provides them with more energy.

Notes page #22

Description of photo-electric effect experiment.

Procedure

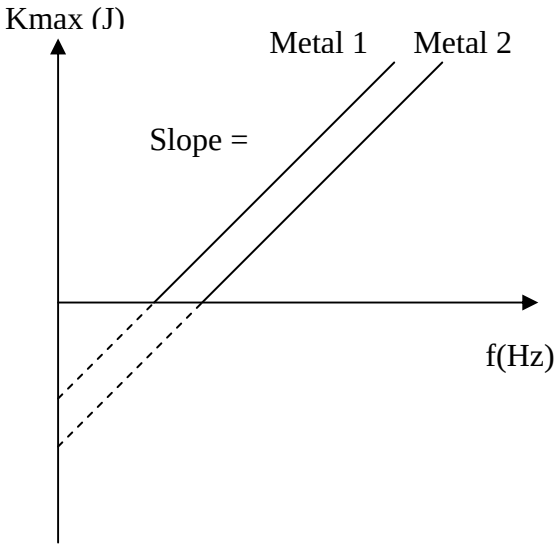
Observations

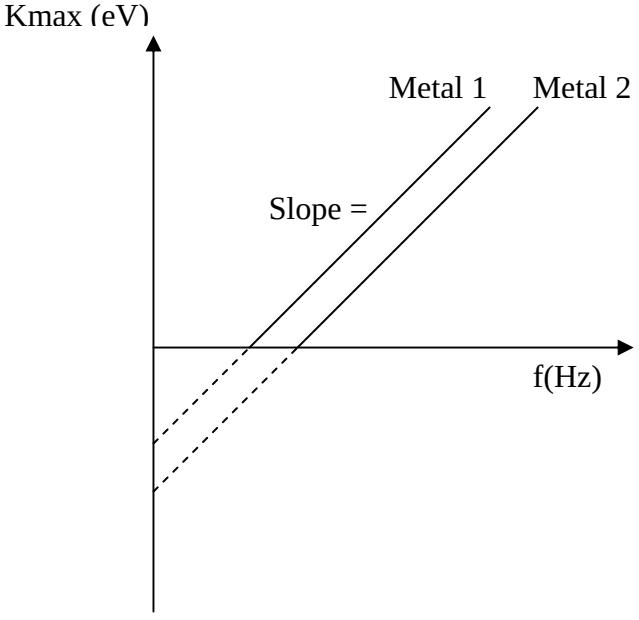
Work function – (W) minimum energy to release an electron from the surface of a material

$W = hf_o$

Einstein's explanation of the photoelectric effect (1905)

Deduce $K_{\max} = hf - W$



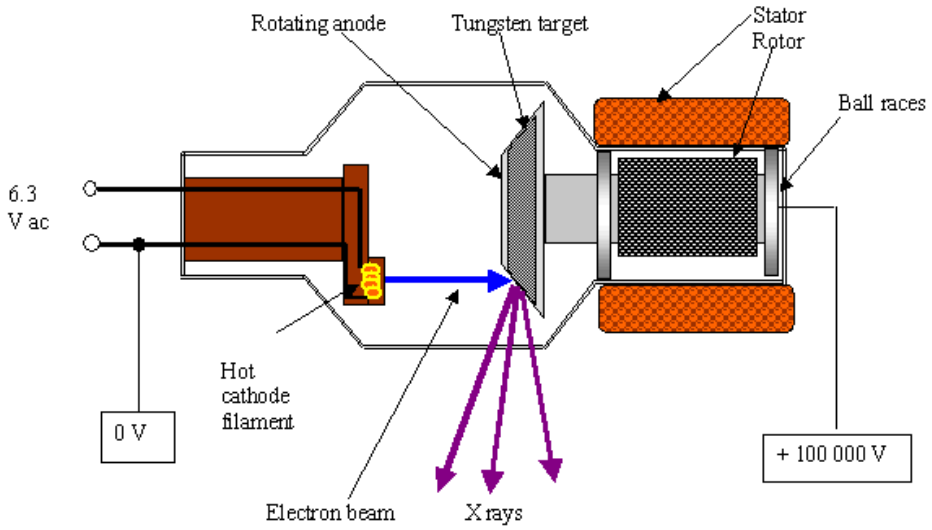


Notes week #23

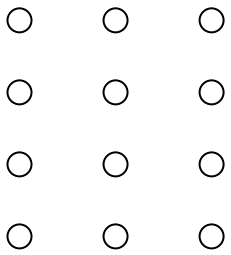
X-rays

Cause of em radiation –

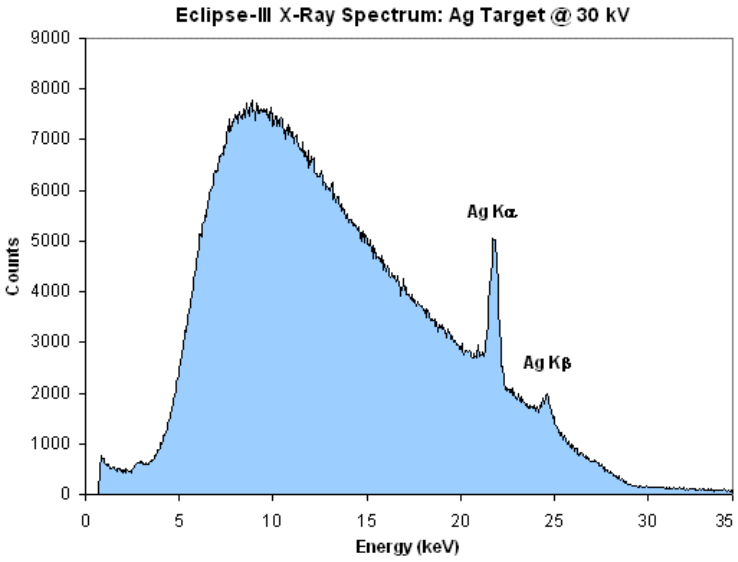
X-rays have large energy. What does that tell us about the acceleration of the charged particles?



Explain how it works



Greatly enlarged view of target



Explain and label the graph of x-ray emissions

Derive $f_{\max} = \dfrac{e\Delta V}{h}$

Application using X-rays

Notes page #24

Wave behaviour of particles

de Broglie $\lambda = \frac{h}{\rho}$

Evidence **Davison- Germer** experiment diffraction patterns of electrons when fired at crystal lattices.

Use $d \sin\theta = m\lambda$ to calculate the wavelengths of electrons used in this experiment.

Calculate the momentum of the electrons used $\rho = mv$ and use to verify $\lambda = \frac{\rho}{h}$

Electron microscopes – how are we able to get higher resolution than light microscopes?

Diffraction

Wavelength

Notes page #25

Atoms and Nuclei

Structure of the Atom

Using spectroscopes – how do they work?

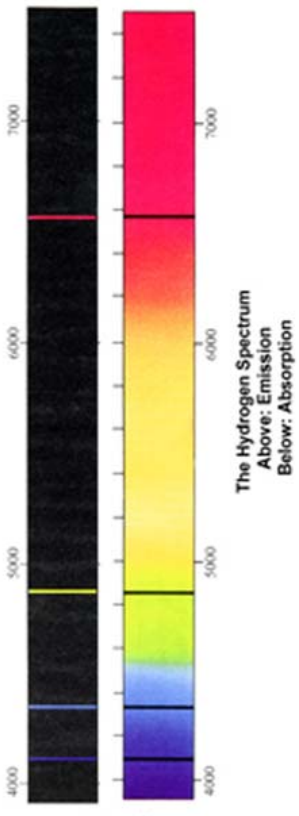
Line emission spectography what is it? What does it tell us about atoms?

Energy levels and transitions in atoms

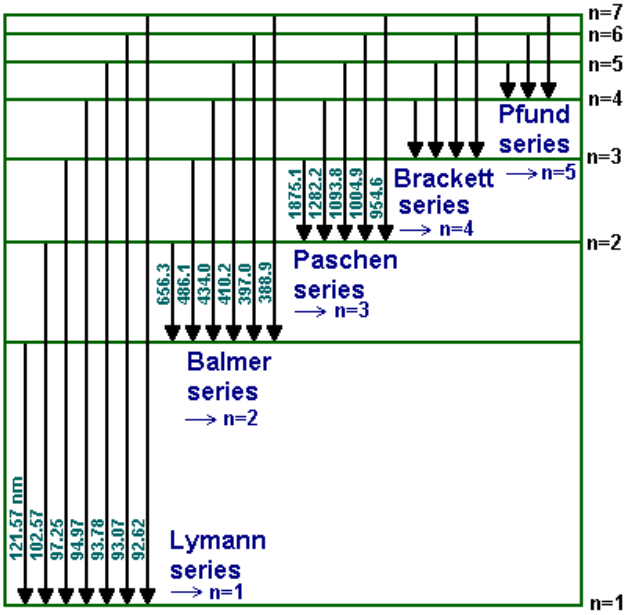
$E_n - E_m = hf$

Draw energy level diagrams

Calculate frequencies of light from energy level diagrams



Spectrum of Hydrogen atom



Notes page #26

Ionisation energy

Definition:

How to determine:

Continuous spectrum is

Line absorption spectrum is

Why doesn't hydrogen gas absorb visible light at room temperature?

Fluorescence is

Stimulated emission is
(identical photons – coherent)

Metastable states are

Lasers:

Notes page #27

The Structure of the Nucleus
Composition of nuclei
$A = Z + N$ and ${}^{A}_{Z}\mathrm{X}$

The nature of the force between nucleons and why it must be there.

Isotopes

Mass defect and binding energy … $E = mc^2$

$E_b = \Delta m\, c^2$

Determine binding energies from changes in mass

Nuclear equations and the conservation laws.

${}^{1}_{0}\mathrm{n} + {}^{32}_{16}\mathrm{S} \longrightarrow {}^{32}_{15}\mathrm{P} + {}^{1}_{1}\mathrm{H}$ Used for the treatment of excess red blood cells

Notes page #28

The production of Medical radioisotopes

$^{1}_{1}H + {}^{18}_{8}O \longrightarrow {}^{18}_{9}F + {}^{1}_{0}n$

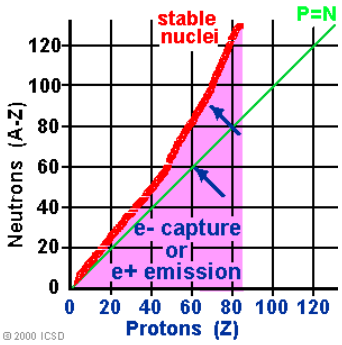
$^{2}_{1}H + {}^{14}_{7}N \longrightarrow {}^{15}_{8}O + {}^{1}_{0}n$

How are they produced?

Radioactivity

Stable and unstable nuclei

Why the increase in neutron to proton ratio?



Types of decay ($\alpha \beta^{+} \beta^{-}$ ~~or~~ $e^{-} e^{+}$ or spontaneous fission) and the reasons they occur.

In detail **Alpha decay**

Notes page #29

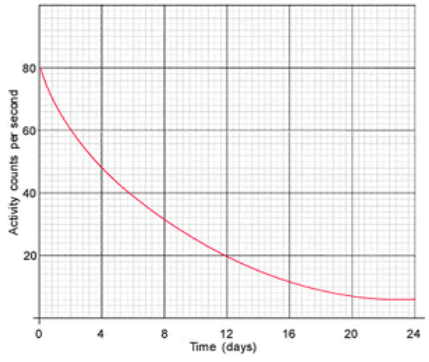
Beta decay and neutrinos

Gamma decay

Properties of radioactive emissions

Effect on living things

Half life activity



Application **Positron emission topography**

Notes page #30

Nuclear Fusion and Nuclear Fission

Spontaneous / induced fission
$E = \Delta m\, c^2$

Chain reactions (see course outline)

Nuclear power Fission vs Fusion