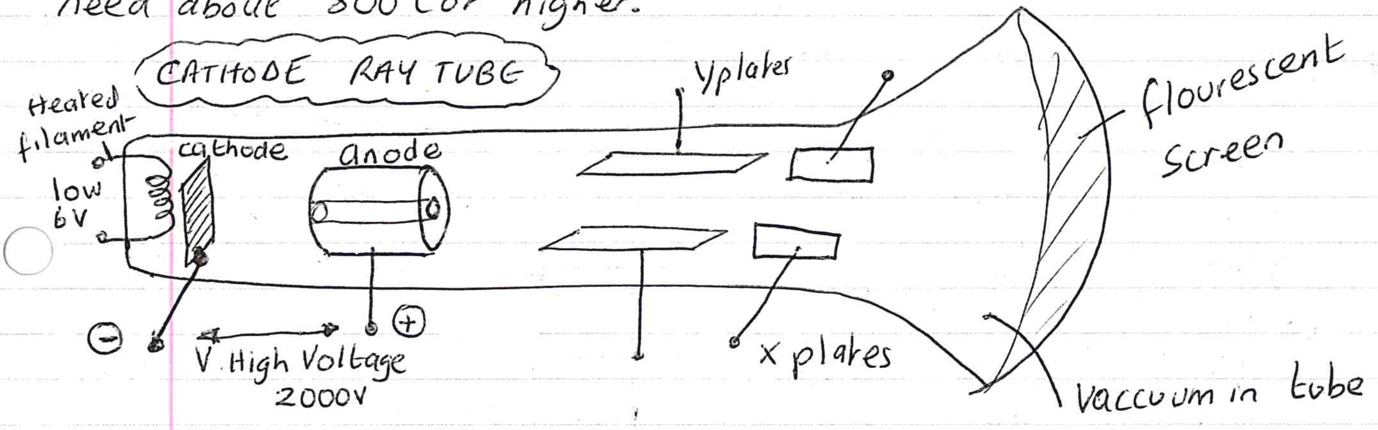
Electron: orbits nucleus, ⊖ charge (1.6×10^{-19} C), $\frac{M_{proton}}{18} = M_{electron}$

smallest charge found in nature (all other charge is a multiple)

GJ Stoney named the electron, Robert Millikan measured its charge in Oil drop Experiment.

Thermionic Emission → metal has free ē. When you give them enough energy (heat) they can escape from forces holding them to metal. need about 800°C or higher.

CATHODE RAY TUBE



electrons emitted from cathode due to thermionic emission
High voltage accelerates them to anode. Some pass through hole
They can be deflected up/down by applying either a voltage or a magnetic field to y plates. They can be deflected left/right by applying a voltage or magnetic field across x plates.
ē then strike the screen ∘ flourescent material. This causes light to be emitted when struck. The stream of ē is called a 'cathode ray'.

* When they leave the cathode, ē have potential energy (position in a force field)
* The high voltage gives the ē kinetic Energy (potential → kinetic)
* This KE is converted into mostly light when ē strike screen.

Since ē loses energy and V = energy lost per Coulomb $V = \frac{E_p}{q}$

so potential energy lost is $E_p = V$

Potential energy is converted into kinetic Energy ($\frac{1}{2} m_e v^2$)

$$\text{So} \quad eV = \frac{1}{2} m_e v_e^2$$

P An ē is accelerated from rest through a voltage of 3000V
Find (i) energy (kinetic) that it gains (ii) Speed it acquires

Q An ē strikes the of C.R.T with speed of 2×10^7 m/s. What is voltage across tube?

Electron Volt : 1eV = amount of energy gained or lost by $\bar{e}$ when it moves thro a potential difference of 1V.

Work done $W = QV$ = energy lost/gained. So $1eV = 1.6 \times 10^{-19}C \times 1V$

so $1eV = 1.6 \times 10^{-19} J$

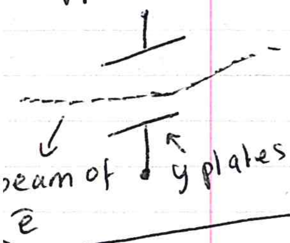
Q: An $\bar{e}$ has an energy of 6×10^{-18} J. What is its energy in eV?

An electron has K. energy of 4 KeV. Express this in joules

pg 332 Q5, 6, 7 Ex

Applications of C.R.T : Old TV's, old computer monitors, medicine (ECG to display hearts electrical signals, EEG)

Cathode ray Oscilloscope used to display electrical signals. Sine wave on y plates makes $\bar{e}$ form sine wave on screen - as they are deflected by the voltage.

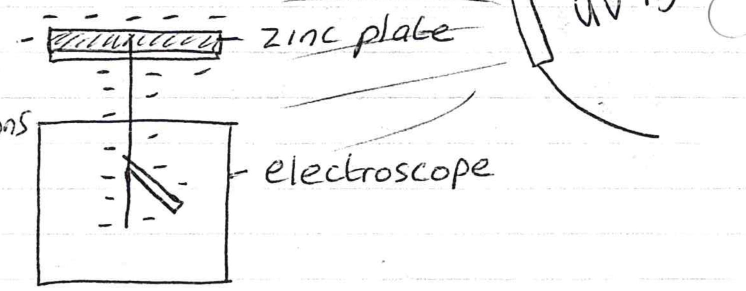


Q6 pg 333, Q10 p333.

PHOTOELECTRIC EFFECT (Photoemission)

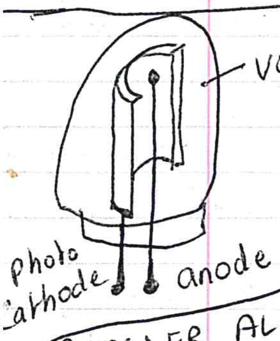
Shine light on metal (zinc) and it causes $\bar{e}$ to be emitted
(U.V. light for zinc)

* need to be able to show this :
⊖ charge electroscope + zinc →
Shine U.V. light on it and leaf collapses because the electrons get energy to escape from zinc.



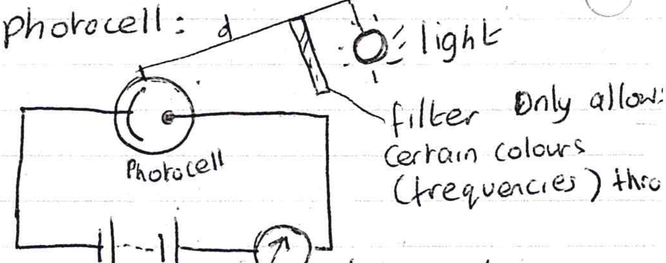
⊛ won't work if you put glass between light & zinc (Leaf doesn't collapse). as UV can't pass through glass

PHOTOCELL : Conducts electricity when light of suitable frequency shines on it. Size of current ∝ Intensity of light.



Cathode coated with material that will undergo photoemission

To demonstrate action of photocell :

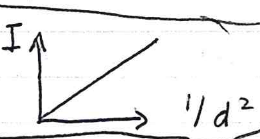


filter Only allows certain colours (frequencies) thro

galvanometer measures small currents

Measure d
Measure I
Vary d, measure I, d

Plot



$I \propto \frac{1}{d^2}$

Shows current $\propto \frac{1}{d^2}$

Also light Intensity $\propto \frac{1}{d^2}$ (know already)

So Intensity ∝ Current

BURGLER ALARM | AUTOMATIC DOORS

1) Varying freq of light using (filter →) shows that for each metal there will be a frequency below which no photoemission occurs (threshold freq)

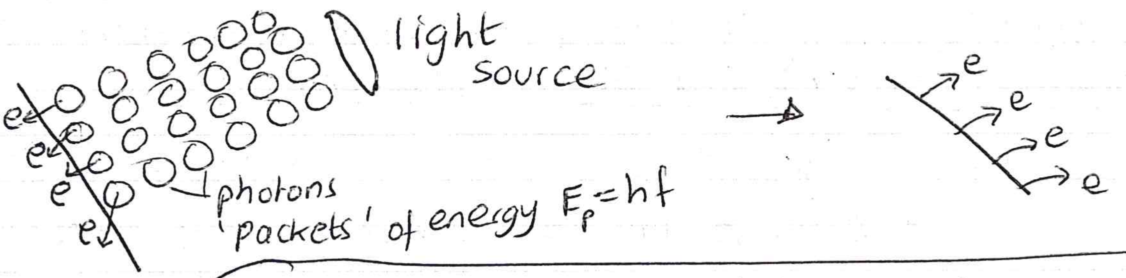
2) Increasing the freq above the threshold does not change the size of the current

3) The intensity of the light (no of photons/sec) does affect the current.

THRESHOLD FREQUENCY = Frequency of light below which photoemission will not occur

Work function of a metal = minimum energy needed to remove the loosest electron from the surface of that metal

Einstein came up with a reason why the current did not depend on the frequency of light as long as it was above the threshold frequency:
- Light is made up of packets of energy called PHOTONS
- Energy of a photon $E = hf$ h = plank's constant
- One electron can only get energy from one photon
- The more photons (Intensity) the more electrons can escape
- For electron to 'escape', the energy of the photon must be greater than the work function. Any extra energy is used as kinetic Energy by the electron.



1 photon passes its energy to 1 electron

amount of energy of Photon ∝ frequency of light

Energy of Photon − work function = Energy left over for kinetic energy $\frac{1}{2}mv^2$

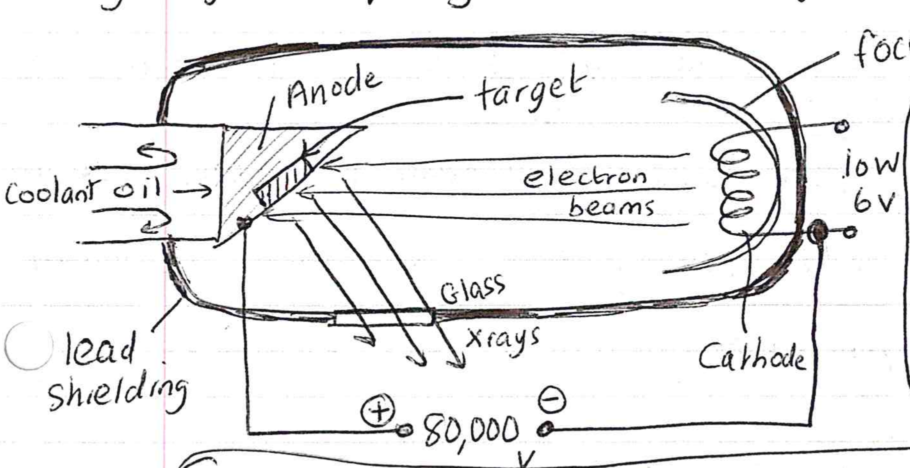
(work function → energy needed for $\bar{e}$ to escape)

Q8, Q13, 14, 15 P 339

X Rays

Discovered by accident by Wilhelm Röntgen (in 1895) - noticed when working with a C.R.T that a flourescent screen gave out light when C.R.T. was on. Even when C.R.T. was covered with black cardboard to block out U.V. and visible light.

X rays - very penetrating, passed thro many metals → not lead. very high frequency (short wavelength)



- electrons emitted from Cathode by thermionic emission
- accelerated through very high voltage 80000V.
- 1% of $\bar{e}$ have their KE converted to x rays, rest of $\bar{e}$ KE converted into heat (need coolant)
- target = tungsten (hi melting pt)

KE of 1% of $\bar{e}$ → electromagnetic Energy xrays

(PENETRATING POWER of X RAYS): depends on its frequency. frequency depends on KE of $\bar{e}$ which depends on Voltage.

$E_x = hf_x \quad f_x = \frac{E_x}{h} \quad E_x = \frac{1}{2}mv^2, \quad \frac{1}{2}mv^2 = eV$

so $E_x = eV$, $f_x = \frac{eV}{h}$

Hard X rays (very penetrating) otherwise SOFT X rays

X rays are:

- EM radiation – travel @ speed of light
- λ's between 10^{-9} and 10^{-15}
- ionise materials (knock $\bar{e}$ off atoms making them ions)
- penetrate materials (more dense material ⇒ less penetration)
- not deflected by electric or magnetic fields
- make zinc sulfide flouresce
- blacken photographic plates
- behave like waves (interfere, undergo diffraction)
- Xrays (like U.V) can cause photoemission

USES of X rays:

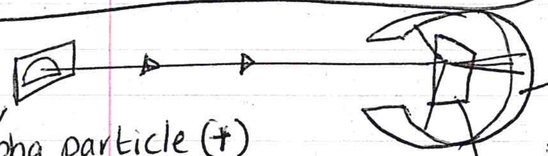
- X ray photos to detect broken bones - Bones block x rays, flesh doesn't
- X ray to kill cancerous cells (more affected by Xrays than normal cells)
- X rays to detect faults/cracks in
- Xrays to determine thickness of materials
- X rays in airport to check luggage contents

DANGERS of Xrays:

- Ionizing radiation – damage human tissue
  – Can cause cancer

ATOM, NUCLEUS, RADIOACTIVITY

1911 RUTHERFORD's gold leaf exp.

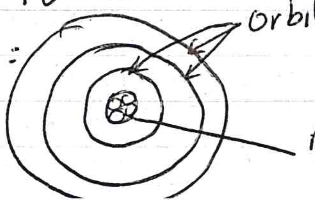


Alpha particles were ⊕, most went straight through foil but some were deflected at a small angle, some (few) bounced back!!

Conclusion: Atom mostly empty space with small dense ⊕ nucleus in centre. $\bar{e}$ orbit nucleus.

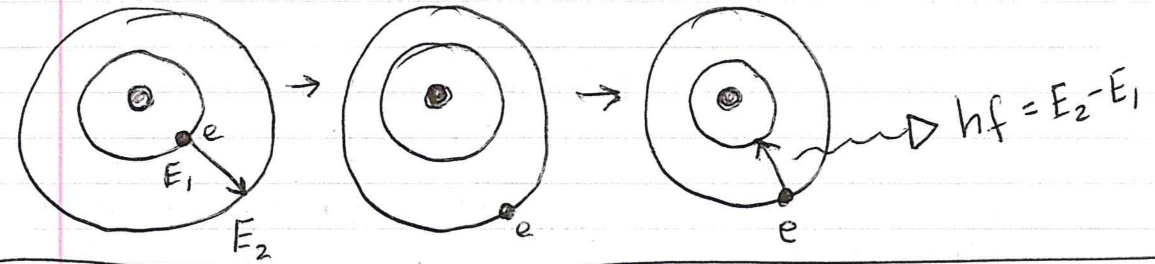
Further research found that radius of a nucleus was ~ 10^{-15}m, radius of the atom ~ 10^{-10}m.

Bohr Model:



If an electron in one energy level E_1 is excited by gaining energy then it can jump to a higher energy level E_2. It will eventually return to its lower orbit and when it does it emits a photon of energy $= E_2 - E_1$. so $hf = E_2 - E_1$

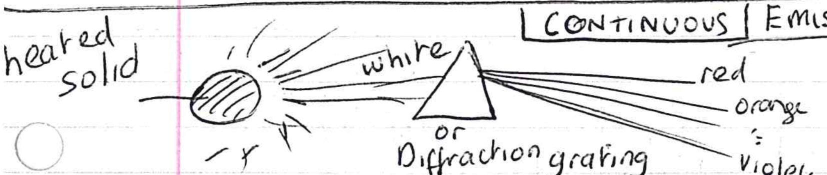
Electrons can jump 2 energy levels and fall 1, or 2 levels back in steps. The energy of any emitted photons $= E_{level\,a} - E_{level\,b}$



CONTINUOUS SPECTRA: Produced by incandescent solids/liquids
ALL visible wavelengths are produced - when solids/liq are heated, they give off light of all λ's because all energy levels are possible so é get excited, fall back, photons emitted for all energies: Spectrum does not depend on material - same for all

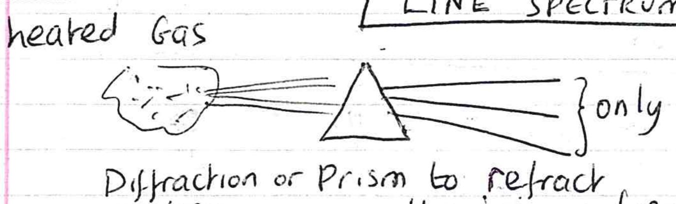
line spectra: Produced by heated gas.
In a gas atoms are separated so there is no overlap of energy levels so only the energy levels of each atom is available. When electrons are excited they can only move to the levels allowed for the particular element. So only photons of certain frequencies will be emitted (corresponding to the type of element and the difference between its energy levels)

CONTINUOUS (EMISSION SPECTRUM)



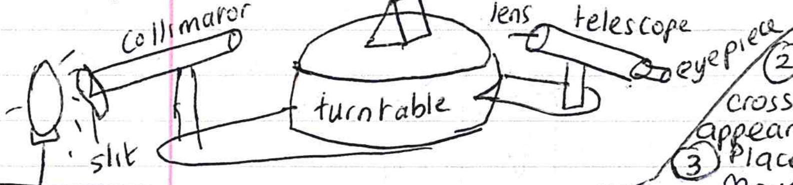
white
Prism refracts light splitting it into its various frequencies (all freq's)

LINE SPECTRUM



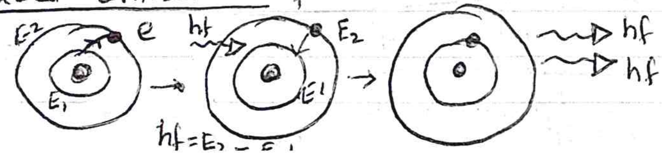
certain Colours visable that correspond to the particular elements energy levels

A spectroscope is used to view the spectrums



1. move eyepiece until cross threads in focus
2. View a distant object with telescope & move cross threads & eyepiece togeter until distant object appears in focus
3. Place light at slit and view slit thro telescope. Move slit until it is in focus.
4. Adjust width of slit and level turntable

LASER: Light Amplification Stimulated Emission of Radiation. Electron excited to higher energy level in atoms. Then photons cause stimulated emission ⇒ more photons produced they cause more emission. All photons of same freq → same λ.



Proton	p	nucleus	$+1.6 \times 10^{-19}$	+1	1.67×10^{-27}	1
Neutron	n	nucleus	0	0	1.68×10^{-27}	1
Electron	e	orbit nucleus	-1.6×10^{-19}	-1	9.1×10^{-31}	1/2000
		Location	Charge in C	Relative charge	Mass	Relative Mass

$^{4}_{2}He$ (atomic mass → 4, atomic no. → 2)

Atomic mass = No. of protons + neutrons

Atomic no = No of protons (diff atomic no => different element)

ISOTOPES: Same atomic no. different Mass no
same no. of protons, different no. neutrons

C^{6}_{14}, C^{6}_{12}

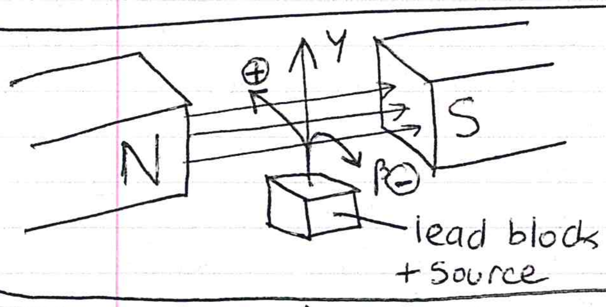
RADIO ACTIVITY: Discovered by Becquerel by accident - a Uranium Salt made a photographic plate go black even though plate was in dark wrapper.

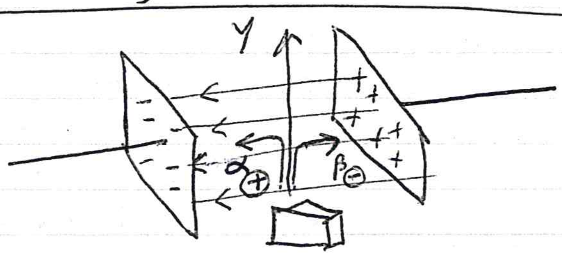
due to unstable isotopes getting rid of energy

α-radiation - Alpha radiation = fast moving Helium Nuclei (2P, 2N) (+)

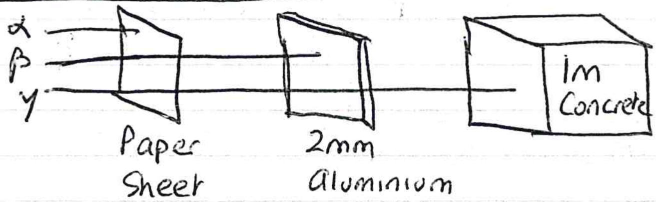
β-radiation - Hi speed electrons (−) or positrons (+)

γ-radiation - V. High frequency Electromagnetic radiation (0)



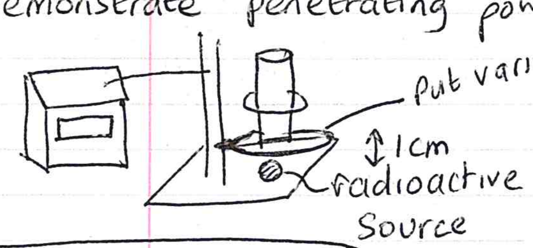


Penetration



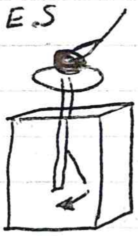
Ionization α = MOST
β = less than α
γ = least (use electroscope to demo)

Demonstrate penetrating power



put various materials paper, aluminium lead between GM tube and source
vary source (α, β, γ)

- charge E.S (+) or (−)



- leaf diverges
- bring source near
- radiation ionizes the charge (+ve or −ve), so leaf collapses

α: W^{x}_{y} (mass, atomic no.) → Z^{x-4}_{y-2} + α^{4}_{2}

β^-: W^{x}_{y} → V^{x}_{y+1} + β^-

1 neutron → 1 proton + $\bar{e}$ + $\bar{\nu}$

$^{1}_{0}n \rightarrow {}^{1}_{1}p + {}^{0}_{-1}e$

p 352 Q7, 8, 9, 13

β^+: W^{x}_{y} → U^{x}_{y-1} + β^+

1 proton → 1 neutron + e^+ + ν = $^{1}_{1}p \rightarrow {}^{1}_{0}n + e^{0}_{+1}$

Ex p350