Cheatography

AQA A-Level Physics: Discovery of The Electron Cheat Sheet

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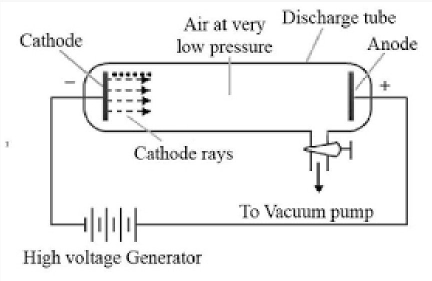
Cathode Ray Tube



Production of Cathode Rays

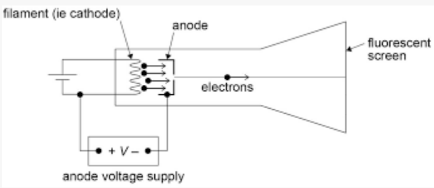
When a high potential difference (p.d) is applied across a discharge tube with a low pressure gas inside, the tube will begin to glow. This glow was brightest at the cathode and was called a cathode ray.

1. The high p.d pulls electrons off the gas atoms, forming positive ion and electron pairs.

2. The positive gas ions are accelerated towards the cathode and upon collision, release more electrons.

3. These electrons are accelerated across the tube due to the low pressure of the gas. They collide with gas atoms causing them to become excited. These atoms will de-excite and release photons of light.

The Electron Gun



Thermionic Emission

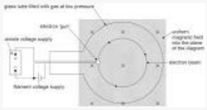
Thermionic emission (TE) is when a metal is heated until the free electrons on the surface gain enough energy and are emitted.

Electron guns use a p.d in order to accelerate electrons. Once the electrons leave the surface via TE, they are accelerated towards an anode with a small gap.

Once the electron reaches the anode. Its kinetic energy is equal to the work done on the electron by the electric field.

$1/2mv^2 = eV$

Fine Beam Tube



Deflection in a magnetic field

The fine beam tube contains a low pressure gas and has a uniform magnetic field passing through.

1. Electrons are accelerated using an electron gun and enter the fine beam tube perpendicular to the direction of the field.

2. The magnetic force on the electrons acts perpendicular to their motion and therefore the electrons move in a circular path.

3. As the electrons move through the fine beam tube, they collide with gas atoms causing them to become excited. The gas atoms then de-excite releasing photons of light meaning that the path of the electrons is visible and the radius of the path can be measured.

$mv^2/r = Bev$

$mv/r = Be$

$v = Ber / m$

$v = sqrt(2eV/m)$

$sqrt(2eV/m) = Ber / m$

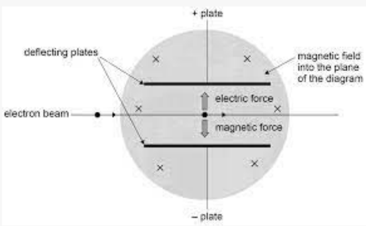
$2eV / m = B^2e^2r^2 / m^2$

$2V = B^2er^2 / m$

$e/m = 2V / B^2r^2$

sqrt = Square root

Thomson's Crossed Fields



Balancing Electric and Magnetic Fields

Balancing Electric and Magnetic Fields (cont)

2. The strengths of these fields are adjusted until the electron beam passes through the crossed fields undeflected. Therefore, the electric and magnetic forces are equal and opposite.

Magnetic Force: F=Bev

Electric Force: F = Ee where E = V/d so F = Ve / d

$Bev = Ve / d$

$v = V / Bd$

$v = sqrt (2eV / m)$

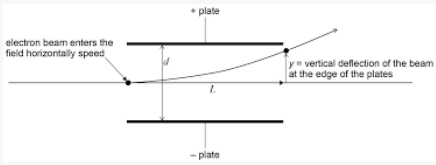
$sqrt (2eV / m) = V / Bd$

$2eV / m = V^2 / B^2d^2$

$e / m = V^2 / 2B^2d^2V$

sqrt = Square root

Electric Field Only



Deflection in an electric field

Electrons of a known speed are fired into a uniform electric field of known length.

Time Taken = Plate length / Electron speed (t = d/v)

Upwards Acceleration (a) = F / m = eV / dm

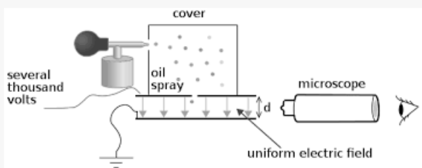
Vertical Distance (s) = $1/2at^2$ because u = 0 hence ut = 0

$s = 1/2ad^2 / v^2$

$a = eV / dm$

$e/m = ad / V$

Milikan's apparatus



Milikan's oil drop experiment

$mv^2 = 2eV$
$v^2 = 2eV / m$
$v = sqrt(2eV / m)$
sqrt = Square root

This apparatus involves magnetic and electric fields which are perpendicular to each other. The electric and magnetic fields deflect the electrons in opposite directions.

1. Electrons are accelerated using an electron gun and enter the apparatus perpendicular to the direction of both fields. The electrons will be deflected upwards due to electric field and downwards due to the magnetic field.

This experiment was formed in order to calculate the charge of an electron.	**Electric Field Disabled:**	**Electric Field Enabled:**

Milikan's oil drop experiment (cont)

An atomizer is used to spray tiny negatively charged droplets of oil into a uniform electric field. The droplets will experience an electric force upwards and a weight downwards. The p.d can be adjusted to where these two quantities become equal.	F = 6πηrv	F = EQ
However, we must find the mass on the droplet and we can't use a mass balance so we turn off the p.d across the plates to remove the electric force and let the oil drop fall freely.	F = mg	F = mg

Milikan's oil drop experiment (cont)

Now the oil drop will experience a downwards weight like before but it will now experience a viscous drag force upwards which can be calculated using Stokes' Law. At terminal velocity, this viscous force and the weight will be equal.	At terminal velocity: mg = 6πηrv	EQ = mg
Milikan observed that the charge of the oil droplets was an integer value of 1.6×10^{-19}. This is significant because it shows the charge was quantised meaning it exists in discrete packets of 1.6×10^{-19}.	m = vρ (where ρ is density)	E = V / d hence QV / d = mg
	$v = 4/3\pi r^3$ (treating the oil drop as a sphere)	
	$m = 4/3\pi r^3 \rho$ hence $W = 4/3\pi r^3 \rho g$	
	$6\pi\eta r v = 4/3\pi r^3 \rho g$	
	$6\eta v = 4/3 r^2 \rho g$	
	$9\eta v / 2 = r^2 \rho g$	

Milikan's oil drop experiment (cont)

$r^2 = 9\eta v / 2\rho g$ hence r = sqrt ($9\eta v / 2\rho g$)
mg = 6πηrv hence m = 6πηrv / g therefore m = 6πηv x sqrt ($9\eta v / 2\rho g$)

sqrt = Square Root