Equations		
$W = QV$	$work\ done = charge \times potential\ difference$	
$E = mc^2$	$energy = mass \times speed\ of\ light^2$	
$E = hf$	$energy = plank's\ constant \times frequency$	
$E = \frac{hc}{\lambda}$	$energy = \frac{plank's\ constant \times speed\ of\ light}{wavelength}$	
$E_k = hf - hf_0$	$kinetic\ energy = (plank's\ constant \times frequency) - work\ function$	
From N5:	$E_k = \frac{1}{2}mv^2$	$v = f\lambda$

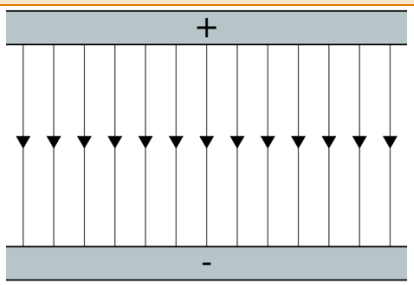
Key Number	Meaning	Key Number	Meaning
6.63×10^{-34} J s	Plank's Constant	9.11×10^{-31} kg	Mass of an electron
$+1.60\times10^{-19}$ C	Charge Proton	1.675×10^{-27} kg	Mass of a neutron
-1.60×10^{-19} C	Charge Electron	1.673×10^{-27} kg	Mass of a proton
3.0×10^{8} ms^{-1}	Speed of light	9.0×10^{16} m^{2}s^{-2}	Speed of light squared

Key Words	Meaning
Electric field	Electric fields are regions in which a charge experiences a force. They exist around charged particles and plates. The direction and strength of the field be visualised by the drawing of field lines.
Potential Difference	Potential difference is the work done in moving a unit charge between two points. 1J is the work done moving a charge of 1C through a p.d of 1V.
Electronvolt	From the formula, *E=QV*, if we accelerate an electron, which is electrically charged by a potential difference of one-volt, it will gain an energy of 1.6×10^{-19}J or 1 'electronvolt', eV.
Standard Model	The standard model is the collection of the fundamental particles that make up everything. There are serval particles included in it.
Fermion	Fermions are matter particles, they consist of quarks and leptons.
Quark	There are 6 types (Up, Down, Charm, Strange, Top, Bottom). Each quark has a fraction of the magnitude charge of an electron.
Lepton	There are 6 types. The Electron, Muon, Tau each have a charge of -1. The Electron Neutrino, Muon Neutrino, Tau Neutrino each have a charge of 0
Hadron	The word comes from Greek meaning heavy. These are particles made up of Quarks.
Baryon	Made up of 3 Quarks, e.g., the proton and the neutron.
Meson	Made of a Quark and Anti-Quark pair. Very short lifespan.
Boson	The Force mediating Particles, consists of Photons, W and Z bosons and gluons.
Particle accelerator	Collisions of particles inside particle accelerators is evidence for the existence of quarks.
Anti-particle	Will have the same magnitude of charge as the corresponding particle, however the sign will be opposite. E.g., and up quark has a charge of 2/3e and an anti-up quark has a charge of -2/3e.
Annihilation	This occurs when a particle comes into contact with its corresponding antiparticle. This produces energy which is evidence for antimatter.
Beta decay	To follow the conservation of energy a third particle must be released during the decay. This particle is the neutrino, and beta decay is used as evidence for the existence of the neutrino.
Photoelectric Effect	Photons incident on a metal can cause the metal to eject an electron. The photons must be of sufficient energy. This phenomenon is called photoemission and is evidence for the particle model of light. *The production of a photoelectron from the surface of a metal when electromagnetic radiation, of sufficiently high frequency is incident on it.*
Threshold Frequency	The minimum frequency to allow photoemission to occur.
Work Function	The minimum energy to allow photoemission to occur.

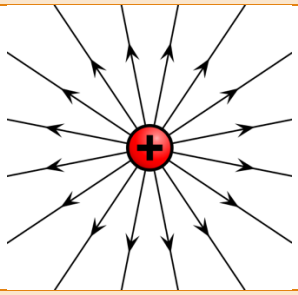
Diagrams

Field Patterns[i]

ii



iii

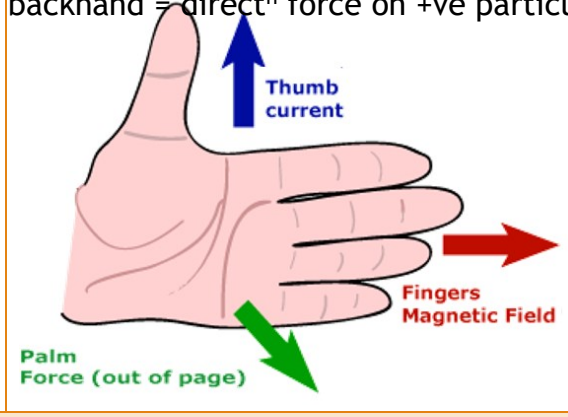


Secret Sign of the Physicist

Grip Rule

Slap rule, thumb= particle motion

palm = direct^{n} force on -ve particle
backhand = direct^{n} force on +ve particle



How does a 3D diagram fit on a page, well things can come out and go in to the page.

Arrow coming towards you (out of the page) ● Arrow going away from you (into the page) ✕

Waves/Particles

Particle	Wave
Spectra	Diffraction
Refraction	Refraction
Reflection	Reflection
Photoelectric effect	Interference*

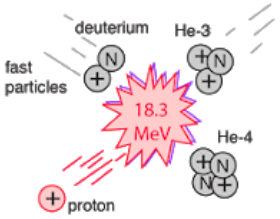
*test for a wave

Fusion[iv]

small nuclei join to form nucleus of larger mass number

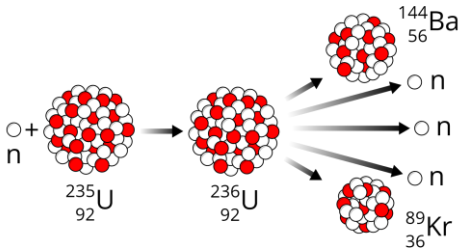
$$^{2}_{1}H + ^{3}_{2}He \rightarrow ^{4}_{2}He + ^{1}_{1}H + 18.3MeV$$

Deuterium-helium-3 Fusion

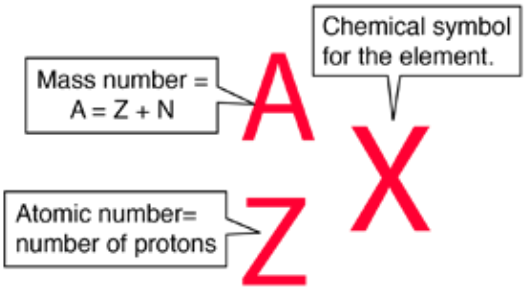


Fission[v]

large nucleus split to form nuclei of smaller mass number



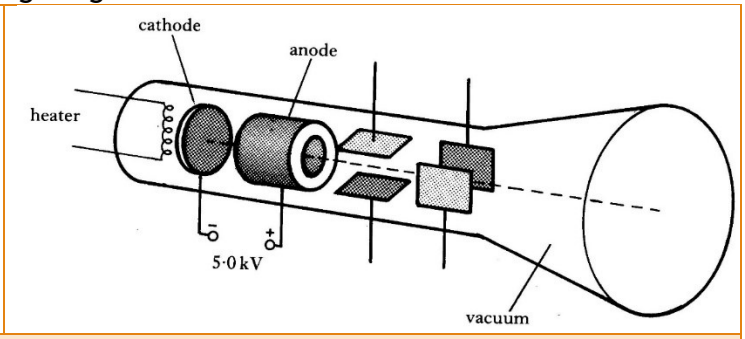
Atomic Equations[vi]



An electron is accelerated from rest through a potential difference of 200 V. Calculate:(a) Ek of the electron; (b) the final speed of the electron.

$E_K = E_w$ by the electric field
$E_K = QV$
$E_K = 1.60 \times 10^{-19} \times 200$
$E_K = 3.20 \times 10^{-17}$ J

$E_K = \frac{1}{2}mv^2$
$3.20 \times 10^{-17} = 0.5 \times 9.11 \times 10^{-31} \times v^2$
$v^2 = 7.025 \times 10^{13}$
$v = 8.38 \times 10^6$ m s^{-1}



Nuclear reaction

A nuclear fission reaction is shown opposite.
This releases energy .

Why is energy released during fusion and fission reactions?

The mass of the products is less than the mass of the reactants. The difference in mass is converted to energy according to $E=mc^2$

$$^1_0n + {}^{235}_{92}U \rightarrow {}^{98}_{42}Mo + {}^{136}_{54}Xe + 2\,{}^1_0n + 4\,{}^0_{-1}e$$

Mass Before		Mass after	
$^{235}_{92}U$	3.90088×10^{-25} kg	$^{98}_{42}Mo$	1.6249×10^{-25} kg
^1_0n	1.6749×10^{-27} kg	$^{136}_{54}Xe$	2.2556×10^{-25} kg
Total 3.917629×10^{-25} kg		$2\,^1_0n$	3.3498×10^{-27} kg
		$4\,^0_{-1}e$	3.32×10^{-30} kg
		Total 3.914031×10^{-25} kg	

Mass difference

Mass Before		Mass after	
$^{235}_{92}U$	3.90088×10^{-25} kg	$^{98}_{42}Mo$	1.6249×10^{-25} kg
^1_0n	1.6749×10^{-27} kg	$^{136}_{54}Xe$	2.2556×10^{-25} kg
Total 3.917629×10^{-25} kg		$2\,^1_0n$	3.3498×10^{-27} kg
		$4\,^0_{-1}e$	3.32×10^{-30} kg
Usually the mass of the beta particles are ignored as they play a minimal effect on the mass difference.		Total 3.914031×10^{-25} kg	

Energy equivalence

mass change = mass before – mass after
mass change = 3.917629×10^{-25} kg - 3.914031×10^{-25} kg
mass change = 3.598×10^{-28} kg

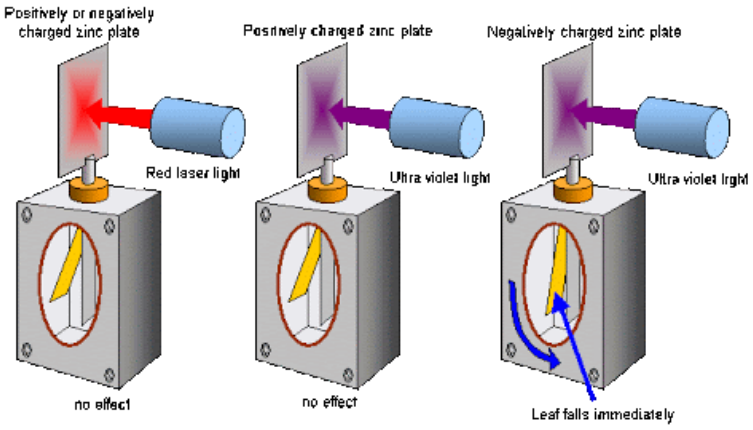
energy equivalence:
$E=mc^2$
$E = 3.598 \times 10^{-28} \times (3 \times 10^8)^2$
$E = 3.598 \times 10^{-28} \times 9 \times 10^{16}$
$E = 3.24 \times 10^{-11}$ J

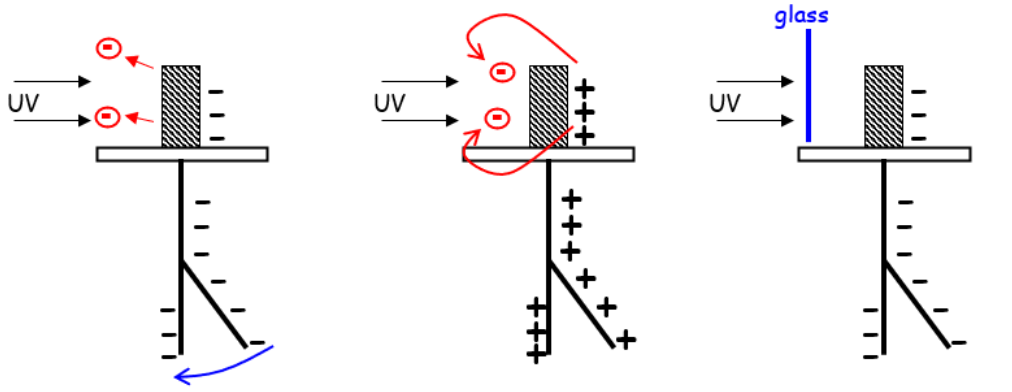
The same method works for fusion reactions

Nuclear fusion reactors require charged particles at a very high temperature (plasma) which have to be contained by magnetic fields.

Photo Electric effect[vii]

The photoelectric effect is evidence for the particle model of light.
Photons of sufficient energy (high frequency) can eject electrons from the surface of materials (photoemission).
The threshold frequency, f_0 is the minimum frequency of a photon required for photoemission.
The work function, W or hf_0 of a material is the minimum energy of a photon required to cause photoemission.



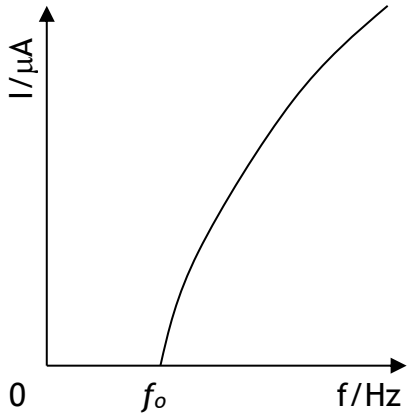


The U.V. makes the leaf fall on a g.l.e.

The freed electrons are drawn back by the +ve charge. The leaf stays up.

Glass absorbs U.V. therefore no electrons are emitted. The leaf stays up.

Evidence	Conclusion
UV discharges the zinc plate of an electro-scope which is negatively charged.	Discharge is the result of ejecting electrons and not a result of ionising the air.
Visible radiation, however bright, doesn't produce the same effect.	It is NOT simply a case of the energy supplied but whether each "bundle" has radiation of the appropriate frequency.



Work function. Energy required to free the electron. (Joules)

$$hf = W + E_k$$

Energy of photon coming in. *(Joules)*

Anything left over becomes E_K. *(Joules)*

The two energies relate to the energy of the photons producing the effect because when a photon is absorbed its energy ejects electrons with a certain amount of E_K.

OR:

$$hf = W + qV_0$$

Incident energy of photo	=	Work function	+	Extra kinetic energy
E	=	W	+	E_K
E	=	hf_0	+	E_K
E	=	hf_0	+	$\frac{1}{2}mv^2$
E	=	W	+	$\frac{1}{2}mv^2$
hf	=	W	+	E_K
hf	=	hf_0	+	E_K
hf	=	hf_0	+	$\frac{1}{2}mv^2$
hf	=	W	+	$\frac{1}{2}mv^2$
hf	=	W	+	stopping energy
E	=	W	+	qV_0
hf	=	W	+	qV_0
hf	=	hf_0	+	qV_0
$\frac{hc}{\lambda}$	=	hf_0	+	qV_0
$\frac{hc}{\lambda}$	=	hf_0	+	$\frac{1}{2}mv^2$

How they can ask photoelectric questions

Incident photon = E= hf = hc/λ

Work function = W= hf_0 = hc/λ

$$I = Nhf$$

I = irradiance (Wm^{-2}) = N = No. of photons per second per square metre ($s^{-1}m^{-2}$) hf = Energy per photon (J)

Extra Ek = Ek = ½mv^2 = qV_0= stopping energy

The energy supplied by light or other electromagnetic radiation takes the form of photons of energy, ***hf***. When a photon goes into the metal it is wholly absorbed by a single electron.

If ***hf < W*** no electron emission

If ***hf = W=hf₀*** then the photon is just able to release an electron from its surface without it having any E_K (f_0 or THRESHOLD FREQUENCY). (hf = W = hf_0)

If ***hf > W*** then excess energy is given to the freed electron as E_K.

$$hf = W + E_K$$

[i] https://physics.stackexchange.com/questions/288172/why-is-electric-field-lines-away-from-and-toward
[ii] https://commons.wikimedia.org/wiki/File:Field_lines_parallel_plates.svg
[iii] https://courses.lumenlearning.com/boundless-physics/chapter/the-electric-field-revisited/
[iv] http://hyperphysics.phy-astr.gsu.edu/hbase/NucEne/fusion.html
[v] https://en.wikipedia.org/wiki/Discovery_of_nuclear_fission
[vi] http://hyperphysics.phy-astr.gsu.edu/hbase/Chemical/atom.html
[vii] http://schoolphysics.org/age16-19/quantum%20physics/text/Photoelectric_effect/index.html