

# WJEC England Physics AS-level

## 2.7 Photons

### Flashcards

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# What are photons?



## What are photons?

Photons are particles of light.

They are sometimes referred to as a quantum of energy of EM radiation. 'A quantum' in this context just means a set (finite) amount.



True or false? The energy of a photon is proportional to the wavelength of the light.



True or false? The energy of a photon is proportional to the wavelength of the light.

False.

It's proportional to the frequency:  $E = hf$

Energy is inversely proportional to the wavelength.



What is 'h' in the equation  $E = hf$ ? Give units.



What is 'h' in the equation  $E = hf$ ? Give units.

h is the Planck constant, measured in Js.



What quantity can be measured in  
electron volts (eV)?





What quantity can be measured in electron volts (eV)?

Energy.



Describe an experiment which can be used to estimate the value of the Planck constant.



## Describe an experiment which can be used to estimate the Planck constant.

An LED will only allow current to pass after a minimum voltage has been put across it.

At this voltage all the electrons will have the same energy as a photon emitted by the LED (which you will know the frequency of).

Finding the threshold voltage by seeing when current flows in the circuit can then be used to find  $h$  from:  $h = E/f$



Describe how to improve the accuracy of the estimate of this experiment.



## Describe how to improve the accuracy of the estimate of this experiment.

To improve the accuracy of this estimate, the experiment can be repeated with a variety of different coloured LEDs, which each emit different wavelengths of light. The values of wavelength and threshold p.d. for each can be recorded, and a graph drawn of  $V$  against  $1/\lambda$ . The gradient of this graph will be equal to  $hc/e$ .

As the speed of light and the electron charge are known constants, we can calculate the value of  $h$  from this.



# What is the photoelectric effect?



## What is the photoelectric effect?

The photoelectric effect is a phenomenon where shining light with enough energy onto a metal releases electrons (and can cause a current to flow).

The electrons emitted are called photoelectrons.



Which features of the photoelectric effect can't be explained if light is a wave?





## Which features of the photoelectric effect can't be explained if light is a wave?

If light was a wave, the energy of the electrons released would increase with increasing intensity of the light - but this isn't the case. Instead the energy of the electrons depends on frequency (and no electrons are released below a certain threshold value, no matter how intense the light is).



How many photons does each photoelectron absorb prior to emission?



How many photons does each photoelectron absorb prior to emission?

Only 1.

If it doesn't contain enough energy the electron will re-emit the energy rather than being released.



How does the photon model of light explain the threshold frequency seen in the photoelectric effect?



How does the photon model of light explain the threshold frequency seen in the photoelectric effect?

Each electron absorbs one photon. This single photon must have enough energy for the electron to be released, if it doesn't the energy is re-emitted. The electron can't build up energy as it could if light was a wave.



What is the name given to the minimum amount of energy an electron requires to leave the surface of a metal?



What is the name given to the minimum amount of energy an electron required to leave the surface of a metal?

The work function (or 'work function energy'),  $\phi$ .



Write a word equation relating the energy of an incident photon to the work function and the kinetic energy of released electrons.





Write a word equation relating the energy of an incident photon to the work function and the kinetic energy of released electrons.

*Photon energy = work function + kinetic energy*



True or false? The rate of emission of photoelectrons is proportional to intensity (provided the light is above threshold frequency).



True or false? The rate of emission of photoelectrons is proportional to intensity (provided the light is above the threshold frequency).

True.

Higher intensity means more photons, this means more electrons can absorb energy and be released.



Does the maximum kinetic energy of a released electron depend on the intensity of light hitting the surface?



Does the maximum kinetic energy of a released electron depend on the intensity of light hitting the surface?

No.

Energy transferred is due to a one-to-one interaction, and so depends on frequency, not intensity.



What experimental evidence appears to show particles behaving as waves?



What experimental evidence appears to show particles behaving as waves?

Electron diffraction.

Electrons will diffract when passed through the spaces between atoms in graphite (like a tiny diffraction grating).

This wouldn't happen if electrons were behaving as particles only.



Which equation relates the wave and particle properties of electrons?





Which equation relates the wave and particle properties of electrons?

The de Broglie equation:  $\lambda = h/p$

Where  $\lambda$  = wavelength (wave-property),  $h$  = Planck's constant, and  $p$  = momentum (particle-property)



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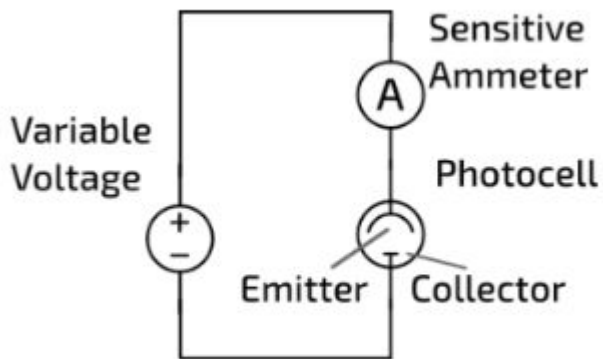


# What is a vacuum photocell?



# What is a vacuum photocell?

A vacuum photocell is a device which can be used to measure the maximum kinetic energy of electrons.



<https://bit.ly/2NOJhxN>



Order the types of electromagnetic radiation from lowest to highest frequency with their wavelengths and typical photon energies.



Order the types of electromagnetic radiation from lowest to highest frequency with their wavelengths and typical photon energies.

Region	Wavelength (order of magnitude)	Typical photon energies
Radio	$10^3 \text{ m}$	$10^{-9} \text{ eV}$
Microwave	$10^{-2} \text{ m}$	$10^{-4} \text{ eV}$
Infrared	$10^{-5} \text{ m}$	$10^{-1} \text{ eV}$
Ultraviolet	$10^{-8} \text{ m}$	$10^2 \text{ eV}$
X-rays	$10^{-10} \text{ m}$	$10^4 \text{ eV}$
Gamma rays	$10^{-12} \text{ m}$	$10^6 \text{ eV}$



# What are vapour lamps?





## What are vapour lamps?

Vapour lamps are tubes containing a gas. A high voltage source is used to provide electrons with energy which then transfer some of their energy to the gas atoms. This excites electrons within the atoms causing them to rise to higher energy states. They then fall back down to the lower energy state (from which they came) releasing a photon. Since there are multiple energy states within atoms, photons of different energies are released. Therefore you would see a combination of the colours from the lamp.



# What is the ionisation energy?



# What is the ionisation energy?

The ionisation energy is the energy an electron requires to escape an atom, leaving it as an ion. This means it is raised up all of the energy states until the state with zero energy. The negative sign for the energies means the electron is bound to the atom. When the energy becomes positive, the electron escapes.

To find the ionisation energy, you need to work out the energy difference between the ground state and the zero energy ( $n=\infty$ ) state.

