Answers to common worded questions – by Learn Physics

A word from the Author

The answers presented in this document are compiled from commonly asked and repeated questions on VCAA physics past papers, and predicted questions that are similar to them. Please note that you are unlikely to get questions worded in the same way as the ones below on your exam. Always make your own cheat sheet, ensure you understand concepts clearly, and use these answers as a guide only. Read each question carefully and cater your answer to the question. Examiners take measures to prevent awarding marks to students who directly copy off cheat sheets. Therefore, alter your answers to be more specific to a question (for example if the question is about a certain point being a bright band on the Young's Double Slit experiment, be very specific and note what the path difference is at that point). These answers have been prepared with care to reflect the study design as accurately as possible. That said, I can't guarantee they are free from error, nor that using them will always result in full marks.

Over the years, I have found that top performing students memorise the answers to questions like the ones found on this document. This helps them save time during the exam, and frees up their minds to be creative and apply their knowledge to the questions asked. Take this opportunity to become a top student! Remember your ATAR is just a number, but you want to do the best you can and get as many marks as you can because that's just the kind of person you are! Reach out to me on dan@learnphysics.com.au if you want clarity on concepts, have found errors, or if you have any feedback on this document. Wishing you the very best of luck!

Unit 4

Standing Waves

Explain how standing waves are formed.

If it is on a string, begin with Travelling waves reflect off the fixed ends.

Else say standing waves are formed when 2 coherent waves travelling in different directions meet.

They undergo superposition and produce an interference pattern (points of constructive interference form antinodes, and points of destructive interference form nodes).

If the length of the string is an exact multiple of half the wavelength, a standing wave will form.

Explain why a point on a standing wave corresponds to a node rather than an antinode.

A node occurs at a point on a standing wave where destructive interference between the two travelling waves is complete. The two waves have equal amplitude but opposite phase, so their displacements cancel out at the node. As a result, the net displacement remains zero, unlike an antinode where constructive interference produces maximum displacement.

<u>**Young's Double Slit Experiment**</u>

Explain why a certain point is a bright band rather than a dark band.

(Calculate the path difference to that point - XXX) The path difference to this point is XXX and this results in constructive interference.

Why is monochromatic light used in Young's double slit experiment?

When white light, which contains a number of different colours, shines through a diffraction grating, each different colour is diffracted by a different amount and forms its own set of coloured fringes. This results in the light being dispersed into its component colours.

Explain how Young's double-slit experiment provides evidence of the wave-like nature of light and not the particle-like nature of light.

Young's experiment demonstrates interference. Interference is a wave phenomenon, so the experiment supports a wave model. The particle model predicts two bright regions only, one behind each slit.

Explain how Young's double-slit experiment provides evidence of wave-particle duality of light and matter.

A single electron or photon leaves the source with particle-like discreteness and creates a single discrete spot on the screen.

The interference pattern, which occurs over time, is a wave property (the particles are undergoing diffraction and interference).

<u>**Diffraction patterns**</u>

Explain why electrons can produce the same spacing of bands in a diffraction patters as a photon (Alternate wording: Explain why the diffraction pattern created by a matter particle and a photon might look similar).

Moving electrons exhibit a wave property. They have a wavelength given by de Broglie's equation wavelength = h/p). As diffraction is dependent on wavelength, if the de Broglie wavelength of the electron is the same as the wavelength of the X-ray then the diffraction patterns will be the same.

Explain how the diffraction pattern of electrons changes with their wavelength.

The diffraction pattern depends on the electron's wavelength via the de Broglie relation $\lambda=h/p$. A longer wavelength (lower momentum) produces wider diffraction fringes, while a shorter wavelength (higher momentum) produces narrower fringes. Therefore, changing the electron's energy changes the fringe spacing.

Photoelectric Effect

Explain what is meant by work function.

The work function is a property of a metal that relates to how strongly electrons are held within its structure. It describes the amount of energy required to release the most loosely bound electron from a metal.

What is threshold frequency?

The threshold frequency, f_0 is the minimum frequency of light required to release photoelectrons from a metal surface. If $f < f_0$, there will be no photocurrent.

Explain why there is a threshold frequency for the emission of electrons in the photoelectric effect.

Electrons are bound to the metal with a minimum energy called the **work function** ϕ. A photon must have energy $E=hf$ at least equal to ϕ to free an electron. If the light frequency is below the threshold, each photon does not have enough energy, and no electrons are emitted regardless of the light's intensity.

Which model of light does the photoelectric effect experiment support? Specify the model and give 3 reasons to justify your answer. (Could also be worded as Explain how observations of the photoelectric effect experiment support a particle model of light as opposed to a wave model of light).

The photelectric effect experiment supports a particle model of light.

1) Existence of a threshold frequency:

Electrons are only emitted if the incident light has a frequency above a certain minimum value (threshold), regardless of the light's intensity.

It is it is consistent with the particle model as photons carrying discrete energy $E=hf$.

This cannot be explained by the wave model as waves deliver energy over time, and it would be expected that the energy would build up until the electron had enough energy to be released regardless of frequency.

2) Instantaneous emission of photoelectrons:

Electrons are ejected almost immediately when light of sufficient frequency shines on the surface, even at very low intensities.

The particle model explains it as a single photon transferring its energy to a single electron instantly.

In the wave model, electrons would need time to absorb enough energy from the wave.

3) Kinetic energy depends on frequency, not intensity:

The maximum kinetic energy of emitted electrons increases with light frequency, but is independent of light intensity.

According to the particle model, the photon energy depends only on frequency (E=hf), not intensity. So higher frequency photons give electrons more kinetic energy.

According to the wave model, increasing intensity (wave amplitude) should increase the energy absorbed by electrons, so higher intensities would be expected to produce higher-energy photoelectrons.

Can the observations of the photoelectric effect experiment be supported by a wave model explanation? Discuss by comparing with particle model explanations.

The photoelectric effect cannot be explained by the wave model of light. The wave model predicts a time delay before electron emission, that electrons could be emitted at any frequency if the light is intense enough, and that electron kinetic energy depends on light intensity — none of which are observed. In contrast, the particle (photon) model correctly predicts the experimental results: electrons are emitted immediately with no time delay, there is a threshold frequency below which no electrons are emitted, and the maximum kinetic energy of electrons is independent of light intensity. The particle model also states that the frequency of a photon determines its energy (E=hf), and for a given frequency, the light intensity corresponds to the number of photons incident per unit time. These predictions match the observations of the photoelectric experiment and clearly support the particle nature of light.

Explain why increasing light intensity increases the number of electrons emitted but does not change their maximum kinetic energy.

In the photon model, light intensity corresponds to the number of photons per unit time. Increasing intensity increases the number of photons hitting the surface, so more electrons are emitted. However, each photon's energy depends only on its frequency E=hf, so the maximum kinetic energy of electrons is determined by frequency, not intensity.

<u>Atomic Absorption and Emission</u>

Explain why the spectrum of light emitted for a hot vapour lamp give discrete spectral lines

Electrons orbit nuclei in shells with discrete energy levels. The electrons can transition between these shells by absorbing or emitting discrete amounts of energy equal to the difference between the two shells. Since transitioning electrons can only release discrete amounts of energy, only discrete spectral lines will be observed.

Explain how a hydrogen absorption spectrum is produced.

The hydrogen absorption spectrum is produced by shining light with a broad spectrum through hydrogen gas and then passing it through a prism to give a spectrum of colours. The electron in the gas orbit nuclei in shells with discrete energy levels. The electrons can transition between these shells by absorbing discrete amounts of energy equal to the difference between the two shells. As a result, only photons with discrete energy (and hence frequency) are absorbed resulting in dark lines in the absorption spectrum.

Disclaimer

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