Quantum Physics Questions – OCR A Level Physics

Praneel Physics

1. Define the term 'photoelectric effect'. **(P)**

Working and Answer:

The emission of electrons from a metal surface when electromagnetic radiation above a threshold frequency is incident on it.

2. What is a photon? **(P)**

Working and Answer:

A quantum of electromagnetic radiation; a discrete packet of energy given by $E = hf$.

3. State the equation relating energy of a photon to frequency. **(P)**

Working and Answer:

$$E = hf$$

Where h is Planck's constant and f is the frequency of radiation.

4. What is meant by the work function of a metal? **(P)**

Working and Answer:

The minimum energy required to release an electron from the surface of a metal.

5. What is the threshold frequency? **(P)**

Working and Answer:

The minimum frequency of incident radiation needed to cause photoemission from a metal surface.

6. Describe what happens if the frequency of light is below the threshold frequency. **(PP)**

Working and Answer:

No electrons are emitted, regardless of the intensity, because the photons do not have enough energy to overcome the work function.

7. Explain how increasing the intensity of incident light affects the photoelectric current. **(PP)**

Working and Answer:

If the frequency is above threshold, increasing intensity increases the number of photons, so more electrons are emitted per second, increasing current.

8. State two observations of the photoelectric effect that cannot be explained by wave theory. **(PP)**

Working and Answer:

1. No emission below threshold frequency.
2. Emission is instantaneous, with no time delay.
3. Maximum kinetic energy is independent of intensity.

9. What is meant by quantisation of energy? **(PP)**

Working and Answer:

Energy is only transferred in discrete amounts (quanta), not continuous values.

10. Calculate the energy of a photon with frequency 5.2×10^{14} Hz. Use $h = 6.63 \times 10^{-34}$ Js. **(PPP)**

Working and Answer:

$$E = hf = 6.63 \times 10^{-34} \times 5.2 \times 10^{14} = 3.45 \times 10^{-19} \text{ J}$$

11. A metal has a work function of 2.1 eV. Light of wavelength 400 nm is shone onto it. Determine if photoemission occurs. **(PPP)**

Working and Answer:

$$E = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^{8}}{400 \times 10^{-9}} = 4.97 \times 10^{-19}\,\text{J} = 3.1\,\text{eV}$$

Since $3.1 > 2.1$, photoemission will occur.

12. Explain the term 'stopping potential'. **(PPP)**

Working and Answer:

The minimum potential difference needed to stop the most energetic photoelectrons reaching the collector in a photoelectric experiment.

13. Write the photoelectric equation and label each term. **(PPP)**

Working and Answer:

$$hf = \phi + KE_{\max}$$

Where hf is the photon energy, ϕ is the work function, and $KE_{\max}$ is the maximum kinetic energy of emitted electrons.

14. Convert 1.5 eV into joules. **(PPP)**

Working and Answer:

$$1.5\,\text{eV} = 1.5 \times 1.6 \times 10^{-19} = 2.4 \times 10^{-19}\,\text{J}$$

15. A photon has energy 4.0×10^{-19} J. The work function is 2.5×10^{-19} J. Calculate the maximum kinetic energy of emitted electrons. **(PPPP)**

Working and Answer:

$$KE = hf - \phi = 4.0 \times 10^{-19} - 2.5 \times 10^{-19} = 1.5 \times 10^{-19}\,\text{J}$$

16. In an experiment, stopping potential is measured to be 0.8 V. Calculate the maximum kinetic energy of photoelectrons. **(PPPP)**

Working and Answer:

$$KE = eV = 1.6 \times 10^{-19} \times 0.8 = 1.28 \times 10^{-19}\ \text{J}$$

17. Describe how a graph of $KE_{\max}$ vs frequency can be used to determine Planck's constant. **(PPPP)**

Working and Answer:

The gradient of the straight-line graph is equal to Planck's constant h. The intercept on the frequency axis gives the threshold frequency.

18. What experimental evidence supports the particle nature of light? **(PPPP)**

Working and Answer:

The photoelectric effect shows that energy transfer occurs in discrete packets (photons), not continuous waves — instantaneous emission and threshold frequency support this.

19. Light of wavelength 300 nm is incident on a metal with work function 2.5 eV. Calculate the maximum speed of emitted photoelectrons. **(PPPPP)**

Working and Answer:

$$E = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^{8}}{300 \times 10^{-9}} = 6.63 \times 10^{-19}\,\text{J}$$

$$KE = E - \phi = 6.63 \times 10^{-19} - 2.5 \times 1.6 \times 10^{-19} = 2.63 \times 10^{-19}\,\text{J}$$

$$KE = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{2 \times 2.63 \times 10^{-19}}{9.11 \times 10^{-31}}} = 7.6 \times 10^{5}\,\text{ms}^{-1}$$

20. A graph of KE vs f has a gradient of 6.6×10^{-34} Js. What does this imply? **(PPPPP)**

Working and Answer:

The gradient represents Planck's constant, confirming the linear photoelectric equation and quantum model of light.

21. Explain why increasing intensity of light with frequency below threshold does not lead to photoemission. **(PPPPP)**

Working and Answer:

Each photon still has insufficient energy, regardless of quantity. Photoemission requires photon energy $hf > \phi$, not just total energy.