

How to use this worksheet. Twenty-eight questions, about 32 minutes, with the answer key at the end. Frequency decides the **energy** of each photoelectron; intensity decides **how many** are emitted. Doubling the frequency **more than** doubles the kinetic energy.

Formula sheet

$$E = hf = hc/\lambda \quad | \quad h = 6.626 \times 10^{-34} \text{ J s} \quad | \quad 1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$$

$$KE_{\max} = hf - W_0 \quad | \quad W_0 = hf_0 \quad | \quad eV_0 = KE_{\max}$$

$$\lambda = h/p = h/mv \quad | \quad \text{for an electron through } V \text{ volts, } \lambda \approx 1.227/\sqrt{V} \text{ nm} \quad | \quad \text{photon } p = h/\lambda = E/c$$

Section A · Level 1 — Photoelectric effect and de Broglie waves

Ten questions. None should take more than twenty seconds.

1. The photoelectric effect demonstrates the:

- (1) Wave nature of light (2) Particle nature of light (3) Wave nature of electrons (4) Existence of the nucleus

2. The minimum energy required to remove an electron from a metal surface is called the:

- (1) Kinetic energy (2) Work function (3) Stopping potential (4) Threshold wavelength

3. Einstein's photoelectric equation is:

- (1) $KE_{\max} = hf + W_0$ (2) $KE_{\max} = hf - W_0$ (3) $KE_{\max} = W_0 - hf$ (4) $KE_{\max} = hf \times W_0$

4. Photoemission occurs only if the frequency of the incident light is:

- (1) Below the threshold frequency (2) Above the threshold frequency (3) Equal to zero (4) Independent of the metal

5. Increasing the intensity of incident light while keeping the frequency fixed increases the:

- (1) Maximum kinetic energy of the electrons (2) Number of photoelectrons emitted (3) Threshold frequency (4) Work function

6. The maximum kinetic energy of the photoelectrons depends on the:

- (1) Intensity of light (2) Frequency of light (3) Area of the surface (4) Time of exposure

7. The stopping potential is the voltage needed to:

- (1) Increase the photocurrent (2) Reduce the photocurrent to zero (3) Change the work function (4) Raise the frequency

8. The de Broglie wavelength of a particle of momentum p is:

- (1) hp (2) h/p (3) p/h (4) h/p^2

9. The rest mass of a photon is:

- (1) Equal to that of an electron (2) Zero (3) Infinite (4) 1 amu

10. The momentum of a photon of wavelength λ is:

- (1) $h\lambda$ (2) h/λ (3) λ/h (4) $hc\lambda$

Working space — Questions 1 to 10

Write the formula before you substitute.

Section B · Level 2 — Photon energy, stopping potential and wavelength

Ten questions. Work in electron volts wherever the question allows it.

11. The energy of a photon of wavelength 500 nm is closest to:

- (1) 1.5 eV (2) 2.5 eV (3) 3.5 eV (4) 5.0 eV

12. A metal has a work function of 2 eV. Light of energy 3 eV falls on it. The maximum kinetic energy of the emitted electrons is:

- (1) 1 eV (2) 2 eV (3) 3 eV (4) 5 eV

13. For the same metal and light, the stopping potential is:

- (1) 1 V (2) 2 V (3) 3 V (4) 5 V

14. If the frequency of incident light is doubled while the work function stays the same, the maximum kinetic energy:

- (1) Doubles (2) More than doubles (3) Increases by less than double (4) Stays the same

15. The threshold wavelength of a metal is the wavelength:

- (1) Below which no emission occurs (2) Above which no emission occurs (3) At which the current is maximum (4) That gives zero intensity

16. A particle has momentum 6.626×10^{-27} kg m/s. Its de Broglie wavelength is:

- (1) 10^{-7} m (2) 10^{-10} m (3) 10^{-34} m (4) 10^{-3} m

17. If the speed of a particle is doubled, its de Broglie wavelength:

- (1) Doubles (2) Halves (3) Is unchanged (4) Becomes four times

18. Which of the following has the longest de Broglie wavelength at the same speed?

- (1) A proton (2) An electron (3) A neutron (4) An alpha particle

19. The photoelectric current depends on:

- (1) The frequency only (2) The intensity of the incident light (3) The work function only (4) The stopping potential only

20. The value of Planck's constant is closest to:

- (1) 6.6×10^{-34} J s (2) 6.6×10^{-19} J s (3) 3.0×10^8 J s (4) 1.6×10^{-19} J s

Working space — Questions 11 to 20 Write the formula before you substitute.

Section C · Level 3 — Why wave theory fails, and graphical relationships

Eight questions. Ask what each graph's slope and intercept represent.

21. The photoelectric effect cannot be explained by the wave theory of light because wave theory predicts that emission would:

- (1) Depend only on frequency (2) Occur at any frequency given enough intensity (3) Never occur (4) Be instantaneous only

22. The emission of photoelectrons is:

- (1) Delayed by several seconds (2) Practically instantaneous (3) Delayed by minutes at low intensity (4) Never immediate

23. A graph of maximum kinetic energy against frequency for a metal is a straight line whose slope is:

- (1) The work function (2) Planck's constant (3) The threshold frequency (4) The electronic charge

24. On that same graph, the intercept on the frequency axis gives the:

- (1) Work function (2) Threshold frequency (3) Planck's constant (4) Stopping potential

25. The de Broglie wavelength of an electron accelerated through a potential difference V is proportional to:

- (1) V (2) $\sqrt{V}$ (3) $1/\sqrt{V}$ (4) V^2

26. Electron diffraction experiments provide evidence for the:

- (1) Particle nature of electrons (2) Wave nature of electrons (3) Existence of photons (4) Photoelectric effect

27. Why is the wave nature of a moving cricket ball never observed?

(1) Its speed is too low (2) Its momentum is so large that its wavelength is unimaginably small (3) It has no wavelength (4) Planck's constant is zero for large objects

28. Two metals have work functions of 2 eV and 4 eV. Light of energy 3 eV falls on both. Emission occurs from:

(1) Both metals (2) Neither metal (3) Only the 2 eV metal (4) Only the 4 eV metal

Working space — Questions 21 to 28 Write the formula before you substitute.

Answer key

Check only after you have attempted every question. Full worked solutions for each one are on the worksheet page at aviatelearnings.com.

1. (2)	7. (2)	13. (1)	19. (2)	25. (3)
2. (2)	8. (2)	14. (2)	20. (1)	26. (2)
3. (2)	9. (2)	15. (2)	21. (2)	27. (2)
4. (2)	10. (2)	16. (1)	22. (2)	28. (3)
5. (2)	11. (2)	17. (2)	23. (2)	
6. (2)	12. (1)	18. (2)	24. (2)	

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