Unit 21 · Photons

WORKSHEET

Full marks 34

Name _____ Class _____ Roll no. _____ Date _____ Marks _____ / 34

1 Key words [4]

Write ✓ for a true statement and ✗ for a false one. Correct the false ones. Each carries 0.5 mark.

i. A photon of higher frequency carries more energy. ☐

ii. Brighter light of the same frequency gives faster photoelectrons. ☐

iii. Below the threshold frequency no electrons come out, however bright the light. ☐

iv. The work function is the least energy needed to remove an electron from the metal's surface. ☐

v. The stopping potential depends on the intensity of the light. ☐

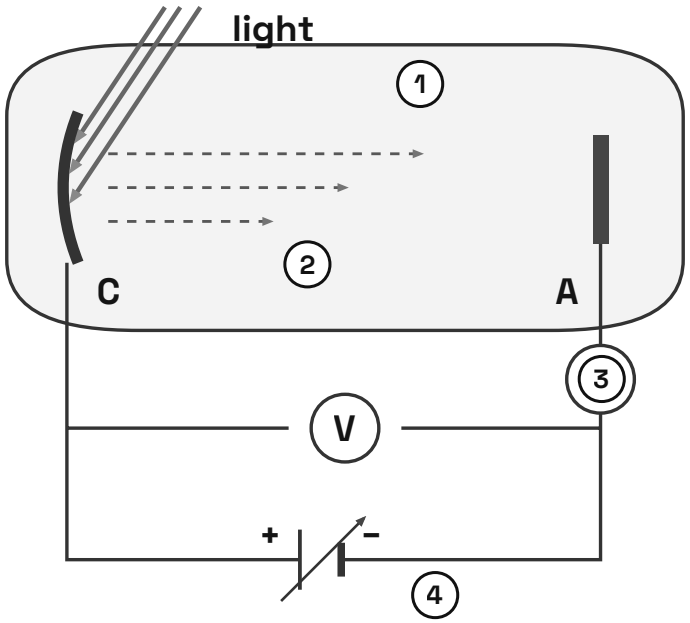
vi. In dim light the photoelectrons come out only after a delay. ☐

vii. The graph of stopping potential against frequency has a slope of h/e. ☐

viii. In a solar cell, light knocks electrons out of the cell's surface. ☐

2 Label the diagram [2]

The diagram shows a photocell circuit. Write the label that belongs in place of 1 to 4. Each carries 0.5 mark.



1. _____ 2. _____

3. _____ 4. _____

3 Multiple choice [5]

Choose the correct option for each of the following questions. Take $h = 6.63 \times 10^{-34}$ J s, $c = 3.0 \times 10^{8}$ m/s and $e = 1.6 \times 10^{-19}$ C.

i. The energy of a photon of green light of wavelength 500 nm is about: [1]

a. 1.3×10^{-48} J
b. 2.5 eV
c. 4.0 eV
d. 3.3×10^{-19} eV

ii. A metal has a work function of 2.0 eV. Its threshold wavelength is about: [1]

a. 400 nm
b. 310 nm
c. 620 nm
d. 1240 nm

iii. Photons of energy 3.0 eV fall on a metal of work function 2.2 eV. The stopping potential is: [1]

a. 5.2 V
b. 2.2 V
c. 3.0 V
d. 0.8 V

iv. The momentum of a photon of wavelength 600 nm is about: [1]

a. 1.1×10^{-27} kg m/s
b. zero, since a photon has no rest mass
c. 3.3×10^{-19} kg m/s
d. 4.0×10^{-40} kg m/s

v. For different metals, the graphs of the greatest kinetic energy of the photoelectrons against the frequency of the light are straight lines that: [1]

a. are parallel, with slope h, but cross the frequency axis at different places
b. all start from the origin
c. have slopes equal to each metal's work function
d. meet at one point on the frequency axis

4 Short answers [6]

Write short answers to the following questions.

a. Why can't the wave theory of light explain the threshold frequency? [2]

b. Photoelectrons come out the instant the light is switched on, even in very dim light. How does the photon idea explain this? [2]

c. As the collector of a photocell is made more and more positive, the photocurrent rises and then stays the same. Why? **[2]**

5 Long answer **[4]**

Write a long answer to the following question.

Using Einstein's photoelectric equation, show that a graph of stopping potential against frequency is a straight line. What do its slope and the point where it meets the frequency axis tell you? How did Millikan use this?

6 Numerical problems **[10]**

Solve the following problems. Show your working. Take $h = 6.63 \times 10^{-34}$ J s, $c = 3.0 \times 10^{8}$ m/s, $e = 1.6 \times 10^{-19}$ C and the mass of an electron 9.1×10^{-31} kg.

a. Light of wavelength 420 nm falls on a metal of work function 2.25 eV. Find i. the energy of each photon in eV, ii. the greatest kinetic energy of the photoelectrons, iii. the stopping potential, and iv. the greatest speed of the photoelectrons. **[4]**

Answer:

b. A red laser pointer of power 3.0 mW gives light of wavelength 650 nm. How many photons does it send out each second? **[3]**

Answer: _____

c. Light of frequency 6.0×10^{14} Hz gives photoelectrons from a metal with a stopping potential of 0.40 V; light of 8.0×10^{14} Hz gives 1.23 V. Find Planck's constant and the metal's work function from these readings. **[3]**

Answer: _____

7 Think **[3]**

Cesium has a work function of 1.9 eV. Infrared photons of 1.2 eV fall on it. Shiva says that two of them together have 2.4 eV, so electrons should come out. Explain why they don't, and what would happen if the infrared were made a hundred times brighter.

8 Activity: Light, a solar cell and a meter (not marked)

Join a small solar panel to a multimeter. Shine a torch on it from the distances in the table, then try red and blue cellophane, then cover it with black paper.

Light	Reading
torch at 10 cm	
torch at 20 cm	
torch at 40 cm	
through red cellophane	
through blue cellophane	
black paper	

Is this photoelectric emission? Explain.