The Energy Slope

Read a photoelectron data table and interpret the slope.

HS-PSII-9.4 "Describe the slope of the graphical representation of the kinetic energy of a photoelectron vs. frequency in terms of Planck's constant."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline how the passage says to find a line's slope, circle the constant that the slope represents, and number the two axes named in the text.

What Changes When Light Changes?

(1) At a metal surface, light can knock electrons loose. Each photon brings energy set by its frequency: photon energy equals Planck's constant, h, times frequency, f. An electron must spend some of that energy escaping the metal. The energy left over is the maximum kinetic energy of a released photoelectron.

(2) The table records a classroom model of one metal under four light frequencies. The first listed frequency is its threshold, where the fastest released electrons have zero kinetic energy. Above threshold, plot frequency on the horizontal axis and maximum kinetic energy on the vertical axis. The plotted points form a straight line.

ONE METAL: MAXIMUM PHOTOELECTRON ENERGY

Frequency (10^{14} Hz)	Maximum kinetic energy (10^{-20} J)
6.0	0
7.0	6.6
8.0	13.2
9.0	19.8

(3) For a different metal, photons may need a different minimum frequency to free electrons. Yet the rise in maximum kinetic energy per unit increase in frequency is unchanged. This rise divided by run is the line's slope. Its value is Planck's constant, h, approximately 6.6×10^{-34} joule-seconds, because energy gained per extra hertz is universal.

2 ANSWER WITH EVIDENCE

Use the passage

1 Between 7.0 and 8.0 in the table, how much does maximum kinetic energy rise per 1.0×10^{14} Hz increase in frequency?

2 Use the first and last table rows to calculate the line's slope in J·s. Which constant does this slope represent?

3 A second metal has a lower threshold frequency than the metal in the table. Would its maximum kinetic energy versus frequency line be steeper, flatter, or have the same slope? Explain.

4 For the metal in the table, a student predicts that raising frequency by 0.5×10^{14} Hz will raise maximum kinetic energy by 6.6×10^{-20} J. Use the slope to correct the prediction.

3 YOUR TURN

Your own words

Imagine a metal with a threshold frequency of 5.0×10^{14} Hz. On the grid, plot maximum photoelectron kinetic energy at 5.0, 6.0, and 7.0×10^{14} Hz using $h = 6.6 \times 10^{-34}$ J·s, label both axes, draw the line, and write one sentence explaining its slope.



ANSWER KEY

The Energy Slope

PART 1 · READ AND MARK

Underline how the passage says to find a line's slope, circle the constant that the slope represents, and number the two axes named in the text. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Between 7.0 and 8.0 in the table, how much does maximum kinetic energy rise per 1.0×10^{14} Hz increase in frequency?	**It rises by 6.6×10^{-20} J per 1.0×10^{14} Hz.**
2	Use the first and last table rows to calculate the line's slope in J·s. Which constant does this slope represent?	**$(19.8 \times 10^{-20}$ J) ÷ $(3.0 \times 10^{14}$ Hz) = 6.6×10^{-34} J·s, Planck's constant.**
3	A second metal has a lower threshold frequency than the metal in the table. Would its maximum kinetic energy versus frequency line be steeper, flatter, or have the same slope? Explain.	**It would have the same slope. The slope is Planck's constant, even when the threshold changes.**
4	For the metal in the table, a student predicts that raising frequency by 0.5×10^{14} Hz will raise maximum kinetic energy by 6.6×10^{-20} J. Use the slope to correct the prediction.	**The increase is 3.3×10^{-20} J, because the frequency increase is half of 1.0×10^{14} Hz.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Horizontal axis: frequency (10^{14} Hz). Vertical axis: maximum kinetic energy (10^{-20} J). Plot (5.0, 0), (6.0, 6.6), and (7.0, 13.2), then draw a straight line through them. The slope is Planck's constant, 6.6×10^{-34} J·s, so each 1 Hz increase adds 6.6×10^{-34} J of maximum kinetic energy.

Accept equivalent units for slope, including J/Hz. The new metal's line must begin at its stated threshold and rise by 6.6×10^{-20} J for each 1.0×10^{14} Hz increase.