Light Sets Electrons Free

Graph photon frequency and predict photoelectric current.

HS-PSII-9.3 "Develop graphical and mathematical representations that describe the relationship between the frequency of a photon and the kinetic energy of an electron emitted through the photoelectric effect and apply those representations to..."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline the equation for maximum kinetic energy, circle the numerical threshold frequency in paragraph 1, and number the table rows that show emission from lowest to highest kinetic energy. These marks will help you trace what changes when frequency rises.

A Metal Plate Under Light

1. At a museum exhibit, light strikes a clean metal plate while a meter measures electrons escaping into a collector. Each photon carries energy E = hf, where f is frequency and h is Planck's constant. This metal needs a minimum energy W to release an electron. Its threshold frequency is 5.0×10^{14} Hz.

2. Above the threshold, an emitted electron's maximum kinetic energy is $K_{max} = hf - W$. The table shows this metal's predicted values. A graph of maximum kinetic energy against frequency would be a straight line above the threshold. Its slope is h, about 4.14×10^{-15} eV·s. Below the threshold, no electrons escape.

PREDICTED RESULTS FOR THE METAL PLATE

Frequency ($\times 10^{14}$ Hz)	Maximum kinetic energy (eV)
4.0	No emission
6.0	0.414
7.0	0.828
8.0	1.242

3. A collector records current when emitted electrons reach it. At a fixed frequency above threshold, doubling light intensity doubles the photon arrival rate, so current doubles if collection is complete. Intensity does not change an electron's maximum kinetic energy. Increasing frequency can start emission across the threshold, but at fixed intensity it does not necessarily increase current.

2 ANSWER WITH EVIDENCE

Use the passage

1. Use the 6.0 and 8.0 frequency rows to calculate the slope of a maximum-kinetic-energy-versus-frequency graph. Show the energy change divided by the frequency change.

2. Name two points on the emitting part of the frequency-versus-maximum-kinetic-energy graph. What shape should that part of the graph have?

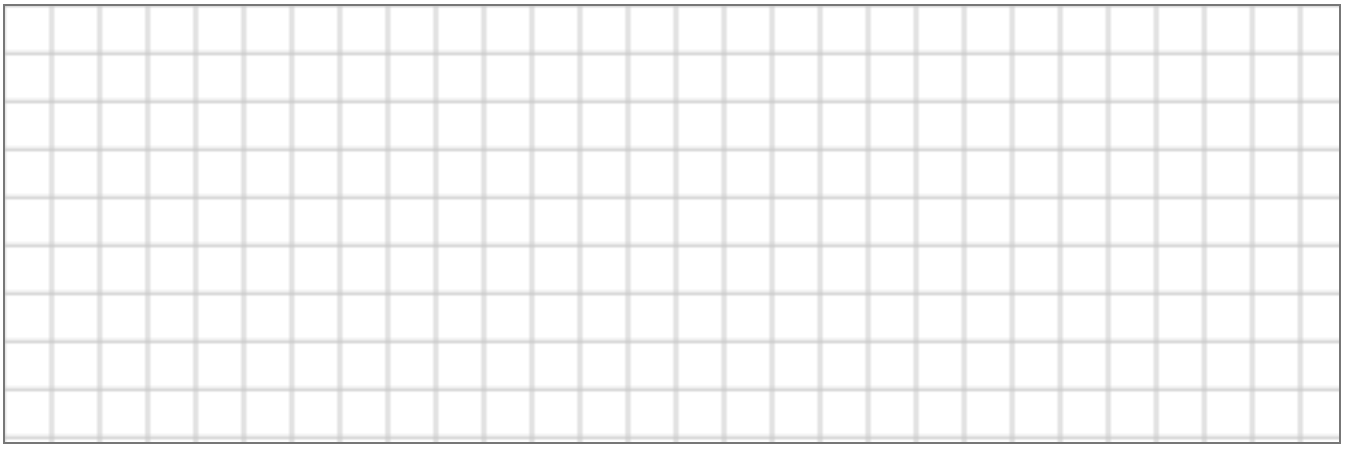
3. If light frequency changes from 4.0×10^{14} Hz to 6.0×10^{14} Hz, what changes about emission and current?

4. At 6.0×10^{14} Hz, a collector measures 2.0 microamperes with complete electron collection. Predict the current and maximum kinetic energy if light intensity doubles.

3 YOUR TURN

Your own words

On the grid, put frequency ($\times 10^{14}$ Hz) on the horizontal axis and maximum kinetic energy (eV) on the vertical axis. Plot the emitting rows, extend their line back to the threshold, mark the no-emission region, and add a short note predicting what doubling intensity at 7.0×10^{14} Hz does to current and maximum kinetic energy.



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PART 1 · READ AND MARK

Underline the equation for maximum kinetic energy, circle the numerical threshold frequency in paragraph 1, and number the table rows that show emission from lowest to highest kinetic energy. These marks will help you trace what changes when frequency rises. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Use the 6.0 and 8.0 frequency rows to calculate the slope of a maximum-kinetic-energy-versus-frequency graph. Show the energy change divided by the frequency change.	**(1.242 − 0.414) eV ÷ [(8.0 − 6.0) × 10^{14} Hz] = 0.828 eV ÷ (2.0 × 10^{14} Hz) = 4.14 × 10^{-15} eV·s.**
2	Name two points on the emitting part of the frequency-versus-maximum-kinetic-energy graph. What shape should that part of the graph have?	**For example, (6.0 × 10^{14} Hz, 0.414 eV) and (7.0 × 10^{14} Hz, 0.828 eV). The emitting points lie on a straight line.**
3	If light frequency changes from 4.0 × 10^{14} Hz to 6.0 × 10^{14} Hz, what changes about emission and current?	**At 4.0 × 10^{14} Hz, no electrons escape, so there is no photoelectric current. At 6.0 × 10^{14} Hz, electrons escape and can produce current.**
4	At 6.0 × 10^{14} Hz, a collector measures 2.0 microamperes with complete electron collection. Predict the current and maximum kinetic energy if light intensity doubles.	**Current doubles to 4.0 microamperes. Maximum kinetic energy stays at 0.414 eV.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

The horizontal axis is frequency (× 10^{14} Hz), and the vertical axis is maximum kinetic energy (eV). Plot (6.0, 0.414), (7.0, 0.828), and (8.0, 1.242) on a straight line that reaches 0 eV at 5.0. Mark frequencies below 5.0 as no emission. Note: At 7.0 × 10^{14} Hz, doubling intensity doubles the current if collection is complete, while maximum kinetic energy stays 0.828 eV.

Accept equivalent axis scales and slope calculations with correct units. The line represents emitted electrons only; students should mark frequencies below the threshold as no emission, not as negative kinetic energy.