



AP[®] Physics B (Operational) 2004 Sample Student Responses

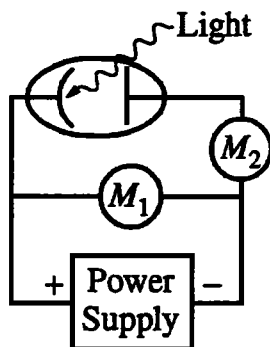
The materials included in these files are intended for noncommercial use by AP teachers for course and exam preparation; permission for any other use must be sought from the Advanced Placement Program[®]. Teachers may reproduce them, in whole or in part, in limited quantities, for face-to-face teaching purposes but may not mass distribute the materials, electronically or otherwise. This permission does not apply to any third-party copyrights contained herein. These materials and any copies made of them may not be resold, and the copyright notices must be retained as they appear here.

The College Board is a not-for-profit membership association whose mission is to connect students to college success and opportunity. Founded in 1900, the association is composed of more than 4,500 schools, colleges, universities, and other educational organizations. Each year, the College Board serves over three million students and their parents, 23,000 high schools, and 3,500 colleges through major programs and services in college admissions, guidance, assessment, financial aid, enrollment, and teaching and learning. Among its best-known programs are the SAT[®], the PSAT/NMSQT[®], and the Advanced Placement Program[®] (AP[®]). The College Board is committed to the principles of excellence and equity, and that commitment is embodied in all of its programs, services, activities, and concerns.

For further information, visit www.collegeboard.com

Copyright © 2004 College Entrance Examination Board. All rights reserved. College Board, Advanced Placement Program, AP, AP Central, AP Vertical Teams, APCD, Pacesetter, Pre-AP, SAT, Student Search Service, and the acorn logo are registered trademarks of the College Entrance Examination Board. PSAT/NMSQT is a registered trademark of the College Entrance Examination Board and National Merit Scholarship Corporation. Educational Testing Service and ETS are registered trademarks of Educational Testing Service. Other products and services may be trademarks of their respective owners.

For the College Board's online home for AP professionals, visit AP Central at apcentral.collegeboard.com.



6. (10 points)

A student performs a photoelectric effect experiment in which light of various frequencies is incident on a photosensitive metal plate. This plate, a second metal plate, and a power supply are connected in a circuit, which also contains two meters, M_1 and M_2 , as shown above.

The student shines light of a specific wavelength λ onto the plate. The voltage on the power supply is then adjusted until there is no more current in the circuit, and this voltage is recorded as the stopping potential V_S .

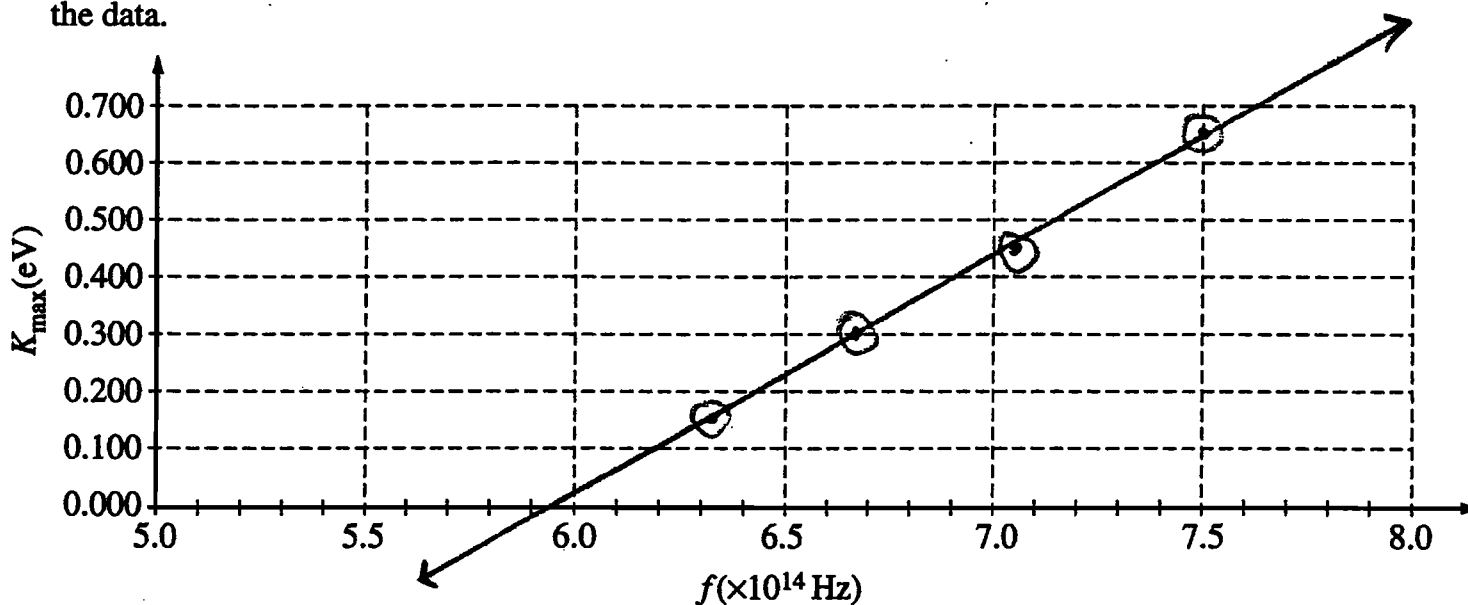
The student then repeats the experiment several more times with different wavelengths of light. The data, along with other values calculated from it, are recorded in the table below.

| | | | | |
|-----------------|-----------------------|-----------------------|-----------------------|-----------------------|
| λ (m) | 4.00×10^{-7} | 4.25×10^{-7} | 4.50×10^{-7} | 4.75×10^{-7} |
| V_S (volts) | 0.65 | 0.45 | 0.30 | 0.15 |
| f (Hz) | 7.50×10^{14} | 7.06×10^{14} | 6.67×10^{14} | 6.32×10^{14} |
| K_{\max} (eV) | 0.65 | 0.45 | 0.30 | 0.15 |

(a) Indicate which meter is used as an ammeter and which meter is used as a voltmeter by checking the appropriate spaces below.

| | | |
|-----------|-------------------------|-------------------------|
| | <u>M_1</u> | <u>M_2</u> |
| Ammeter | _____ | ✓ _____ |
| Voltmeter | ✓ _____ | _____ |

(b) Use the data above to plot a graph of K_{\max} versus f on the axes below, and sketch a best-fit line through the data.



GO ON TO THE NEXT PAGE.

(c) Use the best-fit line you sketched in part (b) to calculate an experimental value for Planck's constant.

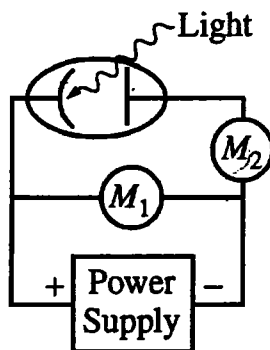
$$h = \frac{\Delta K_{\max}}{\Delta f} = \frac{(0.30 \text{ eV} - 0.15 \text{ eV})}{(6.67 \times 10^{14} \text{ Hz} - 6.32 \times 10^{14} \text{ Hz})}$$

$$h = 4.29 \times 10^{-15} \text{ eV} \cdot \text{s}$$

(d) If the student had used a different metal with a larger work function, how would the graph you sketched in part (b) be different? Explain your reasoning.

$$K_{\max} = hf - \phi$$

If a metal was used with a larger work function, meaning ϕ was greater, then K_{\max} would have been less for each data point, thus shifting the entire graph down a certain number of units. However, a larger work function does not affect the relationship between K_{\max} and f meaning that the slope of the graph K_{\max} vs f would be the same. The K_{\max} of all the points would be reduced equally (by some $\phi_{\text{new}} - \phi_{\text{old}}$) and therefore the change in K_{\max} would not be affected (the change in ϕ would cancel each other out.) Therefore the experimental value for Planck's constant, $\Delta K_{\max} / \Delta f$, would not be affected.



6. (10 points)

A student performs a photoelectric effect experiment in which light of various frequencies is incident on a photosensitive metal plate. This plate, a second metal plate, and a power supply are connected in a circuit, which also contains two meters, M_1 and M_2 , as shown above.

The student shines light of a specific wavelength λ onto the plate. The voltage on the power supply is then adjusted until there is no more current in the circuit, and this voltage is recorded as the stopping potential V_S .

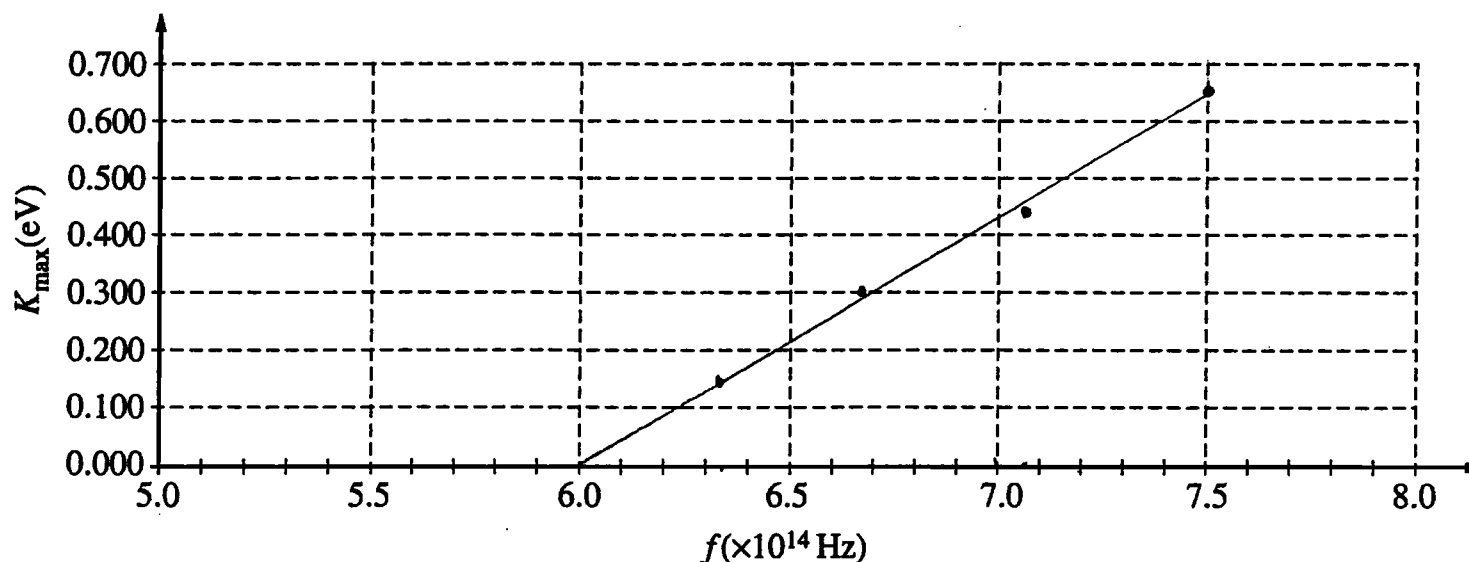
The student then repeats the experiment several more times with different wavelengths of light. The data, along with other values calculated from it, are recorded in the table below.

| | | | | |
|-----------------|-----------------------|-----------------------|-----------------------|-----------------------|
| λ (m) | 4.00×10^{-7} | 4.25×10^{-7} | 4.50×10^{-7} | 4.75×10^{-7} |
| V_S (volts) | 0.65 | 0.45 | 0.30 | 0.15 |
| f (Hz) | 7.50×10^{14} | 7.06×10^{14} | 6.67×10^{14} | 6.32×10^{14} |
| K_{\max} (eV) | 0.65 | 0.45 | 0.30 | 0.15 |

(a) Indicate which meter is used as an ammeter and which meter is used as a voltmeter by checking the appropriate spaces below.

| | | |
|-----------|---|---|
| | M_1 | M_2 |
| Ammeter | _____ | _____ <input checked="" type="checkbox"/> |
| Voltmeter | _____ <input checked="" type="checkbox"/> | _____ |

(b) Use the data above to plot a graph of K_{\max} versus f on the axes below, and sketch a best-fit line through the data.



GO ON TO THE NEXT PAGE.

(c) Use the best-fit line you sketched in part (b) to calculate an experimental value for Planck's constant.

$$h_{\text{experimental}} = \text{slope } e = \frac{\Delta y}{\Delta x}$$

$$h = \frac{(.65 - .15)}{(7.5 \times 10^{14} - 6 \times 10^{14})} = \frac{.5}{1.5 \times 10^{14}}$$

$$h_{\text{exp.}} = 3.33 \times 10^{-15} \text{ eV}\cdot\text{s}$$

(d) If the student had used a different metal with a larger work function, how would the graph you sketched in part (b) be different? Explain your reasoning.

The graph would have been moved to the right in regard to the x-axis, but with the same slope. For a plate with a larger work function, the frequency of light needed for the photoelectric effect would increase, thus moving the graph to the right (see picture).

