AP Physics B
2000 Student Samples

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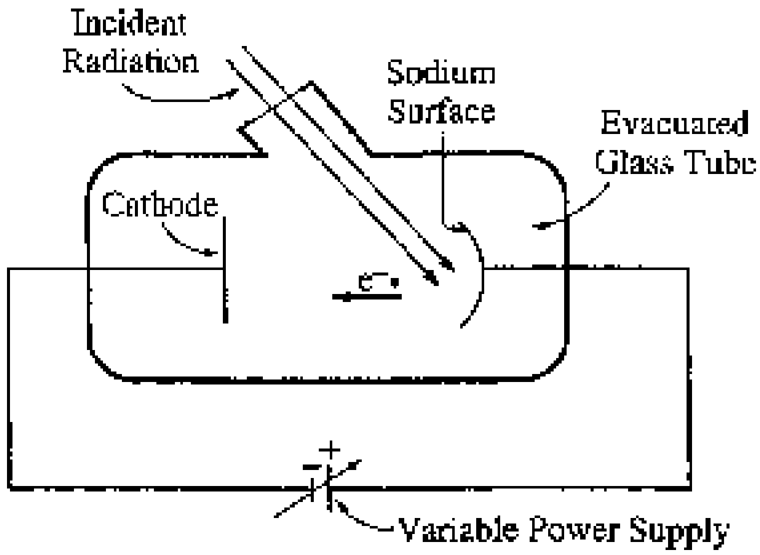
W1



5. (10 points)

A sodium photoelectric surface with work function 2.3 eV is illuminated by electromagnetic radiation and emits electrons. The electrons travel toward a negatively charged cathode and complete the circuit shown above. The potential difference supplied by the power supply is increased, and when it reaches 4.5 V, no electrons reach the cathode.

(a) For the electrons emitted from the sodium surface, calculate the following.

i. The maximum kinetic energy

$K.E_{max} = eV_0 \quad W_0 = 2.3\,eV$

$V_0 = 4.5\,v$

$K.E_{max} = 4.5\,eV$

ii. The speed at this maximum kinetic energy

$K.E = \frac{1}{2}mv^2 \quad 1\,eV = 1.60 \times 10^{-19}\,J$

$K.E = 7.2 \times 10^{-19}\,J = \frac{1}{2}(9.11 \times 10^{-31}\,kg)(v)^2$

$v \approx 1.26 \times 10^{6}\,m/s$

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W2

(b) Calculate the wavelength of the radiation that is incident on the sodium surface.

$\lambda = \frac{h}{p}$

mv

$E = hf \quad E = K.E_{max} + W_o$

$E = 4.5eV + 2.3eV \quad E = 6.8eV$

$10.88 \times 10^{-19} \quad pc = p(3 \times 10^8 m/s) \quad p = 3.63\ kg \cdot m/s$

$\lambda = 1.82 \times 10^{-7} m$ or $182 nm$

(c) Calculate the minimum frequency of light that will cause photoemission from this sodium surface.

$\lambda_{max} = ? \quad f_{min} = ?$

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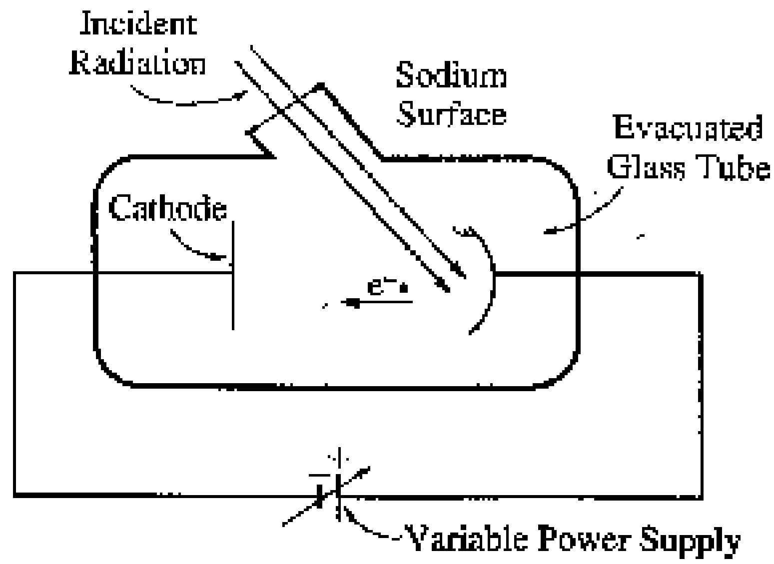
Y1



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A sodium photoelectric surface with work function 2.3 eV is illuminated by electromagnetic radiation and emits electrons. The electrons travel toward a negatively charged cathode and complete the circuit shown above. The potential difference supplied by the power supply is increased, and when it reaches 4.5 V, no electrons reach the cathode.

(a) For the electrons emitted from the sodium surface, calculate the following.

i. The maximum kinetic energy

$K_{max} = eV - \phi$

$= 4.5 - 2.3$

$= 2.2\,eV$

$= 3.52 \cdot 10^{-19}\,J$

ii. The speed at this maximum kinetic energy

$KE = \frac{1}{2}mv^2$

$v^2 = \frac{2KE}{m}$

$v = \sqrt{\frac{2KE}{m}}$

$= \sqrt{\frac{2 \cdot 3.52 \cdot 10^{-19}}{9.11 \cdot 10^{-31}}}$

$= 8.8 \cdot 10^5\,m/s$

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(b) Calculate the wavelength of the radiation that is incident on the sodium surface.

$v = f\lambda$ $\quad \lambda = \frac{v}{f}$ $\quad \lambda = \frac{8.8 \cdot 10^5}{1.09 \cdot 10^{15}} = \boxed{8.1 \cdot 10^{-10} m}$

$K_{max} = hf - \varnothing = eV - \varnothing$

$hf = eV$

$f = \frac{eV}{h} = \frac{(4.5)(1.6 \cdot 10^{-19})}{6.63 \cdot 10^{-34}} = 1.09 \cdot 10^{15}\ Hz$

(c) Calculate the minimum frequency of light that will cause photoemission from this sodium surface.

~~$2.3 \cdot 1.6 \cdot 10^{-19} = 3.68 \cdot 10^{-19} J = \frac{1}{2}mv$~~

~~$v = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{2 \cdot 3.68 \cdot 10^{-19}}{9.11 \cdot 10^{-31}}} = 9 \cdot 10^5 m/s$~~

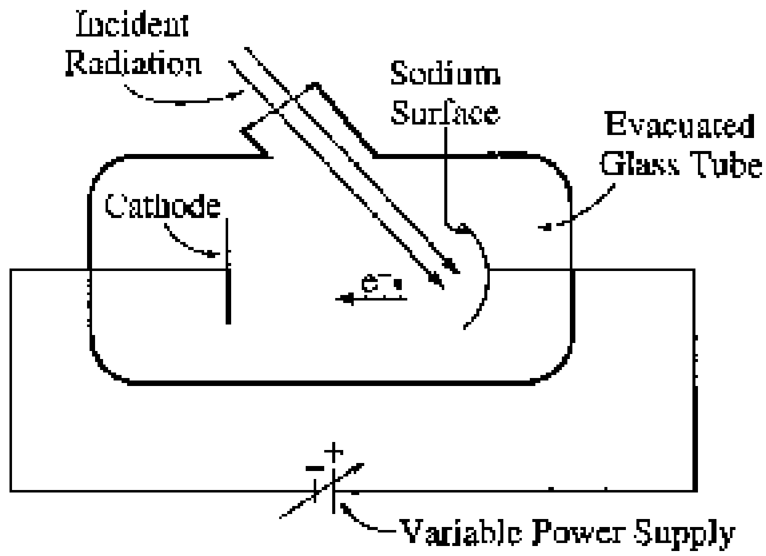
~~$v = f\lambda$~~

$hf - \varnothing = 0$

$hf = \varnothing$

$f = \frac{\varnothing}{h} = \frac{2.3 \cdot 1.6 \cdot 10^{-19}}{6.63 \cdot 10^{-34}} = \boxed{5.6 \cdot 10^{14}\ Hz}$

VI



5. (10 points)

A sodium photoelectric surface with work function 2.3 eV is illuminated by electromagnetic radiation and emits electrons. The electrons travel toward a negatively charged cathode and complete the circuit shown above. The potential difference supplied by the power supply is increased, and when it reaches 4.5 V, no electrons reach the cathode.

(a) For the electrons emitted from the sodium surface, calculate the following.

i. The maximum kinetic energy

$K_{max} = hf - \phi$

$\phi = 2.3\ eV$

$h = 4.14 \times 10^{-15}\ eVs$

when $K_{max} < V \cdot e$, no electrons reach the cathode

$K_{max} = 4.5\ eV = 4.5\ \frac{J}{C} \cdot 1.6 \times 10^{-19} C = 7.2 \times 10^{-19}\ J$

ii. The speed at this maximum kinetic energy

$E_k = \frac{1}{2} m v^2$

$v^2 = \frac{2 E_k}{m}$

$v = \sqrt{\frac{2 E_k}{m}}$

$m = 9.11 \times 10^{-31}$

$v = 1258112\ \frac{m}{s}$

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V2

(b) Calculate the wavelength of the radiation that is incident on the sodium surface.

$K_{max} = hf - \phi$

$\phi = 2.3\ eV$, $h = 4.14 \times 10^{-15}\ eV \cdot s$

$c = f\lambda$

$f = \frac{c}{\lambda}$

$K_{max} = h\frac{c}{\lambda} - 2.3\ eV$

$4.5\ eV = h\frac{c}{\lambda} - 2.3\ eV$

$c = 3 \times 10^{8}\ \frac{m}{s}$

$\frac{6.8\ eV}{h} = \frac{c}{\lambda}$

$\lambda = \frac{c}{1.64 \times 10^{15}\ s}$

$1.64 \times 10^{15}/s = \frac{c}{\lambda}$

$\lambda = 1.826 \times 10^{-7}\ m$

(c) Calculate the minimum frequency of light that will cause photoemission from this sodium surface.

$K = hf - \phi$

for photoemission to occur → k must be greater than 0

$0 = hf - \phi$

$\phi = hf$

$f = \frac{\phi}{h} = \frac{2.3\ eV}{4.14 \times 10^{-15}\ eVs}$

$f = 5.555 \times 10^{14}\ \frac{1}{s} = 5.555 \times 10^{14}\ Hz$

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