NAME ______________________ DATE ______________ CLASS ________________

Atomic Physics

Problem B

THE PHOTOELECTRIC EFFECT

PROBLEM

Light of wavelength 3.5×10^{-7} m shines on a cesium surface. Cesium has a work function of 2.14 eV. What is the maximum kinetic energy of the photoelectrons?

SOLUTION

Given: $\lambda = 3.5 \times 10^{-7}$ m $\quad hf_t = 2.14$ eV

Unknown: $KE_{max} = ?$

Choose the equation(s) or situation: Use the equation for the maximum kinetic energy of a photoelectron, given on page 835.

$$KE_{max} = hf - hf_t = \frac{hc}{\lambda} - hf_t$$

$$KE_{max} = \frac{(6.63 \times 10^{-34}\ \mathrm{J \cdot s})(3.0 \times 10^{8}\ \mathrm{m/s})}{(1.60 \times 10^{-19}\ \mathrm{J/eV})(3.5 \times 10^{-7}\ \mathrm{m})} - 2.14\ \mathrm{eV}$$

$$KE_{max} = \boxed{1.41\ \mathrm{eV}}$$

ADDITIONAL PRACTICE

1. Light of wavelength 240 nm shines on a potassium surface. Potassium has a work function of 2.3 eV. What is the maximum kinetic energy of the photoelectrons?
2. Light of wavelength 519 nm shines on a rubidium surface. Rubidium has a work function of 2.16 eV. What is the maximum kinetic energy of the photoelectrons?
3. Light of frequency 6.5×10^{14} Hz illuminates a lithium surface. The ejected photoelectrons are found to have a maximum kinetic energy of 0.20 eV. Find the threshold frequency of this metal.
4. Light of frequency 9.89×10^{14} Hz illuminates a calcium surface. The ejected photoelectrons are found to have a maximum kinetic energy of 0.90 eV. Find the threshold frequency of this metal.
5. The threshold frequency of platinum is 1.36×10^{15} Hz. What is the work function of platinum?
6. The threshold frequency of copper is 1.1×10^{15} Hz. What is the work function of copper?
7. Manganese has a work function of 4.1 eV. What is the wavelength of the photon that will just have the threshold energy for manganese?

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8. Cobalt has a work function of 5.0 eV. What is the wavelength of the photon that will just have the threshold energy for cobalt?

9. Light shines on a photoelectric metal and the maximum kinetic energy is measured to be 0.6 eV. What is the speed of the photoelectrons?

10. Light shines on a photoelectric metal and the maximum kinetic energy is measured to be 1.2 eV. What is the speed of the photoelectrons?

Problem Bank Answers

Atomic Physics

Additional Practice A

Givens	*Solutions*
1. $\lambda = 527\text{ nm} = 5.27 \times 10^{-7}\text{ m}$	$E = hf = \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34}\text{ J}\bullet\text{s})(3.00 \times 10^{8}\text{ m/s})}{5.27 \times 10^{-7}\text{ m}} = \boxed{3.77 \times 10^{-19}\text{ J}}$
2. $\lambda = 430.8\text{ nm} = 4.308 \times 10^{-7}\text{ m}$	$E = hf = \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34}\text{ J}\bullet\text{s})(3.00 \times 10^{8}\text{ m/s})}{4.308 \times 10^{-7}\text{ m}} = \boxed{4.62 \times 10^{-22}\text{ J}}$
3. $E = 20.7\text{ eV}$	$f = \frac{E}{h} = \frac{(20.7\text{ eV})(1.60 \times 10^{-19}\text{ J/eV})}{6.63 \times 10^{-34}\text{ J}\bullet\text{s}} = \boxed{5.00 \times 10^{15}\text{ Hz}}$
4. $E = 1.24 \times 10^{-3}\text{ eV}$	$f = \frac{E}{h} = \frac{(1.24 \times 10^{-3}\text{ eV})(1.60 \times 10^{-19}\text{ J/eV})}{6.63 \times 10^{-34}\text{ J}\bullet\text{s}} = \boxed{2.99 \times 10^{11}\text{ Hz}}$
5. $E = 1.78\text{ eV}$	$f = \frac{E}{h} = \frac{(1.78\text{ eV})(1.60 \times 10^{-19}\text{ J/eV})}{6.63 \times 10^{-34}\text{ J}\bullet\text{s}} = \boxed{4.30 \times 10^{14}\text{ Hz}}$
6. $E = 12.4\text{ MeV} = 1.24 \times 10^{7}\text{ eV}$	$\lambda = \frac{hc}{E} = \frac{(6.63 \times 10^{-34}\text{ J}\bullet\text{s})(3.00 \times 10^{8}\text{ m/s})}{(1.24 \times 10^{7}\text{ eV})(1.60 \times 10^{-19}\text{ J/eV})} = \boxed{1.00 \times 10^{-13}\text{ m}}$
7. $E = 939.57\text{ MeV} = 9.3957 \times 10^{8}\text{ eV}$	$\lambda = \frac{hc}{E} = \frac{(6.63 \times 10^{-34}\text{ J}\bullet\text{s})(3.00 \times 10^{8}\text{ m/s})}{(9.3957 \times 10^{8}\text{ eV})(1.60 \times 10^{-19}\text{ J/eV})} = \boxed{1.32 \times 10^{-15}\text{ m}}$ $1.32 \times 10^{-15}\text{ m} = 1.32 \times 10^{-6}\text{ nm}$ If a photon were to have this wavelength, it would not lie within the visible part of the spectrum.
8. $E = 3.1 \times 10^{-6}\text{ eV}$	$\lambda = \frac{hc}{E} = \frac{(6.63 \times 10^{-34}\text{ J}\bullet\text{s})(3.00 \times 10^{8}\text{ m/s})}{(3.1 \times 10^{-6}\text{ eV})(1.60 \times 10^{-19}\text{ J/eV})} = \boxed{0.401\text{ m}}$

Additional Practice B

1. $\lambda = 240\text{ nm} = 2.4 \times 10^{-7}\text{ m}$ $hf_t = 2.3\text{ eV}$	$KE_{max} = \frac{hc}{\lambda} - hf_t$ $KE_{max} = \frac{(6.63 \times 10^{-34}\text{ J}\bullet\text{s})(3.00 \times 10^{8}\text{ m/s})}{2.4 \times 10^{-7}\text{ m})(1.60 \times 10^{-19}\text{ J/eV})} - 2.3\text{ eV}$ $KE_{max} = 5.2\text{ eV} - 2.3\text{ eV} = \boxed{2.9\text{ eV}}$

Givens	Solutions
2. $\lambda = 519\ \text{nm} = 5.19 \times 10^{-7}\ \text{m}$ $hf_t = 2.16\ \text{eV}$	$KE_{max} = \dfrac{hc}{\lambda} - hf_t$ $KE_{max} = \dfrac{(6.63 \times 10^{-34}\ \text{J}\bullet\text{s})(3.00 \times 10^8\ \text{m/s})}{(5.19 \times 10^{-7}\ \text{m})(1.60 \times 10^{-19}\ \text{J/eV})} - 2.16\ \text{eV}$ $KE_{max} = 2.40\ \text{eV} - 2.16\ \text{eV} = \boxed{0.24\ \text{eV}}$
3. $f = 6.5 \times 10^{14}\ \text{Hz}$ $KE_{max} = 0.20\ \text{eV}$	$f_t = \dfrac{hf - KE_{max}}{h}$ $f_t = \dfrac{[(6.63 \times 10^{-34}\ \text{J}\bullet\text{s})(6.5 \times 10^{14}\ \text{Hz}) - (0.20\ \text{eV})(1.60 \times 10^{-19}\ \text{J/eV})]}{6.63 \times 10^{-34}\ \text{J}\bullet\text{s}}$ $f_t = \boxed{6.0 \times 10^{14}\ \text{Hz}}$
4. $f = 9.89 \times 10^{14}\ \text{Hz}$ $KE_{max} = 0.90\ \text{eV}$	$f_t = \dfrac{hf - KE_{max}}{h}$ $f_t = \dfrac{(6.63 \times 10^{-34}\ \text{J}\bullet\text{s})(9.89 \times 10^{14}\ \text{Hz}) - (0.90\ \text{eV})(1.60 \times 10^{-19}\ \text{J/eV})}{6.63 \times 10^{-34}\ \text{J}\bullet\text{s}}$ $f_t = \boxed{7.72 \times 10^{14}\ \text{Hz}}$
5. $f_t = 1.36 \times 10^{15}\ \text{Hz}$	$hf_t = \dfrac{(6.63 \times 10^{-34}\ \text{J}\bullet\text{s})(1.36 \times 10^{15}\ \text{Hz})}{1.60 \times 10^{-19}\ \text{J/eV}} = \boxed{5.64\ \text{eV}}$
6. $f_t = 1.1 \times 10^{15}\ \text{Hz}$	$hf_t = \dfrac{(6.63 \times 10^{-34}\ \text{J}\bullet\text{s})(1.1 \times 10^{15}\ \text{Hz})}{1.60 \times 10^{-19}\ \text{J/eV}} = \boxed{4.6\ \text{eV}}$
7. $hf_t = 4.1\ \text{eV}$	$\lambda = \dfrac{hc}{E} = \dfrac{(6.63 \times 10^{-34}\ \text{J}\bullet\text{s})(3.00 \times 10^8\ \text{m/s})}{(4.1\ \text{eV})(1.60 \times 10^{-19}\ \text{eV})} = 3.0 \times 10^{-7}\ \text{m} = \boxed{300\ \text{nm}}$
8. $hf_t = 5.0\ \text{eV}$	$\lambda = \dfrac{hc}{E} = \dfrac{(6.63 \times 10^{-34}\ \text{J}\bullet\text{s})(3.00 \times 10^8\ \text{m/s})}{(5.0\ \text{eV})(1.60 \times 10^{-19}\ \text{eV})} = 2.5 \times 10^{-7}\ \text{m} = \boxed{250\ \text{nm}}$
9. $KE_{max} = 0.62\ \text{V}$ $m_e = 9.109 \times 10^{-31}\ \text{kg}$	$KE_{max} = h_f - hf_t = \frac{1}{2} m_e v^2$ $v = \sqrt{\dfrac{2KE_{max}}{m_e}} = \sqrt{\dfrac{2(0.62\ \text{eV})(1.60 \times 10^{-19}\ \text{J/eV})}{9.109 \times 10^{-31}\ \text{kg}}}$ $v = \boxed{4.7 \times 10^5\ \text{m/s}}$
10. $KE_{max} = 1.2\ \text{eV}$ $m_e = 9.109 \times 10^{-31}\ \text{kg}$	$KE_{max} = hf - hf_t = \frac{1}{2} m_e v^2$ $v = \sqrt{\dfrac{2KE_{max}}{m_e}} = \sqrt{\dfrac{2(1.2\ \text{eV})(1.60 \times 10^{-19}\ \text{eV})}{9.109 \times 10^{-31}\ \text{kg}}}$ $v = \boxed{6.5 \times 10^5\ \text{m/s}}$

V