Chapter 40 Solutions

40.9 Each photon has an energy $E = hf = (6.626 \infty 10^{-34})(99.7 \infty 10^{6}) = 6.61 \infty 10^{-26}$ J

This implies that there are $\dfrac{150 \infty 10^{3} \text{ J/s}}{6.61 \infty 10^{-26} \text{ J/photons}}$ =

$\boxed{2.27 \infty 10^{30} \text{ photons/s}}$

40.16 $K_{\text{max}} = \frac{1}{2} m v_{\text{max}}^{2} = \frac{1}{2}(9.11 \infty 10^{-31})(4.60 \infty 10^{5})^{2} = 9.64 \infty 10^{-20} \text{ J} =$ 0.602 eV

(a) $\phi = E - K_{\text{max}} = \dfrac{1240 \text{ eV} \cdot \text{nm}}{625 \text{ nm}} - 0.602 \text{ eV} = \boxed{1.38 \text{ eV}}$

(b) $f_c = \dfrac{\phi}{h} = \dfrac{1.38 \text{ eV}}{6.626 \infty 10^{-34} \text{ J} \cdot \text{s}} \left(\dfrac{1.60 \infty 10^{-19} \text{ J}}{1 \text{ eV}} \right) = \boxed{3.34 \infty 10^{14} \text{ Hz}}$

40.20 From the photoelectric equation, we have: $e(\Delta V_{S1}) = E_{\gamma 1} - \phi$

and $e(\Delta V_{S2}) = E_{\gamma 2} - \phi$

Since $\Delta V_{S2} = 0.700(\Delta V_{S1})$, then

$$e(\Delta V_{S2}) = 0.700(E_{\gamma 1} - \phi) = E_{\gamma 2} - \phi$$

or

$$(1 - 0.700)\phi = E_{\gamma 2} - 0.700 E_{\gamma 1}$$

and the work function is: $\phi = \dfrac{E_{\gamma 2} - 0.700\, E_{\gamma 1}}{0.300}$

The photon energies are:

$$E_{\gamma 1} = \frac{hc}{\lambda_1} = \frac{1240 \text{ nm} \cdot \text{eV}}{410 \text{ eV}} = 3.03 \text{ eV}$$

and

$$E_{\gamma 2} = \frac{hc}{\lambda_2} = \frac{1240 \text{ nm} \cdot \text{eV}}{445 \text{ eV}} = 2.79 \text{ eV}$$

Thus, the work function is

$$\phi = \frac{2.79 \text{ eV} - 0.700(3.03 \text{ eV})}{0.300} = 2.23 \text{ eV}$$

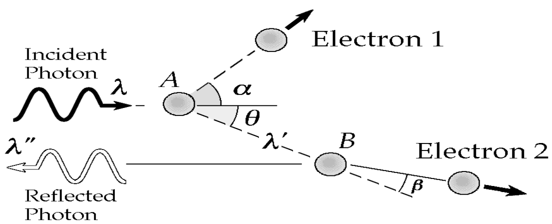
and we recognize this as characteristic of $\boxed{\text{potassium}}$.

40.32 $$\lambda' - \lambda = \frac{h}{m_e c}(1 - \cos\theta)$$

$$\lambda'' - \lambda' = \frac{h}{m_e c}\left[1 - \cos(\pi - \theta)\right]$$

$$\lambda'' - \lambda = \frac{h}{m_e c} - \frac{h}{m_e c}\cos(\pi - \theta) + \frac{h}{m_e c} - \frac{h}{m_e c}\cos\theta$$

Now $\cos(\pi - \theta) = -\cos\theta$, so $\lambda'' - \lambda = 2\frac{h}{m_e c} = \boxed{0.00486 \text{ nm}}$



40.38 (a) $\lambda_{\min} = \frac{hc}{E_{\max}}$

Lyman ($n_f = 1$): $\lambda_{\min} = \frac{hc}{|E_1|} = \frac{1240 \text{ eV}\cdot\text{nm}}{13.6 \text{ eV}} = \boxed{91.2 \text{ nm}}$

(Ultraviolet)

Balmer ($n_f = 2$): $\lambda_{\min} = \frac{hc}{|E_2|} = \frac{1240 \text{ eV}\cdot\text{nm}}{\left(\frac{1}{4}\right)13.6 \text{ eV}} = \boxed{365 \text{ nm}}$ (UV)

Paschen ($n_f = 3$): $\lambda_{\min} = \ . \ . \ . = 3^2(91.2 \text{ nm}) = \boxed{821 \text{ nm}}$

(Infrared)

Bracket ($n_f = 4$): $\lambda_{\min} = \ . \ . \ . = 4^2(91.2 \text{ nm}) = \boxed{1460 \text{ nm}}$ (IR)

(b) $E_{\max} = \frac{hc}{\lambda_{\min}}$

Lyman: $E_{\max} = \boxed{13.6 \text{ eV}}$ $\left(= |E_1|\right)$

Balmer: $E_{\max} = \boxed{3.40 \text{ eV}}$ $\left(= |E_2|\right)$

Paschen: $E_{\max} = \boxed{1.51 \text{ eV}}$ $\left(= |E_3|\right)$

Brackett: $E_{\max} = \boxed{0.850 \text{ eV}}$ $\left(= |E_4|\right)$

***40.44** We use $E_n = \dfrac{-13.6\text{ eV}}{n^2}$

To ionize the atom when the electron is in the n^{th} level, it is necessary to add an amount of energy given by

$$E = -E_n = \frac{13.6\text{ eV}}{n^2}$$

(a) Thus, in the ground state where $n = 1$, we have $\boxed{E = 13.6\text{ eV}}$

(b) In the $n = 3$ level, $E = \dfrac{13.6\text{ eV}}{9} = \boxed{1.51\text{ eV}}$