Balmer's formula for hydrogen wavelengths

$$\frac{1}{\lambda} = R\left[\frac{1}{N^2} - \frac{1}{n^2}\right]$$

N = number of inner orbit

n = number of outer orbit

R = Rydberg constant (1.097×10^7 m^{-1})

λ = wavelength of emitted or absorbed photon

Comparison with *Practicing Physics* 23.4

$$E = \frac{hc}{\lambda} \Rightarrow \frac{1}{\lambda} = \frac{E}{hc}$$

$$\frac{1}{\lambda} = \frac{E}{hc} = R\left[\frac{1}{N^2} - \frac{1}{n^2}\right]$$

$$E = hcR\left[\frac{1}{N^2} - \frac{1}{n^2}\right]$$

$$hcR = (1239\text{ eV}\cdot\text{nm})(1.097\times10^7\,/\,\text{m}) = (13.6\text{ eV})$$

$$E = hcR\left[\frac{1}{N^2} - \frac{1}{n^2}\right] \Rightarrow E = (13.6\text{ eV})\left[\frac{1}{N^2} - \frac{1}{n^2}\right]$$

$$\frac{1}{\lambda} = R\left[\frac{1}{N^2} - \frac{1}{n^2}\right]$$

$$\frac{1}{\lambda_\alpha} = (1.097 \times 10^7 \text{ m}^{-1})\left[\frac{1}{2^2} - \frac{1}{3^2}\right]$$

$$\lambda_\alpha = 656.3 \text{ nm}$$

What is the Energy?

- $E = hc/\lambda$
- E = (1239 eV nm)/(656.3 nm)
- E = 1.88 eV

Example

Electrons in an x-ray tube are accelerated by a potential difference of 10 kV. What is the wavelength of the emitted x-rays?

$E = hc/\lambda$ $\qquad$ $hc = 1240\ eV\cdot nm$

Answer

$E = hc/\lambda \rightarrow \lambda = hc/E$

$E = qV = (1e)(10\ kV) = 10\ keV$

$\lambda = (1240\ eV\cdot nm) / (10\ keV)$

$\lambda_{minimum} = 1240 \times 10^{-3}\ nm = .124\ nm$

10 keV electrons produce .124 nm wavelength X-rays. What would the wavelength be if V = 20 kV?