Solution to problems 4 & 5
Exam II

4 a. The Energy E is given by

$$E_n = \frac{n^2 h^2}{8mL^2} \qquad n = 1, 2, ..$$

Here, $L = 0.5\ nm = 0.5 \times 10^{-9}$ meters

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

$h = 6.63 \times 10^{-34}\ Js$

Plugging values

$$E_n = n^2 \times 2.4 \times 10^{-19}\ J$$

The first two levels are for $n=1$ and $n=2$

$E_{n=1} = 2.4 \times 10^{-19}\ J$

$E_{n=2} = 9.6 \times 10^{-19}\ J$

b. The energy lost must be the difference between $E_{n=2}$ and $E_{n=1}$

$\Rightarrow \Delta E = E_2 - E_1 = 7.2 \times 10^{-19}\ J$

c. The energy lost, calculated in b, must now be the energy of the electron (assuming no energy is lost)

$$\Rightarrow E_{photon} = \Delta E = 7.2 \times 10^{-19} J$$

We now recall that $E_{photon} = \frac{hc}{\lambda}$

$$\Rightarrow \frac{hc}{\lambda} = 7.2 \times 10^{-19}$$

$$\Rightarrow \lambda = \frac{h \cdot c}{7.2 \times 10^{-19}} = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{7.2 \times 10^{-19}}$$

$$= 2.76 \times 10^{-7} \text{ m}$$

$$= 276 \times 10^{-9} \text{ m} = 276 \text{ nm}$$

5. The width is given by

$$W = \frac{2\lambda L}{a}$$

here $a = 1\,\mu m = 10^{-6}$ m ; $L = 2$ m

To calculate λ, we use the de-Broglie relation

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

$$\Rightarrow W = \frac{2 \times \frac{h}{mv} \times L}{a} = \frac{2hL}{mva}$$

$$= \frac{2 \times 6.6 \times 10^{-34} \times 2}{9.1 \times 10^{-31} \times 4 \times 10^{6} \times 10^{-6}}$$

$$= 0.73 \times 10^{-3} \text{ m}$$

$$= 0.73 \text{ mm}$$