LECTURE 12

5) → 9) SELF STUDY.

1). $\lambda = 400\ nm \rightarrow 700\ nm$.

a) FREQUENCIES... $\lambda\nu = c$ $\quad \nu = \frac{c}{\lambda}$

400 nm ⇒ $\nu = \frac{3 \times 10^8}{400 \times 10^{-9}} = \frac{3}{4} \times 10^{15}$ Hz

$= 0.75 \times 10^{15}$ Hz $= 7.5 \times 10^{14}$ Hz.

700 nm ⇒ $\nu = \frac{3 \times 10^8}{700 \times 10^{-9}} = \frac{3}{7} \times 10^{15}$ Hz

$= 0.43 \times 10^{15}$ Hz $= 4.3 \times 10^{14}$ Hz.

n.b. 10^{12} Hz = THz so spm is also

430 — 750 THz.

b). Energies

$(h = 6.6 \times 10^{-34}\ m^2\, kg\, s^{-1})$.

$E = h\nu$

400 nm ⇒ $E = 6.6 \times 7.5 \times 10^{-34} \times 10^{14}$ J

$= 49.5 \times 10^{-20}$ J

$= 4.95 \times 10^{-19}$ J

$= \frac{4.95 \times 10^{-19}}{1.60 \times 10^{-19}}$ eV

$= 3.09$ eV

LECTURE 12

1) CONTD...

700 nm $$E = 6.6 \times 4.3 \times 10^{-34} \times 10^{14} \text{ J}$$
$$= 28.38 \times 10^{-20} \text{ J}$$
$$= \underline{\underline{2.838 \times 10^{-19}}} \text{ J}$$

$$= \frac{2.838 \times 10^{-19}}{1.60 \times 10^{-19}} \text{ eV}$$

$$= \underline{\underline{1.77 \text{ eV}}}.$$

LECTURE 12

2) . # of PHOTONS PER SECOND.

$$= \frac{\text{POWER (ENERGY / SECOND)}}{\text{ENERGY OF 1 PHOTON (ENERGY)}}$$

$\Rightarrow$ UNITS $\Rightarrow$ SECOND^{-1}

a) RED LASER $\lambda = 690$ nm. $P = 1$ mW

1 PHOTON ENERGY $= \frac{hc}{\lambda} \Rightarrow \frac{6.62 \times 2.99 \times 10^{-34} \times 10^{8}}{690 \times 10^{-9}}$ J

$$= \frac{6.62 \times 2.99}{6.9} \times 10^{-19} \text{ J}$$

$$= 2.869 \times 10^{-19} \text{ J.}$$

So @ 1 mW $\#/\text{sec} = \frac{1 \times 10^{-3}}{2.869 \times 10^{-19}}$ s^{-1}

$$= \underline{3.49 \times 10^{15}} \quad s^{-1}$$

b) μ Wave Freq $= 2.45$ GHz, $P = 750$ W.

1 PHOTON ENERGY $= h\nu = 6.62 \times 2.45 \times 10^{-34} \times 10^{9}$ J

$= 16.22 \times 10^{-25}$ J

$= \underline{1.62 \times 10^{-24} \text{ J.}}$

So @ 750 W $\#/\text{sec} = 750 / 1.62 \times 10^{-24}$ s^{-1}

$= 463 \times 10^{24}$ s^{-1} $= \underline{4.63 \times 10^{26} \; s^{-1}}$

LECTURE 12

3). $\lambda = \frac{h}{p}$ ← Planck's const. ← momentum

a) electron at Brillouin-Zone edge

$$p = k\hbar = \frac{\pi h}{2\pi a} = \frac{h}{2a}$$

look up a for GaAs → unit cell = 5.65 Å

$$\lambda = \frac{h}{p} = \frac{h2a}{h} = 2a = 1.13 \text{ nm}$$

b). Photon with energy = 1.42 eV

$$E = h\nu \;,\; \nu\lambda = c \;,\; \text{so } E = \frac{hc}{\lambda} \;,\; \therefore \lambda = \frac{hc}{E}$$

$$\lambda = \frac{6.626 \times 10^{-34} \times 3 \times 10^{8}}{1.42 \times 1.6 \times 10^{-19}} = \frac{6.626 \times 3}{1.42 \times 1.6} \times 10^{-7} \text{ m}$$

$$= 8.26 \times 10^{-7} \text{ m} = 0.826 \text{ µm or } 826 \text{ nm}$$

c) Assume he weighs 100kg (just for easy calculation!)

$$p = mv = 100 \times 10 = 1000 \text{ kg.m.s}^{-1}$$

$$\lambda = \frac{h}{p} = \frac{6.626 \times 10^{-34}}{1000} = 6.626 \times 10^{-37} \text{ m}$$

LECTURE 12

4). THIS IS "LIFETIME BROADENING" GOVERNED BY HEISENBERG'S U. P.

$$\Delta E \Delta t = \frac{\hbar}{2} = \frac{h}{4\pi}$$

$$\Delta E = \frac{h}{4\pi \Delta t} = \frac{6.626 \times 10^{-34}}{4 \times \pi \times 1 \times 10^{-12}} \text{ J}$$

$$= \frac{6.626}{4 \times \pi} \times 10^{-22} \text{ J}$$

$$= 0.527 \times 10^{-22} \text{ J}$$

$$= 5.27 \times 10^{-23} \text{ J.}$$

in eV...

$$= \frac{5.27 \times 10^{-23}}{1.60 \times 10^{-19}} \text{ eV}$$

$$= \underline{3.3 \text{ meV}}$$