Unit 3: Radiation & Matter

Energy transitions.

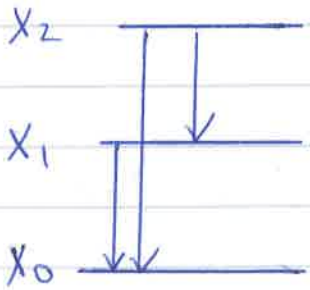
(1)

(a.) downwards energy level transitions,

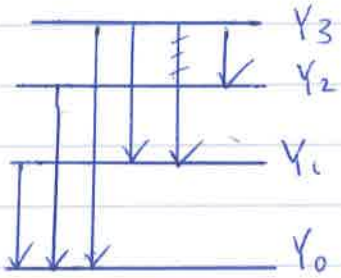
$X = 3$ $Y = 6$

(b) $X = 3$
$Y = 6$ (assuming all transitions are in visible range.)

(c) Atom X:



Atom Y:



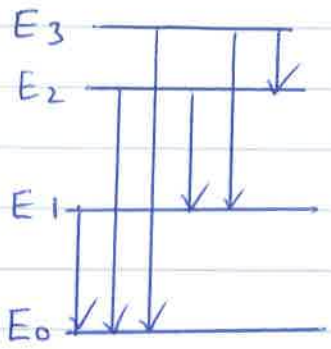
(d)

(i) Lowest frequency in X : $X_2 - X_1$
Lowest frequency in Y : $Y_3 - Y_2$.

(ii) shortest λ in X : $X_2 - X_0$
shortest λ in Y : $Y_3 - Y_0$

(2)

(a)



6 possible transitions.

(b)(i) largest energy transition : $E_3 - E_0$

$$= -2.62\times10^{-19} - (-15.83\times10^{-19})$$
$$= 1.321\times10^{-18}\ J$$

$$f = \frac{E}{h}$$

$$f = \frac{1.321\times10^{-18}}{6.63\times10^{-34}}$$

$$f = 1.99\times10^{15}\ Hz.$$

(ii) Smallest energy transition : $E_3 - E_2$

$$E = -2.62\times10^{-19} - (-4.08\times10^{-19})$$
$$E = 1.46\times10^{-19}\ J.$$

$$f = \frac{E}{h}$$

$$f = \frac{1.46\times10^{-19}}{6.63\times10^{-34}}$$

$$f = 2.2\times10^{14}\ Hz.$$

(c) Transition $E_3 - E_0$ is most likely to produce photons which would cause photoemission as the high frequency is in the UV range of ~~elem~~ electromagnetic spectrum.

(3) a) 6 lines as a result of 6 transitions.

b) Greatest energy : $E_3 - E_0$

$$E_3 - E_0 = hf$$
$$-5.5 \times 10^{-19} - -24.6 \times 10^{-19} = 6.63 \times 10^{-34} f$$
$$1.91 \times 10^{-18} = 6.663 \times 10^{-34} f$$
$$f = 2.88 \times 10^{15} \text{ Hz}$$

$$\lambda = \frac{v}{f}$$

$$= \frac{3 \times 10^8}{2.88 \times 10^{15}}$$

$$= \underline{104 \text{ nm}}$$

Least energy : $E_3 - E_2$

$$E_3 - E_2 = hf$$
$$-5.5 \times 10^{-19} - -9.4 \times 10^{-19} = 6.63 \times 10^{-34} f$$
$$3.9 \times 10^{-19} = 6.63 \times 10^{-34} f$$
$$f = 5.88 \times 10^{14} \text{ Hz}$$

$$\lambda = \frac{v}{f}$$

$$= \frac{3 \times 10^8}{5.88 \times 10^{14}}$$

$$= \underline{510 \text{ nm}}$$

(4) $\lambda = 589.6\text{nm}$ if photon is to be absorbed

(a)

$$\lambda = \frac{V}{f}$$

$$\lambda = \frac{3\times10^{8}}{5.085\times10^{14}}$$

$$\lambda = 590\text{nm}.$$

(b) $$f = \frac{E}{h}$$

$$f = \frac{3.369\times10^{-19}}{6.63\times10^{-34}}$$

$$f = 5.081\times10^{14}\text{Hz}.$$

$$\lambda = \frac{V}{f}.$$

$$\lambda = \frac{3\times10^{8}}{5.081\times10^{14}}$$

$$\lambda = 590\text{nm}.$$

Spectra

(5)(a) This kind of emission spectrum is called a line spectrum.

(b) When an electron falls to a lower energy level, it emits a photon. The energy of the photon depends on the difference in energy levels. The frequency of the depends on the energy of the photon. If the photon has a frequency that is in the visible region it will appear as a coloured line which corresponds to the photon's frequency.

(c) $f = \frac{v}{\lambda}$

$f = \frac{3 \times 10^8}{680 \times 10^{-9}}$

$f = 4.41 \times 10^{14}$ Hz

$E = hf$

$E = 6.63 \times 10^{-34} \times 4.41 \times 10^{14}$

$E = 2.93 \times 10^{-19}$ J

(d) A continuous spectra would be observed

(6) White light consists of radiation at all frequencies of the visible spectrum. Most of the photons will pass through the sodium vapour, however, some of the photons will have just the right energy (frequency) to excite electrons in the sodium vapour to higher energy levels (When the electrons fall, they emit photons of the same energy as those which were absorbed but in different directions.) The result is a continuous spectrum with dark lines which corresponds to the position of the lines of the emission spectrum of Sodium.

(7) (a) The dark lines are due to photons of certain energies being absorbed by relatively cooler gas round the sun.

(b) The position of the dark lines corresponds to the positions of the lines in the emission spectra of a number of elements. The lines indicate the presence of hydrogen, helium, sodium and other elements in the sun.

(8) (a) The sodium vapour lamp emits photons which have the right energy (frequency) to excite electrons in the sodium flame to higher energy levels. This results in a dark shadow as no photons strike the screen.

(b) The photons emitted by the cadmium lamp do not have the right energy (frequency) to excite electrons in the sodium flame. Hence photons strike the screen and there is no dark shadow as before.