INTRODUCTION TO NATURAL SCIENCE

CHEMISTRY HOMEWORK, WINTER 2007, WEEK 2

Chapter 7

(1) (a) microwaves (b) red light (c) infrared

(3)(a) green signal

(b) $$\nu = \frac{c}{\lambda} = \frac{3.00 \times 10^{8}\ \text{m s}^{-1}}{500\ \text{nm}} \times \boxed{\frac{10^{9}\ \text{nm}}{1\ \text{m}}} = \underline{6 \times 10^{14}\ \text{s}^{-1}}$$

(5) $$E = h\nu = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34}\ \text{J s})(3.00 \times 10^{8}\ \text{m s}^{-1})}{5.0 \times 10^{2}\ \text{nm}} \times \boxed{\frac{10^{9}\ \text{nm}}{1\ \text{m}}}$$

$$E_1 = 3.9756 \times 10^{-19}\ \text{J} = \underline{4.0 \times 10^{-19}\ \text{J}}$$

$$E_2 = nh\nu = \frac{nhc}{\lambda} = n(E_1) = (6.02 \times 10^{23}\ \text{mol}^{-1})(4.0 \times 10^{-19}\ \text{J})$$

$$= \underline{2.4 \times 10^{5}\ \text{J/mol}}$$

(8) 285.2 nm = UV region

383.8 nm, 518.4 nm } visible region (383.8 nm ~~could be~~ is close to the UV region)

Most energetic line is at 285.2 nm

$$E = \frac{nhc}{\lambda} = \frac{(6.02 \times 10^{23}\ \text{photons})(6.626 \times 10^{-34}\ \text{J s})(3.00 \times 10^{8}\ \text{m s}^{-1})}{(285.2 \times 10^{-9}\ \text{m})}$$

$= 4.1958 \times 10^{5}\ J = \underline{\underline{4.196 \times 10^{5}\ J}}$

(10) radar < microwave oven < red light from neon sign < UV from sun lamp < γ rays

⟶ energy increases

(11) $E = 2.0 \times 10^{2}\ \frac{kJ}{mol} = \frac{hc}{\lambda}$ $\lambda = \frac{hc}{E}$

$$\lambda = \frac{(6.626 \times 10^{-34}\ Js)(3.00 \times 10^{8}\ m s^{-1})}{2.0 \times 10^{2}\ kJ\ mol^{-1}} \times \left(\frac{10^{-3}\ kJ}{J}\right) \times 6.022 \times 10^{23}\ mol^{-1}$$

$$= 5.98 \times 10^{-7}\ m \times \frac{10^{9}\ nm}{m} = 598\ nm = \underline{\underline{6.0 \times 10^{2}\ nm}}$$

This light is in the visible region.

(12) $\lambda = 540\ nm$

$$E = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34}\ Js)(3.00 \times 10^{8}\ m s^{-1})}{(540 \times 10^{-9}\ m)} = 3.681 \times 10^{-19}\ J$$

This energy is not sufficient to remove an electron from the metal. If the wavelength is greater than 540 nm, the energy would be even smaller, hence inadequate to remove an $\bar{e}$ from the metal.

(14) (a)
865.438 nm
837.761 nm → nearer to visible
878.062 nm
878.357 nm
1885.387 nm

} IR region

(c) most energetic is at 837.761 nm

(d) $\nu = \frac{c}{\lambda} = \frac{3.0 \times 10^{8}\ m s^{-1}}{865.438\ nm} \times \boxed{\frac{10^{9}\ nm}{m}}$

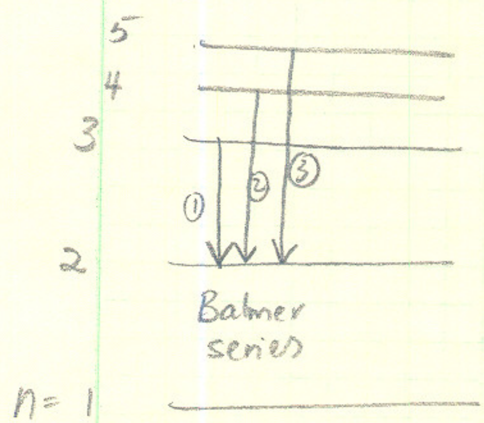
$= \underline{\underline{3.46645 \times 10^{14}\ s^{-1}}}$

$E = h\nu = (6.626 \times 10^{-34}\ J s)(3.46645 \times 10^{14}\ s^{-1})$

$= \underline{2.29687 \times 10^{-19}\ J}$

(15) 410.2 nm is in the violet.

Since it is in the visible region, it is a Balmer series line with $n_1 = 2$



$\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] \quad n_2 > n_1$

$\frac{1}{410.2\ nm} = 1.0974 \times 10^{7}\ m^{-1}\left[\frac{1}{4} - \frac{1}{n_2^2}\right]$

$\frac{1}{(410.2 \times 10^{-9}\ m)(1.0974 \times 10^{7}\ m^{-1})} = \frac{1}{4} - \frac{1}{n_2^2}$

$0.2221465 = \frac{1}{4} - \frac{1}{n_2^2}$

$\frac{1}{n_2^2} = \frac{1}{4} - 0.2221465 = 0.02785$

$n_2^2 = 35.90207$

$n_2 = 5.99 \approx \underline{\underline{6}}$

(17) (a) from $n=5$ to $n=4$, $n=3$, $n=2$, $n=1$ = 4 lines

from $n=4$ to $n=3$, $n=2$, $n=1$ = 3 lines

from $n=3$ to $n=2$, $n=1$ = 2 lines

from $n=2$ to $n=1$ = 1 lines

10 transitions

(b) Highest frequency ⇒ highest energy ~~UV region~~ UV region

$n=5$ to $n=1$

(c) longest wavelength ⇒ lowest energy ~~(IR region)~~ IR region

$n=5$ to $n=4$

(18) (a) $n=4$ to $n=3, 2, 1$ = 3 lines

$n=3$ to $n=2, 1$ = 2 lines

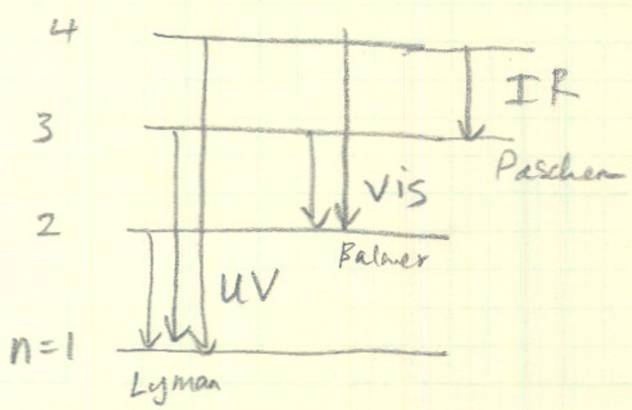
$n=2$ to $n=1$ = 1 lines

6 lines

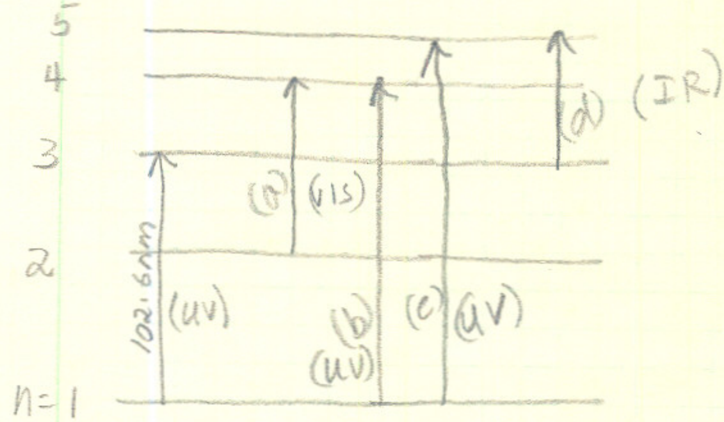
(b) lowest energy is from $n=4 \rightarrow n=3$ (IR)

(c) shortest wavelength ⇒ highest energy (UV region

$n=4 \rightarrow n=1$



(20)



102.6 nm is in the UV region (n=1 to n=3)
longer wavelength radiation must be in the visible & IR regions

(a) $n=2 \rightarrow n=4$

(d) $n=3 \rightarrow n=5$

(b) and (c) are in the UV and have higher energy than 102.6 nm ($n=1 \rightarrow 3$) transition. Therefore they have <u>shorter</u> wavelength than 102.6 nm.

(22)

$$\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] \qquad n_2 > n_1 \quad \therefore n_1 = 3, \; n_2 = 4$$

$$\frac{1}{\lambda} = 1.0974 \times 10^{7}\ m^{-1}\left[\frac{1}{9} - \frac{1}{16}\right] = 5.334583 \times 10^{5}\ m^{-1}$$

$$\lambda = 1.875 \times 10^{-6}\ m \times \frac{10^9\ nm}{1\ m} = \underline{1874.561\ nm}$$

$$\nu = \frac{c}{\lambda} = (3.00 \times 10^{8}\ ms^{-1})\left[5.334583 \times 10^{5}\ m^{-1}\right]$$

$$= \underline{1.600375 \times 10^{14}\ s^{-1}} \qquad \underline{\text{IR region}}$$