Name: ________________________________

Physics 117

Quiz 9 (5/9/2003)

Use as far as possible formula and try to explain your reasoning.

A) A photon has a frequency of 10^{15} Hz.
What is its energy expressed in Joules and in eV?
(Planck constant $h=6.63\times 10^{-34}$ J·s)

$$E = hf = 6.63\times 10^{-34}\, J\cdot s \times 10^{15}\, s^{-1} = 6.63\times 10^{-19}\, J$$

$$1\ J = \left(1.6\times 10^{-19}\right)^{-1}\ eV \Rightarrow\ E = \frac{6.63\times 10^{-19}}{1.6\times 10^{-19}}\, eV \approx 4.1\ eV$$

B) What is the angular momentum of an electron in the n=2 level of the Hydrogen atom?
What is the radius of its orbit?
(Planck constant $h=6.63\times 10^{-34}$ J·s, $r_1=5.3\times 10^{-11}$ m)

$$L_n = n\frac{h}{2\pi},\quad r_n = n^2 r_1 \qquad r_1 = 5.3\times 10^{-11}\, m$$

$$n = 2 \Rightarrow \begin{cases} L_2 = \dfrac{h}{\pi} = \dfrac{6.63\times 10^{-34}}{\pi}\, J\cdot s = 2.11\times 10^{-34}\, J\cdot s \\ r_2 = 4r_1 = 21.2\times 10^{-11}\ m \end{cases}$$

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C) What is the frequency of the photon emitted when an electron drops to the ground state from an excited state which has 6000 eV more energy?

$$E = hf$$
$$f = \frac{E}{h} = \frac{6000\ eV}{6.63 \times 10^{-34} J \cdot s}\left(\frac{1.6 \times 10^{-19}\ J}{1\ eV}\right) \approx 1.45 \cdot 10^{18} Hz$$

D) An electron is in the innermost orbit of a hydrogen atom (n=1) and to go to the nearest energy level (n=2) requires an energy jump of about 10.2 eV. Describe what will happen if the electron is hit by a photon with an frequency equal to

1) $f=10^{14}$ Hz
2) $f=2.46 \times 10^{15}$ Hz

The electron can absorbe the photon only if its energy exactly correspond to the one required for the jump from one level to the other.

Case 1)

$$E = hf = 6.63 \times 10^{-34} J \cdot s \times 10^{14} s^{-1} = 6.63 \times 10^{-20} J$$

$$1\ J = \left(1.6 \times 10^{-19}\right)^{-1}\ eV \Rightarrow E = \frac{6.63 \times 10^{-20}}{1.6 \times 10^{-19}} eV \approx 0.4\ eV$$

This energy is insufficent to jump to the nearest excited level so the electron does not absorb the photon

Case 2)

$$E = hf = 6.63 \times 10^{-34} J \cdot s \times 2.46 \times 10^{15} s^{-1} = 16.3 \times 10^{-19} J$$

$$1\ J = \left(1.6 \times 10^{-19}\right)^{-1}\ eV \Rightarrow E = \frac{16.3 \times 10^{-19}}{1.6 \times 10^{-19}} eV \approx 10.2\ eV$$

This energy is exactly the one necessary to make the jump, the electron will jump to the next level.

ALTERNATIVE SOLUTION

An energy jump of 10.2 eV corresponds to a photon which has frequency:

$$f = E/h = \frac{10.2\ eV}{6.63 \times 10^{-34} J \cdot s} = \frac{10.2 \times 1.6 \times 10^{-19}\ J}{6.63 \times 10^{-34} J \cdot s} = 2.46 \times 10^{15}\ Hz$$

So meanwhile the first photon has not enough energy for the jump the secnd has exactly the right energy.