Name Date

PH 102 Quiz 8: Probably you won't drop this one.

20Apr07 LeClai

$$
\begin{aligned}
E &= hf = \frac{hc}{\lambda} \\
e\Delta V &= KE_{\text{max}} = hf - \phi \\
E_n &= -13.6\,\text{eV}/n^2 \\
h &= \lambda|\vec{\mathbf{p}}|
\end{aligned}
$$

$$
\begin{aligned}
\Delta E \Delta t &\geq \frac{h}{4\pi} \\
h &= 6.624 \times 10^{-34}\,\text{J}\cdot\text{s} \\
e &= 1.602 \times 10^{-19}\,\text{C} \\
c &= 3.00 \times 10^{8}\,\text{m/s} \\
m_e &= 9.11 \times 10^{-31}\,\text{kg}
\end{aligned}
$$

1. What is the energy of a photon that, when absorbed, could cause an electronic transition from the $n=3$ to the $n=6$ state in a Hydrogen atom?

- ⊗ 1.13 eV
- ○ 1.85 eV
- ○ 2.24 eV
- ○ 0.85 eV

The photon itself has to have an energy equal to the *difference in energy* between the $n=3$ and $n=6$ states. Remember that for any old n, the energy values are given by:

$$E_n = \frac{-13.6\,\text{eV}}{n^2} \tag{1}$$

So ... calculate the energy for $n=3$ and $n=6$, then subtract them:

$$
\begin{aligned}
E_3 &= \frac{-13.6}{3^2} = -1.51\,\text{eV} \\
E_6 &= \frac{-13.6}{6^2} = -0.378\,\text{eV} \\
|E_6 - E_3| &= 1.13\,\text{eV}
\end{aligned}
$$

2. What is the energy of a photon that, when absorbed, could cause an electronic transition from the $n=2$ to the $n=3$ state in a Hydrogen atom?

- ○ 1.13 eV
- ⊗ 1.89 eV
- ○ 2.24 eV
- ○ 0.85 eV

Repeat the previous question, with 2 in place of 6.

3. A pulsed ruby laser emits light at 694.3 nm. For a 13.6 ps pulse containing 3.40 J of energy, how many photons are in the pulse? 1 ps is 10^{-12}s.

- ○ 2×10^{20}
- ⊗ 1×10^{19}
- ○ 3×10^{21}
- ○ 5×10^{17}

The total energy of the pulse has to be the energy per photon times the number of photons. If the laser light all has the same wavelength, then all the photons have the same energy. That's it. The pulse time is irrelevant here.

$$E_{\text{total}} = (\#\text{photons})\, E_{\text{photon}} = (\#\text{photons})\,\frac{hc}{\lambda} = 3.40\,\text{J} \tag{2}$$

Rearrange ...

$$(\#\text{photons}) = \frac{E_{\text{total}}\lambda}{hc} = \frac{[3.4\,\text{J}]\left[694.3 \times 10^{-9}\,\text{m}\right]}{[6.624 \times 10^{-34}\,\text{J}\cdot\text{s}]\,[3.00 \times 10^{8}\,\text{m/s}]} \approx 10^{19} \qquad (3)$$

4. What is the orbital speed of a Hydrogen atom in the $n=1$ state according to the Bohr model?

- ◯ 2×10^4 m/s
- ◯ 1×10^7 m/s
- ◯ 3×10^8 m/s
- ⊗ 2×10^6 m/s

Clearly from the choices given, we only want an estimate. We know the total energy of the Hydrogen atom, given above: $E_n = -13.6\,\text{eV}/n^2$. As an approximation, we will just ignore the potential energy, and set the *total* energy equal to $\frac{1}{2}mv^2$. This is wrong, but it should be within a factor of 2 or so - close enough for our purposes.

$$|E_1| = (13.6\,\text{eV})\left(1.602 \times 10^{-19}\,\text{J/eV}\right) \approx \frac{1}{2}mv^2 \qquad (4)$$

The proper way to do this problem is in Sect. 28.3, but it is far too time-consuming for a quiz ... if you only have to pick the answer within a factor of 10 or so, your method only needs to be that good. Plus: with the minimal formulas and constants given above, it was either this or quickly re-derive the Bohr model as done in 28.3.

5. Which color was not one of the Hydrogen lines you saw yesterday?

- ◯ blue
- ◯ violet
- ◯ red
- ⊗ yellow