Spectrometer Lab Questions

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These are the 10 questions I chose:

1)
Planck's constant: $6.626 \times 10^{-34}\ J \cdot s$

$$1\ J \cdot s = 1\ \frac{m^2 kg}{s}$$

$$[\vec{L}] = [\vec{r} \times \vec{p}] = m \cdot \frac{m kg}{s} = \frac{m^2 kg}{s} \qquad \text{thus, } \boxed{[h] = [L]}$$

8) $E = hf = \frac{hc}{\lambda}$

red photon: $600 nm = 600 \times 10^{-9} m$
blue photon: $400 nm = 400 \times 10^{-9} m$

$$E_r = \frac{(6.626 \times 10^{-34} J \cdot s)(3.00 \times 10^{8} m/s)}{600 \times 10^{-9} m} = \boxed{3.31 \times 10^{-19} J \text{ or } 2.07 eV}$$

$$E_b = \frac{(6.626 \times 10^{-34} J \cdot s)(3.00 \times 10^{8} m/s)}{400 \times 10^{-9} m} = \boxed{4.97 \times 10^{-19} J \text{ or } 3.11 eV}$$

9) The wavelength of light will be measured using the number of lines per millimeter (d, given on the grating plate), the number m which is the order of the scattered light, and theta (θ), which is found experimentally using our instrument. Using these and $d \sin\theta = m\lambda$, we find λ, our desired wavelength.

10) The photon from $n=2$ to $n=1$ produces the shortest wavelength, in the ultraviolet spectrum.
The photon from $n=3$ to $n=2$ produces the medium wavelength, in the visible spectrum.
The photon from $n=4$ to $n=3$ produces the longest wavelength, in the infared spectrum.

4) Our Rydberg: $1 \times 10^{7} m^{-1}$

$$\lambda = \left(\frac{1}{\lambda}\right)^{-1} = \left(\frac{1}{(1)^2} - \frac{1}{(2)^2}\right)^{-1} \left(1 \times 10^{7} \frac{1}{m}\right)^{-1} = \boxed{1.33 \times 10^{-7} m}$$

5) Our Rydberg: $1 \times 10^{7} m^{-1}$

$$\lambda = \left(\frac{1}{\lambda}\right)^{-1} = \left(\frac{1}{(3)^2} - \frac{1}{(4)^2}\right)^{-1} \left(1 \times 10^{7} \frac{1}{m}\right)^{-1} = \boxed{2.06 \times 10^{-6} m}$$

6) $\Delta E = \frac{1}{\varepsilon_0^2} \frac{m_e e^4}{8h^2}\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$ $\qquad R = \frac{m_e e^4}{8\varepsilon_0^2 h^3 c}$

$Rhc = \frac{m_e e^4}{8\varepsilon_0^2 h^2}$

$\Delta E = Rhc\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$ $\quad$ if $n_f \to \infty$, $\frac{1}{(n_f)^2} \to 0$

$E = \frac{Rhc}{n_i^2}$ $\quad$ if $n_i = 1$, $E = Rhc$

$E = (1.09\times10^{7}\frac{1}{m})(3.00\times10^{8}\frac{m}{s})(6.626\times10^{-34}\,J\cdot s)$

$E = \boxed{2.17\times10^{-18}\,J = 13.5\,eV}$

2) The Bohr radios is given by: $r = \varepsilon_0 \frac{h^2}{\pi m_e e^2}$

$r = (8.85\times10^{-12}\,F/m)\frac{(6.626\times10^{-34}\,J\cdot s)^2}{(3.14)(9.109\times10^{-31}\,kg)(1.60217\times10^{-19}\,C)^2}$

$\boxed{r = 5.3\times10^{-11}\,m}$

19) longest visible wavelength:

$d\sin\theta = \lambda m$ $\qquad m = 5$ $\qquad d = \frac{1}{315000}$

$\sin(90°) = 1$

$\frac{1}{315000}m = 5\lambda$ $\qquad \lambda = 6.35\times10^{-7}\,m$

or $\lambda = 635\times10^{-9}\,m$

or $\boxed{\lambda = 635\,nm}$

3) Electrostatic Force = Centripetal Force

$\frac{mv^2}{r} = \frac{e^2}{4\pi\varepsilon_0 r^2}$

$v = \sqrt{\frac{e^2}{4\pi m\varepsilon_0 r}} = \frac{e}{2\sqrt{\pi m\varepsilon_0 r}} = \frac{1.6\times10^{-19}\,C}{2\sqrt{(3.14)(9.1\times10^{-31}\,kg)(8.85\times10^{-12}\frac{F}{m})(5.3\times10^{-11}\,m)}}$

$\boxed{v = 2.19\times10^{6}\,\frac{m}{s}}$