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CH 201
Post Lab 4

Emission Spectra and Flame Experiment

Data:

Data Table 1: Emission Spectra

Element	**Line 1** Color - Wavelength	**Line 2** Color - Wavelength	**Line 3** Color - Wavelength	**Line 4** Color - Wavelength
Hydrogen	Indigo - 500 nm	Light Blue - 560 nm	Yellow - 660 nm	Red - 760 nm
Helium	Yellow - 670 nm	Red - 750 nm	Teal - 580 nm	Indigo - 500 nm
Neon	Yellow - 660 nm	Orange - 670 nm	Red - 720 nm	Dark Red - 750 nm
Mercury	Indigo - 500 nm	Green - 620 nm	Yellow - 660 nm	Red - 690 nm

Data Table 2: Solutions in Flame

Solution	**Description**
LiCl	Vibrant maroon - purple red
NaCl	Yellow-orange, bright
KCl	White with purple and yellow hints, mostly white, not very bright
$CaCl_2$	Bright deep orange
$SrCl_2$	Bright red-orange, slightly pink
$BaCl_2$	White with a weak green tint
$CuCl_2$	Starts off green/teal then turns bright deep blue
Unknown 1	Very bright, deep red
Unknown 2	Deep bright magenta, purple red
Unknown 3	Yellow-orange not very intense

Energy Levels Based On Visible Color:

Highest -> Lowest
$CuCl_2$ > KCl > $BaCl_2$ > NaCl > $CaCl_2$ > $SrCl_2$ > LiCl

Calculations:

1. Line 1:

$\lambda = 500\,nm \cdot \frac{1\,m}{10^9\,nm} = 5.0 \times 10^{-7}\,m$

$v = \frac{c}{\lambda} = \frac{2.99 \times 10^8\,m/s}{5.0 \times 10^{-7}\,m} = 6.0 \times 10^{14}\,s^{-1}$

$E = h \cdot v = 6.6262 \times 10^{-34}\,Js \cdot 6.0 \times 10^{14}\,s^{-1} = 4.0 \times 10^{-19}\,J$

Line 2:

$\lambda = 560\,nm \cdot \frac{1\,m}{10^9\,nm} = 5.6 \times 10^{-7}\,m$

$v = \frac{c}{\lambda} = \frac{2.99 \times 10^8\,m/s}{5.6 \times 10^{-7}\,m} = 5.3 \times 10^{14}\,s^{-1}$

$E = h \cdot v = 6.6262 \times 10^{-34}\,Js \cdot 5.3 \times 10^{14}\,s^{-1} = 3.5 \times 10^{-19}\,J$

Line 3:

$\lambda = 660\,nm \cdot \frac{1\,m}{10^9\,nm} = 6.6 \times 10^{-7}\,m$

$v = \frac{c}{\lambda} = \frac{2.99 \times 10^8\,m/s}{6.6 \times 10^{-7}\,m} = 4.5 \times 10^{14}\,s^{-1}$

$E = h \cdot v = 6.6262 \times 10^{-34}\,Js \cdot 4.5 \times 10^{14}\,s^{-1} = 3.0 \times 10^{-19}\,J$

Line 4:

$\lambda = 760\,nm \cdot \frac{1\,m}{10^9\,nm} = 7.6 \times 10^{-7}\,m$

$v = \frac{c}{\lambda} = \frac{2.99 \times 10^8\,m/s}{7.6 \times 10^{-7}\,m} = 3.9 \times 10^{14}\,s^{-1}$

$E = h \cdot v = 6.6262 \times 10^{-34}\,Js \cdot 3.9 \times 10^{14}\,s^{-1} = 2.6 \times 10^{-19}\,J$

2. Line 1:

$$\text{Percent Error} = \left| \frac{4.0 \times 10^{-19}\,J - 3.028 \times 10^{-19}\,J}{3.028 \times 10^{-19}\,J} \right| \cdot 100 = 32\%$$

Line 2:

$$\text{Percent Error} = \left| \frac{3.5 \times 10^{-19}\,J - 4.086 \times 10^{-19}\,J}{4.086 \times 10^{-19}\,J} \right| \cdot 100 = 14\%$$

Line 3:

$$\text{Percent Error} = \left| \frac{3.0 \times 10^{-19}\,J - 4.582 \times 10^{-19}\,J}{4.582 \times 10^{-19}\,J} \right| \cdot 100 = 35\%$$

Line 4:

$$\text{Percent Error} = \left| \frac{2.6 \times 10^{-19}\,J - 4.854 \times 10^{-19}\,J}{4.854 \times 10^{-19}\,J} \right| \cdot 100 = 46\%$$

3. Line 1:

$$-4.0\times10^{-19} = -2.18\times10^{-18}\,J\left[\frac{1}{2^2}-\frac{1}{n_i^2}\right]$$

$\div$

$$.1834 = \frac{1}{4}-\frac{1}{n_i^2} \rightarrow \left(-.0665 = -\frac{1}{n_i^2}\right)-1$$

$-\frac{1}{4}$

$$\left(.0665 = \frac{1}{n_i^2}\right)^{-\frac{1}{2}} \rightarrow 3.87 \rightarrow \boxed{n_i = 4}$$

Line 2:

$$-3.5\times10^{-19} = -2.18\times10^{-18}\left[\frac{1}{2^2}-\frac{1}{n_i^2}\right]$$

$$.1606 = \frac{1}{4}-\frac{1}{n_i^2} \rightarrow \left(-.08945 = -\frac{1}{n_i^2}\right)-1$$

$-\frac{1}{4}$

$$\left(.08945 = \frac{1}{n_i^2}\right)^{-\frac{1}{2}} \rightarrow 3.34 \rightarrow \boxed{n_i = 3}$$

Line 3:

$$-3.0\times10^{-19} = -2.18\times10^{-18}\left[\frac{1}{2^2}-\frac{1}{n_i^2}\right]$$

$$.1376 = \frac{1}{4}-\frac{1}{n_i^2} \rightarrow \left(-.1123 = -\frac{1}{n_i^2}\right)-1$$

$-\frac{1}{4}$

$$\left(.1123 = \frac{1}{n_i^2}\right)^{-\frac{1}{2}} \rightarrow 2.98 \rightarrow \boxed{n_i = 3}$$

Line 4:

$$-2.6\times10^{-19} = -2.18\times10^{-18}\left[\frac{1}{2^2}-\frac{1}{n_i^2}\right]$$

$$.1193 = \frac{1}{4}-\frac{1}{n_i^2} \rightarrow \left(-.1307 = -\frac{1}{n_i^2}\right)-1$$

$-\frac{1}{4}$

$$\left(.1307 = \frac{1}{n_i^2}\right)^{-\frac{1}{2}} \rightarrow 2.77 \rightarrow \boxed{n_i = 3}$$

Results:

Results Table 1:
Emission Spectra Results

Line Color	**Frequency (s^{-1})**	**Energy (J/photon)**	**Percent Error**	**Excited State ($n_{initial}$)**
Indigo	6.0×10^{14}	4.0×10^{-19}	32%	4
Light Blue	5.3×10^{14}	3.5×10^{-19}	14%	3
Yellow	4.5×10^{14}	3.0×10^{-19}	35%	3
Red	3.9×10^{14}	2.6×10^{-19}	46%	3

Results Table 2:
Flame Emission Results

Unknown Sample	**Metal Cation Identity**
Unknown 1	Li^{+1}
Unknown 2	Sr^{+2}
Unknown 3	Na^{+1}

Results Table 3:
Metal Atom Electron Configurations

Known Metal Atom	**Full Electron Configuration**	**Quantum numbers for valence electron**
Li	$1s^2$ $2s^1$	2,0,0,+1/2
Na	$1s^2$ $2s^2$ $2p^6$ $3s^1$	3,0,0,+1/2
K	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^1$	4,0,0,+1/2
Ca	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$	4,0,0,+1/2
Sr	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$	5,0,0,+1/2
Ba	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^8$ $4p^6$ $5s^2$ $4d^{10}$ $5p^6$ $6s^2$	6,0,0,+1/2
Cu	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^1$ $3d^{10}$	4,0,0,+1/2

Results Table 4:
Metal Cation Electron Configurations

Known Metal Cation	**Full Electron Configuration**	**Quantum numbers for valence electron**
Li^{+1}	$1s^2$	1,0,0,+1/2
Na^{+1}	$1s^2\ 2s^2\ 2p^6$	2,1,-1,+1/2
K^{+1}	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$	3,1,-1,+1/2
Ca^{+2}	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$	3,1,-1,+1/2
Sr^{+2}	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6$	4,1,-1,+1/2
Ba^{+2}	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^8\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6$	5,1,-1,+1/2
Cu^{+2}	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^9$	3,2,-1,+1/2

Discussion and Conclusion:

The purpose of this lab was to investigate light properties of various gasses and solutions. A spectroscope was used to view the emission spectrum of gasses, and visual inspection was done when various solutions were placed in the flame of a bunsen burner. The various measurements and visual appearance was recorded. For the gasses the four strongest emission spectra wavelengths were used to calculate their corresponding frequencies, energy per photon, and the initial electron state of each. For the Flame Emission experiment, several known solutions were burned and then compared to 3 unknown solutions. The metal ions present in the unknown solutions were guessed based on the observation of the known solutions. This lab aims to demonstrate the properties of electrons in atoms by using Bohr's model of the atom. By exciting isolated atoms and exciting them by either placing them in an electric field, as was done with the various gasses, or by heating them in the flame of a bunsen burner, as was done with the molecules in solutions, it is possible to gain insight into the nature of electrons in the atom. These methods make possible the identification of unknown substances.

For Part A the results had fairly high percent error, between 14 and 46 percent error. This could be due to inaccuracies in the use of the spectroscope, defections in the spectroscope itself or a misalignment with the provided energy levels. For Part B, the unknown substances 1-3 were guessed to be Li^{+1}, Sr^{+2}, and Na^{+1}. The alkali metals appeared to have the most vibrant appearances when burned. The certainty of the unknown solutions is fairly low. For example, unknown substance 1 had the appearance of $CuCl_2$ but when placed in the flame appeared to burn like Li^{+1}, this was unexpected and the identity of the solution is still unknown.

Supplementary Problems:

1. A. n = 1 l = 0 B. n = 3 l = 1 C. n = 4 l = 2 D. n = 5 l = 3
2. A. There are 1 possible orbitals. B. There are 3 possible orbitals C. There are 5 possible orbitals D. There are 16 orbitals in all sublevels of n = 4
3. A. 2 B. 2 C. 2 D. 14
4. A. Aluminum B. Niobium C. Lead D. Lithium
5. A. Not allowed, the sublevel l can only be a max value n-1 B. Allowed C. Allowed D. Allowed
6. E = -2.18*10^-18J*(1^2)*(1/inf^2 - 1) → E = 2.18*10^-18 J