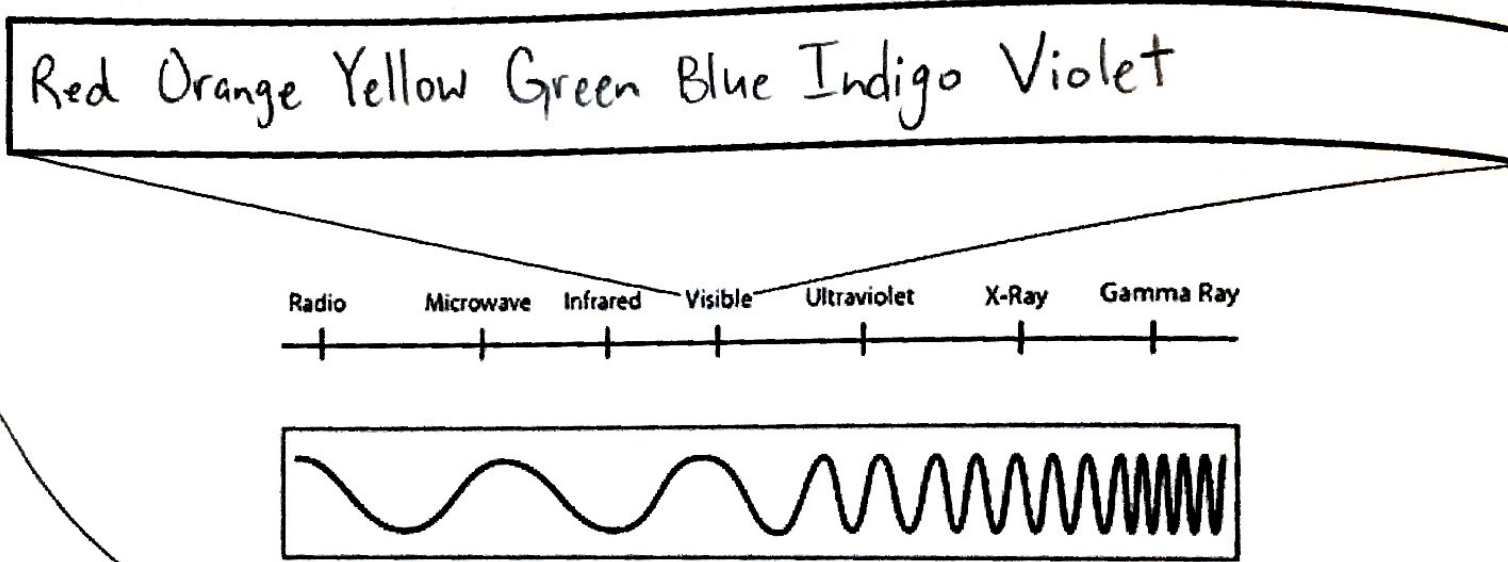# Unit 3: Atomic Theory and the Nuclear Atom

Free Response Review #2

Directions: The suggested time is about 15 minutes for answering the constructed response section of the chemistry test. The parts within a question may not have equal weight. For calculations, show all your work in the spaces provided after each part. Pay particular attention to the proper use of units. Be sure your final answer is rounded to the correct number of significant figures. Make sure your work is legible. Illegible work will receive a grade of zero.

Question 1 [10 POINTS]

A generalized diagram for the electromagnetic radiation spectrum is pictured below.

Red Orange Yellow Green Blue Indigo Violet

Radio   Microwave   Infrared   Visible   Ultraviolet   X-Ray   Gamma Ray

A. Using the box above the spectrum, label the visible portion of the spectrum with its colors in order of increasing *energy*. **[1 POINT]**   ROY-G-BIV!

B. Is the frequency of red light higher, equal to, or lower than the frequency of violet light? Explain using the relationship between frequency and energy. **[2 POINTS]**

ν (red light) $< \nu$ (violet light), b/c E (red) $<$ E (violet), and E is directly proportional to ν (since $E = h\nu$)

C. An excited chlorine atom releases energy. As its excited electron returns to the ground state, a photon is emitted.

   i. *Show a numerical setup and* calculate the wavelength, in nm, of the photon emitted if the energy of the photon is 3.86×10^{-19} J. **[2 POINTS]**

$$E = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{E} = \frac{(6.626 \text{E-}34 \text{ J·s})(2.998 \text{E8 m/s})}{3.86 \text{E-}19 \text{ J}} = 5.15 \times 10^{-7} \text{ m}$$

$$\frac{5.15 \text{E-}7 \text{ m}}{} \left| \frac{1 \text{E9 nm}}{1 \text{ m}} \right. = \boxed{515 \text{ nm}}$$

ii. The chart below gives the wavelength ranges for each color of light in order of increasing energy. Label these wavelength ranges with your colors in your diagram on the front page. **[1 POINT]**

Color	Wavelength	Color
Lowest energy color	750 nm – 620 nm	red
	620 nm – 590 nm	orange
	590 nm – 570 nm	yellow
	570 nm – 520 nm	green
	520 nm – 500 nm	blue
	500 nm – 440 nm	indigo
Highest energy color	440 nm – 380 nm	violet

iii. What color would you expect the light emitted from the chlorine atom to be? Explain your reasoning. **[1 POINT]**

Blue: 515 nm is within the blue range (520 - 500 nm)

D. Write a set of quantum numbers describing the energy for EACH of the valence electrons in the ground state chlorine atom. **[3 POINTS]**

$$Cl: [Ne] 3s^2 3p^5 \left(\frac{\uparrow\downarrow}{3s} \quad \frac{\uparrow\downarrow}{} \frac{\uparrow\downarrow}{3p} \frac{\uparrow}{} \right)$$

$\underline{3s}$

3, 0, 0, +½

3, 0, 0, -½

$\underline{3p}$

3, 1, -1, +½

3, 1, -1, -½

3, 1, 0, +½

3, 1, 0, -½

3, 1, +1, +½