Honors Chemistry
Mr. MacGillivray
Worksheet:
Light and Quantum Theory

1. Arrange the seven types of electromagnetic radiation that we discussed in class in order of **DECREASING** energy:

    a. _____ (highest E)
    b. _____
    c. _____
    d. _____
    e. _____
    f. _____
    g. _____ (lowest E)

2. In the list above, use words and arrows to indicate how the wavelength and frequency are changing.

3. Repeat #1 and #2 with the colors of the visible spectrum.

    a. _____ (highest E)
    b. _____
    c. _____
    d. _____
    e. _____
    f. _____
    g. _____ (lowest E)

4. "If the wavelength of light is very short, then the energy is very _____ and the frequency is very _____."

5. "If the wavelength of light is very long, then the energy is very _____ and the frequency is very _____."

6. Wavelength and frequency are _____ly related. Energy and frequency are _____ly related.

7. Energy is measured in these units: _____.
8. Wavelength is measured in these units: _____.
9. Frequency is measured in these units: _____, also written as _____ or _____.
10. Convert the following wavelengths to nm:
    a. $\lambda = 513$ m

    b. $\lambda = 8.03 \times 10^{-6}$ m

11. Convert the following wavelengths to m:
    a. $\lambda = 755$ nm

    b. $\lambda = 0.272$ nm

12. Find the energy of a photon of light with a frequency of 5.22×10^{21} 1/s.

13. Find the energy of a photon of light with a wavelength of 425 nm.

14. Find the wavelength of light with a frequency of 5.28×10^{15} s^{-1}.

15. Using your reference tables, answer these questions:
    a. Is the light in question #10(a) visible? How about #10(b)?

    b. How did you know? (Explain your answers to the 15(a).)

    c. Is it too high in energy or too low in energy to be seen?

    d. What type of light is each (to which region of the electromagnetic spectrum does it belong – infrared, microwaves, etc)?

16. Using your reference tables, indicate whether each one of these electron transitions represents an ABSORPTION (energy goes into the atom) or EMISSION of energy (energy is given off by the atom):
    a. n=3 to n= 1
    b. n=1 to n= 3
    c. n=6 to n= 2
    d. n=2 to n= 6
    e. n=6 to n= 3
    f. n=3 to n= 6

17. For each transition in #16 which resulted in an emission of energy, look up or calculate the wavelength (λ), frequency (ν), and energy (E) of light given off by the atom. To which region of the electromagnetic spectrum does each emission belong (visible, gamma rays, etc.)?

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1. Arrange the seven types of electromagnetic radiation that we discussed in class in order of **DECREASING** energy:

   a. gamma (highest E)
   b. x-rays
   c. U.V. rays
   d. visible light
   e. infrared
   f. microwaves
   g. radiowaves (lowest E)

   shortest λ ↓ longest λ
   highest ν ↓ lowest ν

2. In the list above, use words and arrows to indicate how the wavelength and frequency are changing.

3. Repeat #1 and #2 with the colors of the visible spectrum.

   a. violet (highest E)
   b. (indigo)
   c. blue
   d. green
   e. yellow
   f. orange
   g. red (lowest E)

   shortest λ ↓ longest λ
   highest ν ↓ lowest ν

4. "If the wavelength of light is very short, then the energy is very high and the frequency is very high."

5. "If the wavelength of light is very long, then the energy is very low and the frequency is very low."

6. Wavelength and frequency are inverse ly related. Energy and frequency are direct ly related.

7. Energy is measured in these units: J.
8. Wavelength is measured in these units: m. (or nm)
9. Frequency is measured in these units: Hz, also written as 1/s or s^{-1}.
10. Convert the following wavelengths to nm:
    a. $\lambda = 513\ m \times \frac{10^9\ nm}{1\ m} = 5.13 \times 10^{11}\ nm$
    b. $\lambda = 8.03 \times 10^{-6}\ m \times \frac{10^9\ nm}{1\ m} = 8.03 \times 10^{3}\ nm$
11. Convert the following wavelengths to m:
    a. $\lambda = 755\ nm \times \frac{1\ m}{10^9\ nm} = 7.55 \times 10^{-7}\ m$
    b. $\lambda = 0.272\ nm$

$$0.272\ nm \times \frac{1\ m}{10^9\ nm} = 2.72 \times 10^{-10}\ m$$

12. Find the energy of a photon of light with a frequency of 5.22×10^{21} 1/s.

$E = h\nu = (6.626 \times 10^{-34}\ Js)\left(5.22 \times 10^{21}\ \frac{1}{s}\right) = 3.46 \times 10^{-12}\ J$

13. Find the energy of a photon of light with a wavelength of 425 nm.

$425\ nm \times \frac{1\ m}{10^9\ nm} = 4.25 \times 10^{-7}\ m \quad C = \lambda\nu \Rightarrow \nu = \frac{c}{\lambda} = \frac{3.00 \times 10^8\ \frac{m}{s}}{4.25 \times 10^{-7}\ m} = 7.06 \times 10^{14}\ \frac{1}{s}$

14. Find the wavelength of light with a frequency of $5.28 \times 10^{15}\ s^{-1}$.

$c = \lambda\nu \Rightarrow \lambda = \frac{c}{\nu} = \frac{3.00 \times 10^8\ \frac{m}{s}}{5.28 \times 10^{15}\ \frac{1}{s}} = 5.68 \times 10^{-8}\ m$ or $56.8\ nm$

$E = h\nu = (6.626 \times 10^{-34}\ Js)\left(7.06 \times 10^{14}\ \frac{1}{s}\right)$

$E = 4.68 \times 10^{-19}\ J$

15. Using your reference tables, answer these questions:
    a. Is the light in question #10(a) visible? How about #10(b)?

NO NO

    b. How did you know? (Explain your answers to the 15(a).)

10(a) = radio wave 10(b) = infrared (see ref tables) they are not in visible region of spectrum.

    c. Is it too high in energy or too low in energy to be seen?

Both are too low in energy to be seen.

    d. What type of light is each (to which region of the electromagnetic spectrum does it belong – infrared, microwaves, etc)?

10(a) = radio wave 10(b) = infrared

16. Using your reference tables, indicate whether each one of these electron transitions represents an ABSORPTION (energy goes into the atom) or EMISSION of energy (energy is given off by the atom):
    a. n=3 to n= 1 emission
    b. n=1 to n= 3 absorption
    c. n=6 to n= 2 emission
    d. n=2 to n= 6 absorption
    e. n=6 to n= 3 emission
    f. n=3 to n= 6 absorption

17. For each transition in #16 which resulted in an emission of energy, look up or calculate the wavelength (λ), frequency (ν), and energy (E) of light given off by the atom. To which region of the electromagnetic spectrum does each emission belong (visible, gamma rays, etc.)?

17(a) $\lambda = 103\ nm$ – UV light

$c = \lambda\nu \quad \nu = \frac{c}{\lambda} = \frac{3.00 \times 10^8\ \frac{m}{s}}{1.03 \times 10^{-7}\ m} \quad \nu = 2.91 \times 10^{15}\ \frac{1}{s}$

$E = h\nu = (6.626 \times 10^{-34}\ Js)\left(2.91 \times 10^{15}\ \frac{1}{s}\right) = 1.93 \times 10^{-18}\ J$

17(c) $\lambda = 410\ nm$ = visible light

$c = \lambda\nu \quad \nu = \frac{c}{\lambda} = \frac{3.00 \times 10^8\ \frac{m}{s}}{4.1 \times 10^{-7}\ m} \quad \nu = 7.32 \times 10^{14}\ \frac{1}{s}$

$E = h\nu = (6.626 \times 10^{-34}\ Js)\left(7.32 \times 10^{14}\ \frac{1}{s}\right) = 4.85 \times 10^{-19}\ J$

17(e) $\lambda = 1094\ nm$ = IR light

$c = \lambda\nu \quad \nu = \frac{c}{\lambda} = \frac{3.00 \times 10^8\ \frac{m}{s}}{1.094 \times 10^{-6}\ m} = 2.74 \times 10^{14}\ \frac{1}{s}$

$E = h\nu = (6.626 \times 10^{-34}\ Js)\left(2.74 \times 10^{14}\ \frac{1}{s}\right) = 1.82 \times 10^{-19}\ J$