Can You See the Music?

Name _____ Date _____ Teacher _____

Introduction:

Max Planck determined the relationship among energy, frequency and wavelength in 1900 in his publication of the quantum theory of light. Planck assumed that the amount of energy lost or gained at the atomic level during the absorption or emission of radiation was only allowed in specific amounts he called quanta. Each quantum of energy is mathematically equal to $h\nu$, where h equals Planck's constant, 6.626×10^{-34} J x s, and ν is the frequency of the radiation. Planck determined that the energy emitted or absorbed by the atom as photons of light is directly proportional to the frequency and inversely proportional to the wavelength. The frequency of the waves times their wavelengths always equals the speed of light, c, 3.0×10^{8} m/s. Therefore, a series of mathematical formulae can be derived to describe each type of EMR found from cosmic rays to visible light to hertzian waves of TV and radio signals.

RADIATION ENERGY FORMULAE

Wavelength:	$\lambda = \frac{c}{\bar{\nu}}$	or	$\lambda = \frac{h.c}{E}$
Frequency:	$\bar{\nu} = \frac{c}{\lambda}$	or	$\bar{\nu} = \frac{E}{h}$
Energy:	$E = h\bar{\nu}$	or	$E = \frac{h.c}{\lambda}$

NOTE: $C = 3.00 \times 10^{10} cm.s^{-1}$ $h = 6.626 \times 10^{-34} J.s^{-1}$ $\therefore h.c = 1.9878 \times 10^{-23} J \cdot cm.s^{-1}$

ELECTROMAGNETIC RADIATION WORKSHEET

1. Determine the energy of an EMR having a frequency of $4.5 \times 10^{14}\ s^{-1}$. _____

2. Determine the wavelength of an EMR having an energy value of 6.78×10^{-19} J. _____

3. Determine the frequency of an EMR produced by a pure red light source. _____

4. Determine the energy of an EMR having a wavelength of 7700 Angstroms. _____

5. Determine the wavelength of an EMR having a frequency of $2.35 \times 10^{14}\ s^{-1}$. _____

6. Determine the frequency of an EMR produced by an energy input of 1.23×10^{-19} J. _____

ELECTROMAGNETIC RADIATION WORKSHEET THOUGHT QUESTIONS

A. In what way is polarization related to the transverse nature of an EMR?

_____
_____

B. Discuss how the energy and wavelength of an EMR are related to each other.

_____
_____

C. Discuss five forms of electromagnetic radiation by giving examples of their source, energy values, frequencies and wavelengths.

1. _____
2. _____
3. _____
4. _____
5. _____

D. Discuss the relationship of the speed of light to the frequency and wavelength of an EMR.

_____
_____

E. Discuss how the energy and frequency of an EMR are related to each other.

_____
_____

ANSWERS TO ELECTROMAGNETIC RADIATION WORKSHEET

1. $E = 4.5 \times 10^{14}\ s^{-1}$ **X** $6.626 \times 10^{-34}\ J/s^{-1} = 2.982 \times 10^{-19}\ J$

2. $\lambda = \dfrac{6.626 \times 10^{-34}\ J/s^{-1}\ \mathbf{X}\ 3 \times 10^{10}\ cm \cdot s^{-1}}{6.78 \times 10^{-19}\ J} = 3.165 \times 10^{-5}\ cm$

3. $\nu = \dfrac{3 \times 10^{10}\ cm \cdot s^{-1}}{7 \times 10^{-5} cm} = 4.286 \times 10^{14} s^{-1}$ Red = 7000 Angstroms $= 7 \times 10^{-5} cm$

4. $E = \dfrac{6.626 \times 10^{-34}\ J/s^{-1}\ \mathbf{X}\ 3 \times 10^{10}\ cm \cdot s^{-1}}{7.7 \times 10^{-5}\ cm} = 2.582 \times 10^{-19}\ J$

5. $\lambda = \dfrac{3 \times 10^{10}\ cm \cdot s^{-1}}{2.35 \times 10^{14}\ s^{-1}} = 1.277 \times 10^{-4}\ cm$

6. $\nu = \dfrac{1.23 \times 10^{-19}\ J}{6.626 \times 10^{-34}\ J/s^{-1}} = 1.856 \times 10^{14}\ s^{-1}$