HW – PERIODIC GROUPS

NAME______________________________

I. Review. Complete the following light-related problems:

1. Ultraviolet Radiation (UV) waves have wavelengths in the order of 10^{-8}m. Let's say on a sunny day that you are sitting on the beach absorbing UV rays with a wavelength of 5.91×10^{-8}m.

   a. What unit of length would be appropriate for measuring this wavelength? Convert the wavelength of the rays you are absorbing to that unit.

   nm (nano) 59.1nm (nm = 10^{-9})

   b. At what speed is this type of radiation traveling?

   3.00×10^{8} m/s (all EM)

   c. Calculate the frequency of these waves.

   $f = \frac{c}{\lambda}$ ← meters! ← meters! $5.08 \times 10^{15}\ s^{-1}$

   d. Calculate the amount of energy in a photon of this type of UV radiation.

   3.37×10^{-18} J

   e. If 1 square inch of your skin is bombarded with 3.67×10^{17} UV photons per second, how much energy does 1 square inch of your skin feel per minute?

   $\frac{h \cdot c}{\lambda} = E_{photon}$

   74.0632 ~ 74.1 J/min

2. Calculate the wavelength of light emitted when an electron jumps from the 3rd Energy Level to the 1st Energy level in a Bohr-model hydrogen atom.

   $E_n = \frac{-2.178 \times 10^{-18}}{n^2}$ $E = \frac{h \cdot c}{\lambda}$

   $\frac{h \cdot c}{E} = \lambda = 1.027 \times 10^{-7} = 102.675$ nm ≈ 103 nm

   Negative ok! means light EMITTED not stored.

3) Calculate the deBroglie wavelength of an electron (9.10939×10^{-31}kg) traveling at 80% of the speed of light.

   de Broglie = $\lambda = \frac{h}{m v}$

   $\lambda = \frac{6.626 \times 10^{-34}}{9.10939 \times 10^{-31}\,kg\,(.8 \cdot 3.00 \times 10^{8}\,m/s)}$

   3.0307×10^{-12} m or 3.03 pm

HW – QUANTUM NUMBERS

NAME______________________

6) Answer the statements below with the letter that represents the scientist associated with that statement:

a. Dalton b. Thomson c. Rutherford d. Bohr e. Planck f. DeBroglie g. Heisenberg
h. Democritus i. Einstein j. Crookes k. Chadwick

_____ a) Described atoms as having a positive nucleus with negative electrons in planet-like orbits called Energy Levels.
_____ b) Stated that it is impossible to know both the velocity and location of an electron at the same time.
_____ c) Described the photoelectric effect as being a result of quanta of energy in purple light ~~having sufficient electrons to force electrons from a metal.~~
_____ d) Greek philosopher responsible for coining the term "atom" as a piece of indivisible matter.
_____ e) First described energy being transported in "packets" he called quanta – quantum theory
_____ f) First described the modern concept of atoms as indivisible, fundamental particles of matter; said atoms of the same element were the same themselves.
_____ g) Claimed that matter had wave-like properties.

_____ h) Discovered electrons through his work with cathode rays; developed the "plum pudding" model of the atom.
_____ i) First developed the Cathode Ray Tube.

_____ j) Performed the "gold foil" experiment which resulted in him concluding that atoms were composed primarily of empty space with a positively-charged nucleus.

7. Calculate the deBroglie wavelength of a proton (m = 1.67262 x 10^{-27} kg) moving at a velocity of 90% of the speed of light.

FORMULA IN NOTES

$\lambda = \dfrac{6.626\times10^{-34}\ \text{J s}^{-1}\ \text{kg m s}^{-1}}{1.67262\times10^{-27}\ \text{kg}\ (.9)\ 3.00\times10^{8}\ \text{m s}^{-1}} = 1.467203\times10^{-15}$

1.47×10^{-15}

8. Calculate the deBroglie wavelength of a tennis ball (m = 0.060 kg) moving at 90% of the speed of light. Can you throw this hard?

2SF

$\lambda = 4.0901\times10^{-41}$

4.1×10^{-41} 4.1

9. Using the values in #5, what is the mass of a violet photon? a red photon? (remember, they move at speed of light, seeing as they *are* light….)

VIOLET $\text{kg} = \dfrac{6.626\times10^{-34}\ \text{kg m s}^{-1}}{400\ (3.00\times10^{8}\ \text{m/s})}$ = 5.52×10^{-36} kg (-26?) 45 wrong!

400 → 400×10^{-9} meters!

5.521666

RED = 700 → 700×10^{-9} needs to be same units

3.155238

3.16×10^{-36} kg (-36?)

10. Fiber optics uses composite fibers to guide photons of light ~~rather than copper~~ wires which guide electrons. Using the mass of a violet photon from #12, how much more massive is an electron (m = 9.10939 x 10^{-31} kg) than a violet photon?

$\dfrac{\text{electron}\ \ 9.10939\times10^{-31}\ \text{kg}}{\text{violet photon}\ \ 5.52\times10^{-36}\ \text{kg}} =$

3SF! 165025 times more massive! ~165000

HW – QUANTUM THEORY

NAME______________________

1. List the 7 types of electromagnetic radiation from the ***largest*** wavelength to the ***smallest***:
   * then note below the list where the area of highest and lowest frequency exist.

Low frequency, large λ — Radio – Microwave – Infrared – Visible – Ultraviolet – Xray – gamma — high freq, small λ

2. Mr. V listens to 96.1 FM in his car (are you surprised?). This number represents a frequency of 96.1 MHz. What is the wavelength of these radio waves?

$H = \frac{c}{\lambda}$

3.12 m

M = mega = 1,000,000

$\frac{3.00\times10^8 \text{ m/s}}{96{,}100{,}000 \frac{1}{s}} = 3.12 \text{ m}$

96.1 MHz | 1000 Hz / 1 MHz = 96,100,000 Hz

3. Your microwave oven emits radiation with a wavelength on the order of 1.0 cm. What is the frequency of this radiation?

$H = \frac{c}{\lambda}$

1.0 cm | .01 m / 1 cm

$\frac{3.00\times10^8 \text{ m/s}}{1.0\times10^{-2} \text{ m}} = 3.00\times10^{10} \frac{1}{s}$

4. Calculate the energy of the two waves in #2 and #3.

$E = \frac{h\cdot c}{\lambda}$

$\frac{6.626\times10^{-34} \text{ J} \cdot 3.00\times10^8 \text{ m}}{\#2\ 3.12 \quad \#3\ .010 \text{ m}}$ (2 SF)

6.3711×10^{-26} J ~ 6.37×10^{-26} J

1.9878×10^{-23} ~ 2.0×10^{-23} J

5. A photon of violet light has a wavelength of about 400 nm, and a photon of red light has a wavelength of about 700 nm. Which color of light should have the most energy?

Smaller λ = HIGHER E
Purple/violet

6. Calculate the amount of energy in a red and a purple photon of light.

$E_{ph} = \frac{h\cdot c}{\lambda}$

E of one photon

$P = \frac{6.626\times10^{-34} \text{ J} \cdot 3.00\times10^8 \text{ m}}{400\times10^{-9}} = 4.9695\times10^{-19}$ J
4.97 J

$r = \frac{6.626\times10^{-34} \text{ J} \cdot 3.00\times10^8 \text{ m}}{700\times10^{-9}} = 2.8397\times10^{-19}$
2.84 J

E_{ph} = E of 1 photon (1 atom)

HW – QUANTUM THEORY

Take a breath. Relax. It's simple. Read it and think about it.

NAME

7. According to Bohr's Model, every time an electron in a hydrogen atom travels from an excited state to ground state it must release energy in certain quanta. Using your answer from #6, if a mole of excited hydrogen atoms release a red photon, how much energy does that represent (express your answer in kJ)? How much energy would be represented by a mole of violet photons?

$6.02 \times 10^{23} \cdot 4.97 \times 10^{-19}\ J = \frac{299163.9\ J}{} \Big| \frac{1\ kJ}{1000\ J} = 299\ kJ$

violet/purple = 299 kJ
red = 171 kJ

$6.02 \times 10^{23} \cdot 2.84 \times 10^{-19}\ J = \frac{170950.8\ J}{} \Big| \frac{1\ kJ}{1000\ J} = 171\ kJ$

8. Calculate the wavelength of light emitted when each of the following transitions occur in a hydrogen atom. What type of electromagnetic radiation is emitted in each transition?

$E_n = \frac{-2.178 \times 10^{-18}\ J}{n^2}$ → $\lambda = \frac{h\ J\cdot s \cdot c\ m/s}{E\ J}$ $\left(E_{ph} = \frac{h \cdot c}{\lambda}\right)$

a. n = 3 → n = 2

$\lambda = 6.571 \times 10^{-7} \approx 657\ nm$ (red light) visible

b. n = 4 → n = 2

$\lambda = 4.8675 \times 10^{-7} \approx 487\ nm$ (~~purple light~~ blue-green) visible light

c. n = 2 → n = 1

$\lambda = 1.21689 \times 10^{-7} \approx 122\ nm$ near ultraviolet

9. Explain Einstein's reasoning for the photoelectric effect (i.e. why was violet light able to force electrons to move, but red was not)

Light energy is carried in discreet "quantized" packets. ~~Einstein~~ Red light lacks the energy to dislodge.

See simulation on website

See website for simulation.