Mr. Bracken
AP Chemistry

Name BRACKEN KEY
Period _____

Atomic Structure: Frequency & Wavelength Calculations

$E = hv$
$h = 6.63 \times 10^{-34}$ Joules-seconds
1 mole = 6.02×10^{23}

$c = \lambda v$
$c = 3.00 \times 10^{8}$ m/s
1 nm = 1×10^{-9} meters

1. A certain light has a frequency of 6.0×10^{14} sec^{-1}.

   (a) What is the energy of a single photon of light at this frequency?

   $E = (6.63 \times 10^{-34})(6.0 \times 10^{14}) = 3.98 \times 10^{-19}\ \frac{Joules}{photon}$

   (b) What is the wavelength of this light in nanometers?

   $3.00 \times 10^{8} = \lambda \cdot (6.0 \times 10^{14})$

   $\lambda = 5.0 \times 10^{-7}$ meters

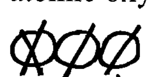
   $\frac{5.0 \times 10^{-7} \text{ meters}}{1} \times \frac{1 \text{ nm}}{1 \times 10^{-9} \text{ meters}} =$ 500 nm

2. The following reaction occurs in the upper atmosphere if photons having wavelengths of 240 nm and shorter strike a molecule of oxygen gas.

   $O_2 \rightarrow 2\,O$

   (a) Write the electron configuration of O. $1s^2 2s^2 2p^4$

   (b) Is atomic oxygen (O) considered diamagnetic or paramagnetic? Explain.

   $2p^4$ ← 2 unpaired electrons so paramagnetic!

   (c) What is the electron configuration of the oxide ion, O^{2-}? $1s^2 2s^2 2p^6$

   (d) How much energy does a single photon of wavelength 240 nm possess?

   $3.00 \times 10^{8} = (240 \times 10^{-9})v$

   $v = 1.25 \times 10^{15}$ sec^{-1}

   $E = (6.63 \times 10^{-34})(1.25 \times 10^{15})$

   $E = 8.29 \times 10^{-19}\ \frac{Joules}{photon}$

   (e) How much energy does a mole of photons at 240 nm possess?

   $\left(8.29 \times 10^{-19}\ \frac{Joules}{photon}\right)\left(6.02 \times 10^{23}\ \frac{photons}{Mole}\right) = 499058\ \frac{Joules}{mole}$

   499 KJ/mole

3. What is the energy of a photon of radiation whose wavelength is 413 nm?

$3.00 \times 10^{8} = (413 \times 10^{-9})\nu$

$\nu = 7.26 \times 10^{14}\ sec^{-1}$

$E = (6.63 \times 10^{-34})(7.26 \times 10^{14})$

$E = 4.81 \times 10^{-19}\ \frac{Joules}{photon}$

4. What wavelength (in nm) of radiation has photons of energy 6.06 x 10^{-19} Joules?

$6.06 \times 10^{-19} = (6.63 \times 10^{-34})\nu$

$\nu = 9.14 \times 10^{14}\ sec^{-1}$

$3.00 \times 10^{8} = \lambda(9.14 \times 10^{14})$

$\lambda = 3.28 \times 10^{-7}\ meters$

$3.28 \times 10^{-7}\ meters \times \frac{1\ nm}{1 \times 10^{-9}\ meters} = 328\ nm$

5. A green laser pointer emits light at a wavelength of 532 nm.

(a) What is the frequency of this light?

$3.00 \times 10^{8} = (532 \times 10^{-9})\nu$

$\nu = 5.64 \times 10^{14}\ sec^{-1}$

(b) What is the energy of one of these photons?

$E = (6.63 \times 10^{-34})(5.64 \times 10^{14})$

$E = 3.74 \times 10^{-19}\ \frac{Joules}{photon}$

6. The energy from radiation can be used to break chemical bonds. A minimum energy of 242,000 Joules/mole is required to break a Cl-Cl bond in Cl_2. What is the longest wavelength of radiation that possesses the necessary energy to break this bond?

$\frac{242\,000}{6.02 \times 10^{23}} = 4.02 \times 10^{-19}\ \frac{Joules}{photon}$

$4.02 \times 10^{-19} = (6.63 \times 10^{-34})\nu$

$\nu = 6.06 \times 10^{14}\ sec^{-1}$

$3.00 \times 10^{8} = \lambda(6.06 \times 10^{14})$

$\lambda = 4.95 \times 10^{-7}\ meters$

$4.95 \times 10^{-7}\ meters \times \frac{1\ nm}{1 \times 10^{-9}\ meters} =$

$495\ nm$