

# AP Chemistry Atomic Structure - 3 Worksheet

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1. At its closest approach, Mars is 36 million km from Earth. How long would it take a radio message that is sent from Earth to Mars when the planets are at this closest distance?

$$c = 3 \times 10^8 \text{ m/s} \quad \lambda = 36 \times 10^6 \text{ km} = 36 \times 10^9 \text{ m} \quad \lambda = \frac{c}{\nu} \Rightarrow \nu = \left( \frac{3 \times 10^8}{36 \times 10^9} \right) = \boxed{2.1 \times 10^7 \text{ Hz}}$$

2. The second is defined as the time it takes for 919,263,173 wavelengths of a certain radiation of the vacuum light to pass a fixed point. What is (a) the frequency of the electromagnetic radiation? (b) its wavelength?

Frequency:  $\nu = \frac{c}{\lambda} \Rightarrow \lambda = \frac{c}{\nu} = \frac{3 \times 10^8 \text{ m/s}}{919,263,173 \text{ s}^{-1}} = \boxed{3.26 \times 10^{-10} \text{ m}}$

3. The energy required to dissociate the  $\text{O}_2$  molecule to O atoms is 248 kJ/mol  $\text{O}_2$ . If the dissociation of 1 mol  $\text{O}_2$  molecule were accomplished by the absorption of a single photon whose energy was exactly that quantity required, what would be its wavelength (in meters)?

$$\frac{248 \text{ kJ/mol}}{6.022 \times 10^{23} \text{ mol}^{-1}} = 4.118 \times 10^{-19} \text{ J} \quad \lambda = \frac{hc}{E} = \frac{6.626 \times 10^{-34} \text{ J}\cdot\text{s} \times 3 \times 10^8 \text{ m/s}}{4.118 \times 10^{-19} \text{ J}} = \boxed{4.8 \times 10^{-7} \text{ m}}$$

4. In the atmosphere, ultraviolet radiation with a frequency of  $1.55 \times 10^{16} \text{ s}^{-1}$  can break C-C bonds in chlorofluorocarbons (CFCs), which can lead to destruction of the ozone. Calculate the energy per quantum of this radiation.

$$E = h\nu = 6.626 \times 10^{-34} \text{ J}\cdot\text{s} \times (1.55 \times 10^{16} \text{ s}^{-1}) = \boxed{1.03 \times 10^{-17} \text{ J}}$$

5. Four possible electron transitions in a hydrogen atom are given below:

	From	To
(a)	2	1
(b)	3	1
(c)	3	2
(d)	4	2

(a) Which transition(s) represent a loss of energy?  $n=2 \rightarrow n=1$  (a) & (b)

(b) For which transition does the atom gain the greatest quantity of energy?

$$3 \rightarrow 1$$

(c) Which transition corresponds to emission of the greatest quantity of energy?

$$3 \rightarrow 1$$

6.  $\text{Li}^{2+}$  is a hydrogen-like ion. Such an ion has a nucleus of charge +Ze and a single electron outside this nucleus. The energy levels of the ion are  $-Z^2 R_H/n^2$ , where  $Z$  is the atomic number. What is the wavelength of the transition from  $n = 2$  to  $n = 1$  for  $\text{Li}^{2+}$ ? In what region of the spectrum does this emission occur?

$$\frac{1}{\lambda} = -Z^2 R_H \left( \frac{1}{n_1^2} - \frac{1}{n_2^2} \right) \quad R_H = 1.097 \times 10^7 \text{ m}^{-1}$$

$$\frac{1}{\lambda} = -2^2 (1.097 \times 10^7 \text{ m}^{-1}) \left( \frac{1}{1^2} - \frac{1}{2^2} \right) = -2.7425 \times 10^7 \text{ m}^{-1} \Rightarrow \lambda = \boxed{3.64 \times 10^{-8} \text{ m}}$$