AP CHEMISTRY

TOPIC 4: ATOMIC STRUCTURE & THE PERIODIC TABLE, PART A

Day 46:

- Electromagnetic Radiation
- Periodic Table
- Quantum Numbers
- Aufbau Principle
- Pauli Exclusion Principle
- Hund's Rule
- Diamagnetism and Paramagnetism
- Energy of an Electron

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1) The amount of energy that is required to remove a mole of electrons from the surface of solid lithium is 279.7 kJ / mol. Calculate the wavelength of the light capable of removing **ONE ELECTRON** from the surface of a lithium atom.

Answers:

$$\frac{279.7\ kJ}{mol} \times \frac{1\ mol}{6.022 \times 10^{23}} = 4.645 \times 10^{-22}\ kJ\ , \ \textbf{\textit{Now convert to joules,}}\ \frac{4.645 \times 10^{-22}\ kJ}{} \times \frac{1000\ J}{1\ kJ} = 4.645 \times 10^{-19}\ J$$

$$E = h\nu \ \ and \ \ C = \lambda \nu$$

$$E = h\nu\ ;\ \nu = \frac{E}{h} = \frac{4.645 \times 10^{-19}\ J}{6.63 \times 10^{-34}\ J \cdot \text{sec}} = 7.01 \times 10^{14}\ \frac{1}{\text{sec}}$$

$$C = \lambda \nu\ ;\ \lambda = \frac{C}{\nu} = \frac{3.00 \times 10^{8}\ m\ (\text{sec})}{\left(7.01 \times 10^{14}\right)(\text{sec})} = 4.28 \times 10^{-7}\ m$$

OR

$$\nu = \frac{C}{\lambda}\ \ and\ \ E = h\nu\ \ \textbf{\textit{combine the two equations to get,}}\ \ E = h\frac{C}{\lambda}$$

$$E = \frac{h\,C}{\lambda}\ \ \textbf{\textit{rewrite as:}}\ \ \lambda = \frac{h\,C}{E} = \frac{\left(6.626 \times 10^{-34}\,J \cdot \text{sec}\right)\left(3.00 \times 10^{8}\ m\right)}{\left(4.645 \times 10^{-19}\ J\right)(\text{sec})} = 4.28 \times 10^{-7}\ m$$

2) What are the possible values for the quantum numbers *n*, *l*, and m_l (starting at the first energy level to the fourth)?

Answers:

n	***l*** ***(0 → n - 1)***	m_l ***(l → 0 → - l)***	m_s
1	0	0	½ , - ½
2	0, 1	1, 0 , -1	½ , - ½
3	0, 1, 2	2, 1, 0, -1, -2	½ , - ½
4	0, 1, 2, 3	3, 2, 1, 0, -1, -2, -3	½ , - ½

3) Which of the following orbital designations are incorrect: 1*s*, 1*p*, 7*d*, 9*s*, 3*f*, 4*f*, 2*d*, 3*s*, 5*p*, 2*p*?

Answers:

1*s*, **1*p***, 7*d*, 9*s*, **3*f***, 4*f*, **2*d***, 3*s*, 5*p*, 2*p*

("s" orbitals start @ 1, "p" orbitals start @ 2, "d" orbitals start @ 3, "f" orbitals start @ 4, and "g" orbitals start @ 5)

4) Which of the following sets of quantum numbers are not "legal"? For the sets of quantum numbers that are incorrect, state what is wrong in each set.

a) $n = 2, l = 1, m_l = -1$
b) $n = 1, l = 1, m_l = 0$
c) $n = 8, l = 7, m_l = -6$
d) $n = 1, l = 0, m_l = 2$
e) $n = 2, l = 1, m_l = -3$

Answers:

b, when the principle quantum number is one, "l" cannot be equal to one (which represents "p" orbitals.)

d, when the principle quantum number is one, "m_l" cannot be equal to 2 (which represents an orientation for at least the second principle quantum number)

e, when the principle quantum number is two, "m_l" cannot be equal to -3 (which represents an orientation for at least the third principle quantum number)

5) The laser in a CD player used light with a wavelength of 7.80×10^2 nm. Calculate the frequency of this light?

Answers:

$$\frac{7.80\times10^{2}\ nm}{}\times\frac{1\ m}{1\times10^{9}\ nm} = 7.80\times10^{-7}\ m$$

$$\nu = \frac{c}{\lambda} = \frac{3.00\times10^{8}\ m}{7.80\times10^{-7}\ m\ (\text{sec})} = 3.85\times10^{14}\ \frac{1}{\text{sec}}$$

6) Calculate the mass of the photon discussed in the previous question, which is traveling at 2.83×10^8 m sec^{-1}.

Answers:

$$\lambda = \frac{h}{m\upsilon} \quad \textbf{\textit{rewrite as:}} \quad m = \frac{h}{\lambda\upsilon}$$

convert the units for Planck's constant – Joules to $\frac{kg\cdot m^2}{\text{sec}^2}$

$$m = \frac{h}{\lambda\upsilon} = \frac{6.626\times10^{-34}\ kg\cdot m^2\cdot\text{sec}\ (\text{sec})}{(7.80\times10^{-7}\ m)\left(\text{sec}^2\right)(2.83\times10^{8}\ m)} = 3.00\times10^{-36}\ kg$$