Ch. 13 - Electrons in Atoms

p. 361-385

13.1 - The Development of the Atomic Models

The electron travels around the nucleus in the ________________ __________. The electron cloud is made up of several ________________ ____________, which are areas around the nucleus where the electron is most ____________ to be found.

Energy levels are like the ____________ on staircase, where each stair in one energy level. A person can climb up or down the staircase by going from step to step. However, a person on a staircase can ______ stand ______________ steps, nor can an electron exist ________________ energy levels. Unlike the staircase, the energy levels of an atom are not equally spaced.

A quantum is a small ________________ of _________________. A quantum is enough energy to make an electron jump from its current energy level up to the next one. The electrons in atoms are ________________, meaning that an electron can ______ be moved only a _________________, but must be moved to the next ________________ __________ or remain where it is. The term quantum leap refers to electrons ________________ from one energy level to the next.

Continuous           Quantized
If your car was quantized with units of 10 mph, you could only travel at speeds ending with a zero (0 mph, 10, 20, 30, etc.)

13.1 - The Quantum Mechanical Model of the Atom

The ____________ understanding of the electrons in atom is called the ______________ ______________________ model and was developed in large part by Erwin Schrödinger.

Schrödinger's model said you can not _________ the __________ ________________ of the electron, as Bohr thought he could, but instead describes areas of ________________ where the electron is most ______________ to be found. So the electron cloud is very much like a blurry cloud of negative charge.

This is similar to a student during the school day. If I did not have a copy of your schedule I could not predict exactly where in the building you would be at any point in time, but I could predict that you are probably somewhere in the building.

The cloud is ____________ __________ when the likelihood of finding the electron is _________ and it is least dense when the likelihood of finding the electron is _________. So it is difficult to say where the cloud ________. It is like walking in thick fog. You can not tell where the fog starts and ends.
Atomic Orbitals (a.k.a. Sublevels)

The energy levels we have been discussing are designated by the __________ quantum number, ___.  n can be 1, 2, 3, 4, 5, 6, or 7  Again the energy levels are like stairs in a staircase or levels of a 7 story building.

Sublevels are __________ of energy levels. Each energy level has ______ or ______ sublevel.

The first energy level, n = 1, will only have only _____ sublevel, a ____ sublevel.
The second energy level, n = 2, will have ______ sublevels, a ____ and a ____ sublevels.
The third energy level, n = 3, will have __________ sublevels, a _____, _____, and ____ sublevels.
The fourth energy level, n = 4, will have ________ sublevels, a ____ , ____ , ____ , and ____ sublevels.
Since there are only four common sublevels the n = 5, 6, and 7 will also have ____ , ____ , ____ , and ____ sublevels.

When referring to a sublevel we identify it with its energy level and sublevel. So the p sublevel in the 3rd energy level is called ____.

s sublevels are ________________ p sublevels are ________________
d and f are beyond simple description.
s sublevels have ___ orbital and a maximum of ___ electrons
p sublevels have ___ orbitals and a maximum of ___ electrons
d sublevels have ___ orbitals and a maximum of ___ electrons
f sublevels have ___ orbitals and a maximum of ___ electrons

\[ n = 1 \quad 2 \quad 3 \quad 4 \]

How many orbital's do each of the energy levels contain? _____ _____ _____ _____
Each orbital can hold _____ electrons, so calculate the
Maximum number of electrons each energy level can contain. _____ _____ _____ _____

The general equation for the number of _______________ in an energy level is
______ and the general equation for the maximum number of electrons in an energy
level is ______.

All electrons have either ______________________ or
______________________________ spins. Spinning electrons create magnetic
fields. If two electrons have the _________________ spin near each other then they
__________ each other out.

13.2 Electron Configurations
We have two systems for describing the electrons around an atom. One is called
__________________________ diagrams and the other is called
__________________________ . Both are used to describe the
arrangement of _________________ around a ______________ of an atom. To use
either of these methods we first need to learn three rules for how to place electrons.
Rule # 1 - The Aufbau principle - Electrons fill orbitals from ___________ energy sublevel first. Electron orbitals fill just like a glass of milk -- from the bottom up.

Rule # 2 - The Pauli exclusion principle - No two electrons can have the same four quantum numbers. So, electrons in the ___________ ______________ must have opposite ____________.

Rule # 3 - Hund’s Rule - When electrons occupy _______________ of the same ______________ one electron will enter ________ orbital before the second enters any.

This is similar to being on a bus full of people you don’t know. Passengers will put one person in each empty seat, before two people will sit next to each other.

Electron Configurations and the Periodic Table

We can relate the quantum numbers to the periodic table.

The energy level, n, is the ___________ (horizontal row) on the periodic table.

The sublevel, l, is the ___________ of the periodic table. Groups 1A and 2A make up the ___ block.

Groups 3A - 8A make up the ___ block. All "B" groups make up the ___ block and the two rows at the bottom make up the ___ block.

If you read the periodic table from left to right, just like a book, it corrects all order changes due to sublevels overlapping.

___________ electrons are only the electrons in the ___________ energy ___________
13.3 Light and Atomic Spectra

__________ light is one form of ______________________________ energy.

Other forms include radio, infrared, ultraviolet, and X-ray waves. Electromagnetic energy travels in the form of waves. Look at p. 373 of your text to see the entire electromagnetic ______________. Notice that visible light is a small part of the electromagnetic spectrum. The rainbow’s order is ________ ______.

All waves can be described by ________ characteristics: ________________, ________________, ________________, __________________, and ________.

- crest
- wavelength, \( \lambda \)
- amplitude
- origin
- trough

The first is __________________. This is a wave’s height. Amplitude is the distance from the ____________ to the ____________.
Next is wavelength. ____________________ is the distance between ____________. A diagram showing wavelength is below. Wavelength is represented by 𝜆 and is read "lambda".

The third is frequency. The ____________________ of a wave is the ____________ of times that the wave completes a cycle each _____________. Frequency is symbolized by 𝑓, which is called ____.

Per second = 1/s = s⁻¹ = 1 Hertz = 1 Hz.

The last is ____________. Electromagnetic radiation moves through space at 3.00x10⁸ m/s.

\[ c = \text{the speed of light} \]

\[ \lambda = \text{frequency} \]

\[ \lambda = \text{wavelength} \]

1) Calculate the frequency of an x-ray having a wavelength of 2.5 x 10⁻⁹ m.

2) Calculate the wavelength of a wave with the frequency of 5.0 x 10¹⁴ Hz.

13.3 The Quantum Concept

Plank discovered the relationship between the frequency of light and the amount of energy it contains.

\[ E = h \cdot \lambda \]

\[ E = \text{energy} \]

\[ h = \text{Plank's constant} = 6.626 \times 10^{-34} \text{ J's} \]

\[ \lambda = \text{frequency} \]
3) How much energy is there in an infrared quantum with a frequency of $4.5 \times 10^{13} \text{ s}^{-1}$?

4) How much energy is there in a X-ray quantum with a wavelength of $5.42 \times 10^{-9} \text{ m}$?

The Explanation of Atomic Spectra

We normally assume that the atom is at its ______________ __________, which means that all electrons are in their ______________ ____________ levels possible.

When an electron of an atom receives energy, electrons in atoms enter an ______________ ____________ where an electron ______________ its ______ level orbital and moves to one that is ______________ in energy.

Then that electron is attracted back to its nucleus and it ______________ back down to a ______________ energy level. When this happens the ______________ is ______________ ____

by the electron in the form of ______________ energy. Some of this electromagnetic energy is at the right wavelength to be visible light.

Each element gives off different colors of light when the electron falls back down. This light is called a ______________. By studying known element's spectrum, if we have an
unknown element’s spectrum, we can identify it. This is how astronomers can identify what distant stars are burning, by looking at their spectrum.

The Photoelectric Effect

Albert Einstein confirmed this idea when he observed the __________________________ effect. If you were to shine a ______ light on a sheet of metal nothing would happen __________________________ of the __________________________ (amplitude) of the red light. However, if you were to shine a ___________ light on a piece of metal __________________________ of the __________________________ (amplitude) __________________________ are ejected from the surface of the metal. He suggested that quanta of energy behave like tiny ____________________, which he called ______________. The idea of light ejecting electrons on a metal surface is the fundamentals of the __________ cell.