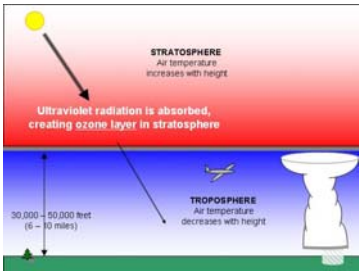


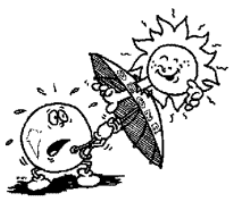
Ozone, O_3, protects Earth's inhabitants from the harmful effects of ultraviolet light arriving from the sun.

This shielding is a maximum for UV light having a wavelength of 295 nm. What is the frequency in hertz of this light?

Recall: speed of light = frequency x wavelength

Recall: 1 m = 10^9 nm

Recall: c = 3.00×10^8 m/s



$$295 \text{ nm} = 295 \times 10^{-9} \text{ m}$$

$$\nu = \frac{c}{\lambda} = \frac{3.00 \times 10^8 \text{ m/s}}{295 \times 10^{-9} \text{ m}} = 1.02 \times 10^{15} \text{ s}^{-1} = 1.02 \times 10^{15} \text{ Hz}$$

PLANCK'S CONSTANT

Planck proposed that the vibrating atoms in a heated solid could absorb or emit electromagnetic energy only in discrete amounts.

The smallest amount of energy, a **quantum,** is given by:

$$E = h\nu$$

as **Planck's constant,** *h*, has a value of **6.626×10^{-34} J s.**

Planck's quantum hypothesis states that energy can be absorbed or emitted only as a quantum or as *whole multiples* of a quantum, thereby making variations *discontinuous,* changes can only occur in discrete amounts.

Calculate the energy in joules of a photon of green light having a wavelength of 560 nm.

E = hv
H = 6.626 X 10-34 J s
v = ?
E = ?
Hmmmmm…what to do next?

$E = h\nu = hc/\lambda$, and $560\ nm = 560 \times 10^{-9}\ m$

$$E = \frac{hc}{\lambda} = \frac{(6.626\times10^{-34}\ J\ s)(3.00\times10^{8}\ m/s)}{(560\times10^{-9}\ m)} = 3.55\times10^{-19}\ J$$

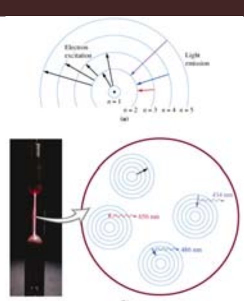
Bohr's Hydrogen Atom

- Each specified energy value is called an **energy level** of the atom

$$E_n = -B/n^2$$

  - n is an integer, and B is a constant which equals 2.179×10^{-18} J
  - The energy is zero when the electron is located infinitely far from nucleus
  - The negative sign represents the forces of attraction

The Bohr Model



Bohr Explains Line Spectra

- Bohr's equation is most useful in determining the energy change (ΔE_{level}) that accompanies the leap of an electron from one energy level to another
- For the final and initial levels:

$$E_f = -B / n_f^2 \qquad E_i = -B / n_i^2$$

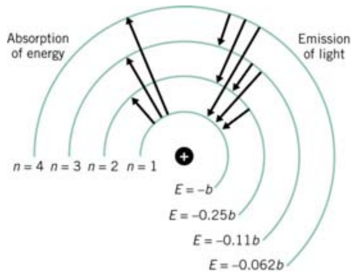
where B is the combined constant (2.18×10^{-19}J)
n are whole numbers starting with 1

- The energy difference between n_f and n_i is:

$$\Delta E_{level} = -B / n_f^2 - -B / n_i^2 = B(1/n_i^2 - 1/n_f^2)$$

- Together, all the photons of this energy produce one spectral line
- The collection of lines is the observed emission spectrum

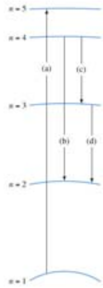
Energy Levels and Spectral Lines for Hydrogen



Ground States and Excited States

- When an atom has its electrons in their lowest possible energy levels, it is in its **ground state**
- When an electron has been promoted to a higher level, it is in an **excited state**
  - Electrons are promoted through an electric discharge, heat, or some other source of energy
  - An atom in an excited state eventually emits photons as the electron drops back down to the ground state

Electronic Transitions



Electrons are
Restricted to certain
Energy levels….

We say that the energy
Of these electrons is
quantized

Quantum Numbers And Atomic Orbitals

- orbitals allow us to visualize the region in which there is a probability of find an electron.

Quantum Numbers

quantum numbers: a specific atomic orbital is defined through defining three quantum numbers

- The **principal quantum number (*n*)**
  - Is independent of the other two quantum number
  - Can only be a positive integer
  - The size of an orbital and its electron energy depend on the *n* number
  - Orbitals with the same value of *n* are said to be in the same **principle shell**

Quantum Numbers (continued)

- The **orbital angular momentum quantum number (*l*)**
  - Determines the shape of the orbital
  - Can have positive integral values from zero to one less than the value of *n*
  - All orbitals having the same value of n and the same value of *l* are said to be in the same **subshell**
  - Orbitals and subshells are also designated by a letter:

Value of *l*	0	1	2	3
Orbital and subshell designations	s	p	d	f

  - Each of these orbitals are a different region of space and a different shape

Quantum Numbers (continued)

- The **magnetic quantum number (m_l):**
  - Determines the orientation in space of the orbitals of any given type in a subshell
  - Can be any integer from -*l* to +*l*
  - The number of possible value for $m_l = 2l + 1$, and this determines the number of orbitals in a subshell

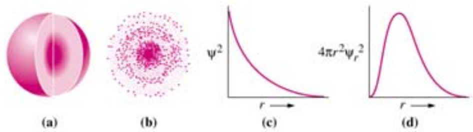
Quantum Numbers Summary

TABLE 7.1 Electronic Shells, Orbitals, and Quantum Numbers.

Principal Shell	1st	2nd				3rd								
n	1	2	2	2	2	3	3	3	3	3	3	3	3	3
l	0	0	1	1	1	0	1	1	1	2	2	2	2	2
m_l	0	0	−1	0	+1	0	−1	0	+1	−2	−1	0	+1	+2
Subshell and orbital designation	1s	2*s*	2*p*	2*p*	2*p*	3s	3*p*	3*p*	3*p*	3*d*	3*d*	3*d*	3*d*	3*d*
Number of orbitals in the subshell	1	1		3		1		3				5		

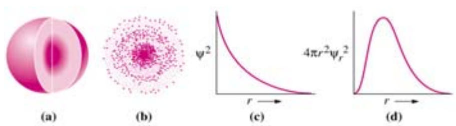
The 1*s* Orbital

- The 1s orbital looks very much like a fuzzy ball, that is, the orbital has *spherical* symmetry.
- The electrons are more concentrated near the center

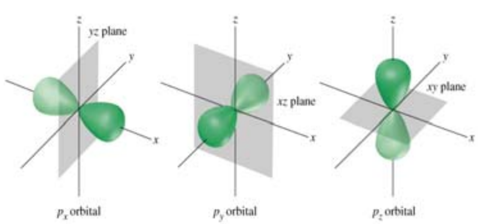


The 2*s* Orbital

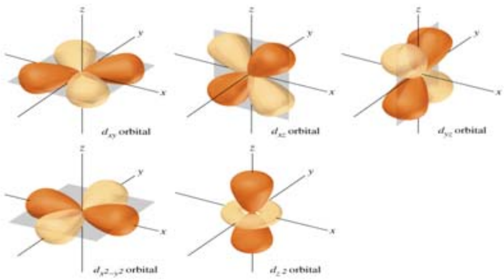
- The 2s orbital has two regions of high electron probability, both being spherical
- The region near the nucleus is separated from the outer region by a spherical *node*- a spherical shell in which the electron probability is zero



The Three *p* Orbitals



The Five *d* Orbital Shapes



Electron Spin

- The **electron spin quantum number (*m_s*)** explains some of the finer features of atomic emission spectra
  - The number can have two values: +1/2 and –1/2
  - The spin refers to a magnetic field induced by the moving electric charge of the electron as it spins
  - The magnetic fields of two electrons with opposite spins cancel one another; there is no net magnetic field for the pair.

Summary (continued)

- The oscillations produce waves that are characterized by their frequencies (*v*), wavelengths (λ), and velocity (*c*).
- The complete span of possibilities for frequency and wavelength is described as the electromagnetic spectrum.
- Planck's explanation of quantums gave us E = *hv*
- The photoelectric effect is explained by thinking of quanta of energy as concentrated into particles of light called photons.
- Wave functions require the assignment of three quantum numbers: principal quantum number, *n*, orbital angular momentum quantum number, *l*, and magnetic quantum number, m_l.

Summary (continued)

- Wave functions with acceptable values of the three quantum numbers are called atomic orbitals.
- Orbitals describe regions in an atom that have a high probability of containing an electron or a high electronic charge density.
- Shapes associated with orbitals depend on the value of *l*. Thus, an *s* orbital (*l* = 0) is spherical and a *p* orbital (*l* = 1) is dumbbell-shaped.
- A fourth quantum number is also required to characterize an electron in an orbital - the spin quantum number, m_s.