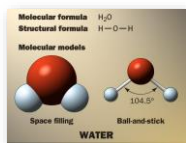


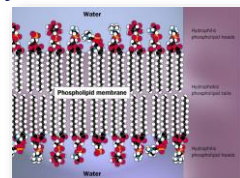
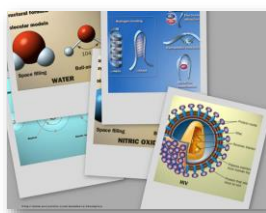
Basics of Chemistry



What? You thought you were all done with the Periodic Table?
NEVER!

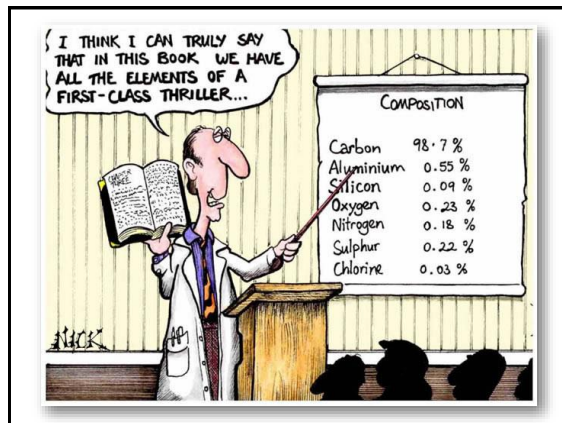
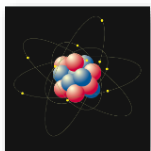
Why are we studying chemistry?

- Biology has chemistry at its foundation

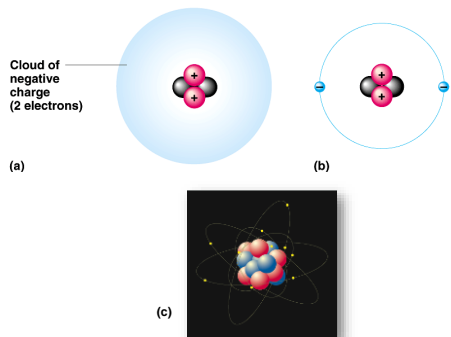


The Basics

- Everything is made of matter
- Matter is made of atoms
- Atoms are made of:
 - ◆ protons + mass of 1 nucleus
 - ◆ neutrons 0 mass of 1 nucleus
 - ◆ electrons - mass << 1 orbits
- Different kinds of atoms = elements

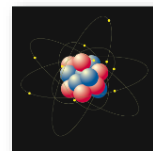


Models of atoms



Atomic structure determines behavior

- The number of protons in an atom determines the element
 - ◆ # of protons = atomic number
 - ◆ this also tells you # of electrons
- All atoms of an element have same chemical properties
 - ◆ all behave the same
 - ◆ properties don't change



Life requires ~25 chemical elements

- About 25 elements are essential for life
 - ◆ Four elements make up 96% of living matter:
 - carbon (C)
 - hydrogen (H)
 - oxygen (O)
 - nitrogen (N)
 - ◆ Four elements make up most of remaining 4%:
 - phosphorus (P)
 - calcium (Ca)
 - sulfur (S)
 - potassium (K)


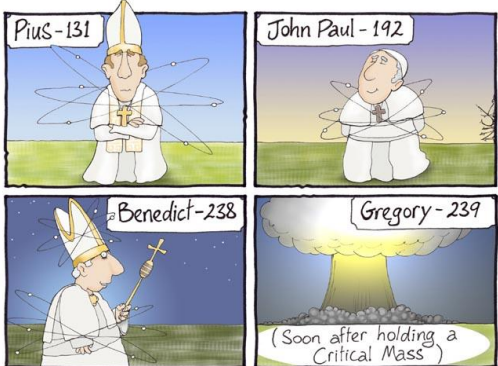
Table 2.1 Naturally Occurring Elements in the Human Body

Symbol	Element	Atomic Number (See p. 29)	Percentage of Human Body Weight
O	Oxygen	8	65.0
C	Carbon	6	18.5
H	Hydrogen	1	9.5
N	Nitrogen	7	3.3
Ca	Calcium	20	1.5
P	Phosphorus	15	1.0
K	Potassium	19	0.4
S	Sulfur	16	0.3
Na	Sodium	11	0.2
Cl	Chlorine	17	0.2
Mg	Magnesium	12	0.1

Trace elements (less than 0.01%): boron (B), chromium (Cr), cobalt (Co), copper (Cu), fluorine (F), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se), silicon (Si), tin (Sn), vanadium (V), and zinc (Zn).

Isotopes

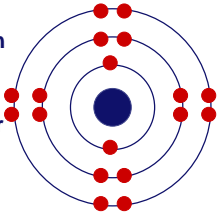
- Different number of neutrons (heavier)
- Some are unstable
 - ◆ nuclear reactions / decay
- Split off neutrons &/or protons
 - ◆ radioactivity
- Biological tool
- Biological hazard

RADIOACTIVE ISOPOPEs

Bonding properties

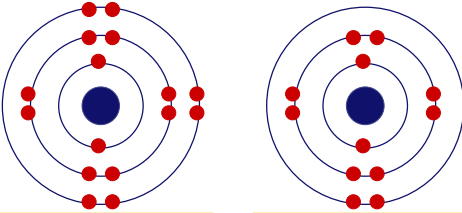
- Effect of electrons
 - ◆ chemical behavior of an atom depends on its electron arrangement
 - ◆ depends on the number of electrons in its outermost shell, the valence shell



How does this atom behave?

Bonding properties

- Effect of electrons
 - ◆ chemical behavior of an atom depends on number of electrons in its outermost shell



How does this atom behave? How does this atom behave?

Elements & their valence shells

Elements in the same row have the same number of shells

First shell	Hydrogen ${}_1\text{H}$							Helium ${}_2\text{He}$
Second shell	Lithium ${}_3\text{Li}$	Beryllium ${}_4\text{Be}$	Boron ${}_5\text{B}$	Carbon ${}_6\text{C}$	Nitrogen ${}_7\text{N}$	Oxygen ${}_8\text{O}$	Fluorine ${}_9\text{F}$	Neon ${}_{10}\text{Ne}$
Third shell	Sodium ${}_{11}\text{Na}$	Magnesium ${}_{12}\text{Mg}$	Aluminum ${}_{13}\text{Al}$	Silicon ${}_{14}\text{Si}$	Phosphorus ${}_{15}\text{P}$	Sulfur ${}_{16}\text{S}$	Chlorine ${}_{17}\text{Cl}$	Argon ${}_{18}\text{Ar}$

Elements & their valence shells

Elements in the same column have the same valence & similar chemical properties

First shell	Hydrogen ${}_1\text{H}$							Helium ${}_2\text{He}$
Second shell	Lithium ${}_3\text{Li}$	Beryllium ${}_4\text{Be}$	Boron ${}_5\text{B}$	Carbon ${}_6\text{C}$	Nitrogen ${}_7\text{N}$	Oxygen ${}_8\text{O}$	Fluorine ${}_9\text{F}$	Neon ${}_{10}\text{Ne}$
Third shell	Sodium ${}_{11}\text{Na}$	Magnesium ${}_{12}\text{Mg}$	Aluminum ${}_{13}\text{Al}$	Silicon ${}_{14}\text{Si}$	Phosphorus ${}_{15}\text{P}$	Sulfur ${}_{16}\text{S}$	Chlorine ${}_{17}\text{Cl}$	Argon ${}_{18}\text{Ar}$

Elements & their valence shells

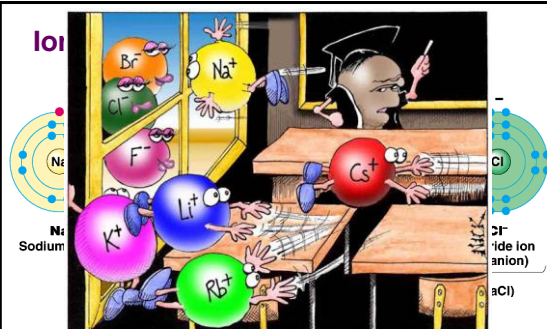
Moving from left to right, each element has a sequential addition of electrons (and protons)

First shell	Hydrogen ${}_1\text{H}$							Helium ${}_2\text{He}$
Second shell	Lithium ${}_3\text{Li}$	Beryllium ${}_4\text{Be}$	Boron ${}_5\text{B}$	Carbon ${}_6\text{C}$	Nitrogen ${}_7\text{N}$	Oxygen ${}_8\text{O}$	Fluorine ${}_9\text{F}$	Neon ${}_{10}\text{Ne}$
Third shell	Sodium ${}_{11}\text{Na}$	Magnesium ${}_{12}\text{Mg}$	Aluminum ${}_{13}\text{Al}$	Silicon ${}_{14}\text{Si}$	Phosphorus ${}_{15}\text{P}$	Sulfur ${}_{16}\text{S}$	Chlorine ${}_{17}\text{Cl}$	Argon ${}_{18}\text{Ar}$

Chemical reactivity

- Atoms tend to
 - Complete a partially filled outer (valence) electron shell
 - Empty a partially filled outer (valence) electron shell

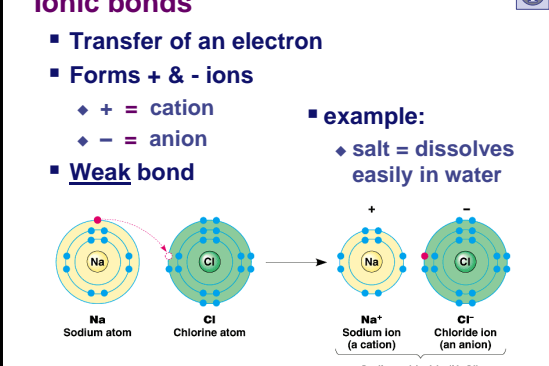
This tendency drives chemical reactions!



Perhaps one of you gentlemen would mind telling me just what it is outside the window that you find so attractive..?

Ionic bonds

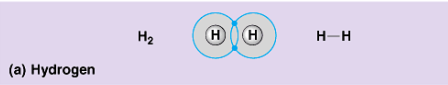
- Transfer of an electron
- Forms + & - ions
 - + = cation
 - = anion
- Weak bond
 - example:
 - salt = dissolves easily in water



Sodium atom Chlorine atom Sodium ion (a cation) Chloride ion (an anion) Sodium chloride (NaCl)

Covalent bonds

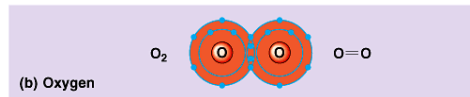
- Two atoms need an electron
- Share a pair of electrons
- **Strong bond**
 - ◆ both atoms holding onto the electrons
- Forms molecules



- **example:**
 - ◆ water = takes energy to separate

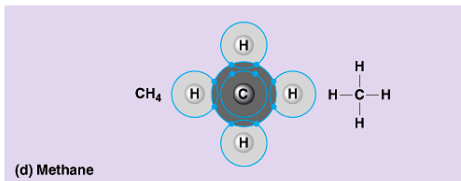
Double covalent bonds

- Two atoms can share more than one pair of electrons
 - ◆ double bonds (2 pairs of electrons)
 - ◆ triple bonds (3 pairs of electrons)
- **Very strong bonds**



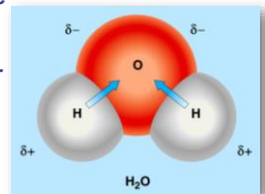
Multiple covalent bonds

- 1 atom can form covalent bonds with two or more other atoms
 - ◆ forms larger molecules
 - ◆ ex. carbon



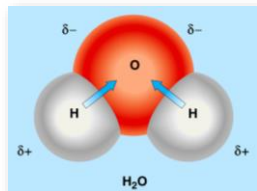
Polar covalent bonds

- Pair of electrons not shared equally by 2 atoms
- Water = O + H
 - ◆ oxygen has stronger "attraction" for the shared electrons than hydrogen
 - ◆ oxygen has higher electronegativity



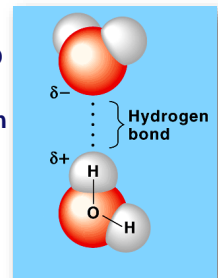
Polar covalent bonds

- 2 hydrogens in the water molecule form an angle
- Water molecule is **polar**
 - ◆ oxygen end is -
 - ◆ hydrogen end is +
- Leads to many interesting properties of water....



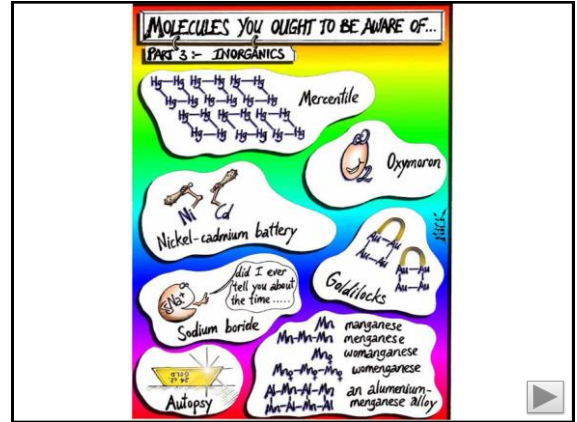
Hydrogen bonds

- Positive H atom in 1 water molecule is attracted to negative O in another
- Can occur wherever an -OH exists in a larger molecule
- **Weak bonds**



Reductionist view of biology

- Matter is made of atoms
- Life requires ~25 chemical elements
- Atomic structure determines behavior of an element
- Atoms combine by chemical bonding to form molecules
- Weak chemical bonds play important roles in chemistry of life
- A molecule's biological function is related to its shape
- Chemical reactions make & break chemical bonds



Any Questions?