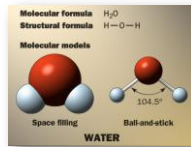


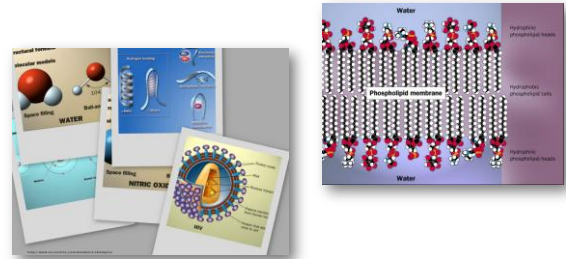
## Chapter 2 Chemistry



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

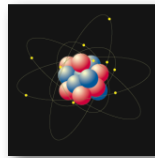
## Why are we studying chemistry?

- 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

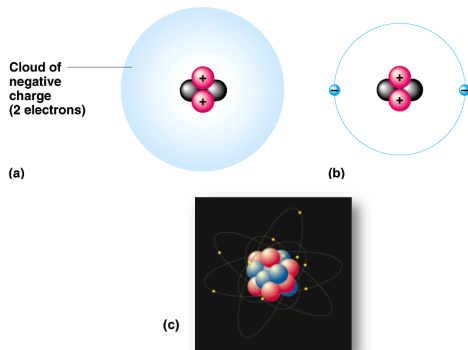


## The World of Elements

Periodic Table of the Elements

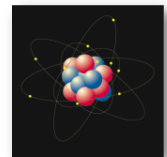
1	IA																IIA										IIIA										IVA										VA										VIA										VIIA										0																																																																																																													
2	Li																Be										B										C										N										O										F										Ne																																																																																																													
3	Na																Mg										Al										Si										P										S										Cl										Ar																																																																																																													
4	K																Ca										Sc										Ti										V										Cr										Mn										Fe										Co										Ni										Cu										Zn										Ga										Ge										As										Se										Br										Kr									
5	Rb																Sr										Y										Zr										Nb										Mo										Tc										Ru										Rh										Pd										Ag										Cd										In										Sn										Sb										Te										I										Xe									
6	Cs																Ba										*La										Hf										Ta										W										Re										Os										Ir										Pt										Au										Hg										Tl										Pb										Bi										Po										At										Rn									
7	Fr																Ra										+Ac										Rf										Ha										Sg										Ns										Hs										Mt										110										111										112										113																																																											
+ Lanthanide Series																Ce										Pr										Nd										Pm										Sm										Eu										Gd										Tb										Dy										Ho										Er										Tm										Yb										Lu																																								
+ Actinide Series																Th										Pa										U										Np										Pu										Am										Cm										Bk										Cf										Es										Fm										Md										No										Lr																																								

## 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)
    - oxygen (O)
    - hydrogen (H)
    - nitrogen (N)
  - ◆ Four elements make up most of remaining 4%:
    - phosphorus (P)
    - sulfur (S)
    - calcium (Ca)
    - potassium (K)

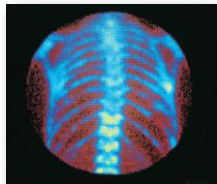
Table 2.1 Naturally Occurring Elements in the Human Body

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).

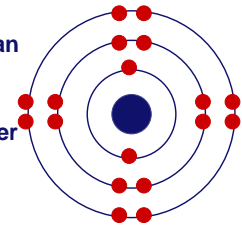
### Isotopes

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



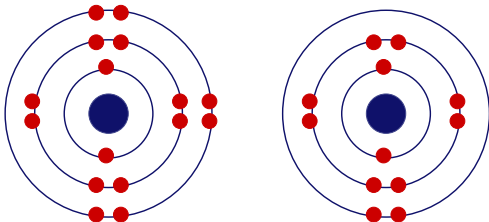
### Bonding properties

- 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



### Bonding properties

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



### Elements & their valence shells

▪ Elements in the same row have the same number of shells

First shell	Hydrogen ${}^1_1\text{H}$							Helium ${}^2_2\text{He}$
Second shell	Lithium ${}^3_3\text{Li}$	Beryllium ${}^4_4\text{Be}$	Boron ${}^5_5\text{B}$	Carbon ${}^6_6\text{C}$	Nitrogen ${}^7_7\text{N}$	Oxygen ${}^8_8\text{O}$	Fluorine ${}^9_9\text{F}$	Neon ${}^{10}_{10}\text{Ne}$
Third shell	Sodium ${}^{11}_{11}\text{Na}$	Magnesium ${}^{12}_{12}\text{Mg}$	Aluminum ${}^{13}_{13}\text{Al}$	Silicon ${}^{14}_{14}\text{Si}$	Phosphorus ${}^{15}_{15}\text{P}$	Sulfur ${}^{16}_{16}\text{S}$	Chlorine ${}^{17}_{17}\text{Cl}$	Argon ${}^{18}_{18}\text{Ar}$

### 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)

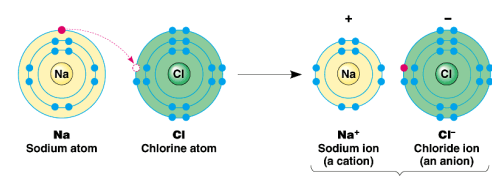
First shell	Hydrogen ${}_1\text{H}$							Helium ${}_2\text{He}$
Second shell	Lithium ${}_3\text{Li}$	Beryllium ${}_4\text{Be}$	Boron ${}_5\text{B}$	Carbon ${}_6\text{C}$	Nitrogen ${}_7\text{N}$	Oxygen ${}_8\text{O}$	Fluorine ${}_9\text{F}$	Neon ${}_{10}\text{Ne}$
Third shell	Sodium ${}_{11}\text{Na}$	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

### Ionic bonds

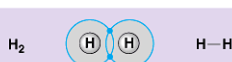
- Transfer of an electron
- Forms + & - ions
  - + = cation
  - = anion
- Weak bond
  - example:
    - salt = dissolves easily in water



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

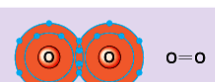


(a) Hydrogen

- example:
  - water = takes energy to separate

### Double covalent bonds

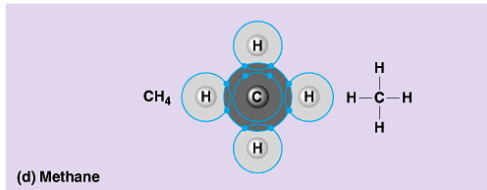
- Two atoms can share more than one pair of electrons
  - double bonds (2 pairs of electrons)
  - triple bonds (3 pairs of electrons)
- Very strong bonds



(b) Oxygen

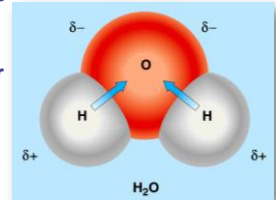
### Multiple covalent bonds

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



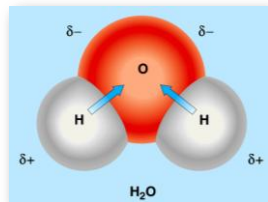
### Polar covalent bonds

- 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



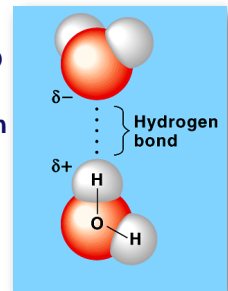
### Polar covalent bonds

- 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



### Van der Waals forces

- Interactions between nonpolar substances
- Due to random variations in the electron distribution of a molecule
- Very weak forces

### 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