Basic Chemistry for Water Plant Operators

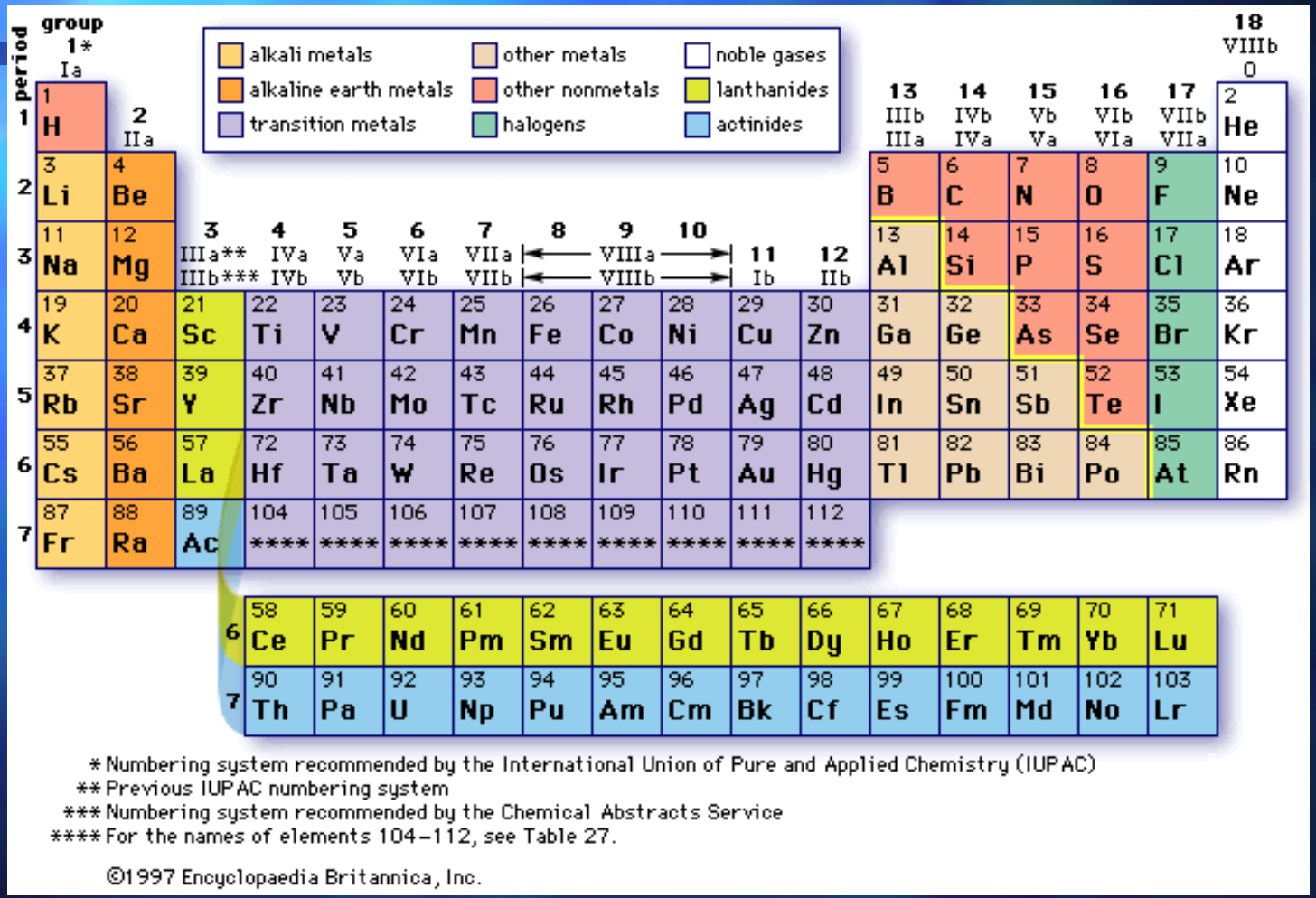
Matter

- Solids
- Liquids
- Gasses

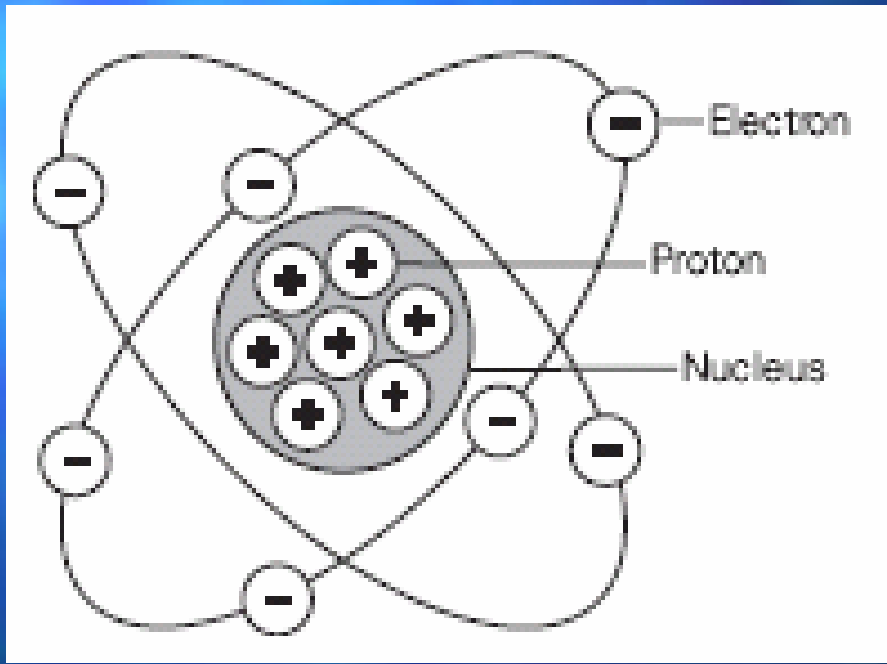
Pure Elements

- Elements are matter built up from subatomic particles
- Properties are determined by their nucleus (protons and neutrons) and by their electron shells.
- All of the atoms of an element have the same number of protons in their nuclei.
- Elements do not break down into simpler elements.
- There are over 118 known elements.
- 92 occur naturally, and others have been produced in the laboratory

Periodic Table of the Elements



Electrons in Outer Shell



The Periodic Chart
Use of Atomic Weight

Atomic Number

Symbol

Name

Atomic Weight

Calculating Molecular Weight of a Compound

The Molecular Weight of a Compound is the sum of the Atomic Weights in the Chemical Formula. For example for H_2O

Hydrogen Atomic Weight = 1

Oxygen Atomic Weight = 16

There are 2 Hydrogen Atoms so the molecular weight of H_2O is 2 + 16 = 18

Common Elements of Water Treatment

Element	Symbol	Element	Symbol	Element	Symbol
Aluminum	Al	Chromium	Cr	Oxygen	O
Arsenic*	As	Fluorine†	F	Phosphorus	P
Barium*	Ba	Hydrogen	H	Potassium	K
Boron	B	Iodine	I	Radium*	Ra
Bromine	Br	Iron	Fe	Selenium*	Se
Cadmium*	Cd	Lead*	Pb	Silicon	Si
Calcium	Ca	Magnesium	Mg	Silver*	Ag
Carbon	C	Manganese	Mn	Sodium	Na
Chlorine	Cl	Mercury*	Hg	Strontium*	Sr
Copper	Cu	Nitrogen	N	Sulfur	S

Equivalent Weight

The equivalent weight of an element is that weight which will combine with or displace 8 grams of oxygen or the equivalent weight of another element.

Atomic weight = Equiv. Weight X Valance

Many elements have more than one valance.

Mole Equivalency in Water Treatment

- A mole is the weight in grams of the molecular weight of a substance.
- One mole of H_2O is equal to 18 grams.
- A mole is a measure that defines how the elements in a substance will combine
- In the above equation 2 grams of hydrogen will combined with 16 grams of oxygen or 1 gram of hydrogen will combine with 8 grams of oxygen.

Molar and Molal Solutions in Water Chemistry

- Molar and Molal solutions are used to determine the concentrations of known compounds in the water.
- A molar solution consists of 1 gram molecular weight dissolved in enough water to make 1 liter.
- A molal solution consists of 1 gram molecular weight dissolved in 1 liter of water.

Solutions and Standards

Aqueous Solution	Mixture completely dissolved in water
Standard Solution	A solution in which the exact concentration (molecular weight is known)
Standardize	Determining the exact strength of solution by comparison with standard of known strength
Titration	Process of adding chemical of known strength to determine concentration of unknown compounds

Acids and Bases
Hydrogen Ions (moles/liter)

pH	Compound	Hydrogen Ions
0	Hydrochloric Acid	10^{0}
1	Stomach Acid	10^{-1}
2	Lemon Juice	10^{-2}
3	Vinegar	10^{-3}
4	Root Beer	10^{-4}
5	Rainwater	10^{-5}
7	Pure Water	10^{-7}
9	Baking Soda	10^{-9}
10	Ammonia	10^{-10}
12	Drain Cleaner	10^{-12}
13	Sodium Hydroxide	10^{-13}

Ions in Water Treatment

- All acids, bases and salts disassociate or ionize in water. These are known as electrolytes.
- Electrolytes normally have the same number of protons as electrons that neutralize one another. When dissolved in water they split into their respective elements or compounds and lose or gain electrons. This results in the elements or compounds becoming positively or negatively charged.
- Sodium and Calcium give up electrons and become positively charged. Positively charged ions are called “cations.”
- Chlorine is negatively charged because it gains electrons. Negatively charged ions are called “anions.”

Important Ions in Water Chemistry and Common Valences

Cations

- H+
- Na+
- Ca++
- Mg++
- Mn++ or +++
- Fe ++ or +++
- S ++
- NH_4+

Anions

- Cl –
- O - -
- OH –
- HCO_3 –
- CO_3 --
- NO_3 -
- SO_4 –
- OCl -

Use of Aluminum and Iron Salts in Coagulation

COMMON COAGULANT CHEMICALS	
Aluminum Sulfate	Al2(SO4)3
Ferric Sulfate	Fe 2 (SO4)3
Ferrous Sulfate	FeSO4
Ferric Chloride	FeCl 3
Sodium Aluminate	NaAlO 3

Oxidation Reduction Reactions

- Oxidation or Reduction is a method of forcing reactions to completion by the reaction of an ion with an oxidant or reducing agent.
- For example, the Cyanide (CN) ion can be oxidized with Chlorine to produce Nitrogen gas and Carbon Dioxide.
- Oxidation/reduction reactions will proceed to completion.

Oxidation in Water Treatment

- Oxidize Inorganic Elements such as Iron and Manganese
- Destruction of Taste and Odor Compounds
- Destruction of Synthetic Organic Chemicals
- Assist in the Coagulation Process by Destabilization of Particles
- Control of Biological Growth

Oxidants Used in Water Treatment

Ozone
Permanganate
Chlorine Dioxide
Chlorine
Oxygen

Inorganic and Organic Chemistry

- The study of compounds containing carbon
- The most basic compounds are hydrocarbons made up of only carbon and hydrogen
- Carbon can bond with each other forming long chains
- Major types include alcohols, polymers and ketones
- Chlorinated hydrocarbons are of particular interest in water treatment

Organic Measurement

TOC	Total Organic Carbon
NOM	Natural Organic Material
SUVA	Specific Ultraviolate Absorbance
Precursor	Proportional to the TOC Concentration
Humic Substances	Products of Natural Vegetative Decay (Color)

Alkalinity/Acidity

Alkali	Soluble Salts that neutralize Acids
Alkaline	Sufficient amount of alkali to raise pH above 7
Alkalinity	Capacity of Water to neutralize acids
	Does not exist below pH 4.5
Acidic	Condition of Water to lower pH below 7
Acidified	Addition of Acid to below pH 2

Water Hardness

Total Hardness	Carbonate and Non-Carbonate
Carbonate	Bicarbonate, Carbonate and Hydroxide
Non-Carbonate	Sulfides and Chlorides
Permanent Hardness	Non-Carbonate Hardness
Natural Hardness	Bicarbonate Alkalinity

Solids and Colloidal Material

Suspended Solids	Suspended in the Water and can be Removed by Conventional Filtration
Colloids	Finely Charged Particles that do not Dissolved
Turbidity	The Cloudy Appearance of Water caused by Suspended Matter and Colloids
Zeta Potential	Electrical Charge of a suspended particle