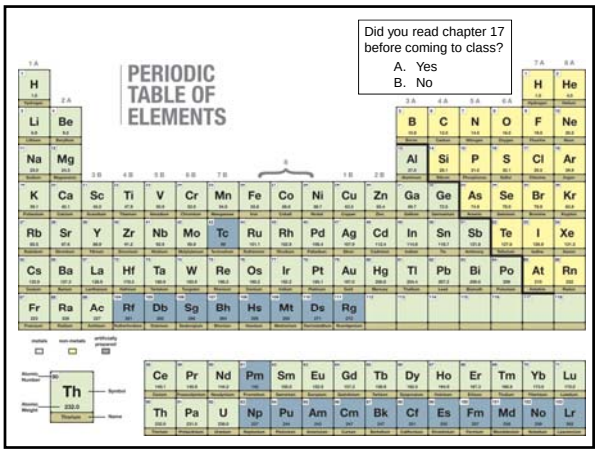

Orbitals

a) Are figments of my professors imagination
b) Describe the path that an electron travels as it orbits the nucleus
c) Are standing probability waves that surround an atom and describe where an electron may be found
d) Were proposed by Rutherford to explain his experiments

On to Chemistry

- Having established the existence of molecules and atoms, we now take several chapters to explore their properties.
  - What varieties are there?
  - What are the natures of the pure elements? Why?
  - How do atoms interact and combine together when they form molecules?

Vocabulary

1. **element**: atoms all having the same number of protons in the nucleus
2. **atomic number**: number of protons in the nucleus
3. **mass number**: total number of nucleons (protons and neutrons) in a nucleus
4. **atomic mass** (atomic weight): the relative mass of the atoms of an element compared to carbon atoms which have arbitrarily been given a mass of twelve (often called atomic mass units)

Chemical properties can vary widely even when other physical properties are similar

Chemical properties can vary widely even when other physical properties are similar

Chlorine

Nitrogen

How can we explain the enormous variety of chemical behaviors with a single model?

Early work led to the law of constant composition:

- Compounds contain a fixed definite proportion of the elements.

  Example: Water

  By mass: 2 parts hydrogen for 16 parts oxygen

  An oxygen is 16 times more massive than a hydrogen atom, so we have two hydrogen atoms per oxygen

John Dalton proposed the atomic theory

- Matter is composed of small indivisible particles called atoms
- An element contains only a single kind of atom. Atoms of a given element are identical in every respect, including mass and chemical behavior.
- Atoms of different elements have different mass and chemical reactivity
- Chemical compounds are composed of two or more atoms that are joined together in fixed ratios
- Chemical reactions correspond to the rearrangement of atoms to form a different compound.

Mendeleev

- Dimitri Ivanovich Mendeleev ordered the elements by atomic weight (mass number) and established that there were re-occurring patterns in the ways that elements combined with other elements. But the first attempt had a few problems.
- Order the elements by atomic number and the periodicity is much better.

Similar Elements are arranged in “Groups”

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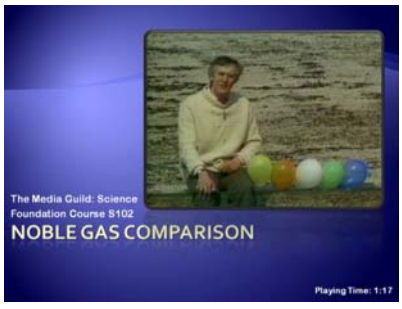
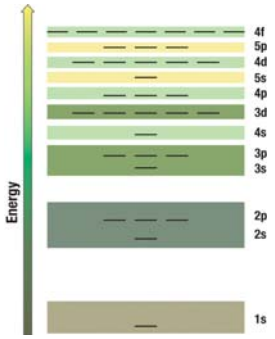


The wave model and the periodic chart

- To understand the main features of the periodic table we must use the wave model. It explains
  - Atomic diameters
  - Periodicities
  - Molecular shapes

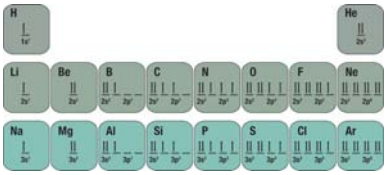
Filling Orbitals

- Orbitals fill the lowest energy first.
  - However, this does not always mean that the lowest shell is filled before electrons begin filling orbitals the next shell.



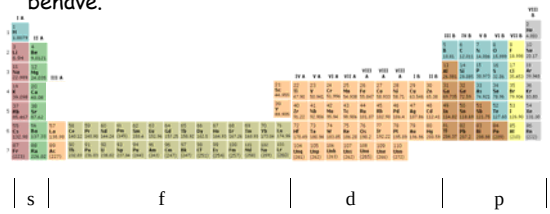
Valence electrons

- Chemical behavior is determined by the outermost electrons, called **valence electrons**
- Elements in the same column (group) of the periodic table have similar valence electron structures, and are chemically similar.



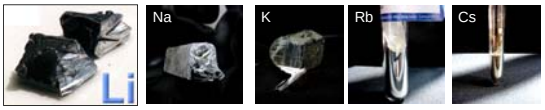
Wave Model and Periodic Table

- The wave model explains similar chemical properties by showing that all elements in a family have the same number of valence electrons in the same orbital types.
- The ***orbital type of valence electrons*** is the most important factor in determining how they behave.



The elements group together in families of similar chemical properties.

- At the left of the periodic table are the alkalai metals: Lithium **Li**, Sodium **Na**, Potassium **K**, etc.
- As we saw, all react energetically with water.



The elements group together in families of similar chemical properties.

- The second column from the right is the halogens: Flourine **F**, Chlorine **Cl**, Bromine **Br**, etc.
- Highly reactive. All form salt compounds

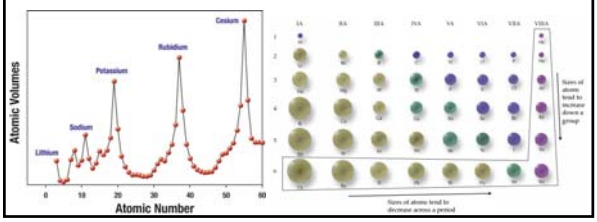
The elements group together in families of similar chemical properties.

- At the right of the table are the noble gasses: Helium **He**, Neon **Ne**, Argon **Ar**, etc.
- These do not easily combine with other elements.

Regular changes occur across "Periods"

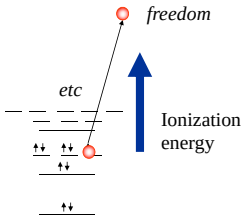
Atomic size

- Atomic size suddenly increase at the beginning of each row then generally *decrease* across the row.
- Atomic diameters increase suddenly when the new electron is in the next shell
- As you move along the row, the outer electrons of elements have their electrons in the same shell; they fill different orbitals, but the diameters of orbitals in the same shell are comparable.
- However, more protons pulling on more electrons tends to squeeze the electron probability clouds in closer to the nucleus, decreasing the diameter.



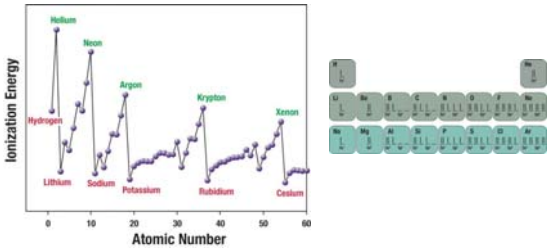
Other Patterns

- Ionization energy:
  - The energy required to strip an electron from the atom.

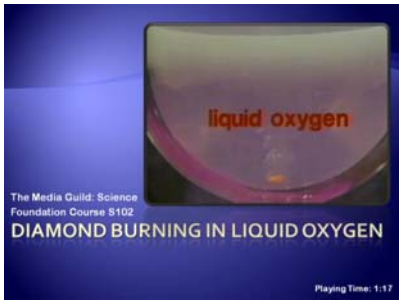


Ionization Energies and the wave model

- Nobel gasses have largest ionization energies.
- Alkali metals have the least.



The similarities are in formulae, but not necessarily reflected in physical properties



The similarities are in formulae, but not necessarily reflected in physical properties

CO_2 SiO_2

Triumphs of the Periodic Table

- Predicted the existence of then undiscovered elements and what their chemical properties would be.
- Gave greater simplicity and order to chemistry.
- Firmly established the existence of atoms.
- Verified the wave model of the atom.

Which of the following elements do you expect to be chemically most similar to Fluorine

a) Oxygen
b) Nitrogen
c) Helium
d) Bromine

Which of the following do you expect to have the largest ionization energy?

a) Neon
b) Sodium
c) Oxygen
d) Nitrogen