Today's Sermon

The “.” - ic

AKA
“The Chemists' Cheat Sheet”

Are you here?
A) Yes
B) No
C) Can I phone a friend?

Did you read chapter 17 before class?
A) Yes
B) No
C) I thought I’d wait till after the exam so I can focus my reading on the most important points.

Important terms:

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)

5. ionization energy: energy required to completely remove an electron from an atom

6. valence electrons: the electrons in the outermost shell (usually unfilled).
7. “family” or “group” of elements: a subset of elements that are similar in appearance, natural state, and chemical behavior. They have the same number of valence electrons.
**Chemical Elements**

identified by the 1st couple of letters of the name, typically in Latin.

<table>
<thead>
<tr>
<th>Ionization number</th>
<th>tells the number of excess or deficient electrons (charge on atom)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass number</td>
<td>the number of nucleons in the atom</td>
</tr>
<tr>
<td>Atomic number</td>
<td>the number of protons in the atom</td>
</tr>
</tbody>
</table>

\[ ^{4}_{2}\text{He}^{2+} \]

**Arranged on the periodic table**

According to atomic number:

- **6**
  - **C**
  - **12.0000**

**All rise**

Anything that repeats over and over again is periodic.

Elements are arranged according to:

1. Atomic number
2. Chemical behavior

Since the same type of chemical behavior repeats in each column, it is a periodic table.

**Why “Periodic” Table**
**Why the periodicity?**

- The chemical properties of the elements are governed by their electrons.
- The number of electrons in a neutral atom is given by the atomic number.
- The chemical properties are governed mostly by the number of valence electrons.
- Elements in a family have the same number and orbital type of valence $e^-$ and the same number of unfilled states in their outermost shell.

**Film festival**

- Nobel gases
- Alkali metals

**Structure of the Table**

- Families in columns
  - Column 1 (alkali metals)
  - Column 8 (noble gases)
- Similar chemistry: why?
  - Same valence electrons

- Periods in rows
  - Chemistry changes gradually
  - First, second, etc.

**A historical note:**

The recognition of pattern in the chemical behavior of elements and the subsequent formulation of the Periodic Table was a grand accomplishment of 19th century chemistry. The understanding of this pattern in terms of the wave model of the atom was a grand accomplishment of physics in the opening decades of the 20th century.

**Filling order of Electron States**

- Lowest energy orbitals fill first

<table>
<thead>
<tr>
<th>Shell filled</th>
<th>#e in shell</th>
<th>#e total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1s</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>2s, 2p</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>3s, 3p</td>
<td>8</td>
<td>18</td>
</tr>
</tbody>
</table>

- After this, order is 4s, then 3d, then 4p

How do we know? - from periodic table.

**Energy Well: Which element is it?**

- A) Na
- B) Cl
- C) N
- D) S

Energy Well:

- Filled shell 2
  - 3p
  - Filled shell 1
    - s

Orbitals
**Practice:**

Order of filling: Periodic Table

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**Periodic Trends**

- Volumes (Sizes)
- Ionization energies
- Chemical Properties

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**Periodic Trends: Sizes**

<table>
<thead>
<tr>
<th>Elements</th>
<th>Sizes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1s</td>
<td>1</td>
</tr>
<tr>
<td>2s</td>
<td>2</td>
</tr>
<tr>
<td>2p</td>
<td>3</td>
</tr>
<tr>
<td>3s</td>
<td>4</td>
</tr>
<tr>
<td>3p</td>
<td>5</td>
</tr>
<tr>
<td>4s</td>
<td>6</td>
</tr>
<tr>
<td>4p</td>
<td>7</td>
</tr>
<tr>
<td>5s</td>
<td>8</td>
</tr>
<tr>
<td>5p</td>
<td>9</td>
</tr>
</tbody>
</table>

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**Ionization Energy**

Elements with ionization energies less than 8 electron volts are **metals**
- Shiny, malleable, solid, good conductors, chemically active

**Metals give away electrons**

Elements with ionization energies greater than 10 electron volts are **nonmetals**
- Missing at least one of the properties of metals

**Nonmetals steal electrons**

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**Ionization Energies**

Note: in same group
Ionization Energies:
General trends

Group Characteristics
Metals on left
Non-metals on right
Noble gases
valence e’s same for all members of family

The Grand Outline
Part 1. Why do things move the way they do?
- Laws of Motion
- Laws of Force
- Conservation Laws
- Symmetry Laws
- Special Relativity
Part 2. What are things made of?
- Models of an atom
  - Law of Increasing Disorder
  - Dual Nature of Matter and Electromagnetic Radiation
  - Wave Model of atom
  - The Exclusion Principle
Part 3.
A. What can fundamental principles tell us about living things?
- Families of elements
- How atoms bond together
- How some of the molecules of life are organized and replicated
B. What do we know about the nucleus of an atom?
- The strong interaction
- Fission and Fusion

The Wave Model of Matter
(As applied to atoms)
1. Atoms are made of tiny, massive, positively charged nuclei surrounded by electrons in “orbitals”
2. Orbitals are standing waves of probability; they predict the probability of finding e- near nucleus; shapes of orbitals are important.
3. No more than 2 e- can occupy orbital. Two e- in same orbital must differ in spin. (Exclusion principle)
4. e-’s associated with different orbitals have different energies. (Represent this with energy well)

The Periodic Table
(as explained by the wave model of the atom)
- existence of shells & number of available energy states governed by wave equation
- periodic patterns due to arrangement of electrons in allowed orbitals and shells
- elements in a family have same number of valence e- & same number of unfilled states in their outermost shell