PREDICTING ION CHARGES

In general

- **metals** (Mg) lose electrons → **cations**
- **nonmetals** (F) gain electrons → **anions**

See CD-ROM Screen 3.5 and book Figure 3.7

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Charges on Common Ions

<table>
<thead>
<tr>
<th>+1</th>
<th>+2</th>
<th>-4</th>
<th>-3</th>
<th>-2</th>
<th>-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>Li</td>
<td>Na</td>
<td>Mg</td>
<td>K</td>
<td>Ca</td>
</tr>
<tr>
<td>Al</td>
<td>Si</td>
<td>P</td>
<td>S</td>
<td>Cl</td>
<td>Ar</td>
</tr>
<tr>
<td>Br</td>
<td>K</td>
<td>Cs</td>
<td>Ba</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
METALS
\[ M \rightarrow n \, e^- + M^{n+} \]
where \( n = \) periodic group
- \( Na^+ \)
- \( Mg^{2+} \)
- \( Al^{3+} \)
- Transition metals: \( M^{2+} \) and \( M^{3+} \) are common

NONMETALS
\[ \text{NONMETAL} + n \, e^- \rightarrow X^{n-} \]
where \( n = 8 - \) Group no.
- \( C^{4-} \) carbide
- \( N^{3-} \) nitride
- \( O^{2-} \) oxide
- \( F^- \) fluoride
Polyatomic ions are groups of atoms with a charge.

**MEMORIZE** the names and formulas in Table 3.1, page 107.

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Some Common Polyatomic Ions

- HNO₃ (nitric acid) → NO₃⁻ (nitrate ion) + H⁺

Many polyatomic ions are derived from acids. Notice that the negative charge symbol is written as a trailing superscript to the entire formula.
Some Common Polyatomic Ions

NH$_4^+$

ammonium ion

Ammonium is one of the few common polyatomic cations.

Some Common Polyatomic Ions

CO$_3^{2-}$
carbonate ion

These arise from carbonic acid, H$_2$CO$_3$

HCO$_3^-$
bicarbonate ion
hydrogen carbonate

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**Some Common Polyatomic Ions**

- $\text{PO}_4^{3-}$: phosphate ion
- $\text{CH}_3\text{CO}_2^-$: acetate ion

![PO4^3- structure image](image)

**Some Common Polyatomic Ions**

- $\text{SO}_4^{2-}$: sulfate ion
- $\text{SO}_3^{2-}$: sulfite ion

![SO4^2- structure image](image)

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Some Common Polyatomic Ions

\[ \text{NO}_3^- \] nitrate ion

\[ \text{NO}_2^- \] nitrite ion

COMPOUNDS FORMED FROM IONS

CATION + ANION → COMPOUND

\[ \text{Na}^+ + \text{Cl}^- \rightarrow \text{NaCl} \]

A neutral compound requires equal numbers of + and - charges.
IONIC COMPOUNDS

ammonium chloride, NH₄Cl

\[ \text{NH}_4^+ \quad \text{Cl}^- \]

Some Ionic Compounds

\[ \text{Ca}^{2+} + 2 \text{F}^- \rightarrow \text{CaF}_2 \]
Name = calcium fluoride

\[ \text{Mg}^{2+} + \text{NO}_3^- \rightarrow \text{Mg(NO}_3)_2 \]
magnesium nitrate

\[ \text{Fe}^{2+} + \text{PO}_4^{3-} \rightarrow \text{Fe}_3(\text{PO}_4)_2 \]
iron(II) phosphate

(See CD-ROM screen 3.12 for naming practice)
**Properties of Ionic Compounds**

- A metal atom can transfer an electron to a nonmetal.
- The resulting cation and anion are attracted to each other by **electrostatic forces**.
- The pair of ions must have **zero** net charge, so the number of cations times their charge equals the number of anions times their charge.

<table>
<thead>
<tr>
<th>Cation</th>
<th>Anion</th>
<th>Formulas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na⁺</td>
<td>Cl⁻</td>
<td>NaCl</td>
</tr>
<tr>
<td>Ca²⁺</td>
<td>Cl⁻</td>
<td>CaCl₂</td>
</tr>
<tr>
<td>Ca²⁺</td>
<td>PO₄³⁻</td>
<td>Ca₃(PO₄)₂</td>
</tr>
<tr>
<td>Xᵐ⁺</td>
<td>Yⁿ⁻</td>
<td>XₙYₘ</td>
</tr>
</tbody>
</table>

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**Electrostatic Forces**

The oppositely charged ions in ionic compounds are attracted to one another by **ELECTROSTATIC FORCE**.

This force is governed by **COULOMB’S LAW**.

See screen 3.7 on the CD-ROM.

KBr crystal

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**Electrostatic Forces**

**COULOMB’S LAW**

\[
\text{Force of attraction} = \frac{(\text{charge on } +)(\text{charge on } -)}{\text{(distance between ions)}^2}
\]

As ion charge increases, the attractive force **INCREASES**.

As the distance between ions increases, the attractive force **DECREASES**.

This law controls chemistry and thus forms the basis of what we’re doing!

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**Results of Coulomb’s Law**

- **NaCl, Na\(^+\) and Cl\(^-\), m.p. 804 °C**

- **MgO, Mg\(^{2+}\) and O\(^{2-}\), m.p. 2800 °C**

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