Periodic Trends aka Periodicity

Atomic Size (Radius)
Ionization Energy

Slide view

Comment on what you think would be the periodic trend for atomic radii (size of atoms) in any one column (such as Ca and Ba).

1. The size of atoms *increases* down the chart.
2. The size of atoms *decreases* down the chart.
3. The size of atoms *stays the same* down to the chart.
4. No trend, random sizing

Comment on what you think would be the periodic trend for atomic radii (size of atoms) in any one column (such as Ca and Ba).

1. The size of atoms *increases* down the chart.
   - This is because there are more electrons in more occupied energy levels
2. The size of atoms *decreases* down the chart.
3. The size of atoms *stays the same* down to the chart.

Select what you think would be the periodic trend for atomic radii (size of atoms) from left to right across the chart. (such as As and Br)

1. The size of atoms increases ($L \rightarrow R$) across the chart.
2. The size of atoms decreases ($L \rightarrow R$) across the chart.
3. The size of atoms stays the same ($L \rightarrow R$) across to the chart.

Comment on what you think would be the periodic trend for atomic radii (size of atoms) from left to right across the chart.

1. The size of atoms increases (L→R) across the chart.
2. The size of atoms decreases (L→R) across the chart.
   - this is because the *effective* nuclear charge increases as we move across the chart. There are more protons pulling on electrons that are the no further away (in the same energy level.)
3. The size of atoms stays the same (L→R) across to the chart.

Slide show next

Coulombs Law

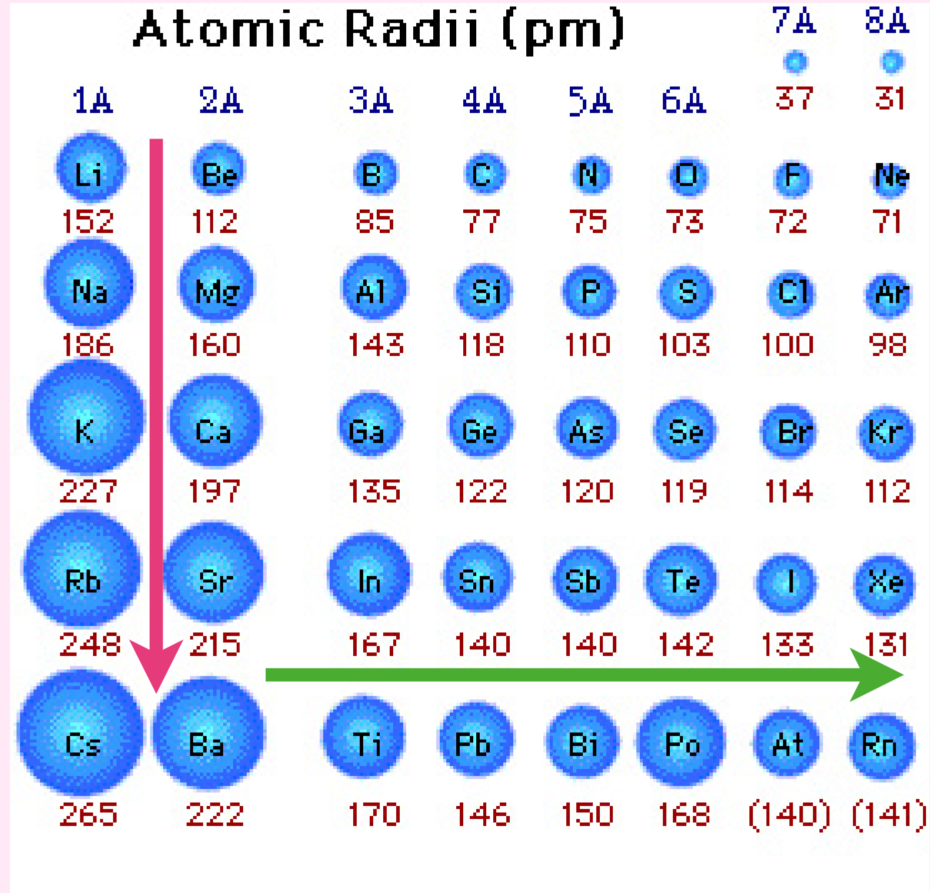
of electrostatic forces

$$F = k\frac{Q^{+}Q^{-}}{d^{2}}$$

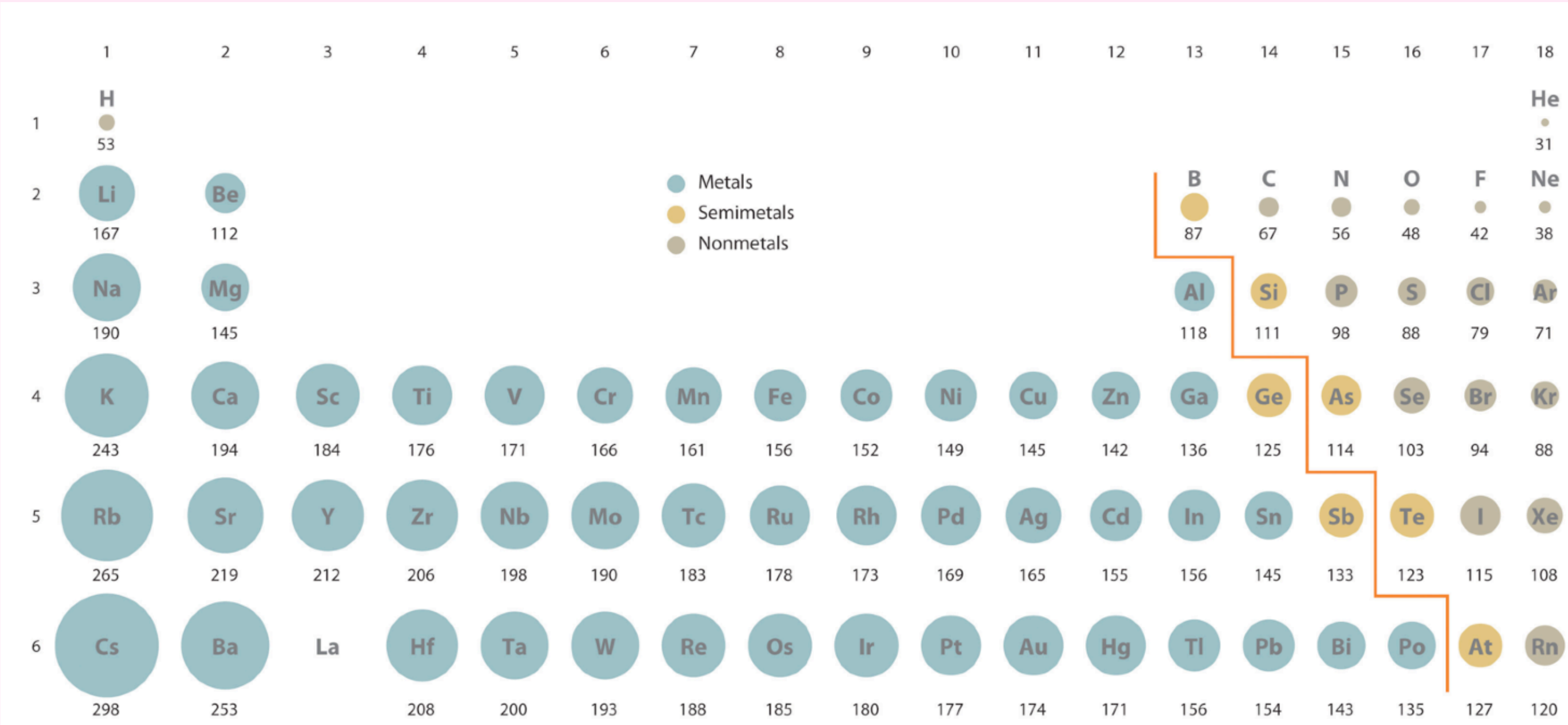
- The force of attraction between opposite charges (protons & a valence electron) is affected by
  - ✓ Q^+, the magnitude of the nuclear charge (1+, 2+, 3-, etc)
  - ✓ d, the distance between the nucleus and the electron of interest.
- We will invoke coulombs law to justify the strength of the attractive force between the nucleus and the electron.
  - ✓ *You will never need to put numbers in this equation, just use it to explain the effects the magnitude of Q & d and the resulting effect on periodic properties.*

The Size of Atoms

- The size of atoms increases down a group.
  - ✓ due to more occupied energy levels
- The size of atoms decreases across to the right on the chart.
  - ✓ due to increased # of protons (attractive force) on the outermost electrons
  - ✓ electrons that are no further away from the nucleus.



The Size of Atoms



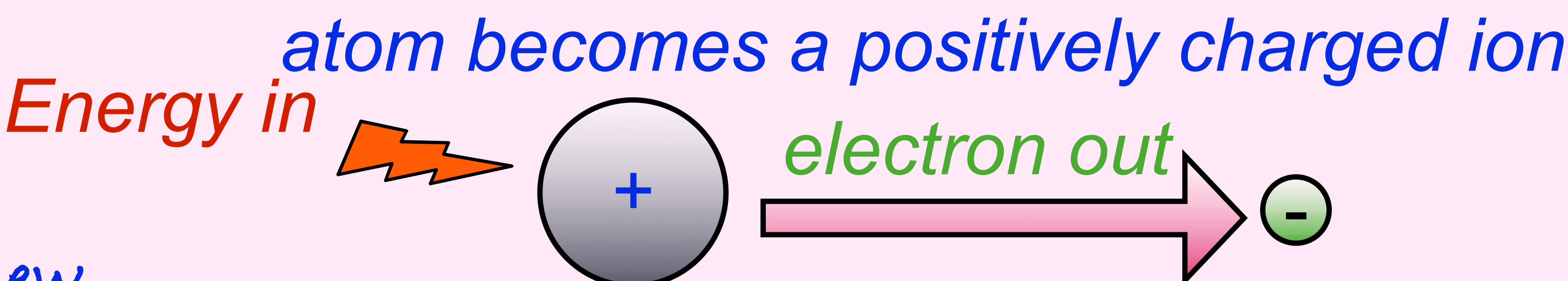
- You are not likely to see questions about the size of “d” atoms.
- Though they do follow the same general trend

How to Learn about Atoms?

- We can’t see individual atoms
- We can’t talk to them
- So we poke them with
  - ✓ heat
  - ✓ light – (not just visible light)
  - ✓ electricity

Ionization Energy

- Ionization Energy
  - ✓ The amount of energy required to forcibly remove an electron from an atom.
- Energy added as heat, light, or electricity
  - ✓ Equation: $X + IE \rightarrow X^{+} + e^{-}$
  - ✓ If an atom's IE is high, we will interpret that as an atom with a stable (and therefore favorable) electron configuration. (in which e- are held tightly)



Slide view

Select what you think would be the periodic trend for ionization energy in any one column.

1. Ionization energy *increases* within a column down the chart.
2. Ionization energy *decreases* within a column down the chart.
3. Ionization energy *stays the same* within a column down the chart.

Select what you think would be the periodic trend for ionization energy in any one column.

1. Ionization energy *increases* within a column down the chart.
2. Ionization energy *decreases* within a column down the chart.
   - this is because size increases as we move down the chart, since the electron removed will be further from the nucleus that is holding it, the electron can be removed more easily.
   - IE is *inversely proportional* to atom size
3. Ionization energy *stays the same* within a column down the chart.

Select what you think would be the periodic trend for ionization energy in any one row.

1. Ionization energy increases (L→R) within a row across the chart.
2. Ionization energy decreases (L→R) within a row across the chart.
3. Ionization energy stays the same (L→R) within a row across to the chart.

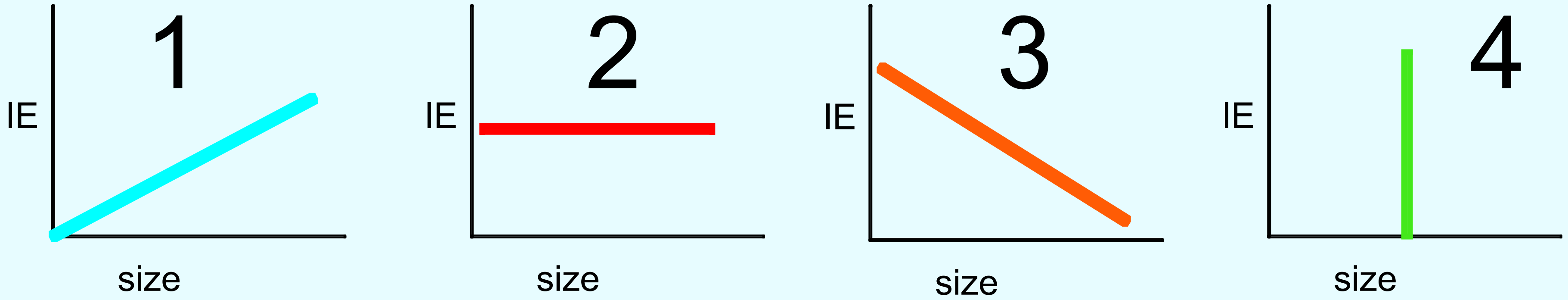
Select what you think would be the periodic trend for ionization energy in any one row.

1. Ionization energy increases (L→R) within a row across the chart.
   - this is because effective nuclear charge increased as we move across the chart (protons increase), since the electron removed will be closer to the nucleus that is holding it, the electron is harder to remove.
   - IE is inversely proportional to atom size
2. Ionization energy decreases (L→R) within a row across the chart.
3. Ionization energy stays the same (L→R) within a row across to the chart.

Slide show

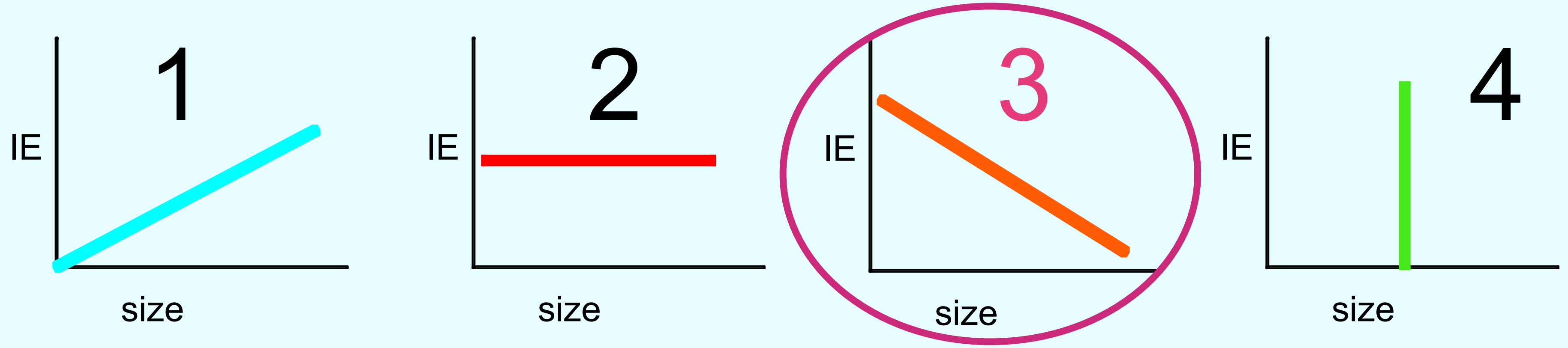
The Relationship between IE & Size

Which graph below would best represent the relationship between first IE and size of atoms?



The Relationship between IE & Size

Which graph below would best represent the relationship between IE and size of atoms?



Smaller atoms are more difficult to remove an electron from because the electron is closer to the proton force that is holding it in place. An *inverse* relationship

Slide show

First Ionization Energy

(The energy required to remove only one electron from an atom.)

- IE decreases down the chart.
  - ✓ Larger size of atom (∴ e- further from protons) thus easier to remove a valence electron.
- IE increases across to the right on the chart.
  - ✓ the increased *effective* nuclear charge (due to more protons with e− in same energy level) thus harder to remove an electron.

First Ionization Energies (kJ/mole)

1	H 1311							He 2370	1
2	Li 521	Be 899	B 799	C 1087	N 1404	O 1314	F 1682	Ne 2080	2
3	Na 496	Mg 737	Al 576	Si 786	P 1052	S 1000	Cl 1245	Ar 1521	3
4	K 419	Ca 590	Ga 579	Ge 762	As 944	Se 941	Br 1140	Kr 1351	4
5	Rb 403	Sr 550	In 558	Sn 709	Sb 832	Te 869	I 1009	Xe 1170	5
6	Cs 376	Ba 503	Tl 589	Pb 716	Bi 703	Po 812	At	Rn 1037	6
7	Fr	Ra							7

IE decreases down

IE increases across

Slide show

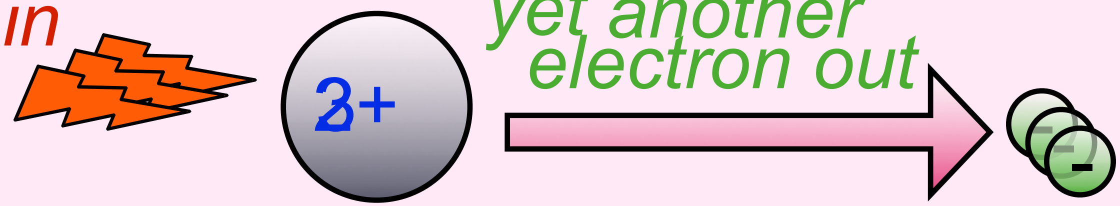
Ionization Energy

Scientists learned lots from knocking of one electron….guess what they decided to do?

Slide view

Successive Ionization Energy

- ✓ The amount of energy required to repeatedly remove electrons.
- ✓ Energy could be added in the form of heat, light, or electricity.
- ✓ First: $X + IE \rightarrow X^{+} + e^{-}$
- ✓ Second: $X^{+} + IE \rightarrow X^{2+} + e^{-}$
- ✓ Third: $X^{2+} + IE \rightarrow X^{3+} + e^{-}$
- ✓ Etc, etc, etc.



Which choice below would you suspect would best describe a successive ionization energy values (the energy to remove a second electron)?

1. the same as the previous IE
2. more than the previous IE
3. less than the previous IE
4. sometimes more, sometimes less, depending on which electron is being removed

Which choice below would you suspect would best describe successive ionization energy values?

1. the same as the previous IE
2. more than the previous IE
- less electrons in the outer shell allows those remaining e− to "skootch" in closer to the nucleus and "feel" more force.
3. less than the previous IE
4. sometimes more, sometimes less, depending on which electron is being removed

Successive Ionization Energy

- ✓ Always more than the previous
  - The remaining electrons may "skootch" in a bit closer because the remaining e− repel each other a little bit less, thus the remaining electrons "feel" greater force since they are closer to the protons
- ✓ removing certain electrons may be extra difficult to remove

So What Does this Tell Us?

- A very high IE indicates that taking an electron away is very difficult implying that the number of e− present before trying to take the e− away was a stable electron configuration.
- The very high IE increase always occurs when knocking off from the next energy level **closer** to the nucleus.
- Taking away one more electron than the number of valence electrons is *very difficult*.
- A very high increase always occurs for the removal of one electron more than the number of valence electrons in the atom.

What are the periodic trends for successive IE values as you move across the chart?

Successive Ionization Energies kJ/mole

	1st	*2nd*	*3rd*	*4th*	*5th*	*6th*	*7th*	*8th*
H	1311							
He	2370	5220						
Li	521	*7304*	11752					
Be	899	1756	*14849*	20899				
B	799	2422	3657	*25019*	32660			
C	1087	2393	4622	6223	*37822*	46988		
N	1404	2856	4573	7468	9446	*53250*	63970	
O	1314	3396	5297	7468	10990	13325	*71312*	83652
F	1682	3367	6050	8423	11028	15167	17869	*91950*
Ne	2080	3946	6165	9301	12138	15148	19972	22963
Na	496	*4564*	6918	9542	13373	16644	20175	25501
Mg	737	1447	*7738*	10546	13624	18033	21767	25742
Al	576	1814	2750	*11578*	14820	18361	23465	27575
Si	786	1582	3232	4361	*16007*	19693	23658	29110
P	1052	1901	2914	4959	6272	*21516*	25858	30489
S	1000	2258	3387	4544	6947	8500	*27112*	31734
Cl	1245	2287	3850	5162	6542	9359	11028	*33442*
Ar	1521	2653	3927	5886	7526	8587	11964	13778

across chart

across chart

Anomalies in the Ionization Energy Trends

- Notice the anomalies in column 3 and 6
- There are reasons for these anomalies that we will not discuss in first year chem.
- Come to AP chem for more detail.

First Ionization Energies (kJ/mole)

	1	2	3	4	5	6	7	8	
1	H 1311							He 2370	1
2	Li 521	Be 899	B 799	C 1087	N 1404	O 1314	F 1682	Ne 2080	2
3	Na 496	Mg 737	Al 576	Si 786	P 1052	S 1000	Cl 1245	Ar 1521	3
4	K 419	Ca 590	Ga 579	Ge 762	As 944	Se 941	Br 1140	Kr 1351	4
5	Rb 403	Sr 550	In 558	Sn 709	Sb 832	Te 869	I 1009	Xe 1170	5
6	Cs 376	Ba 503	Tl 589	Pb 716	Bi 703	Po 812	At 900	Rn 1037	6
7	Fr	Ra							7

Periodicity Review

Modern Atomic Theory

Coulombs Law

Select the largest diameter atom from the group: $_{3}Li$, $_{11}Na$, $_{37}Rb$, $_{53}I$

Be ready to explain your choice.

1. $_{3}Li$
2. $_{11}Na$
3. $_{37}Rb$
4. $_{53}I$
5. Cannot be determined since they are in different *families* and different *periods*

Select the largest atom from the group: $_{3}Li$, $_{11}Na$, $_{38}Sr$, $_{53}I$

1. $_{3}Li$
2. $_{11}Na$
3. $_{37}Rb$
   - *Two extra energy levels* in Rb and I, yet Rb has a lower *effective nuclear charge*, so the force felt by the valence e^- is smaller, resulting Rb's larger size.
4. $_{53}I$
5. Cannot be determined since they are in different *families* and different *periods*

$$F = \frac{\downarrow Q_1^+ Q_2^-}{d^2}$$

Select the *largest* radius particle from the group:
$_{54}Xe$, $_{53}I^{-}$, $_{56}Ba^{2+}$, $_{52}Te^{2-}$
Be ready to explain your choice.

1. $_{54}Xe$
2. $_{53}I^{-}$
3. $_{56}Ba^{2+}$
4. $_{52}Te^{2-}$
5. They are all the same size because they are *isoelectronic*.
6. I can't choose because I don't know what isoelectronic means and I don't know about the size of charged particles.

Select the largest particle from the group: ${}_{54}Xe$, ${}_{53}I^{-1}$, ${}_{56}Ba^{+2}$, ${}_{52}Te^{-2}$

1. ${}_{54}Xe$
2. ${}_{53}I^{-1}$
3. ${}_{56}Ba^{+2}$
4. ${}_{52}Te^{-2}$ This ion has less protons, only 52 to hold the 54 electrons that are repeling each other resulting in a larger size
5. They are all the same size because they are isoelectronic.
6. I can’t choose because I don’t know what isoelectronic means and I don’t know about the size of charged particles.

$_{16}S$ is smaller than $_{11}Na$ because

Select all that apply.

1. $_{16}S$ has more protons and more electrons.
2. $_{16}S$ has more electrons.
3. $_{16}S$ has more protons pulling on electrons in the same energy level.
4. $_{16}S$ has fewer energy levels.
5. $_{16}S$ has more neutrons to allow the atom to squeeze in more.
6. No explanation since S is *bigger* than Na, not smaller.

${}_{16}S$ is smaller than ${}_{11}Na$ because

1. ${}_{16}S$ has more protons and more electrons.
2. ${}_{16}S$ has more electrons.
3. ${}_{16}S$ has more protons pulling on electrons in the same energy level.
   (S has a greater effective nuclear charge)
4. ${}_{16}S$ has fewer energy levels.
5. ${}_{16}S$ has more neutrons to allow the atom to squeeze in more.

Select the atom below with the lowest first ionization energy.

Be ready to explain your choice.

1. ${}_{11}Na$
2. ${}_{12}Mg$
3. ${}_{13}Al$
4. ${}_{14}Si$

Select the atom below with the lowest first ionization energy.

1. $_{11}Na$ because it is largest in size
2. $_{12}Mg$
3. $_{13}Al$
4. $_{14}Si$

The atom that has a *really* large increase for its 3rd ionization energy would be

1. $_{11}Na$
2. $_{12}Mg$
3. $_{13}Al$
4. $_{14}Si$
5. $_{15}P$

The atom with the largest increase for its 3rd ionization energy would be

1. $_{11}Na$ *(for Na it would be the 2nd IE)*
2. $_{12}Mg$ because it has 2 valence electrons and stealing the third electron comes from a full energy level.
3. $_{13}Al$ *(for Al it would be the 4th IE)*
4. $_{14}Si$ *(for Si it would be the 5th IE)*
5. $_{15}P$ *(for P it would be the 6th IE)*

- All successive IE are larger than the previous, however,the really large increase occurs for the electron that is one more than the number of valence electrons.

In which set of elements would all the atoms have very similar *chemical* properties?

1. ${}_{11}Na$, ${}_{12}Mg$, ${}_{13}Al$
2. ${}_{14}Si$, ${}_{32}Ge$, ${}_{50}Sn$
3. ${}_{26}Fe$, ${}_{27}Co$, ${}_{28}Ni$
4. ${}_{8}O$, ${}_{16}S$, ${}_{34}Se$
5. I have no idea how to even begin to answer this question.
   (Hint: chemical families…)

In which set of elements would all the atoms have very similar *chemical* properties?

1. ${}_{11}Na$, ${}_{12}Mg$, ${}_{13}Al$
2. ${}_{14}Si$, ${}_{32}Ge$, ${}_{50}Sn$ this family crosses the metal nonmetal barrier and thus would have different chemical properties
3. ${}_{26}Fe$, ${}_{27}Co$, ${}_{28}Ni$
4. ${}_{8}O$, ${}_{16}S$, ${}_{34}Se$ These elements are all in the same chemical family which all have the same number of valence electrons.
5. I have no idea how to even begin to answer this question.

When rubidium ($_{37}Rb$) turns into its most common ion by losing an electron, *(Select all that apply.)*

1. It is isoelectronic with $_{35}Br^{-1}$
2. It becomes positively charged
3. It turns into Kr
4. The resulting ion will be smaller than the atom it came from
5. Its electrons will be the same as the strontium ion’s electrons ($_{38}Sr^{+2}$)
6. turns into a +1 cation

When rubidium ($_{37}Rb$) turns into its most common ion by losing an electron,

1. It is isoelectronic with $_{35}Br^{-1}$
   » *The bromide ion has gained one e- making 36 electrons*
2. It becomes positively charged
   » *because it lost one electron: 37+ and 36-*
3. It turns into Kr
   » *(Of course the Rb^{+1} ion does not become Kr because it still only has 37 protons, not 36 like Kr)*
4. The resulting ion will be smaller than the atom it came from
   » *Cations (+ ions) are always smaller than their parent atom.*
5. Its electrons will be the same as the strontium ion's electrons ($_{38}Sr^{+2}$)
   » *The electrons for both of these ions will be the same as Kr's electrons: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6$*

Which is more reactive?

1. $_{3}Li$
2. $_{11}Na$
3. $_{19}K$
4. $_{37}Rb$
5. They are equally reactive because they are in the same chemical family.
6. I have no knowledge of how I might even decide this.

Which is more reactive?

1. $_{3}Li$
2. $_{11}Na$
3. $_{19}Na$
4. $_{37}Rb$ rubidium would be most reactive because the alkali metals are **losing** an electron, and the e^- will be lost most vigorously when the electron being lost is **furthest** from the + pull of the nucleus.
5. They are equally reactive because they are in the same chemical family.
6. I have no knowledge of how I might even decide this.

Which is more reactive?

1. $_{9}F$
2. $_{17}Cl$
3. $_{35}Br$
4. $_{53}I$
5. They are equally reactive because they are in the same chemical family.
6. I have no knowledge of how I might even decide this.

Which is more reactive?

1. $_{9}F$ Halogens most commonly gain electrons. A **smaller** halogen **gains e^{-}'s** more vigorously because the **protons** pulling in the electron that is being gained are **closer** to the valence shell, and the closer the incoming e^{-} comes to the nucleus, the more vigorously that electron will be grabbed.
2. $_{17}Cl$
3. $_{35}Br$
4. $_{53}I$
5. They are equally reactive because they are in the same chemical family.
6. I have no knowledge of how I might even decide this.

Which is more reactive?

1. $_{8}O$
2. $_{16}S$
3. $_{34}Se$
4. $_{52}Te$
5. They are equally reactive because they are in the same chemical family.

Which is more reactive?

1. ${}_{8}O$ Like the halogens, these atoms also **gain electrons** and a smaller atom does that more vigorously because the protons are closer to the valence shell and pull in the electrons to be gained more vigorously.
2. ${}_{16}S$
3. ${}_{34}Se$
4. ${}_{52}Te$
5. They are equally reactive because they are in the same chemical family.

Which will normally form a negative ion? *(Select as many as apply.)*

1. $1s^2\ 2s^2 2p^6\ 3s^2$
2. $1s^2\ 2s^2 2p^6\ 3s^1$
3. $1s^2\ 2s^2 2p^6$
4. $1s^2\ 2s^2 2p^4$
5. $1s^2\ 2s^2 2p^3$
6. $1s^2\ 2s^2 2p^6\ 3s^2 3p^1$

Which will normally form a negative ion? *(Select as many as apply.)*

1. $1s^2 2s^2 2p^6 3s^2$
2. $1s^2 2s^2 2p^6 3s^1$
3. $1s^2 2s^2 2p^6$
4. $1s^2 2s^2 2p^4$
5. $1s^2 2s^2 2p^3$
6. $1s^2 2s^2 2p^6 3s^2 3p^1$

Which will normally form a negative ion? *Select as many as apply.*

1. [Ar] $4s^1$
2. [Ar] $4s^2$
3. [Ar] $4s^2 3d^{10} 4p^6$
4. [Ar] $4s^2 3d^{10} 4p^5$
5. [Ar] $4s^2 3d^{10} 4p^2$
6. [Ar] $4s^2 3d^6$

Which will normally form a negative ion? *Select as many as apply.*

1. [Ar] $4s^1$
2. [Ar] $4s^2$
3. [Ar] $4s^2 3d^{10} 4p^6$
4. [Ar] $4s^2 3d^{10} 4p^5$
5. [Ar] $4s^2 3d^{10} 4p^2$
6. [Ar] $4s^2 3d^6$

Which will have the lowest ionization energy?

1. $1s^2\ 2s^2\ 2p^6\ 3s^2$
2. $1s^2\ 2s^2\ 2p^6\ 3s^1$
3. $1s^2\ 2s^2\ 2p^6$
4. $1s^2\ 2s^2\ 2p^4$
5. $1s^2\ 2s^2\ 2p^3$
6. $1s^2\ 2s^2\ 2p^1$

Which will have the lowest ionization energy?

1. $1s^2\ 2s^2\ 2p^6\ 3s^2$
2. $1s^2\ 2s^2\ 2p^6\ 3s^1$
3. $1s^2\ 2s^2\ 2p^6$
4. $1s^2\ 2s^2\ 2p^4$
5. $1s^2\ 2s^2\ 2p^3$
6. $1s^2\ 2s^2\ 2p^1$

Which *metal* would combine with oxygen in a one to one ratio.

Select as many as apply.

1. $1s^2\ 2s^2\ 2p^6\ 3s^2$
2. $1s^2\ 2s^2\ 2p^6\ 3s^1$
3. $1s^2\ 2s^2\ 2p^6$
4. $1s^2\ 2s^2\ 2p^4$
5. $1s^2\ 2s^2\ 2p^3$
6. $1s^2\ 2s^2\ 2p^1$

Which metal would combine with oxygen in a one to one ratio.

Select as many as apply.

1. $1s^2\ 2s^2\ 2p^6\ 3s^2$
2. $1s^2\ 2s^2\ 2p^6\ 3s^1$
3. $1s^2\ 2s^2\ 2p^6$
4. $1s^2\ 2s^2\ 2p^4$
5. $1s^2\ 2s^2\ 2p^3$
6. $1s^2\ 2s^2\ 2p^1$

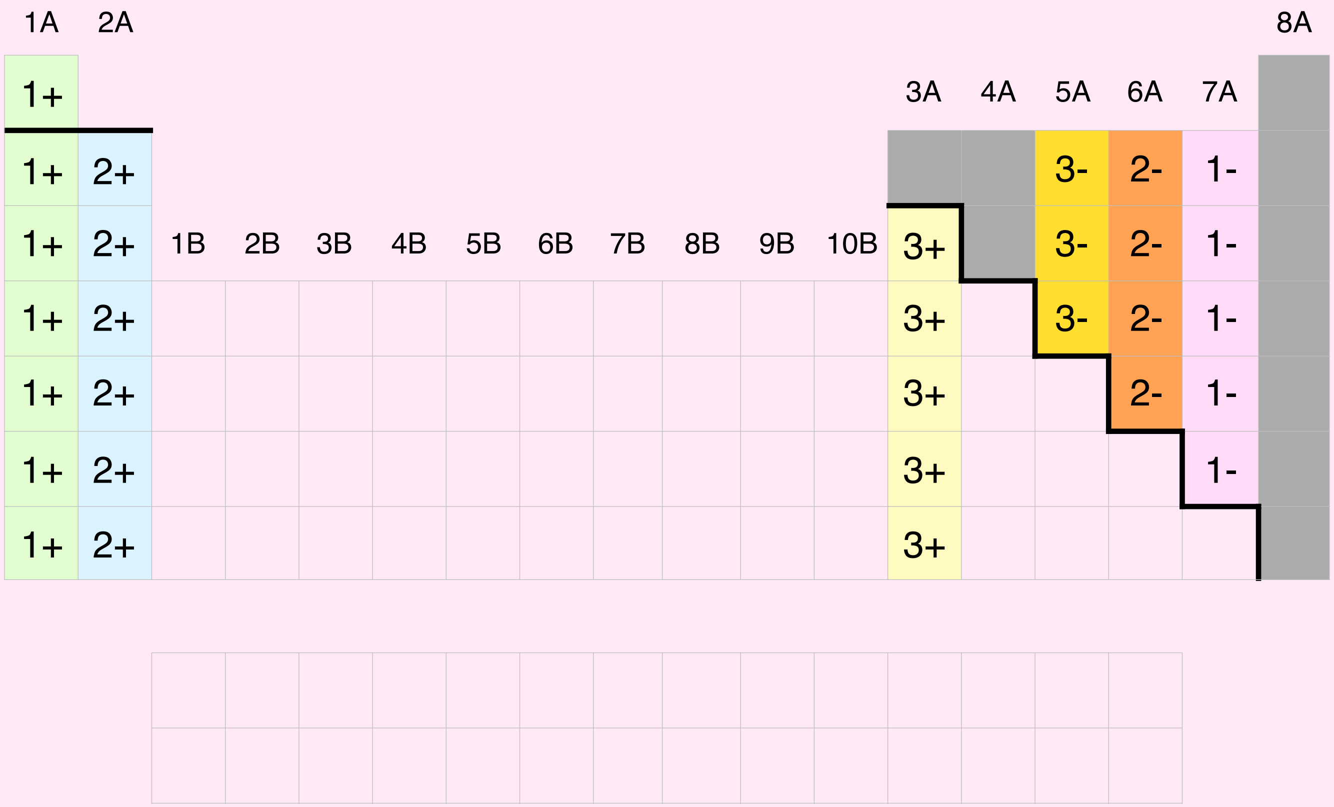
A certain nonmetallic element forms a compound with gallium having the general formula GaX_3. Element X must be a member of which group?

1. 1A
2. 2A
3. 3A
4. 4A
5. 5A
6. 6A
7. 7A

A certain nonmetallic element forms a compound with gallium having the general formula GaX_3. Element X must be a member of which group?

1. 1A
2. 2A
3. 3A
4. 4A
5. 5A
6. 6A
7. 7A

So what do we know about ion formation. Loss and gain of e^-'s.



Unit G

Nomenclature

writing chemical formulas
naming chemical compounds

potassium chromate

potassium dichromate

You know elements can be classified either: **Metals or Nonmetals**

This means there are three possible combinations….we will look at these three one at a time

- Metal + Nonmetal *(when bonded together)*
  - ✓ Ionic Compound (ionic bonds)
- Nonmetal + Nonmetal *(when bonded together)*
  - ✓ Molecular Compound (covalent bonds)
- Metal + Metal *(when mixed together)*
  - ✓ Alloy (metallic bonding)

Ionic Compounds
metal + nonmetal

Binary Ionic

just two elements combined

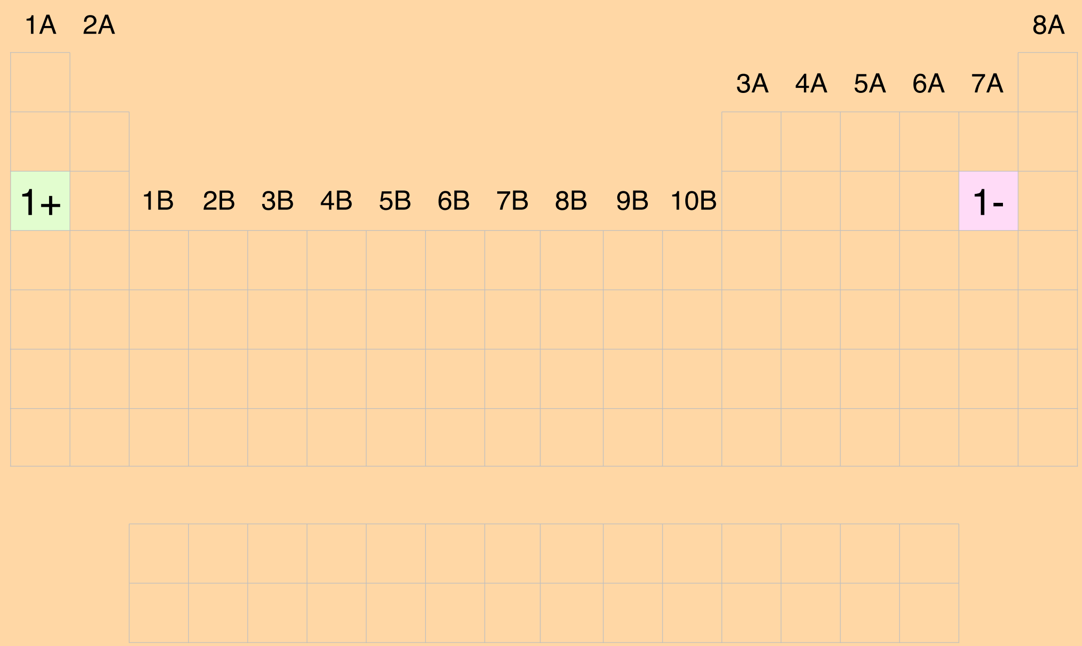
slide show

Ionic Compounds

- Metal + Nonmetal *(bonded together)*
- electrons are transferred when bonding
    - ✓ metals lose e- and form cations +
    - ✓ nonmetals gain e- and form anions -
- Cation written first, anion written second
- metal keeps same name, nonmetal name changed to xyz-ide

Write the chemical formula for sodium chloride

Write the chemical formula for sodium chloride

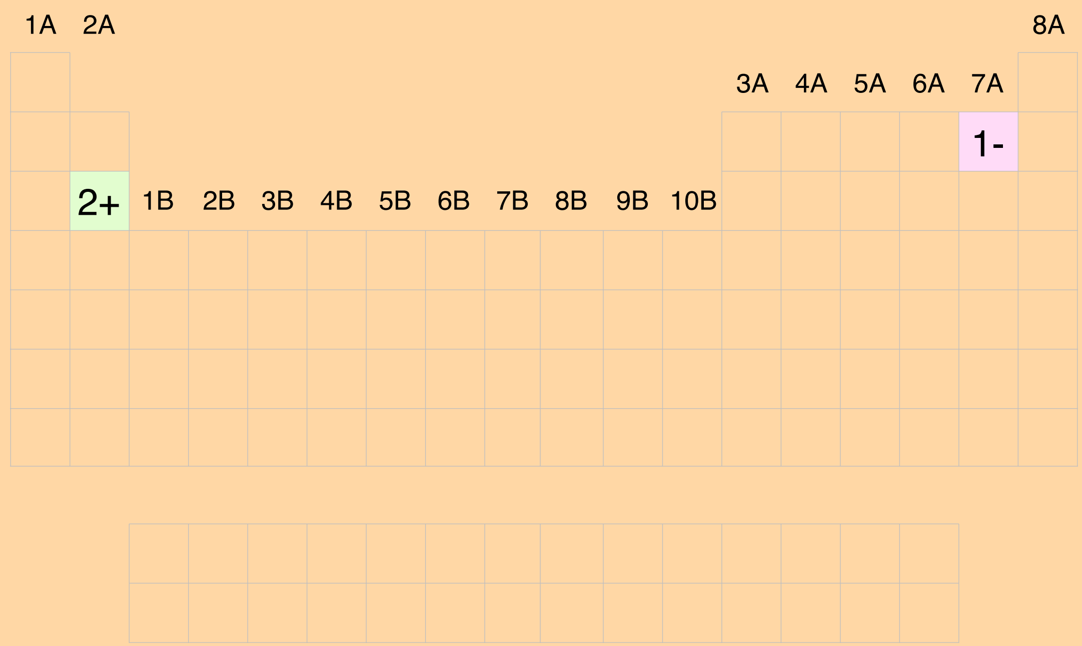


NaCl

- When combined together Na^{+} Cl^{-}
  - ✓ Metals lose e- (+ ion = cation)
  - ✓ Nonmetals gain e- (- ion = anion)

Write the chemical formula for magnesium fluoride

Write the chemical formula for magnesium fluoride



MgF_2

- The number of electrons lost must equal the number of electrons gained.

Write the chemical formula for strontium sulfide

Write the chemical formula for strontium sulfide

SrS

- Sr^{2+} S^{2-} you might have written Sr_2S_2
- remember always write ionic formula in ***<u>lowest whole number ratio</u>***

Write the chemical formula for potassium nitride

Write the chemical formula for potassium nitride

K_3N

- K^+ N^{3-}

Write the chemical formula for Thallium oxide

Write the chemical formula for thallium oxide

Tl_2O_3

- Tl^{3+} O^{2-}

Write the name for $CaBr_2$

Write the name for $CaBr_2$

calcium bromide

So what do we know about ion formation?

- Known charges are shown *(when metals combine with nonmetals.)*
- Grey elements do NOT form ionic compounds.
- The unshaded metals require Roman Numerals to indicate the charge.

1A	2A	1B	2B	3B	4B	5B	6B	7B	8B	9B	10B	3A	4A	5A	6A	7A	8A
H+																	
1+	2+													3-	2-	1-	
1+	2+											3+		3-	2-	1-	
1+	2+											3+		3-	2-	1-	
1+	2+											3+			2-	1-	
1+	2+											3+				1-	
1+	2+											3+					

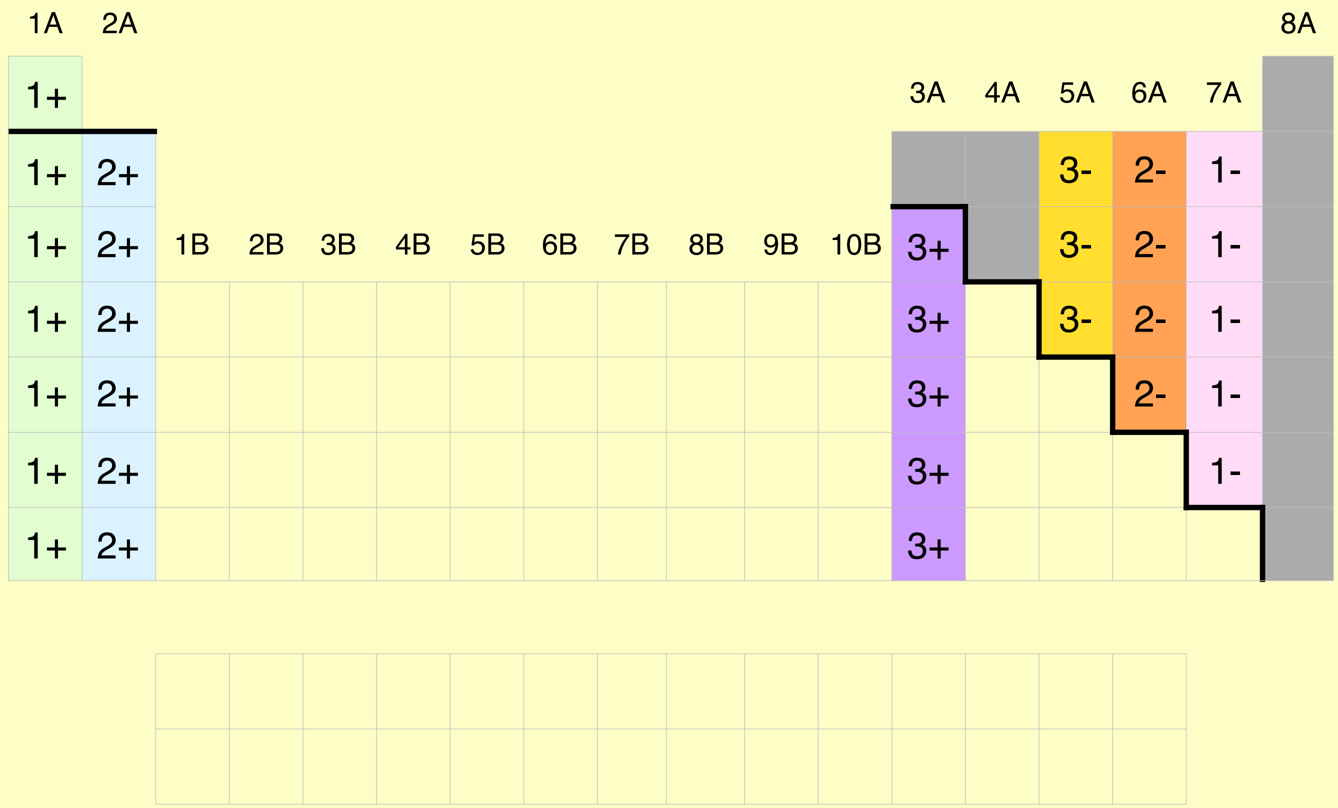
Binary Ionic Compounds Involving Roman #'s

Nomenclature

slide show

What about the “other” metals?

- The metals we haven’t talked about yet.



Metals with “d” electrons

- The presence of “d” electrons often cause the ability of these elements to form multiple different charges
- So when you call me to say you have some cobalt chloride, I wouldn’t know which of the two compounds shown below you have.

Multiple charge possibilities

- Cobalt can be 2+ or 3+ charge depending on how the compound formed.
- So, how to communicate the charge in cobalt chloride?
- Use a Roman numeral to indicate the positive charge on the metal cation.

cobalt(II) chloride

Co^{2+} Cl^{-}

$CoCl_2$

cobalt(III) chloride

Co^{3+} Cl^{-}

$CoCl_3$

Write the chemical formula for iron(III) oxide

Write the chemical formula for iron(III) oxide

Fe_2O_3

- Fe^{3+} O^{2-}

Write the chemical formula for nickel(II) oxide

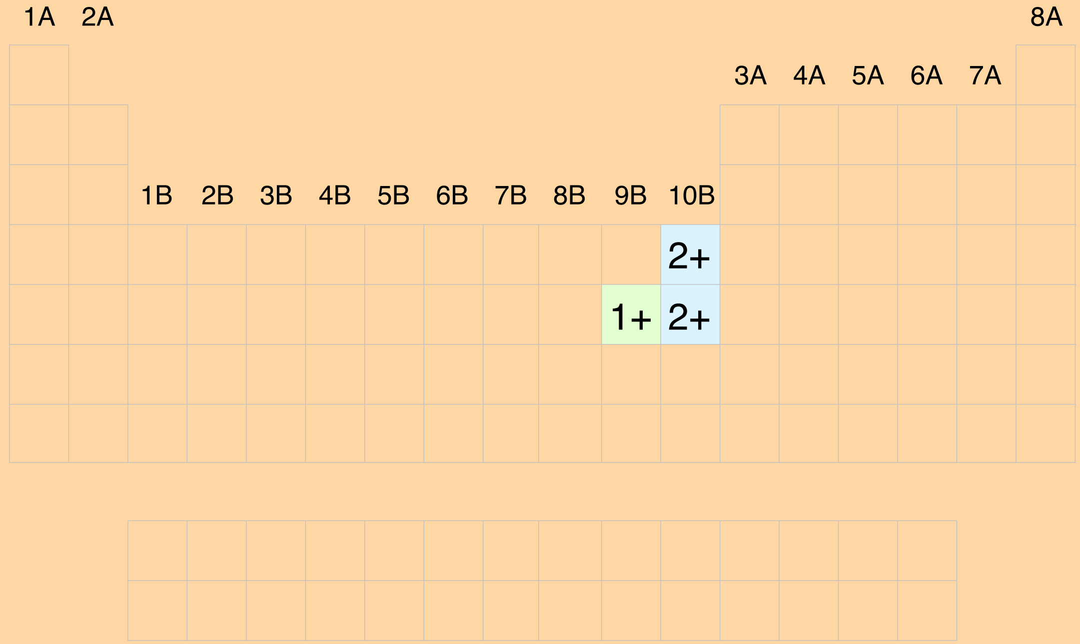
Write the chemical formula for nickel(II) oxide

NiO

- The Roman # tells you the +2 charge on the nickel metal
- Ni^{2+} O^{2-}
- You might have criss-crossed to Ni_2O_2 but then you must reduce it to the lowest whole number ratio.

Write the chemical formula for zinc chloride

Write the chemical formula for zinc chloride



$ZnCl_2$

- Zinc is one of the transition metals that does not require a Roman #, since zinc's charge (oxidation state) is always +2.
- There are 2 others; cadmium and silver

Write the chemical formula for chromium (VI) sulfide

Write the chemical formula for chromium (VI) sulfide

CrS_3

- The Roman # tells you the +6 charge on the chromium metal
- Cr^{6+} S^{2-}
- You might have criss-crossed to Cr_2S_6 but then you must reduce it to the lowest whole number ratio.

Write the name for NiSe

Write the name for NiSe

nickel(II) selenide

- or you can determine the charge on nickel by working backwards from the charge on the anion
    - ✓ $Ni^{?}\ Se^{2-}$
    - ✓ so the nickel must be 2+…. (II)

Write the name for Fe_2O_3

Write the name for Fe_2O_3

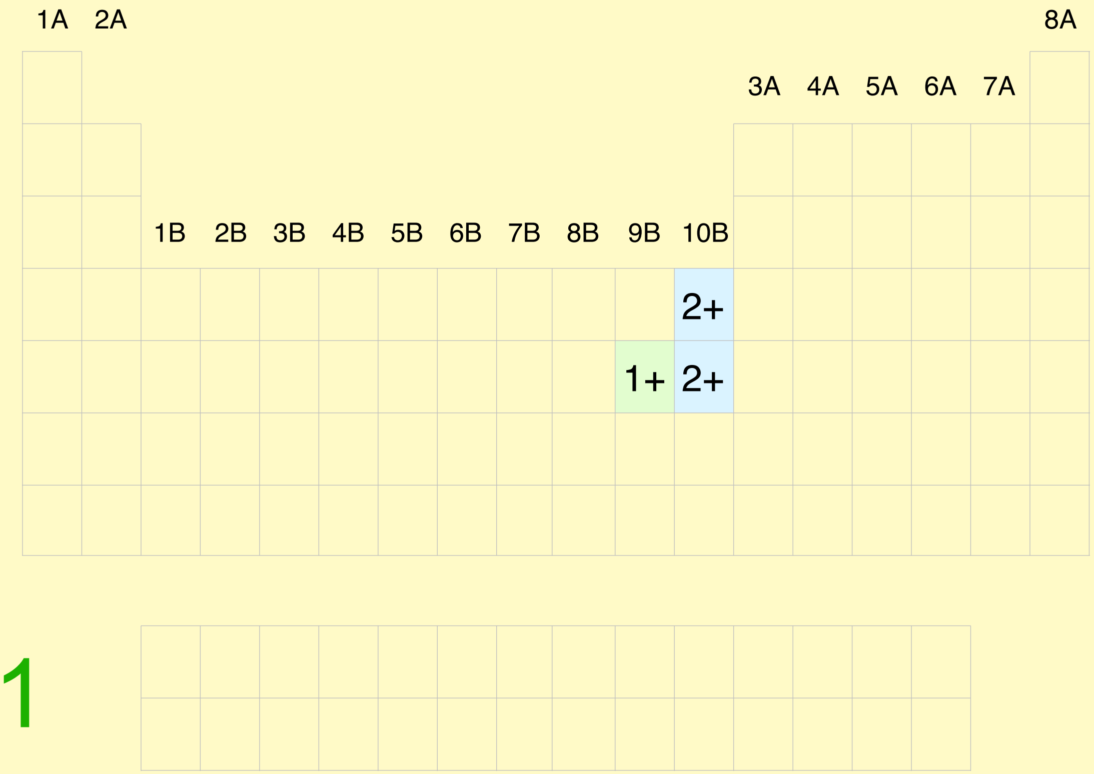
iron(III) oxide

- you can un-criss-cross
- or you can determine the charge on iron by working backwards from the charge on the anion
    - ✓ $Fe_2{}^{?}\,O_3{}^{2-}$
    - ✓ $3 \times 2- = 6-$
    - ✓ so $2 \times ? = 6+$ so ? must equal 3+

Write the name for Ag_2S

Write the name for Ag_2S

silver sulfide



- No need for a Roman # since silver is always +1
  - ✓ (that's a memorize, along with Zn and Cd in blue above)

Write the name for Cu_3P

Write the name for Cu_3P

copper(I) phosphide

- You can "un-criss-cross"
- or you can work backwards into the cation by knowing that the anion is 3−
  - ✓ $Cu_3^{?}\ P^{3-}$
  - ✓ the phosphide ion is $^{3-}$
  - ✓ so 3 x ? = 3+ so ? must equal 3+
    - ✦ the Roman # = the individual oxidation state of *one* of the metal ions (not the total metal charge)

Write the name for $CrAs_2$

Write the name for $CrAs_2$

chromium(VI) arsenide

- you can't just un-criss-cross because this is a formula which has been reduced.
  - ✓ work backwards from the non-metal's charge
  - ✓ $Cr^{?}\ As_2^{3-}$
  - ✓ $2 \times 3- = 6-$
  - ✓ so ? = 6+

Write the name for NiN

Write the name for NiN

nickel(III) nitride

- you can't just un-criss-cross because this is a formula which has been reduced.
  - ✓ work backwards from the non-metal's charge
  - ✓ $Cr^{?}\ N^{3-}$
  - ✓ so ? = 3+

Write the name for HfO_2

Write the name for HfO_2

hafnium(IV) oxide

- you can't just un-criss-cross because this is a formula which has been reduced.

✓ work backwards from the non-metal's charge

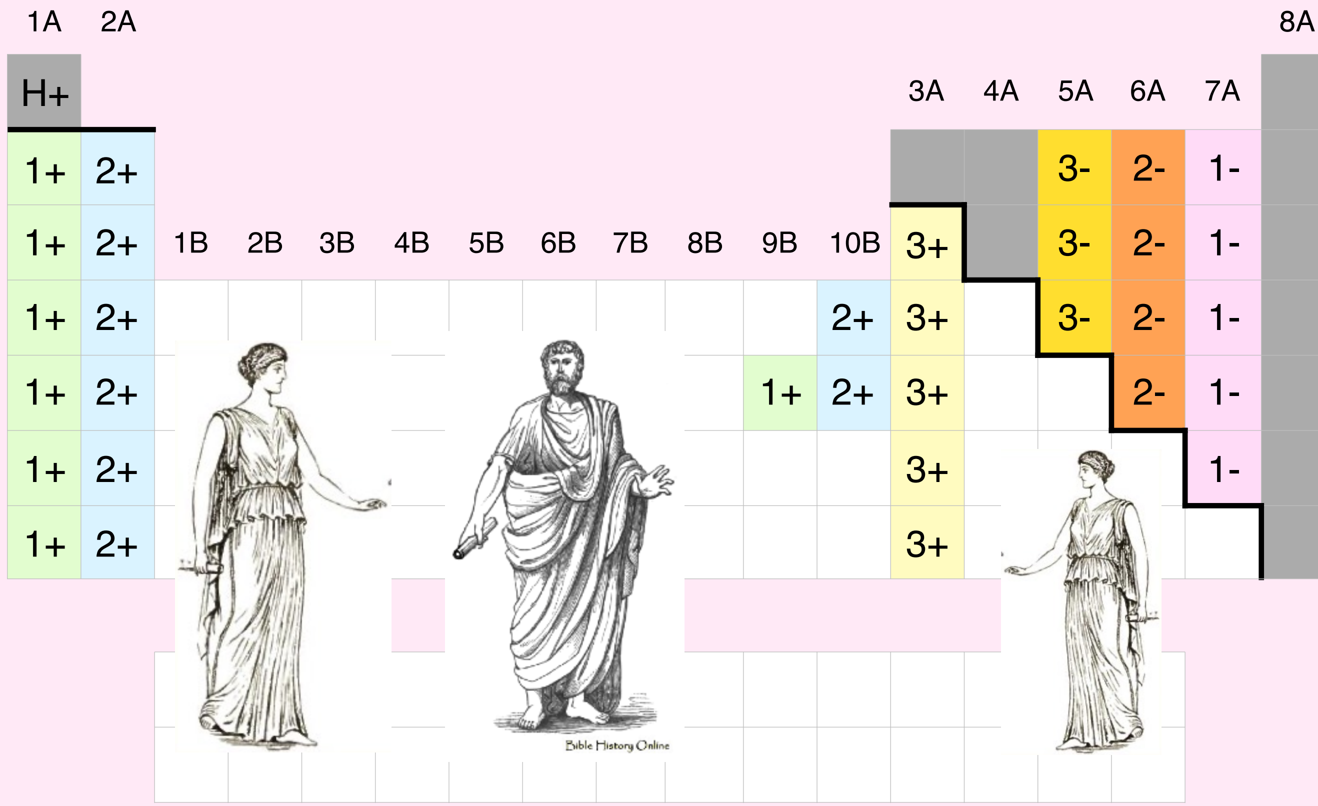
✓ $Hf^{?}\,O_2{}^{2-}$

✓ $2 \times 2- = 4-$

✓ so ? = 4+

So what do we know about ion formation?

- Known charges are shown *(when metals combine with nonmetals.)*
- Grey elements do NOT form ionic compounds.
- White metals require Roman Numerals to indicate the charge.



Ionic Compounds using Polyatomic Ions

3 or more elements in
an ionic compound

slide show

What is a Polyatomic Ion?

- A cluster of atoms (usually nonmetals) that use covalent bonding within the cluster, but that require extra electrons to be satisfied (or lose electrons)

- More than one atom covalently bonded (sharing electrons) together carrying a charge (the group of atoms needs to gain or lose electrons to be a group).

-ates and -ites

nitrite NO_2^-	sulfite SO_3^{2-}	phosphite PO_3^{3-}
nitrate NO_3^-	sulfate SO_4^{2-}	phosphate PO_4^{3-}

What if there's more than two?

hypochlorite	ClO^-
chlorite	ClO_2^-
chlorate	ClO_3^-
perchlorate	ClO_4^-

Notable Exceptions

ammonium a positive polyatomic	NH_4^+
cyanide	CN^-
hydroxide	OH^-
ferricyanide	$Fe(CN)_6^{3-}$
ferrocyanide	$Fe(CN)_6^{4-}$

Write the chemical formula for calcium nitrate

Write the chemical formula for calcium nitrate

$Ca(NO_3)_2$

- Ca^{2+} NO_3^-

NOT $CaNO_6$

NOT $CaNO_{32}$

NOT Ca_3N_2

Write the chemical formula for calcium chlorate

Write the chemical formula for calcium chlorate

$Ca(ClO_3)_2$

- Ca^{2+} ClO_3^-

Write the chemical formula for iron(III) dichromate

Write the chemical formula for iron (III) dichromate

$Fe_2(Cr_2O_7)_3$

- Fe^{3+} $Cr_2O_7^{2-}$
- note that dichromate does not mean two chromates, it is a particular ion
  - ✓ it got its name for the two chromium's in the ion, not because there will be two of the polyatomic ions in the compound

Write the chemical formula for nickel(II) nitrite

Write the chemical formula for nickel(II) nitrite

$Ni(NO_2)_2$

- Ni^{2+} NO_2^{-}
- Note the charge on the nitrite is $^{1-}$ not $2x^{1-}$, the subscript 2 is part of the ion; it does *not* mean two *of* the ions.

NOT $NiNO_2$ NOR $NiNO_{22}$

Write the chemical formula for gallium cyanide

Write the chemical formula for gallium cyanide

$Ga(CN)_3$

- *not* $GaCN_3$
  - ✓ you need 3 cyanides, not 3 N's and 1C *not* GaC_3N_3
  - ✓

Write the name for $Mn(SO_4)_2$

Write the name for $Mn(SO_4)_2$

Manganese(IV) sulfate

- We know that we need a Roman # for the manganese, so we need to figure out its charge.
- $Mn^{?}\ \ (SO_4)^{2-}{}_2$
- $2 \times 2- = 4-$ so $1 \times ? = 4+$
- ? must be 4+

Write the name for $(NH_4)_3PO_4$

Write the name for $(NH_4)_3PO_4$

Ammonium phosphate

- ammonium, NH_4^+ is one of the few positive polyatomic ions

Write the name for $Ca_2Fe(CN)_6$

Write the name for $Ca_2Fe(CN)_6$

calcium ferrocyanide

- How do you know that it is ferrocyanide, not ferricyanide?
- You do know the charge on the calcium ion is 2+
  - ✓ 2 x 2+ = 4+
  - ✓ thus the anion must be 4− to match.
  - ✓ and ferrocyanide is 4−

Write the name for AuSCN

Write the name for AuSCN

gold(I) thiocyanate

- SCN is a polyatomic ion 1−
- thus the gold must be 1+ to balance

Compounds

- How can you tell if a compound is an ionic compound or a molecular compound?
- NF_3 vs WF_3
- What's happening with electrons in a molecular compound compared to an ionic compound?

slide show

Molecular Compounds

- Nonmetal + Nonmetal *(bonded together)*
  - ✓ Molecular Compound
    - ✦ electrons are shared,
      - ✳ covalent bonds
    - ✦ NO ions are formed, NO charges

What is this?

What is this?

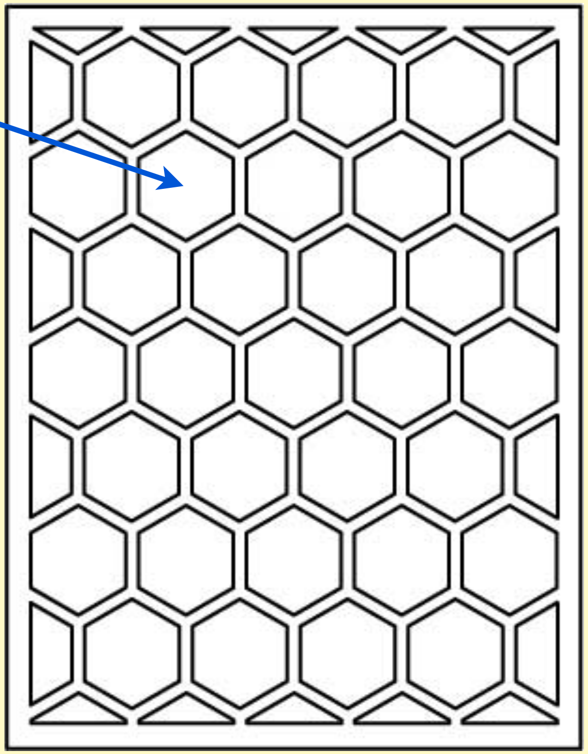
a tricycle

What is this?

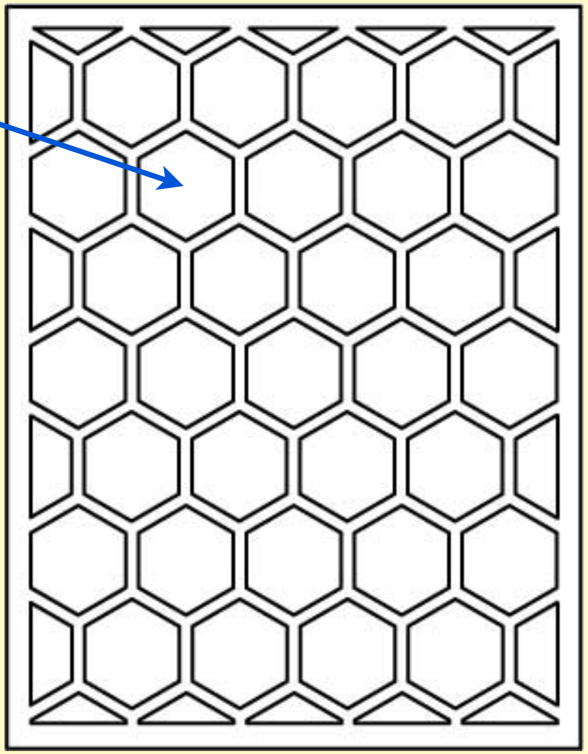
What is this?

a monocle

What are these shapes?



What are these shapes?



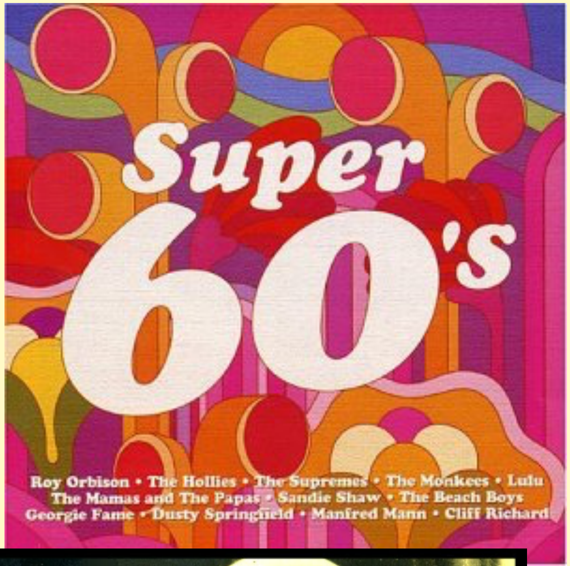
hexagons

Anyone know what building this is?

Anyone know what building this is?

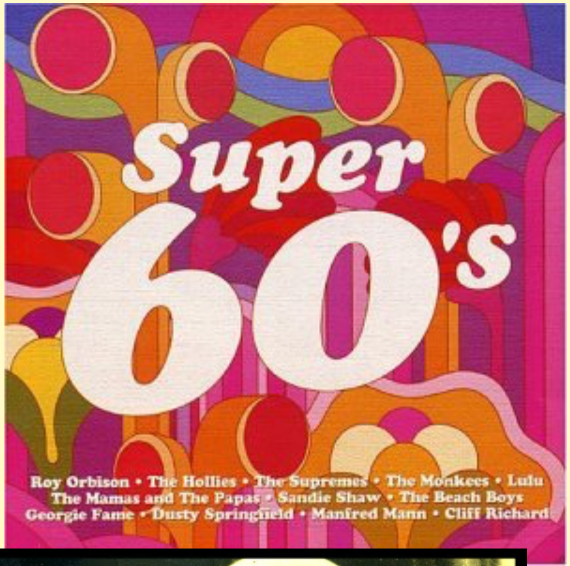
the pentagon

What do we call ten years....



What do we call ten years....

a decade



What is the shape of the stop sign?

What is the shape of the stop sign?

octagon

Wait, what? I thought October was the 10th month?

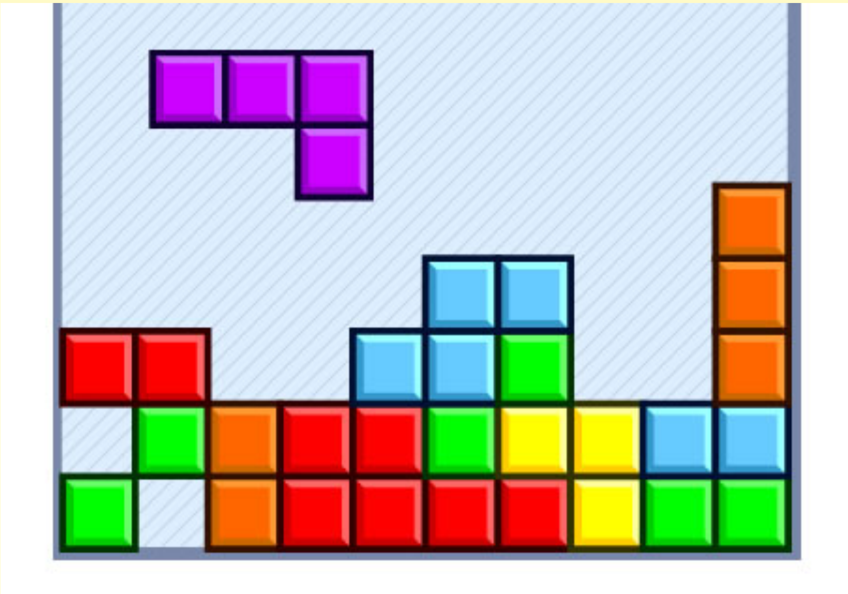
Originally there were 10 months. The ten months were Martius (March), Aprilis (April), Maius (May), Iunius (June), Quintilis (Fifth), Sextilis (Sixth), September (Seventh), October (Eighth), November (Ninth), December (Tenth). January and February were added later.

What multi-sport do these track stars participate in

What multi-sport do these track stars participate in

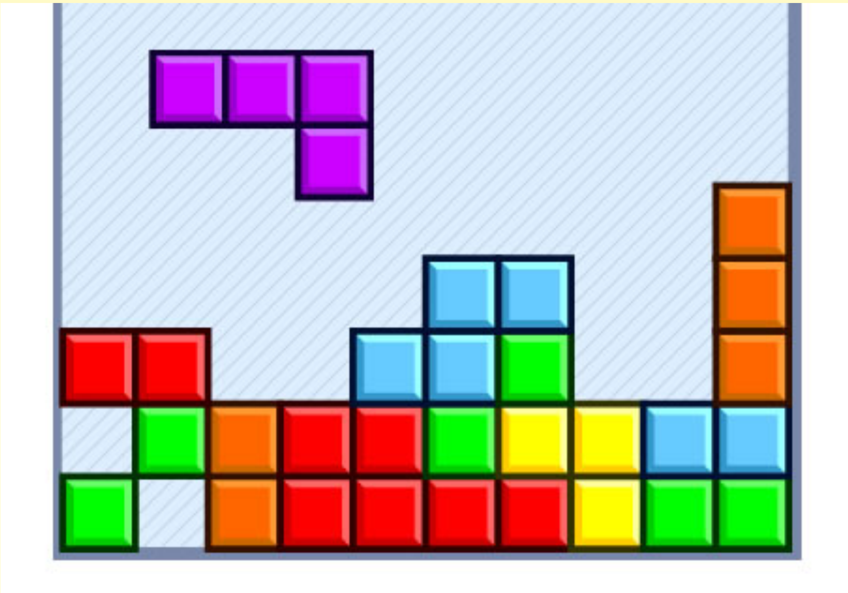
heptathlon

What game is this?

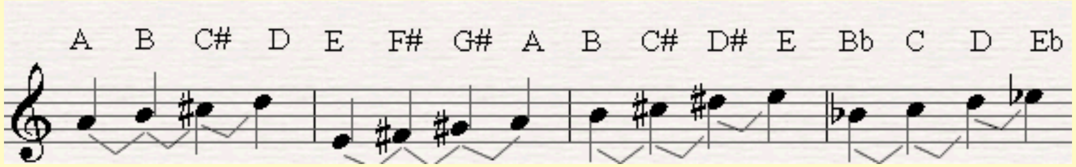


What game is this?

tetris

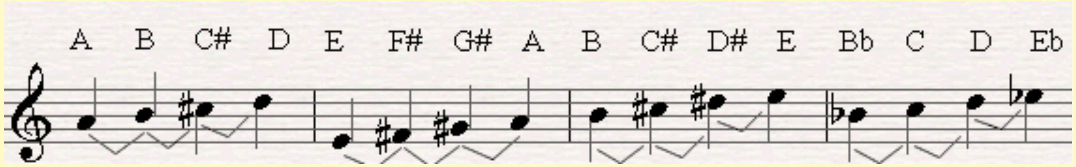


Any musicians in the room?
What are these?



Any musicians in the room?
What are these?

tetrachords



What is this?

What is this?

a bicycle

a chemist would called it a dicycle

H_2

diatomic molecule

Naming binary **molecular** compounds

- Nonmetal combined with nonmetal
- No charges - do not try to figure out the formula with charges - there are none.
- The name tells us the formula
- Prefixes will tell us the number of each atom.
- The second element listed: -ide
- mono is optional

1. mono-
2. di-
3. tri-
4. tetra-
5. penta-
6. hexa-
7. hepta-
8. oct-
9. nono-
10. dec-

Name the Binary Molecular Compounds

- CO_2

Name the Binary Molecular Compounds

- CO_2
  - ✓carbon dioxide

Name the Binary Molecular Compounds

- H_2O

Name the Binary Molecular Compounds

- H_2O
  - ✓dihydrogen monoxide
  - ✓dihydrogen oxide
  - ✓aka: water
- OH_2

Name the Binary Molecular Compounds

- PCl_3

Name the Binary Molecular Compounds

- PCl_3
  - ✓phosphorous trichloride
  - ✓(mono phosphorous trichloride)

Now…name these two

- $AsCl_3$
- AlF_3

Be careful: Ionic or Molecular
Different method for naming

- AsF_3 arsenic trifluoride
  - two nonmetals
- AlF_3 aluminum fluoride
  - metal and nonmetal (NO prefixes)

Write Formulas for the following Binary Molecular Compounds

- Carbon monoxide
- (carbon oxide)
- (monocarbon oxide)
- (monocarbon monoxide)

Write Formulas for the following Binary Molecular Compounds

- Carbon monoxide
  - ✓ CO

Write Formulas for the following Binary Molecular Compounds

- dinitrogen pentoxide

Write Formulas for the following Binary Molecular Compounds

- dinitrogen pentoxide
  - ✓N_2O_5

Write Formulas for the following Binary Molecular Compounds

- carbon tetrachloride

Write Formulas for the following Binary Molecular Compounds

- carbon tetrachloride
  - ✓ CCl_4

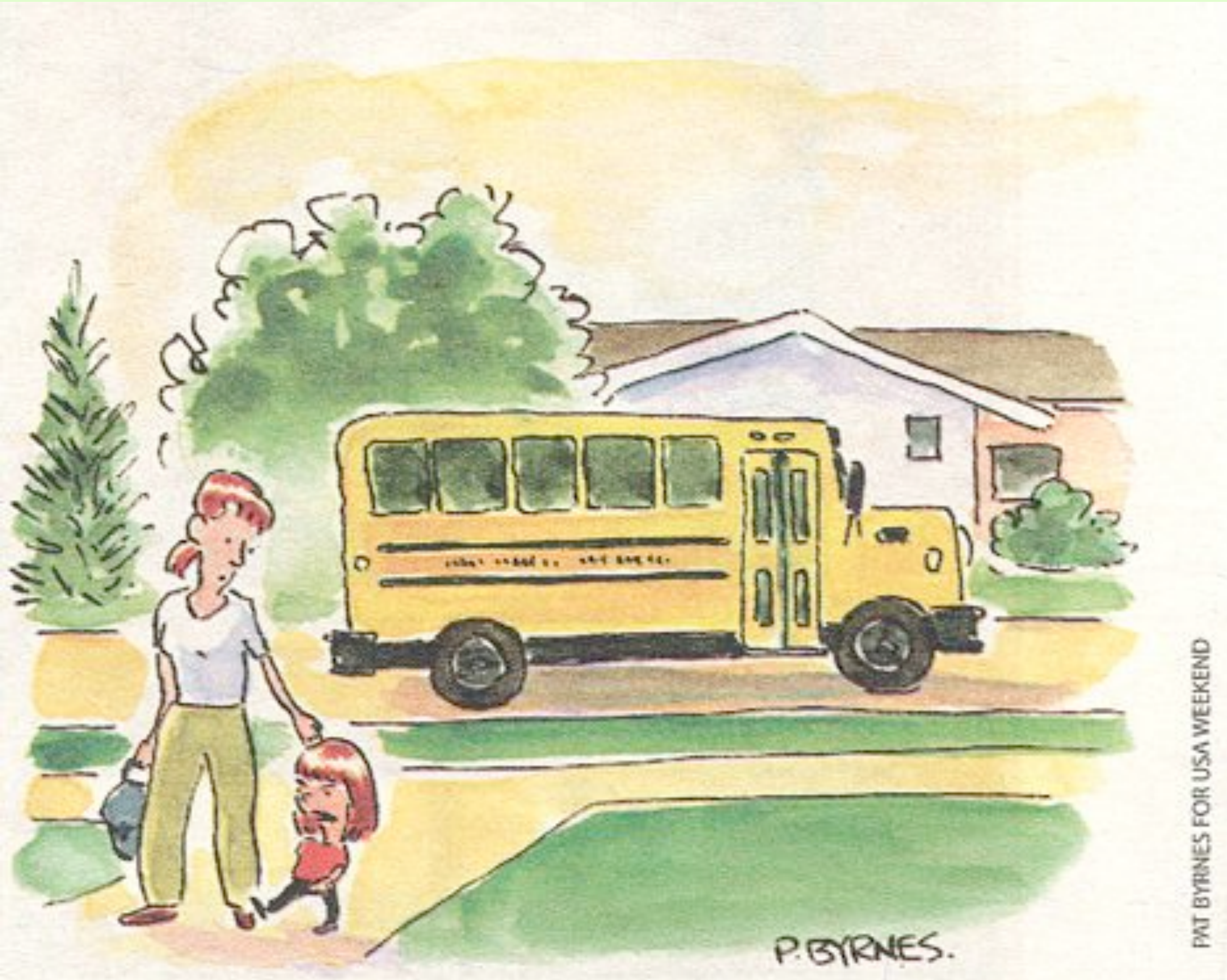
Write Formulas for the following Binary Compounds

- PbS_2

Write Formulas for the following Binary Molecular Compounds

- PbS_2
  - ✓lead(IV) sulfide

It’s all in the name....



“Everyone else in my class is Shamiqua, Taylor or Ashley. or Brad or Chad
How’d I get stuck with a weirdo name like Mary?”

Where are all the names like:

Betty,
Agnes,
or Jane,
David,
or Robert,??

I had an uncle named Moody, and a great grandfather named Pulcifer… say whaaaat?

Acids

Molecular compounds that behave like ionic compounds when dissolved in water.

You have heard of many of the acids

- hydrochloric acid
- nitric acid
- sulfuric acid
- acetic acid
- chlorous acid

- *Just where do they get their names?*

Systematic Method - Naming Acids

Does the anion contain oxygen?

Note Sheet G6 on the back

No
hydro-(anion root)-ic

Yes
check the ending of the root

-ITE
(anion root)-ous

-ATE
(anion root)-ic

HF	hydrofluoric
HCl	hydrochloric
HBr	hydrobromic
HI	hydroiodic
H_2S	hydrosulfuric
HCN	hydrocyanic

nitrous	HNO_2
sulfurous	H_2SO_3
phosphorous	H_3PO_3

HNO_3	nitric
H_2SO_4	sulfuric
H_3PO_4	phosphoric
H_2CO_3	carbonic
$HC_2H_3O_2$	acetic

How to remember the polyatomic acids??

- It's alphabetical!
- −ate ion is an −ic acid (ate something icky)
  - ✓sulfate = sulfuric acid
  - ✓nitrate = nitric acid
  - ✓acetate = acetic acid
- −ite ion is an −ous acid Watch out for tendonitis or appendicitis
  - ✓sulfite = sulfurous acid
  - ✓nitrite = nitrous acid
  - ✓phosphite = phosphorous acid

Write the name for the acid: HCl

Write the name for the acid: HCl

hydrochloric acid

no oxygen

Write the name for the following acids: H_2SO_4

Compare and contrast with

H_2SO_3

H_2S

Write the name for the following acids: H_2SO_4

sulfuric acid (sulfate)

Compare with

H_2SO_3 sulfurous acid (sulfite)

H_2S hydrosulfuric acid (no oxygen)

Write the formula for carbonic acid

Write the formula for carbonic acid

H_2CO_3

carbonate

Write the name for the acid: HIO_3

Compare and contrast with

HIO

HIO_2

HIO_3

HIO_4

Write the name for HIO_2

iodous acid (iodite)

Compare with

HIO hypoiodous acid (hypoiodite)

HIO_2 iodous acid (iodite)

HIO_3 iodic acid (iodate)

HIO_4 periodic acid (periodate)

Write the formula for phosphoric acid

Write the formula for phosphoric acid

H_3PO_4 (phosphate)

Compare with

H_3PO_3

Write the formula for phosphoric acid

H_3PO_4 (phosphate)

Compare with

H_3PO_3 phosphorous acid (phosphite)

More Practice

Nomenclature of all types

molecular, ionic, acids

slide show

Write the chemical formula for tin(IV) hydroxide

Write the chemical formula for tin(IV) hydroxide

$Sn(OH)_4$

Write the name for $CuCO_3$

Write the name for $CuCO_3$

copper(II) carbonate

Write the chemical formula for copper(I) ferrocyanide

Write the chemical formula for copper(I) ferrocyanide

$Cu_2Fe(CN)_6$

Write the name for CoAs

Write the name for CoAs

cobalt(III) arsenide

Write the chemical formula for uranium(VI) fluoride

Write the chemical formula for uranium(VI) fluoride

UF_6

Write the name for this acid

$HC_2H_3O_2$

Write the name for this acid

$HC_2H_3O_2$

Acetic Acid (acetate)

Write the formula for cadmium acetate

Write the name for cadmium acetate

$Cd(C_2H_3O_2)_2$

Write the name of $FeSO_3$

Write the name of $FeSO_3$

iron(II) sulfite

Write the chemical formula for iron(III) sulfite

Write the chemical formula for iron(III) sulfite

$Fe_2(SO_3)_3$

Write the name for $Cr(ClO)_3$

Write the name for $Cr(ClO)_3$

chromium(III) hypochlorite

Write the chemical formula for sulfurous acid

Write the chemical formula for sulfurous acid

H_2SO_3 (sulfite)

Write the name for this acid

HCN

Write the name for this acid

HCN

Hydrocyanic Acid (no oxygen)

Write the chemical formula for ammonium nitrate

Write the chemical formula for ammonium nitrate

NH_4NO_3

Write the name for $Mg(OH)_2$

Write the name for $Mg(OH)_2$

magnesium hydroxide

Write the chemical formula for hydrosulfuric acid

Write the chemical formula for hydrosulfuric acid

H_2S (no oxygen)

Write the chemical formula for $K_3Fe(CN)_6$

Write the chemical formula for $K_3Fe(CN)_6$

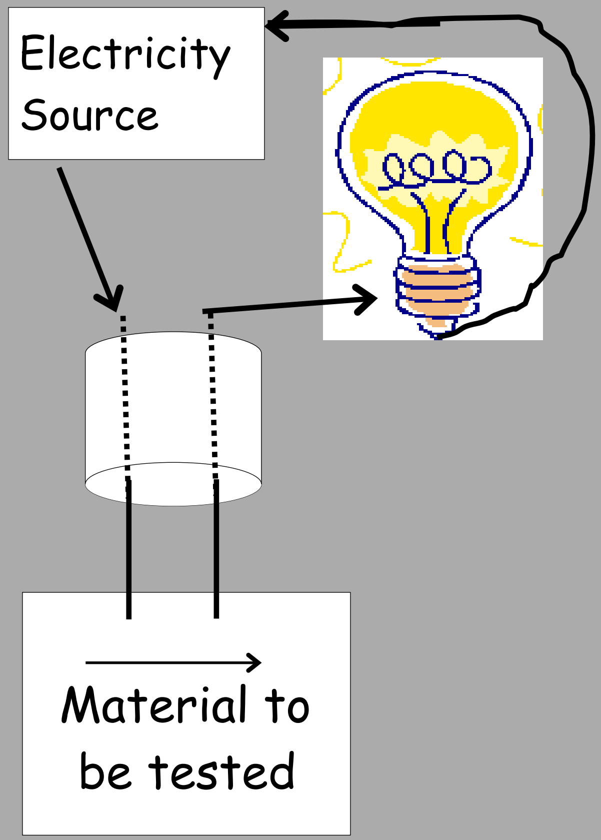
potassium ferricyanide

Write the name for $Pb(Cr_2O_7)_2$

Write the name for $Pb(Cr_2O_7)_2$

lead(IV) dichromate

LAD G3



The arrows indicate the path of electrons

Electrolytes

Chemicals that when dissolved in water produce a solution that conducts electricity.

slide view

For perspective and comparison: Predict which of the following solids you think will conduct electricity?

Select ALL that are conductors.

1. metal
2. wood
3. plastic
4. graphite, carbon
5. diamonds, carbon
6. glass

diamonds and graphite are allotropes of carbon

Solids: Which of the following will conduct electricity? *Mark ALL that apply.*

1. metal
2. wood
3. plastic
4. graphite (a particular allotrope of carbon)
5. diamonds, carbon
6. glass

- For electricity to move, electrons must be able to move through the substance.
- How is it that electrons move in metal and graphite?

slide show

Lab G3

Electricity

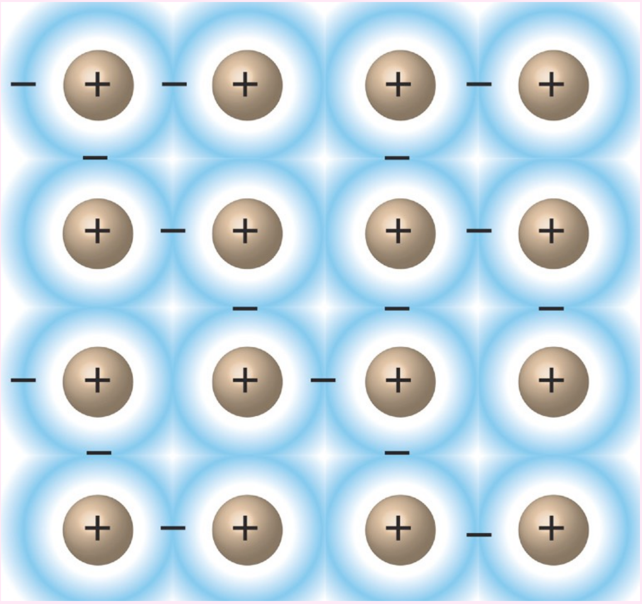
Electrons on the move

slide view

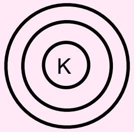
Metallic Solids – *A model to explain metallic properties*

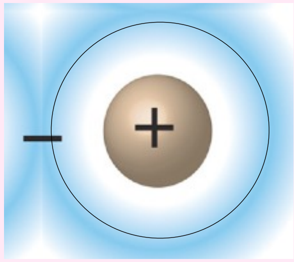
- Metal atoms are aligned in a regular and repeating pattern (crystal)
- The valence electron can wander freely throughout.
- The valence electrons are "delocalized"

Potassium



- The tan portion represents the potassium nucleus and the inner core electrons.





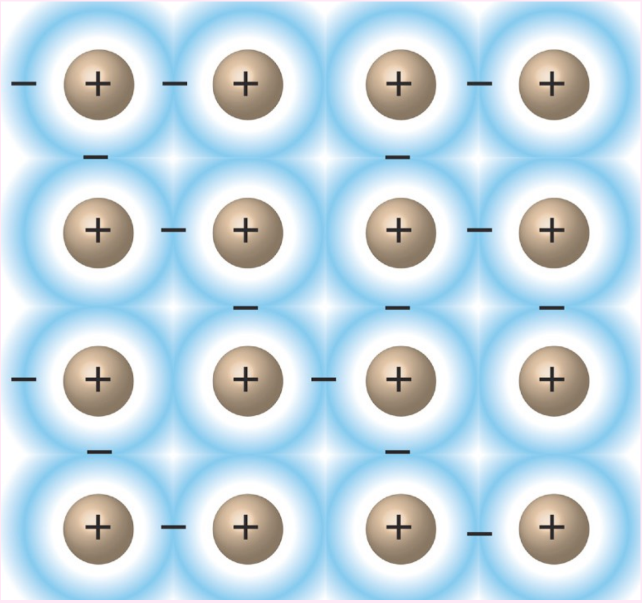
- The fuzzy blue cloud represents the valence shell.
- "Sea of loose valence electrons"

The “sea” of valence electrons. A model to explain metallic properties

Metallic Solids – Loose electrons....

...move easily making metals good conductors of electricity.

...can transmit kinetic energy easily making metals good conductors of heat.



...make for low ionization energies

...cause formation of cations (NOT anions

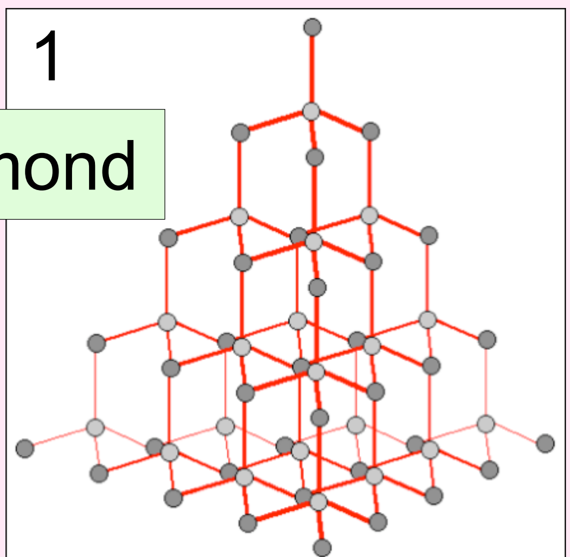
...make metals easily oxidized

...make metals malleable and ductile

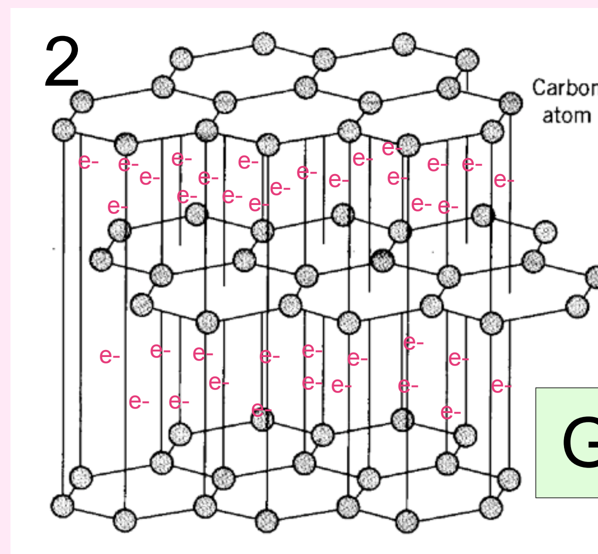
...make metals shiny

Carbon 4 valence electrons

1. In diamonds each C atom is bonded to four other atoms, holding the atoms in the substance very tightly.
   - This makes diamonds very hard, but NOT electrically conductive.
   - The electrons making up the bonds are very much “stuck in place.”
2. In graphite, each C atom is bonded tightly to 3 other atoms and then the 4th electron helps holds the sheets together.
   - The electrons making up the bonds between the sheets are loose and “delocalized” and able to move.
   - This makes the sheets of graphite able to slide, and electrically conductive.



allotropes



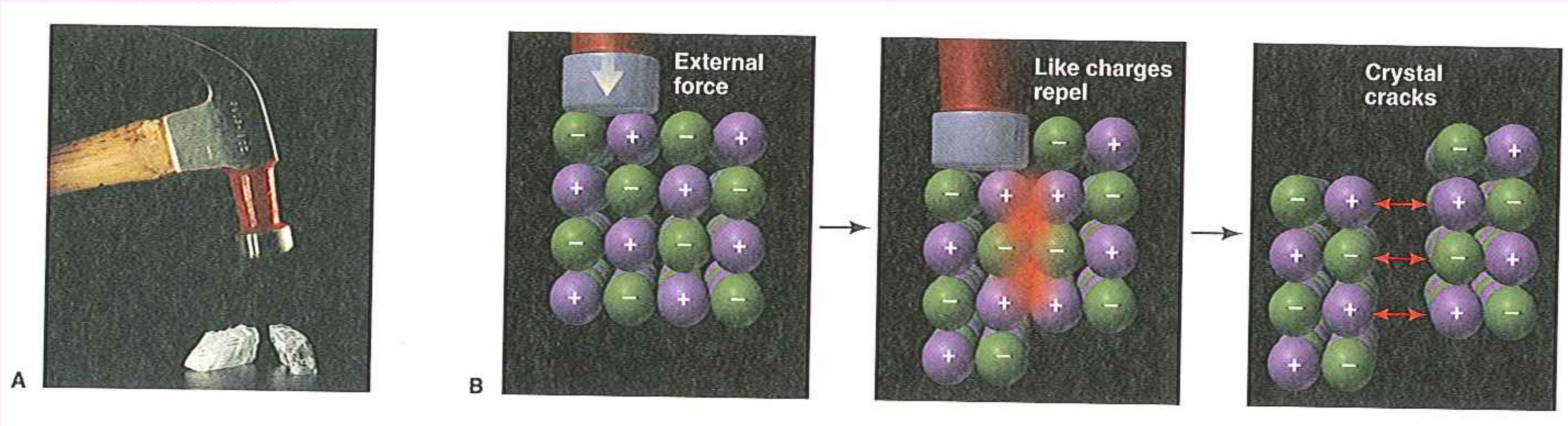
Properties of Metal

- Physical Behavior
  - ✓ malleable, ductile (metal ions slide about in the e−)
- Electrical Conductivity
  - ✓ conducts electricity (loose valence electrons)
- Inter-Particle Forces
  - ✓ not as high MP (loose electrons help cations slide around)
  - ✓ extremely high BP (difficult to completely break the + − attractions)

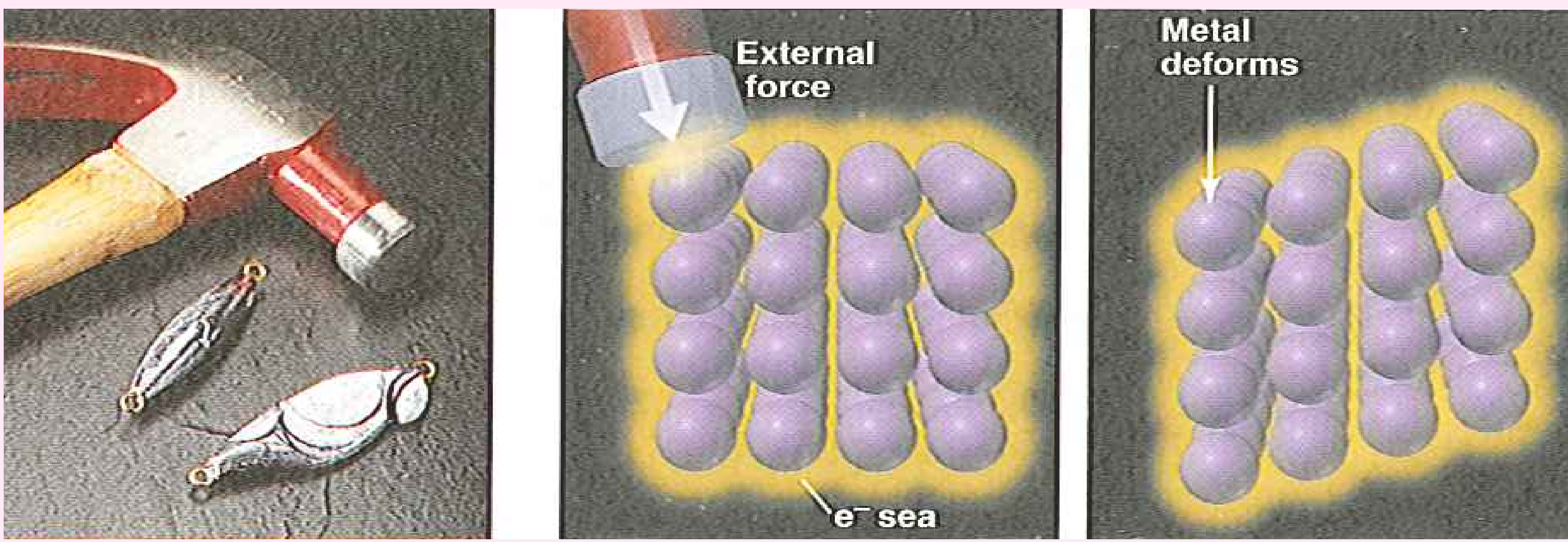
Properties of Ionic Compounds

- Physical Behavior
  - ✓ rigid yet brittle (due to +/- ions)
- Electrical Conductivity
  - ✓ do not conduct solid state, good insulators (no mobile charges)
  - ✓ yes in both molten and dissolved states (ions are mobile)
- Inter-Particle Forces
  - ✓ high melting, and even higher boiling (due to strong +/- interactions)

Ionic Compounds (+ / − lattice) cracks and splits apart upon being hit



in contrast with **Metals**(the sea of loose electrons) allows malleability



What do we need for electricity to flow in solid materials?

- The ability of electrons to move.
  - ✓ metals have mobile electrons
  - ✓ graphite has mobile electrons
- So, moving beyond solids, lets consider the conductivity of liquids and solutions.

So, to recap....

What is a conductor?

- *A substance that has loose electrons that allows electricity to flow.*
- *a non-conductor (aka insulator) does not have lose electrons to carry the electricity*

Ice and liquid water. Which (or both) will conduct electricity? *Mark ALL that apply.*

1. Ice will conduct electricity.
2. Liquid water will conduct electricity.
3. Neither will conduct electricity.

Ice and liquid water. Which (or both) will conduct electricity? *Mark ALL that apply.*

1. Ice will conduct electricity.
2. Liquid water will conduct electricity.
3. Neither will conduct electricity

- Liquid water will conduct ever so slightly....as evidenced by the tiny bulb

Salt, will it conduct electricity? Select ALL that apply.

1. Solid salt will conduct electricity.
2. Melted salt will conduct electricity.
3. Dissolved (in distilled or tap water) salt will conduct electricity.
4. None of them will conduct electricity.

Salt, will it conduct electricity? Mark ALL that apply.

1. Solid salt will conduct electricity.
2. Melted salt will conduct electricity.
3. Dissolved (in water) salt will conduct electricity.
4. None of them will conduct electricity.

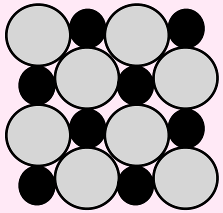
- Why doesn't solid conduct electricity, yet the melted salt and dissolved salt does?

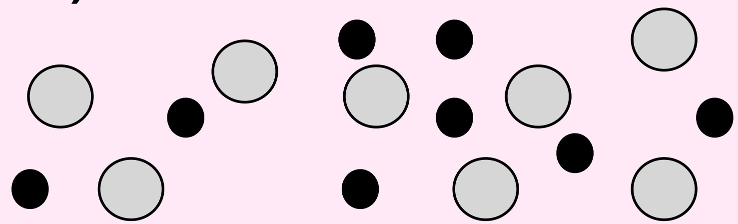
slide show

Why does *melted* salt conduct? Why does *dissolved* salt conduct?

- Melted salt
  - $NaCl \rightarrow$(add heat)$\rightarrow Na^+ + Cl^-$
  - The heat breaks the +/- crystal apart and the ions become free to move and allow for the movement of electrons (electricity).
- Dissolved salt
  - $NaCl \rightarrow$(add water)$\rightarrow Na^+ + Cl^-$
  - The water breaks the +/- crystal apart and the ions become free to move and allow for the movement of electrons (electricity).

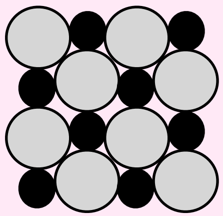
- Melted: NaCl →(add heat)→ Na^+ + Cl^-

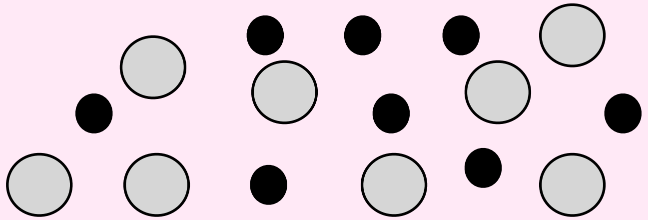




- The heat breaks the +/- crystal apart and the ions become free to move and help with the movement of electrons (electricity).

- Dissolved: NaCl →(add water)→ Na^+ + Cl^-





- The water breaks the +/- crystal apart and the ions become free to move and help with the movement of electrons (electricity).

What do we need for electricity to be able to flow?

- In solids, we needed mobile electrons. (Metals & Graphite)
- In liquids or solutions, we need charged particles that are free to move.
- Electrolytes are compounds that when dissolved in water will produce freely moving ions and thus become a solution that is able to conduct electricity.

Sugar, will it conduct electricity? Mark ALL that apply.

1. Solid sugar will conduct electricity.
2. Melted sugar will conduct electricity.
3. Dissolved sugar will conduct electricity.
4. None of them will conduct electricity.

Sugar, will it conduct electricity? Mark ALL that apply.

1. Solid sugar will conduct electricity.

- Solid sugar (molecular compound) has no loose electrons

2. Melted sugar will conduct electricity.
3. Dissolved sugar will conduct electricity.

- Melted and dissolved sugar does not break up into ions.

4. None of them will conduct electricity.

Will alcohol conduct electricity?

1. Yes
2. No
3. I feel like I can’t even begin to make a prediction.

C_2H_5OH

- Alcohol, like sugar, is a molecular compound, and does not break apart into ions.
- You can tell alcohol is a molecular compound, not ionic, because it is made of all nonmetal atoms no ions.

Will alcohol conduct electricity?

1. Yes
2. No
3. I feel like I can't even begin to make a prediction.

C_2H_5OH

Will salt in alcohol conduct electricity?

1. Yes
2. No
3. I feel like I can't even begin to make a prediction.

C_2H_5OH

Will salt in alcohol conduct electricity?

C_2H_5OH

1. Yes
2. No

- It would conduct if the salt could dissolve and ionize, but salt doesn't dissolve in isopropyl alcohol, since so much of the alcohol is NONpolar, so the salt has no opportunity to ionize.
- *Note: our alcohol was 5% water, and thus a small amount of the salt did dissolve in that water, making the low voltage purple light get brighter.*

3. I feel like I can't even begin to make a prediction.

So we need a model for why some substances conduct and others do not.

Remember that for electricity to conduct, electrons must be able to move.

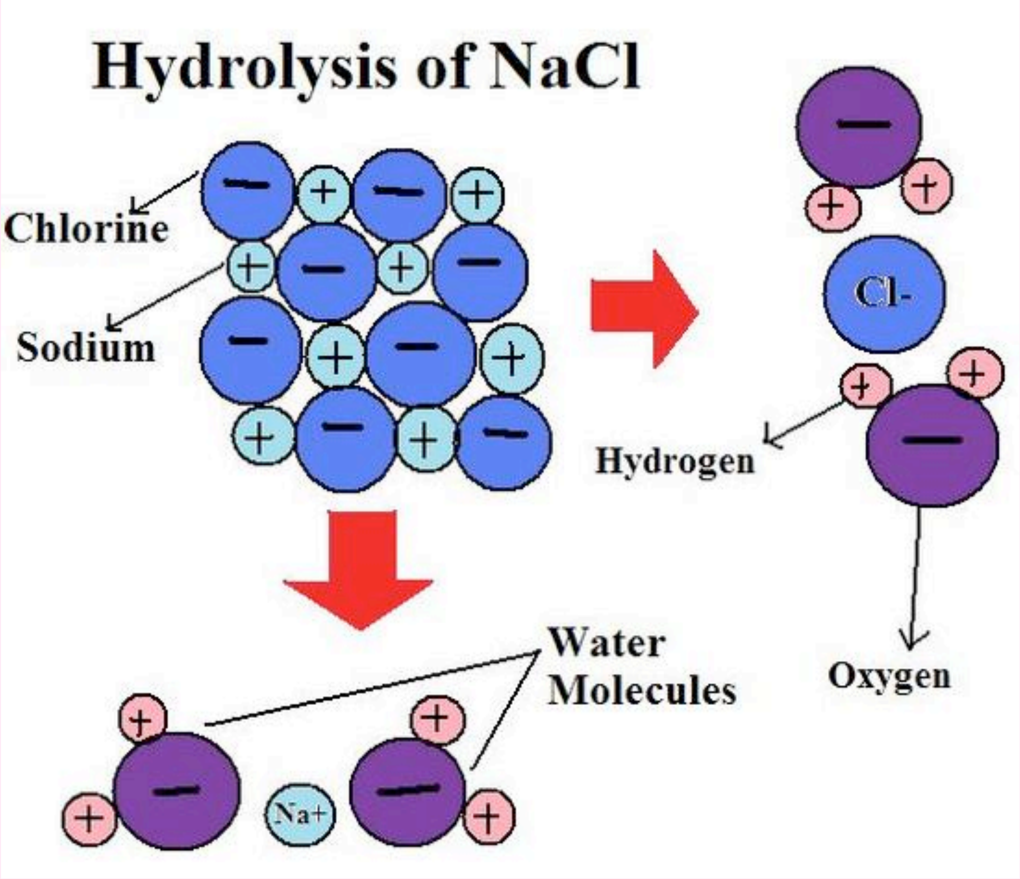
- Ionic compounds can conduct electricity only when they are melted or dissolved, not when they are solid.

- So what is it about being melted or dissolved that lets or helps electrons to move?
  - ✓ Unstuck (mobile) charged ions.

- Molecular compounds such as sugar or alcohol do not conduct electricity as a solid, melted (liquid) or dissolved
  - ✓ Yet in solution sugar molecules are mobile,
  - ✓ But molecular compounds do NOT contain ions. Thus there is no “vehicle” for the electricity (electrons) to ride on.

When ionic compounds dissolve, they dissociate into their charged particles that are able to carry electricity Charged particles in solution = electrolyte.

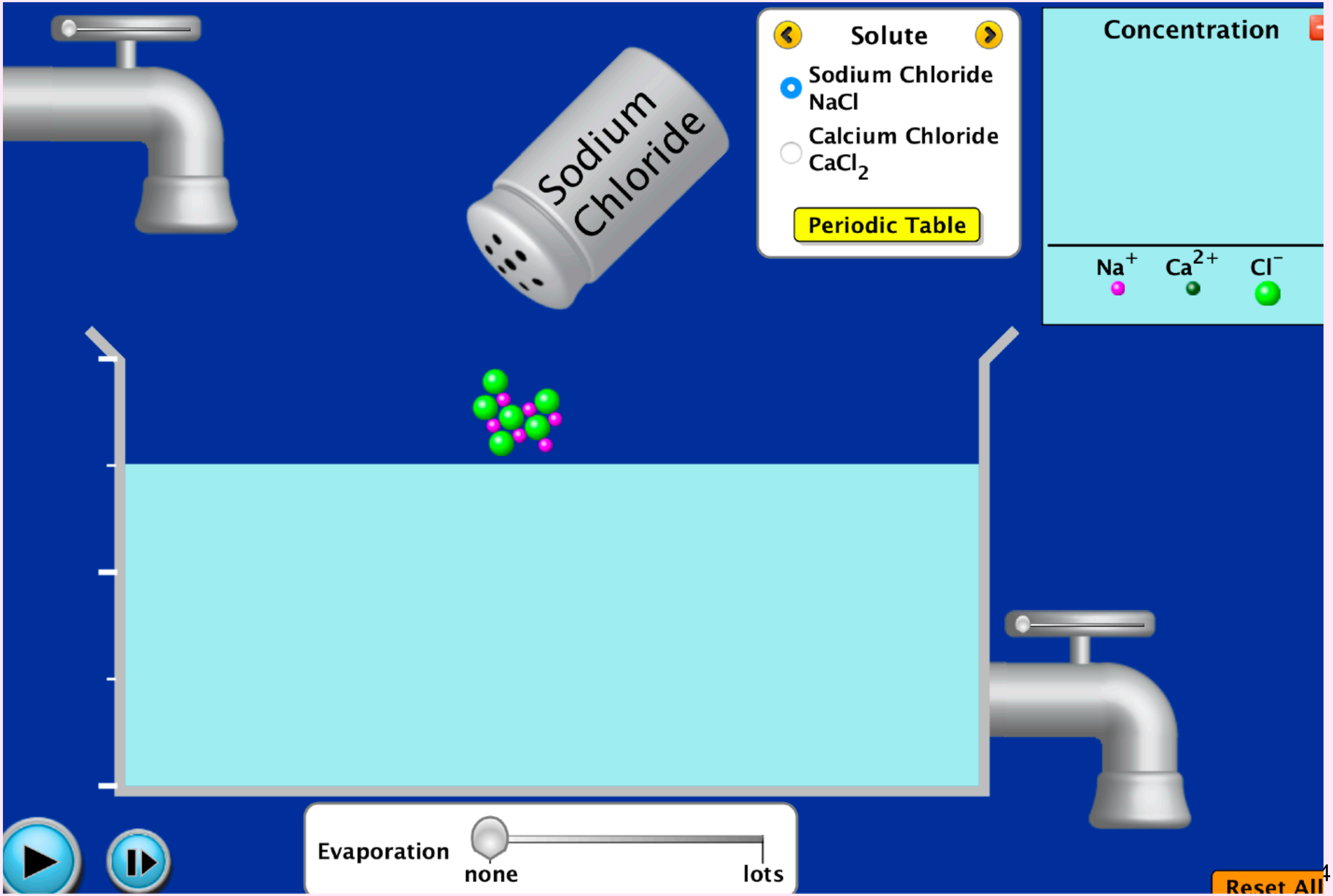
- Generic Reaction for the dissolving of any ionic compound:
  - ✓ $AX_{(s)} \rightarrow A^+ + X^-$



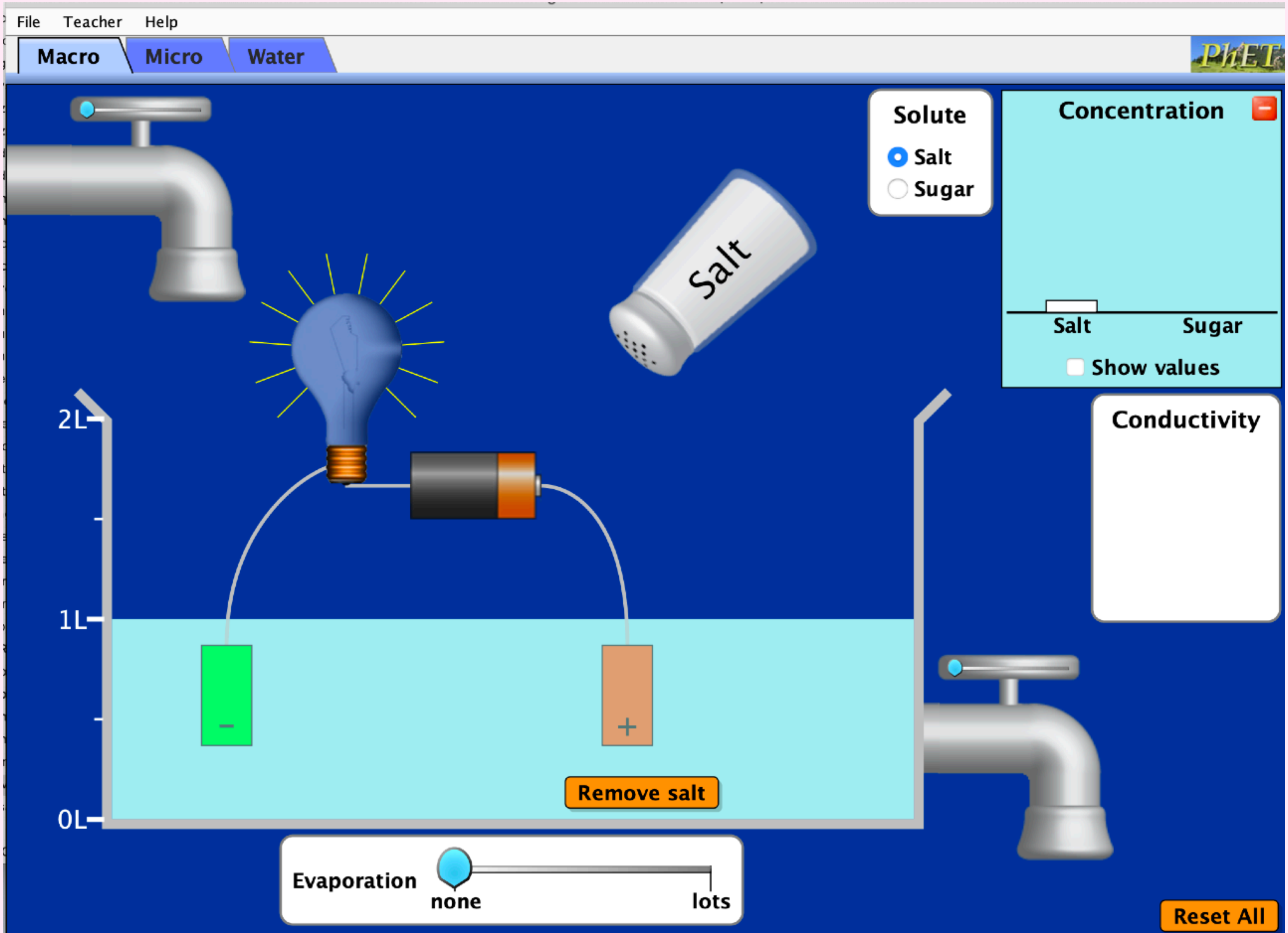
The break up of the salt and subsequent surrounding of ions by water molecules is called hydrolysis.

Notice how the polar water molecules arrange differently around the + compared to the − ions.

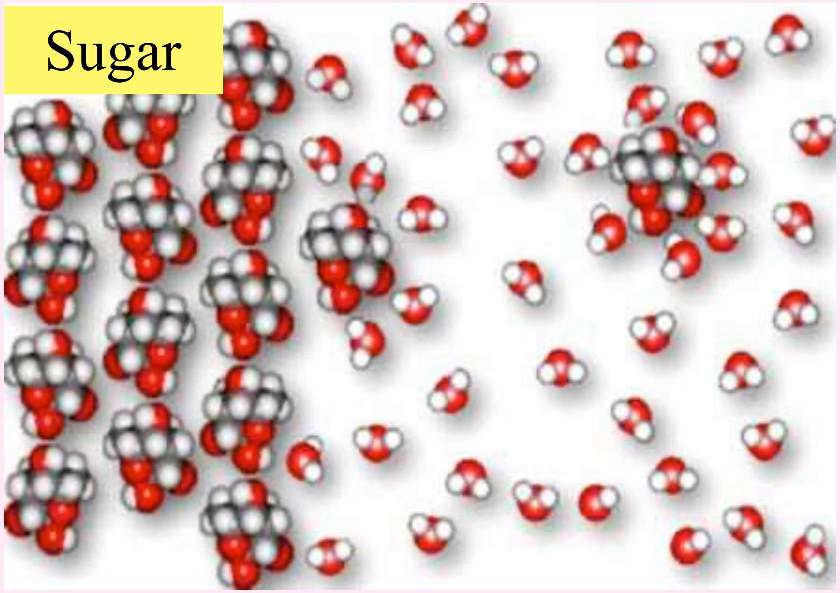
Let's have a look at the PhET simulation: **Sugar & Salt**
This simulation is linked on unit G videos



Let's have a look at the PhET simulation: **Conductivity**
This simulation is linked on unit G videos

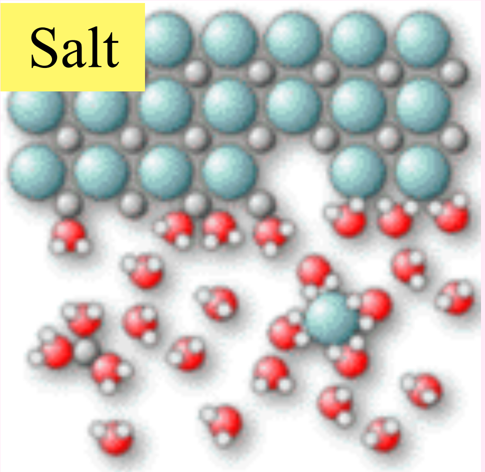


When sugar dissolves in water, the molecules do NOT dissociate into ions and can NOT carry electricity = Non-electrolyte.



We represent this in an equation as:

$$C_6H_{12}O_{6(s)} \xrightarrow{H_2O} C_6H_{12}O_{6(aq)}$$

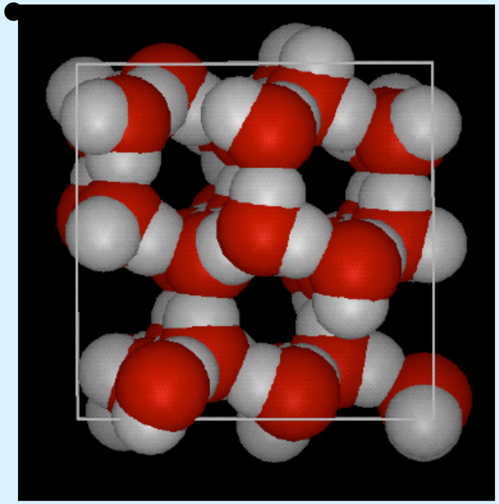


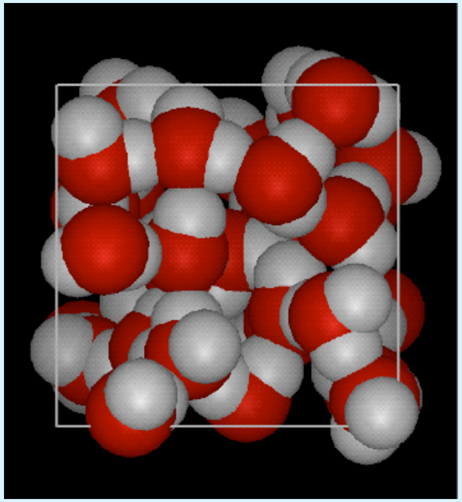
We represent this in an equation as:

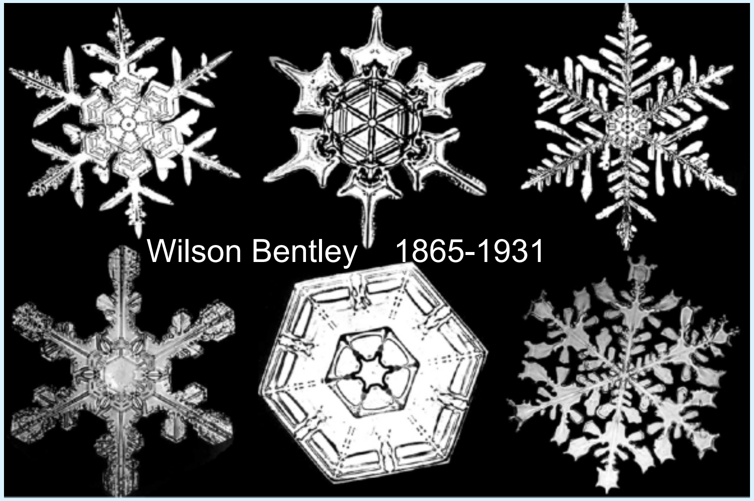
$$NaCl_{(s)} \xrightarrow{H_2O} Na^+ + Cl^-$$

Density of Ice

- Break out the water molecule kits to understand the low density of ice
  - »observe the hexagonal crystals below left
  - »observe the six-sided snow flakes below right
-







Will acids conduct electricity?

hydrochloric acid HCl

acetic acid (vinegar) $HC_2H_3O_2$

1. Yes, vinegar will conduct
2. Yes, hydrochloric acid will conduct
3. Both acids will conduct
4. Neither will conduct (because they are molecular compounds)
5. I can't even begin to make a prediction.

Will acids conduct electricity?
Both acids are the same concentration.
hydrochloric acid HCl
acetic acid (vinegar) $HC_2H_3O_2$

1. Yes, vinegar will conduct
2. Yes, hydrochloric acid will conduct
   - though we notice the HCl conducts better.
3. Neither will conduct (because they are molecular compounds)
4. I can’t even begin to make a prediction.

Acids

- Molecular compounds made of H & (−ion)
  - ✓ HCl, $HC_2H_3O_2$, H_2SO_4, $HClO_3$, HBr, HNO_2, etc
- Molecular compounds that "straddle the line." The "line" that differentiates ionic from molecular.
- An acid molecule is a covalently bonded compound, that when dissolved in water, dissociates (completely or partly) into ions.
- However, the degree to which acids ionize when placed in water, varies from acid to acid.
  - ✓ We call this ability to dissociate, the *strength* or *weakness* of the acid.

strong vs weak

Strength of an electrolyte (and acid) refers to the degree to which the substance ionizes once it dissolves in the water.

- After dissolving, strong electrolytes ionize completely
- After dissolving weak electrolytes only partially ionize, much of the substance remains as molecules.
- All ionic compounds that dissolve *(not all of them dissolve)*, always completely ionize and are all strong electrolytes.
- Molecular compounds such as sugar and alcohol do NOT ionize at all, and are therefore all non-electrolytes.
- Acids “straddle the line,” they are molecular compounds that do ionize in water and are therefore electrolytes.
  - ✓ Strong acids completely ionize and are strong electrolytes.
  - ✓ Weak acids, though most dissolve completely, only partially ionize (dissociate) and are weak electrolytes.

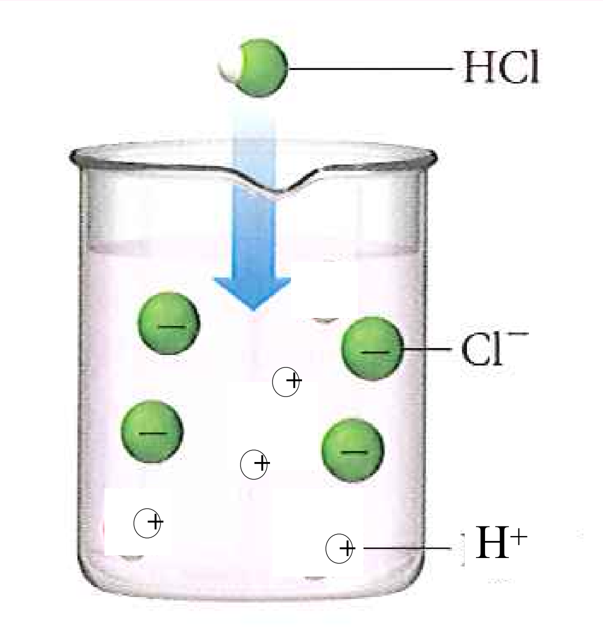
Strength describes the amount dissociated (ionized).

concentrated vs dilute

describes the amount dissolved.

- Concentration refers to the quantity of solute that is dissolved in the solvent.
  - ✓ in other words, how much solute (“stuff”) did you put in the water….
  - ✓ concentrated = lots of solute (“stuff”)
  - ✓ dilute = little bit of solute (“stuff”)

Particle View: strong vs weak

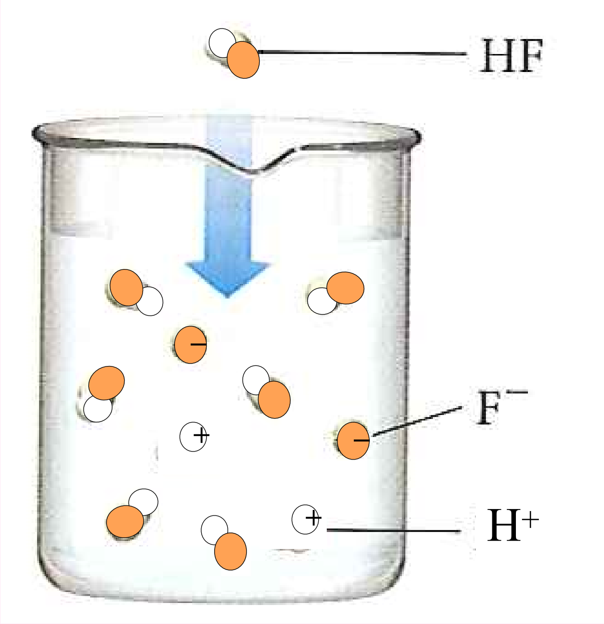


HCl is a strong acid. Plenty of HCl molecules dissolve, and virtually all of them ionize into H^+ and Cl^-

We represent this in an equation as:

$$HCl_{(aq)} \rightarrow H^+ + Cl^-$$

Both acids will be able to neutralize a base equally well.



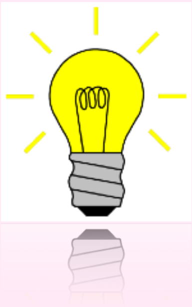
HF is a weak acid. While plenty of HF molecules dissolve, only a fraction of them ionize into H^+ and F^-

We represent this in an equation as:

$$HF_{(aq)} \leftrightharpoons H^+ + F^-$$

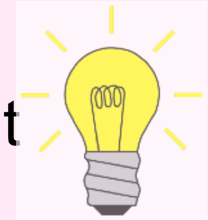
or this $HF_{(aq)} \leftrightharpoons {\scriptstyle H^+ + F^-}$

concentrated vs dilute
and strong vs weak



- You can have a concentrated strong acid
  - ✓ good at conducting electricity

- You can have a dilute strong acid
  - ✓ not as good at conducting electricity



- You can have a concentrated weak acid
  - ✓ not so good at conducting electricity (although might be better than a really dilute strong acid)

- You can have a dilute weak acid
  - ✓ very poor conducting solution, but better than a molecular compound such as pure water or alcohol.

So, to recap....

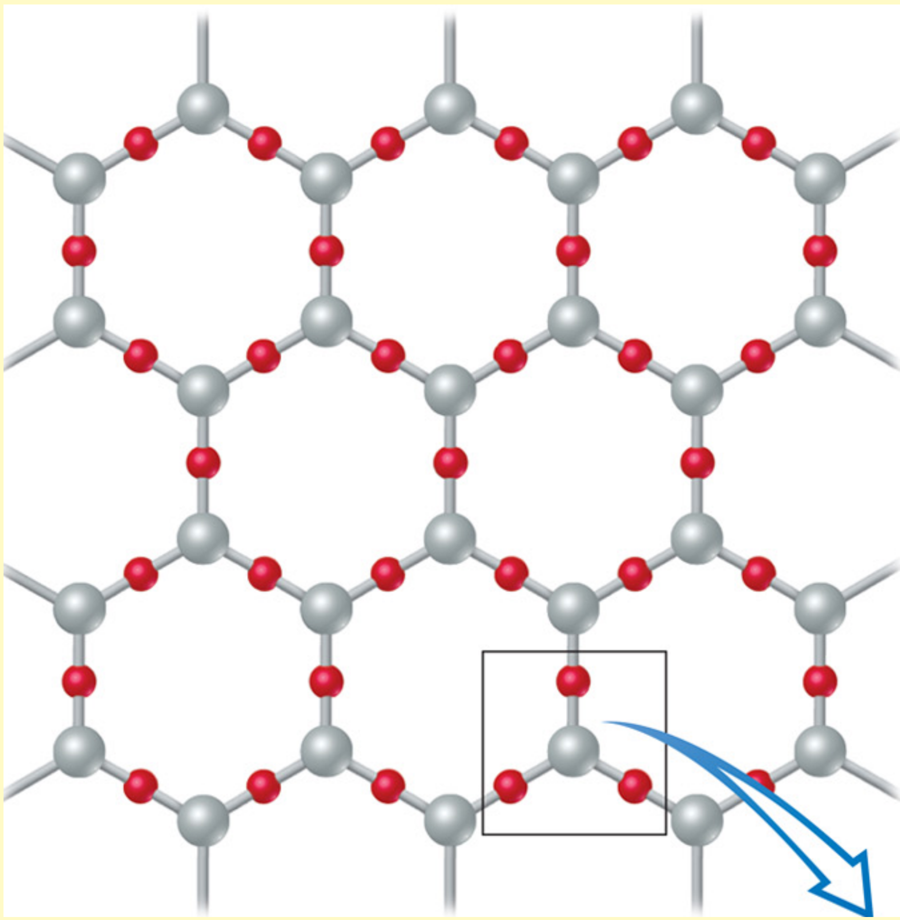
What is an electrolyte?

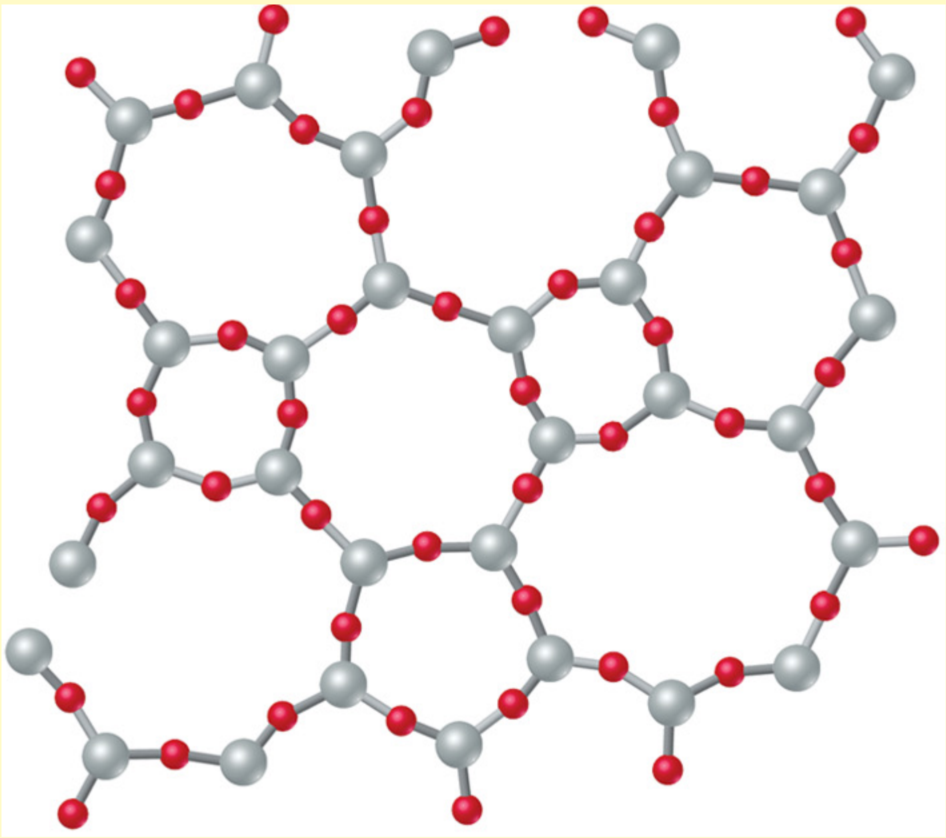
- *A chemical that when dissolved in water will produce a solution that conducts electricity.*

SiO_2 Network Covalent Solid

Network Solid
quartz

Amorphous Solid
glass





Review

Nomenclature

slide show

On your LARGE whiteboard with only the help of your desk mate, Compare and contrast ionic and molecular compounds

Ionic Compounds	Molecular Compounds

Ionic Compounds	Molecular Compounds

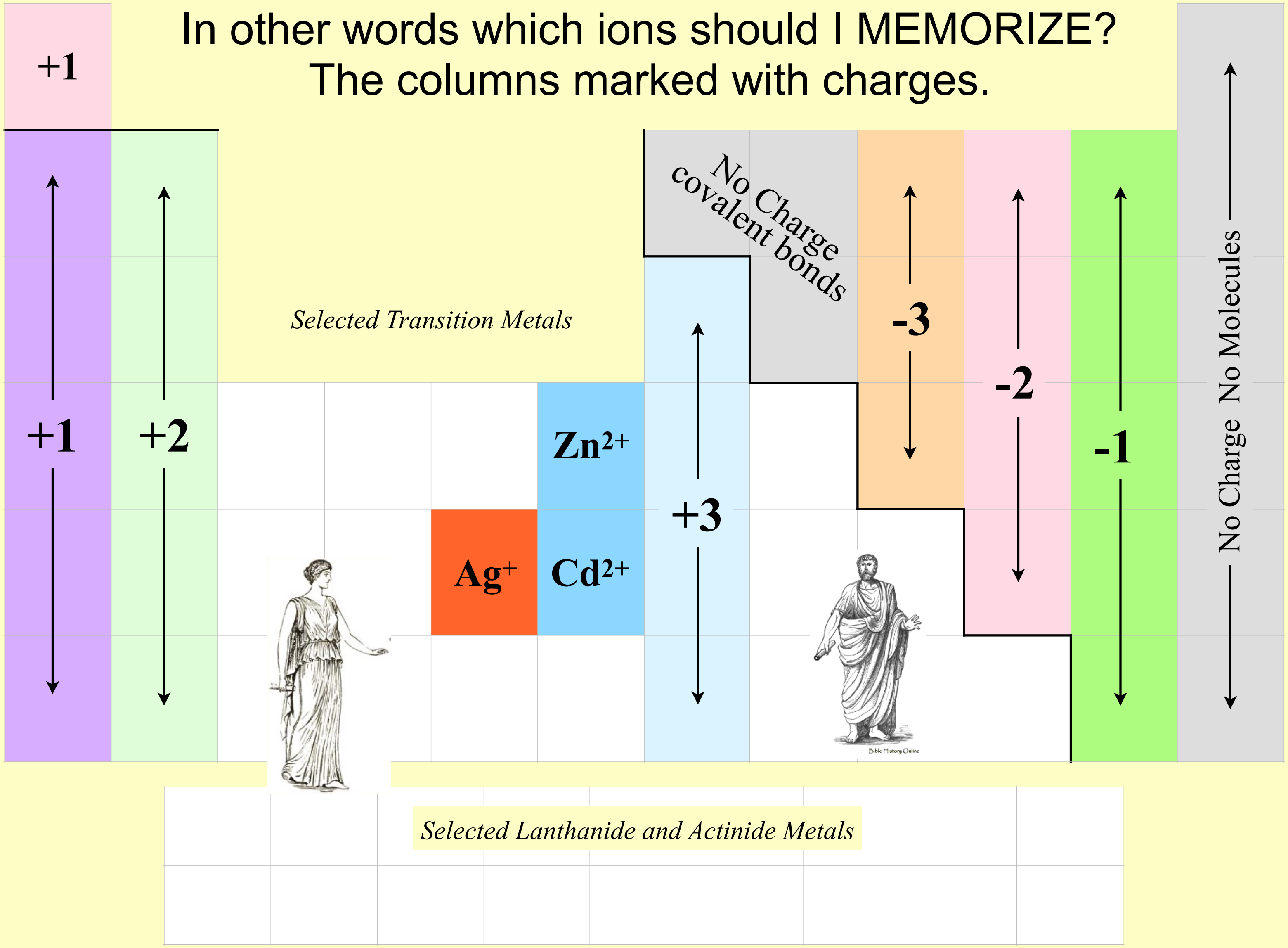
ionic compounds are electrolytes
if they are soluble

Ionic vs Molecular

Metal + Nonmetal	Nonmetal + Nonmetal
Particles called formula units	Particles called molecules
“ionicules” Electrons transferred	Electrons are shared
Metals lose e– and become a + ion (cation)	No ions are formed
-ide, -ate, -ite Nonmetal gain e– and become a – ion (anion)	No ions are formed
Formula is always written in lowest whole number ratio	Formula may not always be in lowest whole number ratio
Some metals require roman # to indicate charge	No Roman Numerals
No prefixes unless part of the polyatomic name	Prefixes are used to indicate the number of atoms in formula

Which ion charges do I need to know?

In other words which ions should I MEMORIZE?
The columns marked with charges.



Every element in white requires a Roman #

Binary Molecular Compounds

- Prefixes (they should be memorized) used to indicate the number of atoms of each element.
  - ✓mono, di, tri, tetra, penta, hexa, hepta, octo, nono, deca, (11?), dodeca
- Element further to the left on the periodic table usually listed first
- Second element listed ends in -ide
- For most compounds with more than two elements we will use their common names, not the IUPAC naming system except for some simple organic compounds

Ionic Compounds

- Cation (+) ion (usually metals) listed first
  - ✓metals retain the same name
  - ✓Ammonium: the + polyatomic ion
- Anion (−) ion listed second
  - ✓Nonmetal (some polyatomic contain metals)
- Binary compounds (only two different elements) end in -ide
- Polyatomic compounds end in −ite or −ate
  - ✓A few exceptions end in −ide
- Certain metals require Roman # to indicate their charge.

Descriptive Symbols

- Put these symbols on your whiteboard and then indicate what information the symbol is telling you.

Fe

F_2

2Fe

F^-

$_9F$

21F

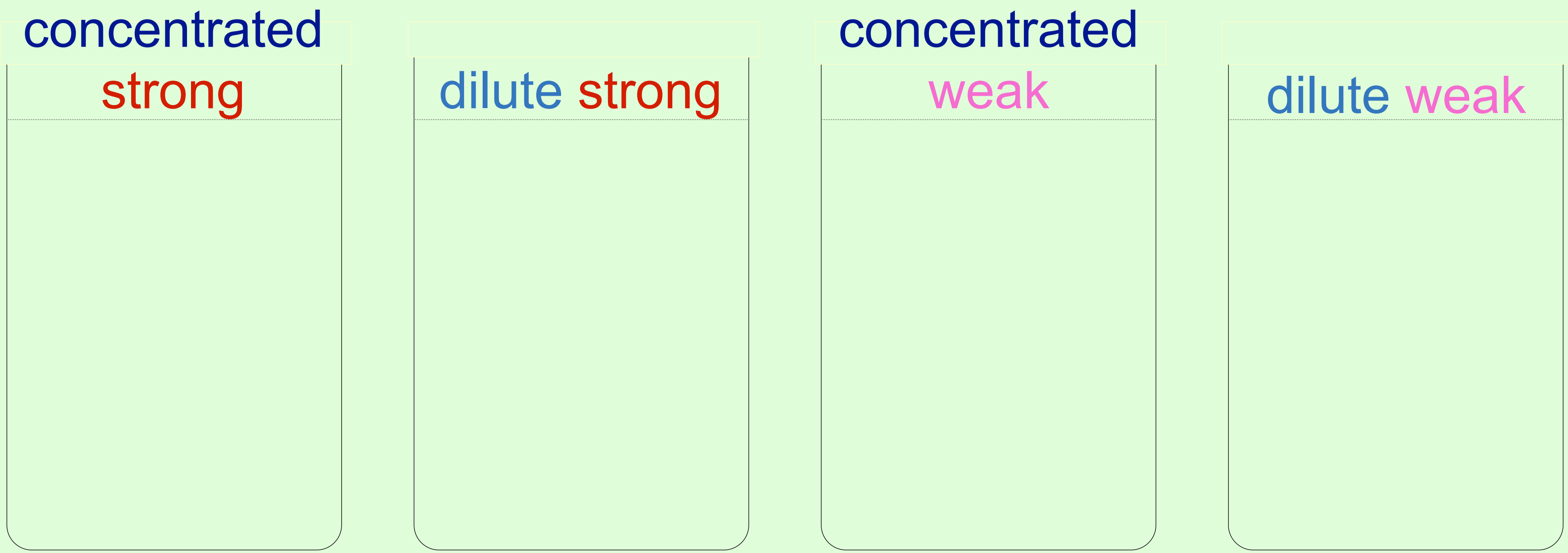
fluorine-21

Descriptive Symbolism

- Single atom Fe
- Two atoms stuck together, diatomic molecule F_2
- Two atoms not stuck together $2Fe$
- A single ion with a 1- charge, having gained 1e- F^-
- An atom showing its atomic number $_9F$
- A nuclide, a particular isotope showing its mass number ^{21}F
- An isotope showing its mass number Fluorine-21

Acids

- HF is a weak acid
- HCl is a strong acid
- Use between 2 to 5 “acid units” HF and HCl in the beakers to describe the following acid solutions.



Acids

- HF is a weak acid
- HCl is a strong acid
- Use between 2 to 5 “acid units, HF and HCl” in the beakers to describe the following acid solutions.

March Madness

Nomenclature

slide show

March Madness !

Which formula contains the most number of “atoms?”

$Mn(SO_4)_2$ $Cr(ClO)_3$

11 “atoms” 7 atoms

March Madness !

Which formula contains the greatest number of ions?

$Mn(SO_4)_2$

3 ions

$Cr(ClO)_3$

4 ions

March Madness !

Which formula has the highest total charge on the anions?

$Mn(SO_4)_2$

$Cr(ClO)_3$

- 4

- 3

March Madness !

Which formula has the largest molar mass?

$Mn(SO_4)_2$

55+2(32)+8(16)

= 247

$Cr(ClO)_3$

52+3(35.5)+3(16)

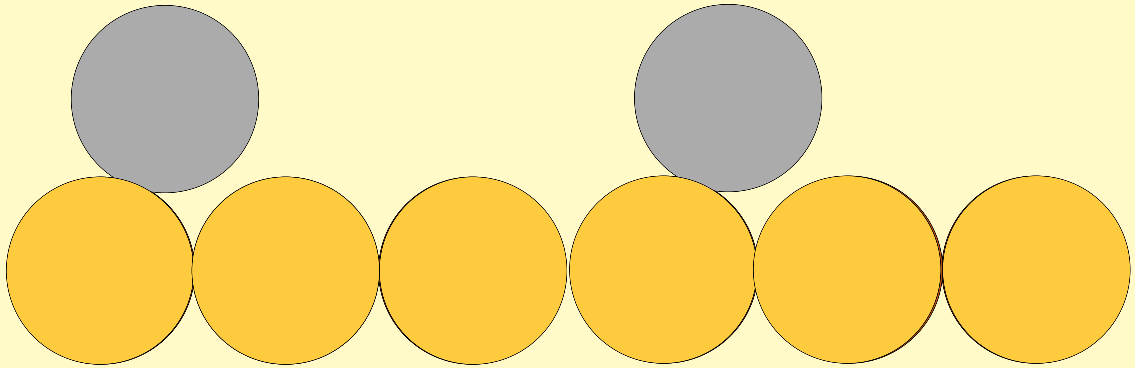
= 206.5

Alloys

Mixtures of
metal atoms

slide show

The Making of a Brass Alloy



- copper colored penny surface
- zinc coated on copper by soaking in solution on the zinc plate (We see silver color.)
- penny heated, atoms vibrate, shift, and move creating a mixture on the surface
- mixture on surface *appears* gold colored