METALLOIDS / SEMICONDUCTORS

- in between metals and nonmetals on the table
- most periodic tables have a zig-zagging line where the metalloids are
- properties tend to be "between" metals and nonmetals, too!
- some have chemical reactivity like a nonmetal, but conduct electricity better than nonmetals
- some have unusual electrical properties (silicon / germanium diodes) , and are useful in electronics

Types of elements on the periodic table

This red line appears in some way on most periodic tables. It's the dividing line between metals and nonmetals You can find the metalloids here!

IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	~~La~~ *	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	~~Ac~~ *	Rf	Db	Sg	Bh	Hs	Mt									

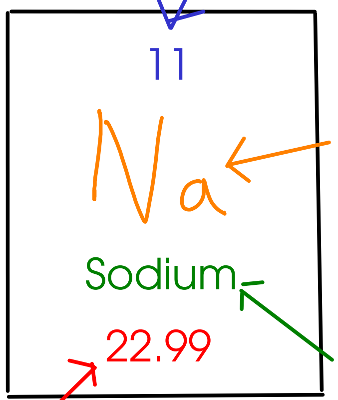
*"inner" transition metals go here

METALS shown in BLACK

NONMETALS shown in BLUE

METALLOIDS shown in PURPLE

Blocks on the periodic table

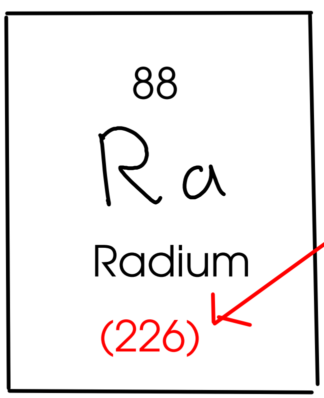


Atomic number: This is always a whole number. The periodic table is arranged by atomic number!

Element symbol: A one or two letter abbreviation for the name of the element. Sometimes, the abbreviation is based on a language OTHER THAN ENGLISH! (Example: Na is short for "natrium", the Latin name of sodium.)

Element name: Sometimes, this is left off of periodic tables, expecially small ones!

Atomic weight: This is a decimal number, but for radioactive elements it is replaced with a number in parenthesis.



For RADIOACTIVE ELEMENTS - elements where the atomic nucleus breaks down, causing the atom to break apart - the MASS NUMBER of the most stable ISOTOPE is given in (parenthesis) instead of the atomic number!

CHEMICAL COMPOUNDS

- Dalton's theory does not mention this, but there is more than one way for atoms to come together to make chemical compounds!

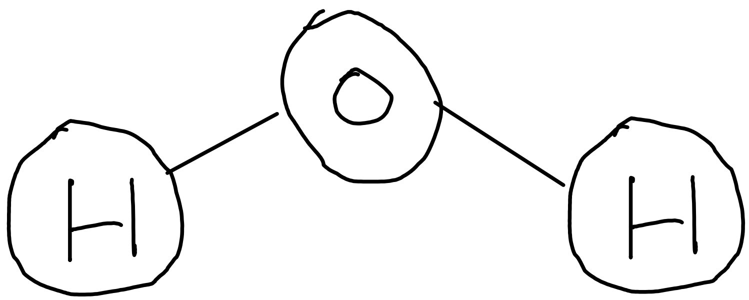
- There are TWO common kinds of chemical compound, classified based on how the atoms in the compound are held together:

(1) MOLECULAR COMPOUNDS

(2) IONIC COMPOUNDS

MOLECULAR COMPOUNDS

- form when atoms SHARE outer electrons with each other. This results in a set of connected atoms called a MOLECULE



Stick figure of a water (H_2O) molecule

- usually form between nonmetals and other nonmetals or between nonmetals and metalloids

Examples:

H_2O	CO_2	CCl_4
CO	N_2O_5	PCl_5

CANDLE WAX is made up of molecular compounds

- some solid at room temperature. These solids tend to have low melting points.

PCl_5 is a solid, mp = 180 °C

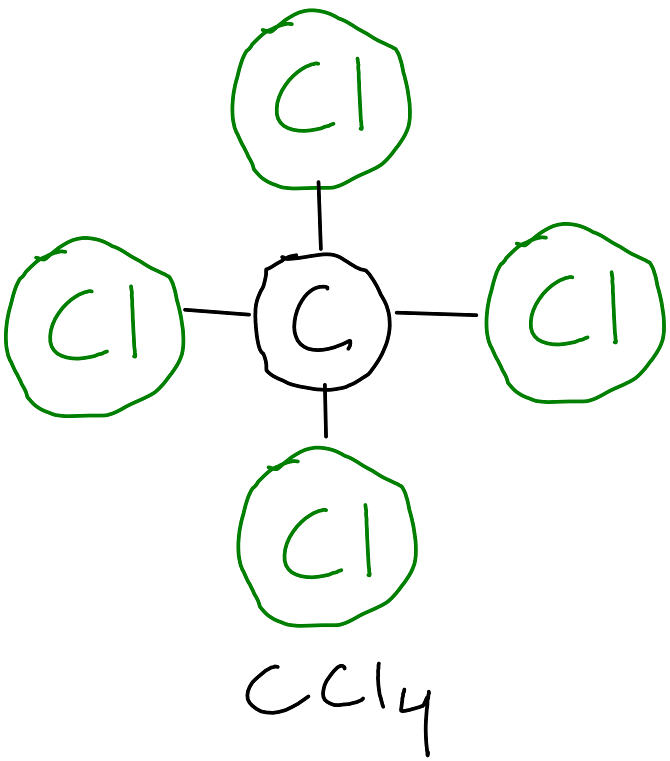
- many are liquids or gases at room temperature

H_2O, CCl_4 : liquids CO, CO_2, N_2O_5 : gases

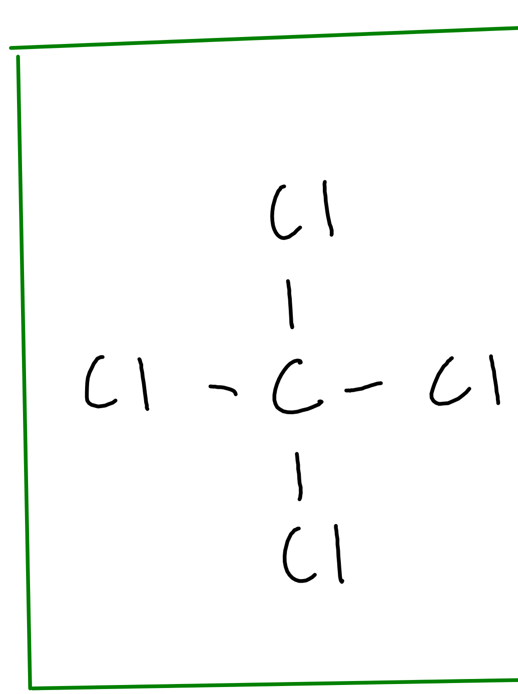
MOLECULAR FORMULAS

- formula of a molecular compound represents the EXACT NUMBER OF ATOMS OF EACH ELEMENT in a single molecule of the compound

Example: Each molecule of CCl_4 contains exactly one carbon atom and four chlorine atoms



"ball and stick" model



Structural formula: shows how atoms are connected in a molecule

IONIC COMPOUNDS

- formed when atoms TRANSFER ELECTRONS between each other forming charged atoms, called IONS.

Two kinds of ions:

cation

1. CATIONS: formed when an atom LOSES one or more electrons.

   - overall, a cation has a POSITIVE charge, because it has more protons in the nucleus than electrons in the electron cloud

   - usually formed by METALS, but occasionally hydrogen will also form a cation

2. ANIONS: formed when an atom GAINS one or more electrons

   - overall, an anion has a NEGATIVE charge, because it has more electrons in the electron cloud than protons in the nucleus

   - usually formed by NONMETALS

IONIC COMPOUNDS

- USUALLY form from metals combining with nonmetals, or from metals combining with metalloids

Examples: $NaCl$ $MgCl_2$ $NaOH$

$Ca(OH)_2$ Na_2CO_3

Fe_2O_3 FeO

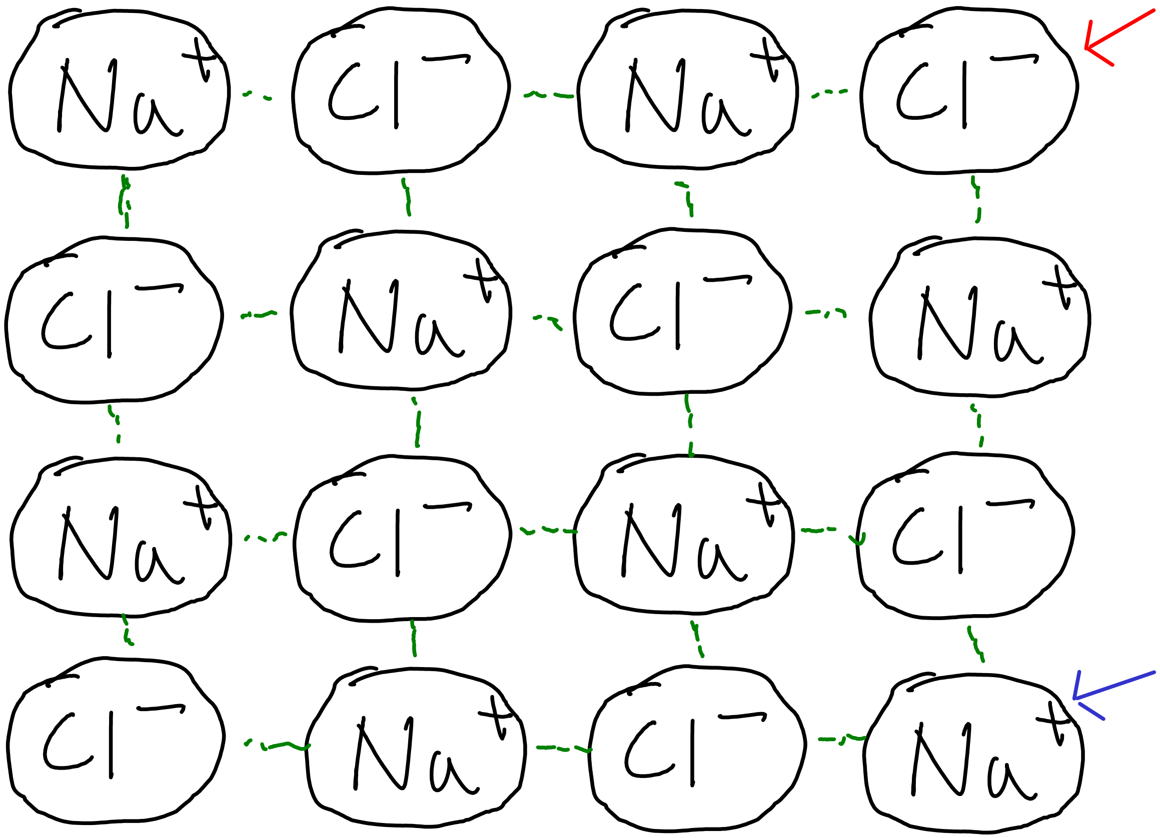
- almost always solid at room temperature, and usually have relatively high melting points

All of the above are solids at room temperature. NaCl has a melting point of 801°C.

- as solids, do not conduct electricity. If dissolved in water (some do not dissolve significantly in water), will form a solution that conducts electricity.

IONIC COMPOUNDS

- ionic compounds are held together by ELECTROSTATIC INTERACTIONS
  (in other words, the attraction between oppositely charged ions!)



Each chloride ion is strongly attracted to ALL of the sodium ions surrounding it!

Each sodium ion is strongly attracted to ALL of the chlorine atoms surrounding it!

There are no "molecules" in ionic compounds - in the sense that you can't point to a discrete unit of atoms that are connected to only each other

IONIC FORMULAS

- since there are no "molecules", an ionic formula cannot describe how many and what kinds of atoms are in a molecule!

- all ionic compounds are observed to be (overall) electrically neutral, so the IONS they contain must be present in such a way that the charges BALANCE EACH OTHER

  - an ionic formula gives the SMALLEST WHOLE NUMBER RATIO OF CATION TO ANION in the ionic compound

Na^{+} Cl^{-} make $NaCl$ (1:1 ratio)

Ca^{2+} Cl^{-} make $CaCl_2$ (1:2 ratio)

Na^{+} N^{3-} make Na_3N (3:1 ratio)

Fe^{3+} O^{2-} make Fe_2O_3 (2:3 ratio)

WRITING AN IONIC FORMULA

- if you know the ions that make up a compound, all you need to do is find the smallest ratio of cation to anion the compound needs to have an overall charge of zero

Example:

Mg^{2+} , P^{3-} ... what is formula?

Mg^{2+} ← more − than +, so add more Mg^{2+}

P^{3-} ← more + than −, so add P^{3-}

Mg^{2+} ← more − than +, so add Mg^{2+}

Mg_3P_2

In the final formula, don't write the charges on the ions!

* Remember, ionic compounds are written with the SMALLEST whole-number ratio!

Ionic formulas are ALWAYS written with the cation first, and the anion second!

Cross method: Mg^{2+} P^{3-} : Mg_3P_2

More examples:

Ca^{2+} F^-

Ca^{2+} F^-
F^-

CaF_2

Ti^{4+} O^{2-}

~~Ti_2O_4~~ → TiO_2

Ti^{4+} O^{2-}
O^{2-}

TiO_2

K^+ N^{3-}

K^+ N^{3-}
K^+
K^+

K_3N

You can also use the "cross method", as described in your textbook, to write formulas. Use caution, as the "cross method" will sometimes give you the wrong formula! It would give you the wrong answer for this one!

PREDICTING CHARGES

- how do you figure out the charge that an element might take when it becomes an ion?

- for many main group elements, you cah predict the charge using the periodic table!

IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB	VIIIB	VIIIB	IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	* ~~La~~	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	* ~~Ac~~	Rf	Db	Sg	Bh	Hs	Mt									

*"inner" transition metals go here

Elements in group VIIIA - the "noble gases" - do not form ions!

Many OTHER main-group elements form either anions or cations that have the same overall number of electrons as the NEAREST (in terms of atomic number) noble gas!

PREDICTING CHARGE

IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB	VIIIB	VIIIB	IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
H																	He
Li	Be											B	C	N	O	F	10 Ne
Na	Mg											Al	Si	P	S	Cl	18 Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	36 Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	54 Xe
Cs	Ba	La*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac*	Rf	Db	Sg	Bh	Hs	Mt									

You can reliably determine the charge using our method for Groups IA, IIA, IIIB, Aluminum, and the Group VA, VIA, and VIIA NONMETALS

*"inner" transition metals go here

Aluminum (Al): At atomic number 13, it is three electrons away from neon (Ne), and 5 electrons away from argon (Ar). Prediction: Aluminum will lose three electrons to form the cation Al^{3+}

Bromine (Br): At atomic number 35, bromine is one electron away from krypton (Kr). Prediction: Bromine will gain one electron to form the anion Br^{-}

Strontium (Sr): At atomic number 38, strontium is two electrons away from krypton. Prediction: Strontium will lose two electrons to form the cation Sr^{2+}

EXAMPLES

IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB	VIIIB	VIIIB	IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	*La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	*Ac	Rf	Db	Sg	Bh	Hs	Mt									

*"inner" transition metals go here

Find the formulas of:

(1) an ionic compound containing Al and Br

(2) an ionic compound containing Mg and O

(3) an ionic compound containing S and K

Al^{3+} Br^{-}

Mg^{2+} O^{2-}

S^{2-} K^{+}

Find the formula of:

* an ionic compound containing Al and Br

Al^{3+} Br^{-}

Al^{3+} Br^{-} Br^{-} Br^{-}

$AlBr_3$

Find the formula of:

* an ionic compound containing Mg and O

Mg^{2+} O^{2-}

MgO

Find the formula of:

* an ionic compound containing S and K

S^{2-} K^{+}

S^{2-} K^{+} K^{+}

K_2S *

* Remember: Write the cation first in an ionic formula

~~SK_2~~

TRANSITION METAL IONS

IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB	VIIIB	VIIIB	IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac*	Rf	Db	Sg	Bh	Hs	Mt									

*"inner" transition metals go here

The transition metals always form CATIONS!

However, many transition metals are capable of forming SEVERAL DIFFERENT CATIONS!

Example: Iron (Fe) forms two cations, depending on the situation: Fe^{2+} or Fe^{3+}

TRANSITION METAL CATIONS

- So how do you know which cation you're dealing with? For now, you'll have to be told

- Either the chemical formula of an ionic compound or the name of an ionic compound can tell you what charge is on the transition metal cation.

Examples:

Fe_3N_2

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

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

Fe^{2+}

$+6$ -6

* We call this form of iron ion "iron(II)"

FeN

Fe^{3+} N^{3-}

$+3$ -3

* We call this form of iron ion "iron(III)"