Chemistry 1010

Salts

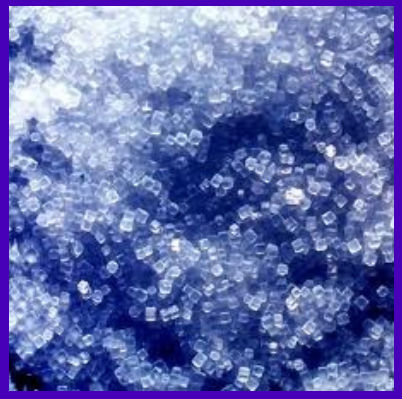
Introduction

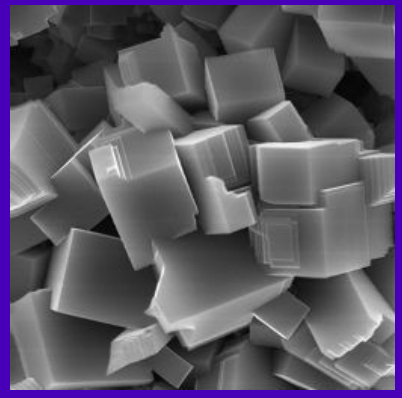
Look at the samples in the two bottles you were given. What observations can you make about them?

both are white
both are solids
both are made of crystals

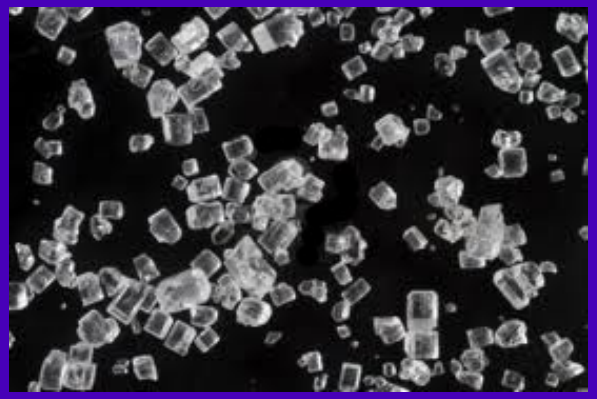
If you could look at them more closely, here's what you would see. Now what observations can you make?

A





B



Both of these substances are safe to ingest.

After tasting them, can you identify them?

A = table salt

B = table sugar

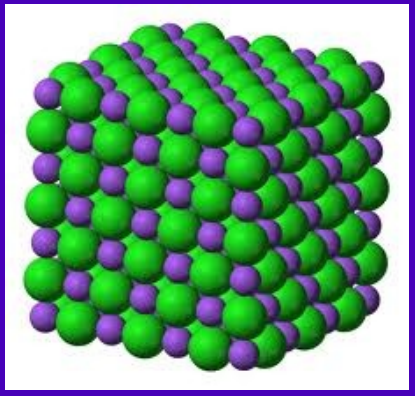
Now that you know what they are, can you think of any other ways in which they are similar?

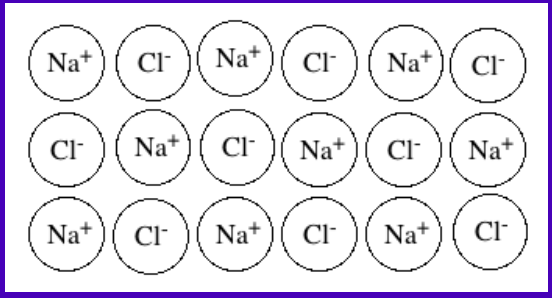
both are tastes the tongue can recognize
both dissolve in water
both can be used to preserve food
both are compounds

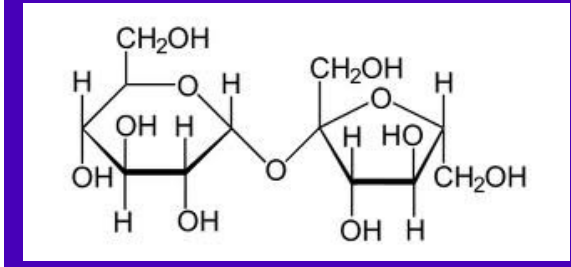
What ways are they different?

	salt	sugar
taste:	salty	sweet
melting point:	801^{o}C	186^{o}C (decomposes)
source:	from the earth salt water or rock deposits	from plants sugar cane or sugar beets

	salt	sugar
chemical name:	sodium chloride	sucrose
formula:	NaCl	$C_{11}H_{22}O_{11}$
type of elements:	metal, nonmetal	all nonmetals
type of compound:	ionic	covalent
molecules or ions:	ions	molecules







how atoms are held together:	attraction of positive and negative ions	sharing of electrons

A bit of review

Since ionic compounds are made of ions, we need to review what we know about ions and chemical bonds.

What is an ion? an atom (or groups of atoms) with a charge

Where does the charge come from? protons (+) electrons (-)

Fill in the following table:

protons	electrons	charge	symbol
8	8	0	O
8	10	-2	O^{-2}
12	12	0	Mg
12	10	+2	Mg^{+2}

What are positive ions called? cations

What are negative ions called? anions

How are electrons organized?

in energy levels

What electrons are involved in forming chemical bonds?

the valence electrons – in the outer level

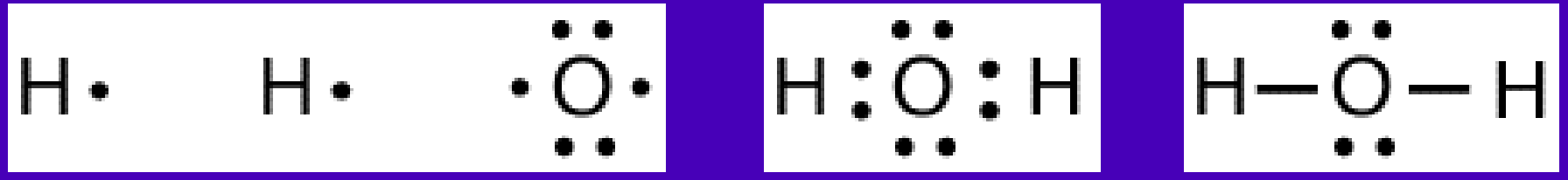
Why do atoms form chemical bonds?

to get 8 valence electrons

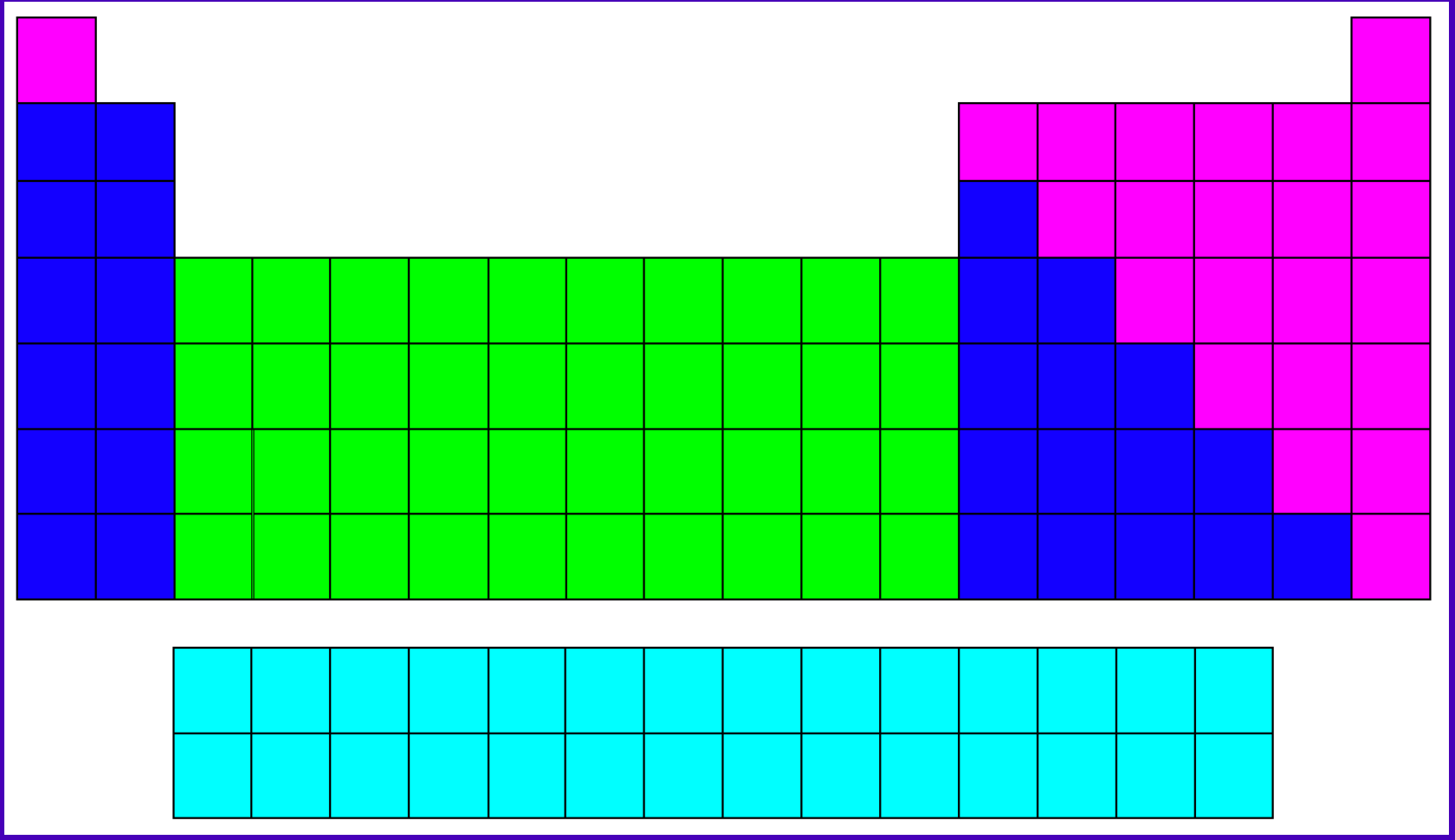
How do nonmetal atoms join to make this happen?

share electrons, form covalent bonds

example: water (H_2O)



Where are the nonmetal atoms? The main group metals? The transition metals?

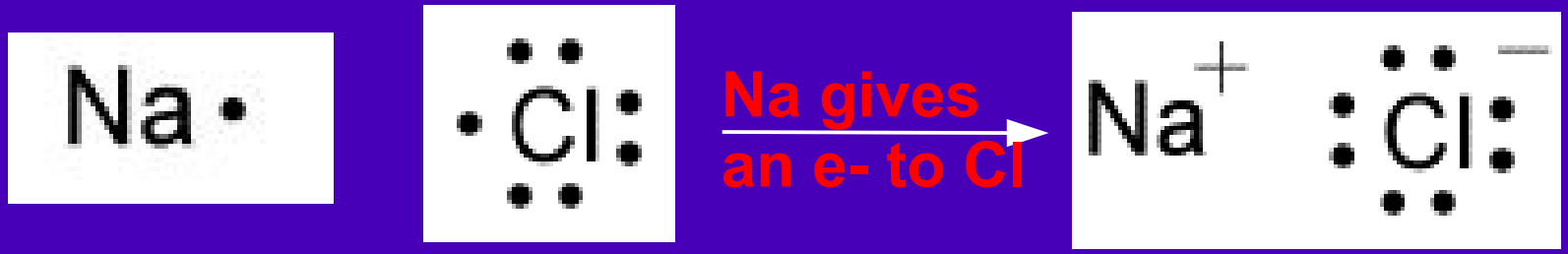


Bonding in NaCl

Can a sodium and a chlorine atom fill the octet by sharing electrons? Why or why not?

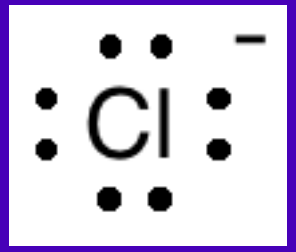
chlorine fills the octet rule but sodium doesn't!

Instead of sharing their electrons, atoms that form ionic compounds transfer electrons.



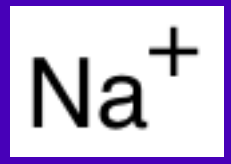
protons	11	17	11	17
electrons	11	17	10	18
charge	0	0	+1	-1

How does the chlorine ion fill the octet rule?



by gaining one electron, it now has eight valence electrons

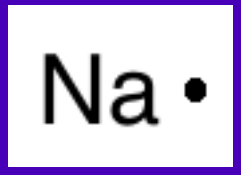
How does sodium fill the octet rule?



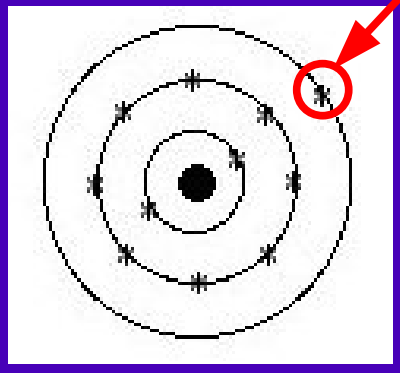
look at the energy levels

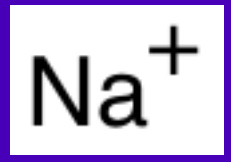
valence electron

valence electrons

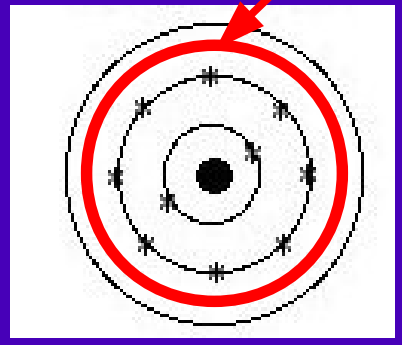


11 electrons



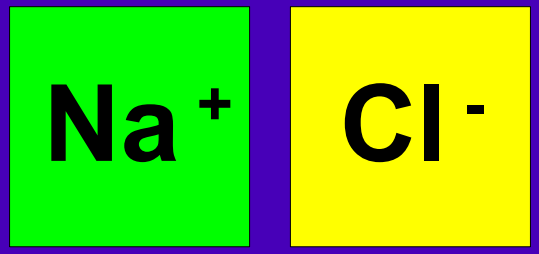


10 electrons



If you take away all the valence electrons, the next level down becomes the highest; it always has 8 electrons.

Why does table salt have the formula NaCl?



you need one of each

loses one electron

gains one electron

Would it be possible to have an ionic compound with the formula Na_2Cl? What about $NaCl_2$?

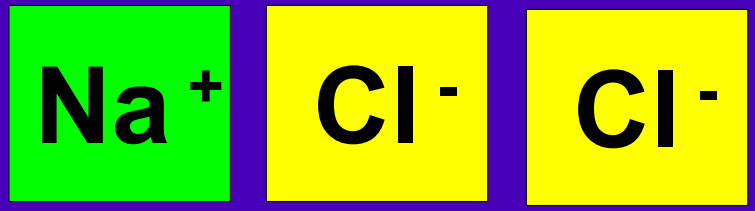
Na_2Cl

no! there would be an extra electron left over

lose 2 e-

gain 1 e-

$NaCl_2$



no! there aren't enough electrons to make 2 Cl^-

lose 1 e-

gain 2 e-

Other salts

Notice that every time we have been talking about sodium chloride, we call it “table salt.” That's because in chemistry, the word “salt” refers to any ionic compound.

There are several categories of salts that we will discuss. What groups do you see here?

KCl – potassium chloride

$FeCl_2$ – iron (II) chloride

$FeCl_3$ – iron (III) chloride

K_2SO_4 – potassium sulfate

$FeSO_4$ – iron (II) sulfate

$Fe_2(SO_4)_3$ – iron (III) sulfate

Which are white?

KCl

K_2SO_4

K – main group metal

Which are colored?

$FeCl_2$

$FeSO_4$

Fe – transition metal

$FeCl_3$

$Fe_2(SO_4)_3$

Which have one nonmetal?

KCl, $FeCl_2$, $FeCl_3$ simple anions

Which have more than one?

K_2SO_4, $FeSO_4$, $Fe_2(SO_4)_3$ polyatomic ions

Main group metals, simple ions

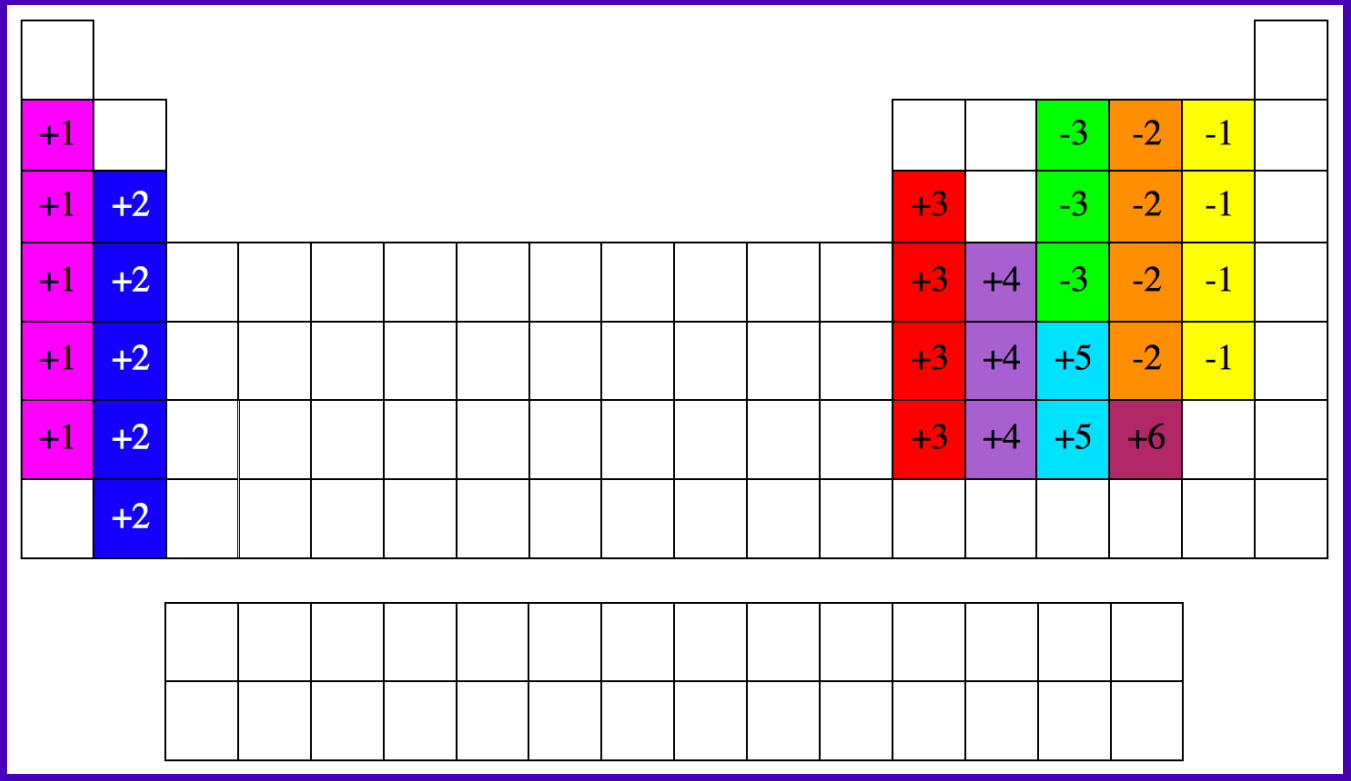
Using the Periodic Table, predict what will happen to each of the following atoms when they form ionic compounds:

	valence electrons	gain/lose e-	symbol
oxygen	6	gain 2 e-	O^{-2}
potassium	1	lose 1 e-	K^{+}
nitrogen	5	gain 3 e-	N^{-3}
magnesium	2	lose 2 e-	Mg^{+2}
aluminum	3	lose 3 e-	Al^{+3}
fluorine	7	gain 1 e-	F^{-}

What pattern do you see?

nonmetals gain electrons, become anions
metals lose electrons, become cations

If we look at all of the nonmetals and main group metals on the Periodic Table, we can see what ions they can form.



- noble gases do not form ions
- Be, B, C, and Si do not form ions
- the larger an atom is, the more electrons it can lose

What compounds could you make with the following ions?

Cl^- O^{-2}

Na^+ Na^+ Cl^- Na^+ Na^+ O^{-2}

$NaCl$ Na_2O

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

$MgCl_2$ MgO

What would these compounds be called?

Na^{+}	Cl^{-}		NaCl	sodium chloride
Mg^{+2}	Cl^{-}	Cl^{-}	$MgCl_2$	magnesium chloride
Na^{+}	Na^{+}	O^{-2}	Na_2O	sodium oxide
Mg^{+2}	O^{-2}		MgO	magnesium oxide

Why doesn't the name give the number of atoms in the formula?

you can figure it out by knowing the charges

What names would the following compounds have?

NaBr sodium bromide

KI potassium iodide

CaF_2 calcium fluoride

BaS barium sulfide

What formulas would the following compounds have?

+2 -1
barium bromide $BaBr_2$

+2 -2
strontium sulfide SrS

+3 -1
aluminum iodide AlI_3

+1 -2
lithium oxide Li_2O

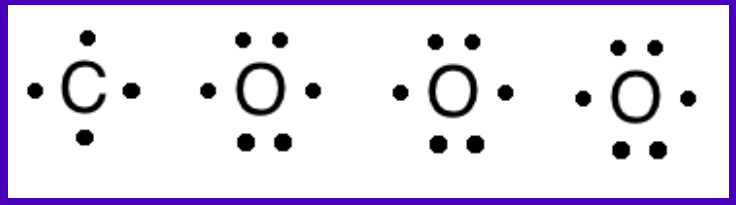
Main group metals, polyatomic ions

Cl^-

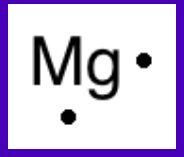
Simple ions involve only one atom with a charge.

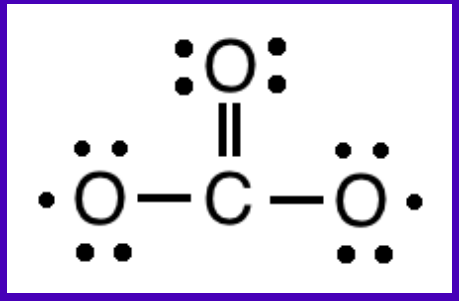
CO_3^{-2}

Polyatomic ions involve more than one atom with a charge. How does this work?

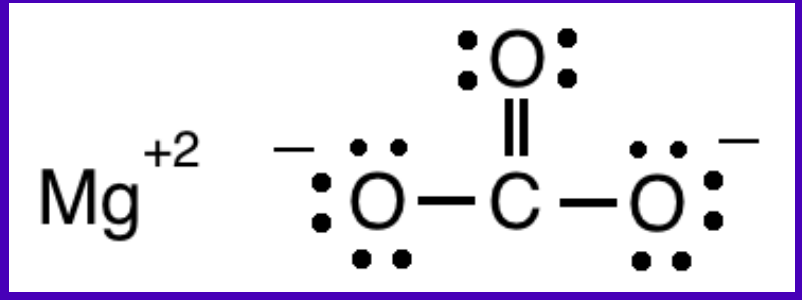


1) Lewis structures for atoms





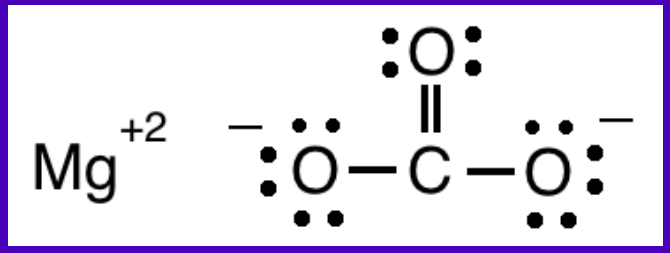
2) sharing electrons, not enough
3) bring in a metal



4) transfer electrons to make all atoms stable

So how do you know what charge a polyatomic ion will have?

1) work out the line structure, figure out how many electrons are needed



(not always so easy)

2) look at the other ion it is with

$MgSO_4$ Mg^{+2} SO_4^{-2}

KNO_3 K^+ NO_3^-

3) memorize them

you will be responsible to remember: CO_3^{-2}, SO_4^{-2}, NO_3^-

What compounds could you make with the following ions?

NO_3^-

SO_4^{-2}

Na^+ Na^+ NO_3^-

$NaNO_3$

Na^+ Na^+ SO_4^{-2}

Na_2SO_4

Mg^{+2} Mg^{+2} NO_3^- NO_3^-

$Mg(NO_3)_2$

Mg^{+2} SO_4^{-2}

$MgSO_4$

What would these compounds be called?

Na^{+}	NO_3^{-}		$NaNO_3$	sodium nitrate
Mg^{+2}	NO_3^{-}	NO_3^{-}	$Mg(NO_3)_2$	magnesium nitrate
Na^{+}	Na^{+}	SO_4^{-2}	Na_2SO_4	sodium sulfate
Mg^{+2}	SO_4^{-2}		$MgSO_4$	magnesium sulfate

Do these names show the number of ions?

no – you have to know the charges to figure out the formula

What names would the following compounds have?

$BaSO_4$ barium sulfate

$LiNO_3$ lithium nitrate

$SrCO_3$ strontium carbonate

$Al_2(SO_4)_3$ aluminum sulfate

What formulas would the following compounds have?

+1 -1
potassium nitrate KNO_3

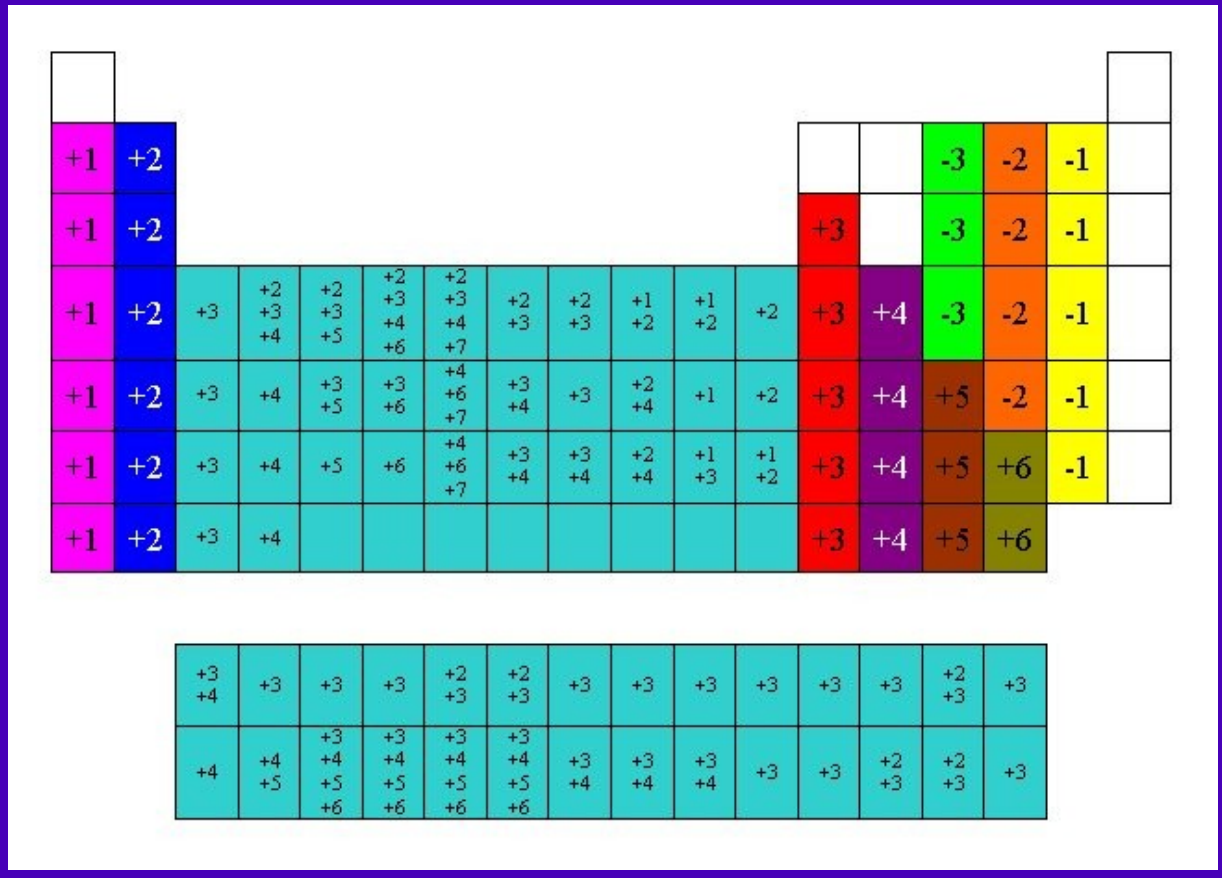
+1 -2
lithium sulfate Li_2SO_4

+2 -1
calcium nitrate $Ca(NO_3)_2$

+4 -2
tin carbonate $Sn(CO_3)_2$

Transition metals and simple or polyatomic ions

What is different about transition metals and inner transition metals?



many of them have more than one possible charge

How are we going to deal with this?

you will always be told the charge, or given a compound

After studying many different compounds containing palladium, it has been found that it commonly makes +2 and +4 ions.

What compounds will palladium form with oxygen?

Pd^{+2} O^{-2} PdO

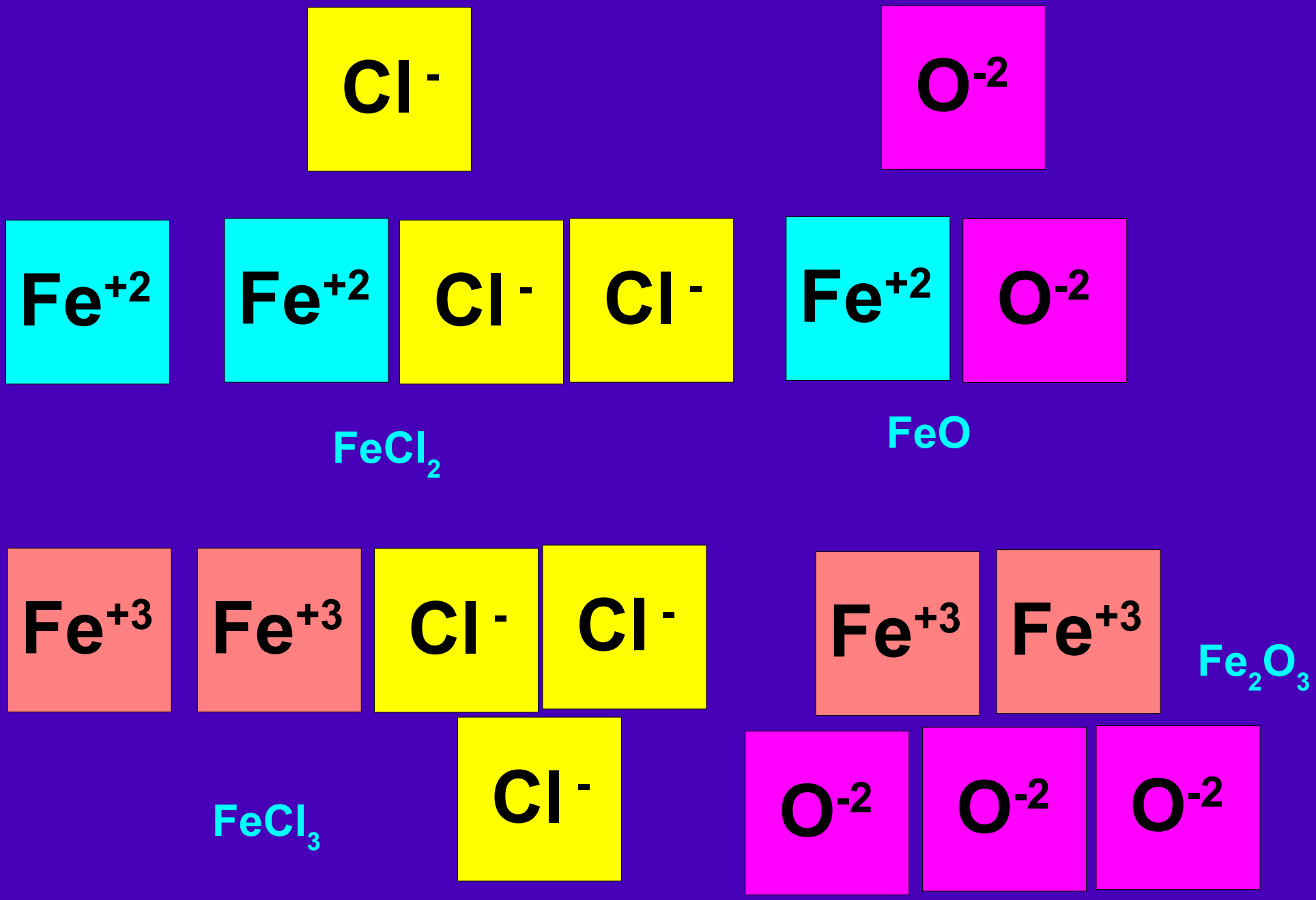
Pd^{+4} O^{-2} O^{-2} PdO_2

The following two gold compounds have been found. What charges does gold have in each compound?

AuCl Au^{+} Cl^{-}

AuN Au^{+3} N^{-3}

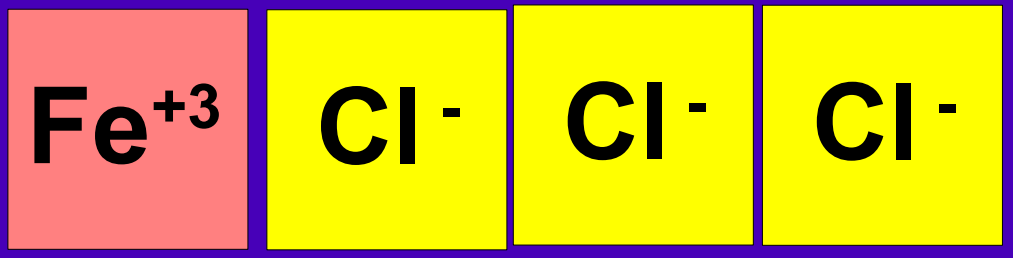
What compounds could you make with the following ions?



How will we name these compounds?

$FeCl_2$ ~~iron chloride~~

iron (II) chloride



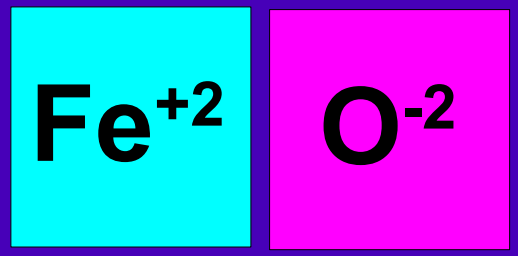
$FeCl_3$ ~~iron chloride~~

iron (III) chloride

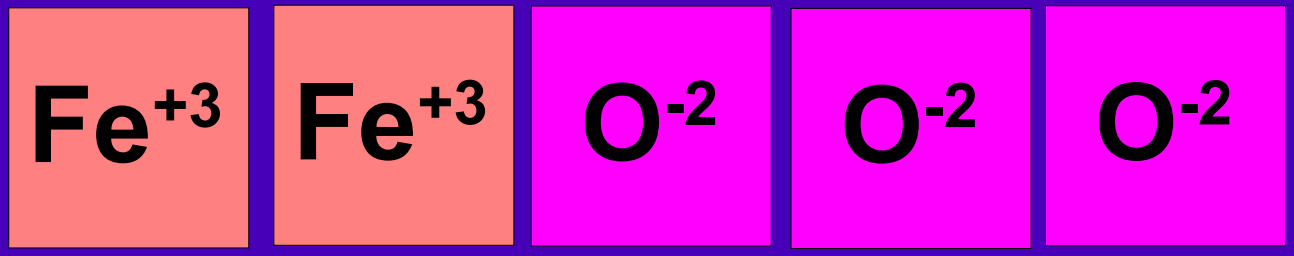
What's wrong?

can't have two different compounds with the same name!

Solution: put the charge in the name



FeO iron (II) oxide



Fe_2O_3 iron (III) oxide

Give the formula for the following compounds.

+1 -2
copper (I) oxide Cu_2O

+2 -2
copper (II) oxide CuO

+2 -1
manganese (II) fluoride MnF_2

+4 -1
manganese (IV) fluoride MnF_4

Give the names of the following compounds.

+2 -1
$FeBr_2$ iron (II) bromide

+3 -1
$FeBr_3$ iron (III) bromide

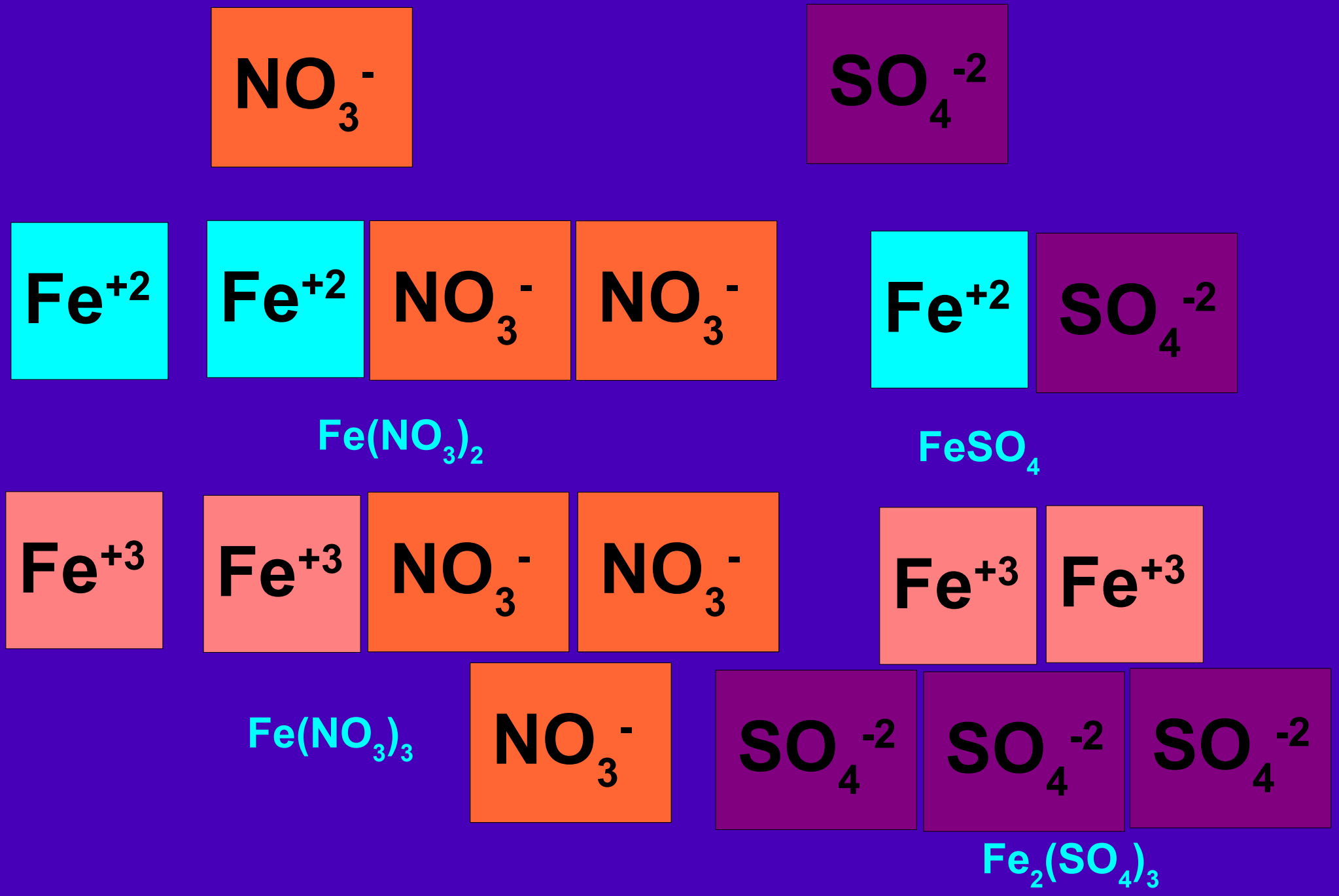
+2 -2
AgS silver (II) sulfide

+1 -2
Ag_2S silver (I) sulfide

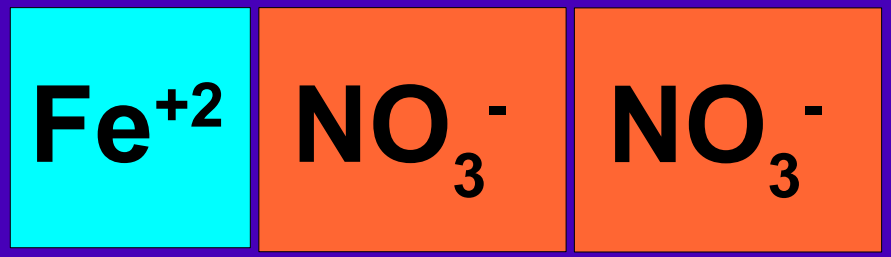
What will always stay the same?

charge on the anion

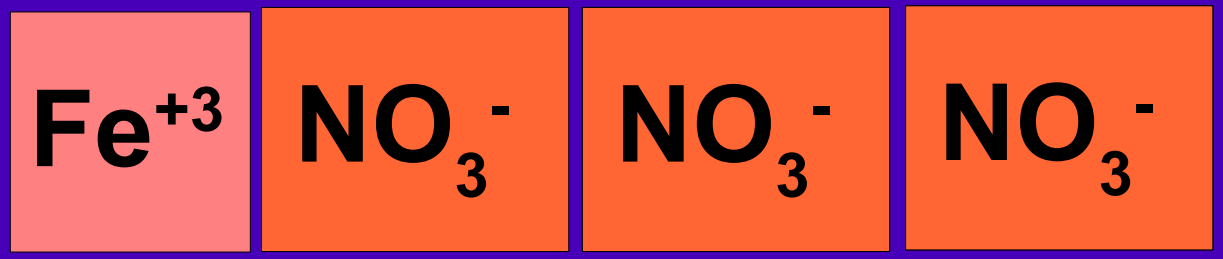
What compounds could you make with the following ions?



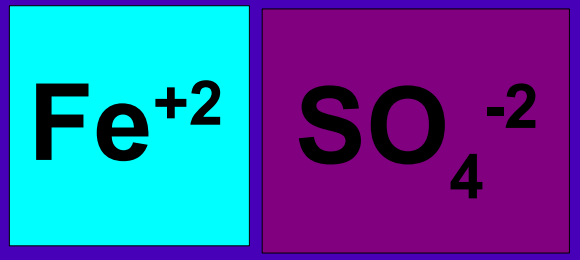
What would these compounds be called?



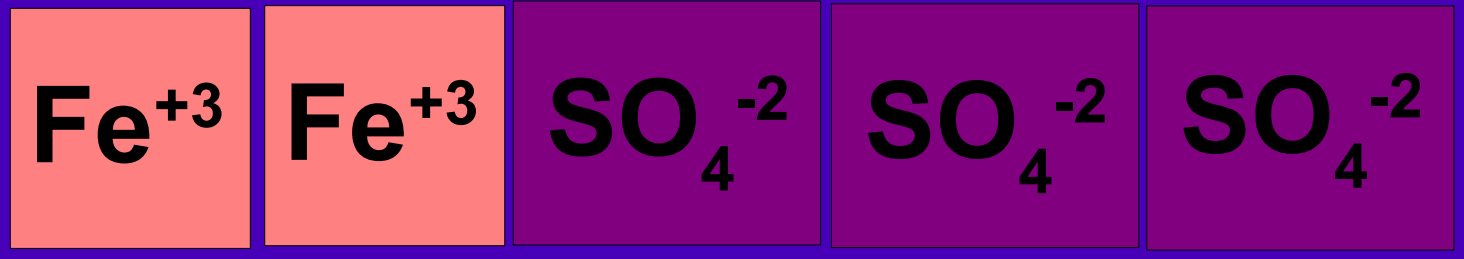
$Fe(NO_3)_2$ iron (II) nitrate



$Fe(NO_3)_3$ iron (III) nitrate



$FeSO_4$ iron (II) sulfate



$Fe_2(SO_4)_3$

iron (III) sulfate

What names would the following compounds have?

$HgSO_4$ mercury (II) sulfate

Hg_2SO_4 mercury (I) sulfate

$Co(NO_3)_2$ cobalt (II) nitrate

$Co(NO_3)_3$ cobalt (III) nitrate

What formulas would the following compounds have?

chromium (III) nitrate $Cr(NO_3)_3$

chromium (II) carbonate $CrCO_3$

nickel (II) nitrate $Ni(NO_3)_2$

nickel (III) carbonate $Ni_2(CO_3)_3$