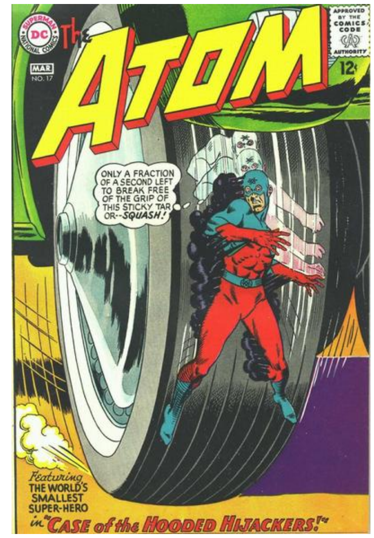
Unit One: Chemistry

Lesson 1: Atomic Structure



Atoms are the smallest particles of matter that still have the properties of that element.

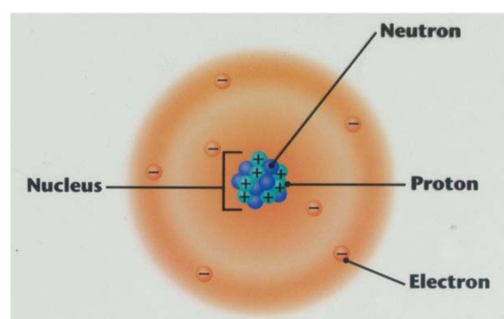
Elements can be found alone as elements (eg He) or they can join together into molecules to form compounds (eg H_2O)

Chemical reactions occur when atoms rearrange and form new partnerships

Atoms contain subatomic particles

Name	Symbol	Charge	Location in atom	Mass (amu)
proton	p	+1	nucleus	1
neutron	n	0	nucleus	1
electron	e	-1	outside the nucleus	0

- The nucleus is at the centre of an atom.
- The nucleus is composed of protons and neutrons.
- Electrons exist in the space surrounding the nucleus.
- # of protons = # of electrons in every atom
- Nuclear charge = charge on the nucleus = # of protons
- Atomic number = # of protons = # of electrons



Element	Atomic number	# Protons	# Electrons	# Neutrons	Atomic Mass
Na	11	11	11	12	23
P					
C					
Ca					
S					
F					
Fe					
I					
Lu					
V					
Ba					
Co					
N					

Metals lose electrons and become positive ions (cations).

Non-metals gain electrons and become negative ions (anions).

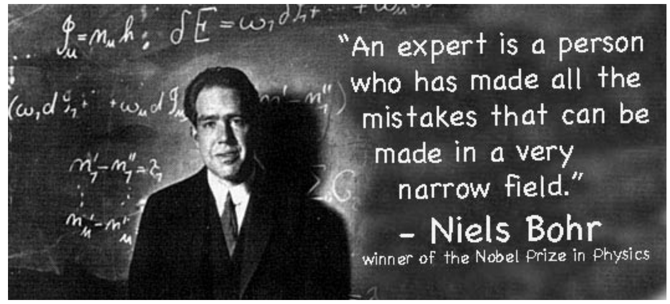
Ion	Atomic number	# Protons	# Electrons	# Neutrons	Atomic Mass
F^{-1}					
Ca^{2+}					
O^{-2}					
N^{-3}					
H^{+1}					
Fe^{3+}					

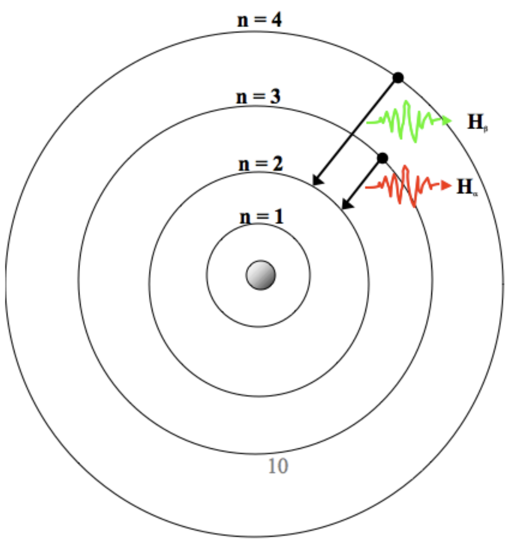
Additional Practice

Symbol	Element name	Atomic Number	# Protons	# Neutrons	# Electrons	Atomic Mass
C						
N						
	Oxygen					
Sr						
	Selenium					
O^{-2}						
	Magnesium					
Li^{+1}						
Cs						
K						
	Bromine					
	Fluorine					
Co^{+3}						
	Neon					
	Radon					
		47			46	
		74				
			13			
			92			
Al^{+3}						
Cu^{+2}						
	Calcium				18	
			24		21	
	Selenium				36	
					76	197

Lesson 2: The Bohr Model of the Atom

Niels Bohr introduced the Bohr model in 1913. It depicts the atom as a small, positively charged nucleus surrounded by electrons that travel in orbitals around the nucleus.

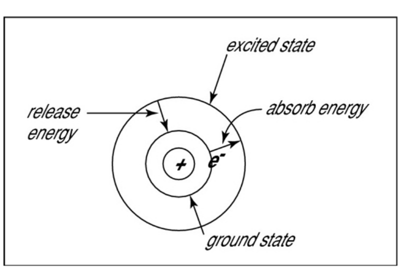


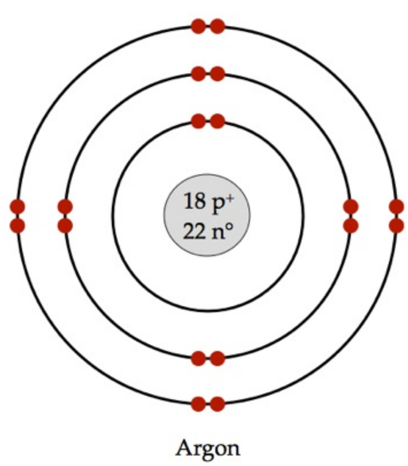


Bohr's model was based on observations and calculations at the time that showed the energy associated with the transitions of electrons moving from one energy level or orbital to another.

These different transitions correspond to the different orbitals, which are at different distances from the nucleus and thus have specific energies.

In the Bohr model the first orbital holds 2 electrons, the next two hold 8 electrons each and the next orbital holds 18 electrons.





- It has 2 + 8 + 8 = 18 electrons, and therefore, 18 protons.
- It has three electron shells, so it is in period 3.
- It has eight electrons in the outer (valence) shell.

Additional Practice

Draw Bohr diagrams for the following atoms or ions:

1. a) Li b) Na c) K

2. a) N b) O c) F

3 a) Li^{+1} b) Na^{+1} c) K^{+1}

4. a) N^{-3} b) O^{-2} c) F^{-1}

d) Ne

Niels Bohr's Flight From the Nazis Was a Science Drama

Danish physicist Niels Bohr was a scientific genius who also displayed a coincidental penchant for espionage and intrigue. He employed these skills, along with a bit of science, to foil the Nazi at several turns.

His small crusade began in 1933 after the Nazis came to power in Germany. Over the next few years several scientists fled Germany with Bohr's help. Many escapees went on to work on the Manhattan Project, including Edward Teller, James Franck and Otto Frisch. Some of them stayed with Bohr in Denmark, working at the Bohr Institute until moving elsewhere. In April 1940 the Nazis crossed the border into Denmark. Bohr stayed despite the danger. As the Germans marched into Copenhagen, he even deprived them of a bit of the loot they intended to claim.

Max Von Laue and James Franck, both Germans, won the Nobel Prize in physics in 1914 and 1925, respectively. Von Laue openly opposed the Nazis and Franck was Jewish. The Nobel Prize included a large gold medal with the winner's name plainly inscribed. Both men previously left their medals at Bohr's Institute for safekeeping, but with the Nazi occupation, the medals seemed as good as gone.

Bohr considered burying them but feared the Germans would find them. A Hungarian chemist, Georgy de Hevesy, worked at the Institute and realized he could dissolve them. Gold is difficult to dissolve but one substance known as "aqua regia" can do it. A few hours later the two medals were rendered into a liquid state, placed into a beaker and stored on a high shelf.

The Nazis arrived and searched the entire building, but ignored the orange-tinted beaker, literally full of liquid gold. Later, after Bohr fled the country, Hevesy left for Sweden. He returned to Denmark after the war and found the beaker intact and undisturbed. The chemist reversed the process, extracted the gold and in 1950 shipped it back to the Nobel Foundation. They recast new medals using the original gold and reissued them to Von Laue and Franck.

Bohr's wartime adventures didn't end with a pair of gold medals. His knowledge of physics and atomic theory brought the attention of the Nazi's head nuclear scientist, Werner Heisenberg. In September 1941 Heisenberg and Bohr met for a stroll in a park in occupied Copenhagen.

Heisenberg and Bohr

What they discussed is still unclear. Heisenberg later wrote he suggested that nuclear scientists in Europe suppress knowledge of atomic weapons to prevent their creation during the war. Bohr claimed Heisenberg boasted of Germany's eventual victory and talked about the creation of the bomb. At the time, Bohr didn't consider an atomic weapon feasible in the near future.

Whatever the case, Bohr's opposition to the Nazis and his mother's Jewish heritage made him a marked man in the eyes of the Third Reich. He also came under the scrutiny of the Allies, who knew Germany had an atomic bomb project. Bohr's presence in occupied Europe meant he could be forced to help the German development effort. Bohr was contacted and agreed to be extracted from Denmark in late September 1943.

The operation was carried out with great secrecy but at the last minute the Nazis learned of the plan and went after Bohr at his home. As they entered the house through the front door, the 58-year-old Bohr ran out the back, pausing at his icebox to grab a beer bottle filled with heavy water. A few Danish resistance fighters laid down covering fire, allowing Bohr to escape.

Soon he boarded a fishing boat that took him to Sweden. Safely ashore, he traveled to Stockholm. The British arranged to secretly fly him out of Sweden, but Bohr had an appointment first. He reportedly met with Swedish leaders and implored them to help Danish Jews. While there is controversy over how much Bohr's efforts effected the decision, Sweden did offer asylum and thousands of Jewish Danes took refuge there.

De Havilland Mosquito

The British sent a De Havilland Mosquito fighter bomber to retrieve the scientist. A modified version of the Mosquito served as a fast transport for special cargoes during the war. Bohr met the definition. On Oct. 7, 1943 the plane took off from a clandestine airstrip with Bohr laying on his back in the converted bomb bay.

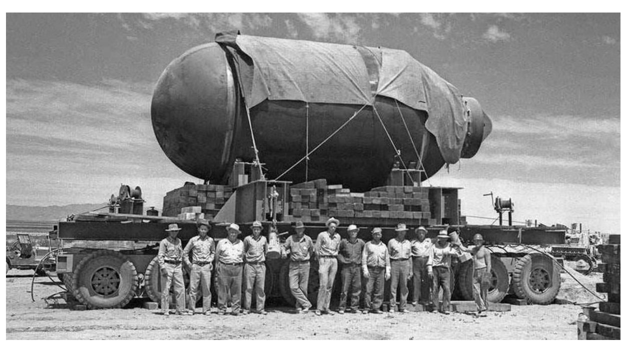
The aircraft flew high and fast to avoid Nazi fighters. This required pilot and passenger to wear oxygen masks due to the altitude. Bohr didn't put his on and soon passed out from oxygen deprivation. When the pilot couldn't talk to the unconscious Dane, he realized what must have happened and descended, saving the man's life.

Bohr didn't regain consciousness until after the plane landed. He went to the hospital still clutching his precious bottle of heavy water.

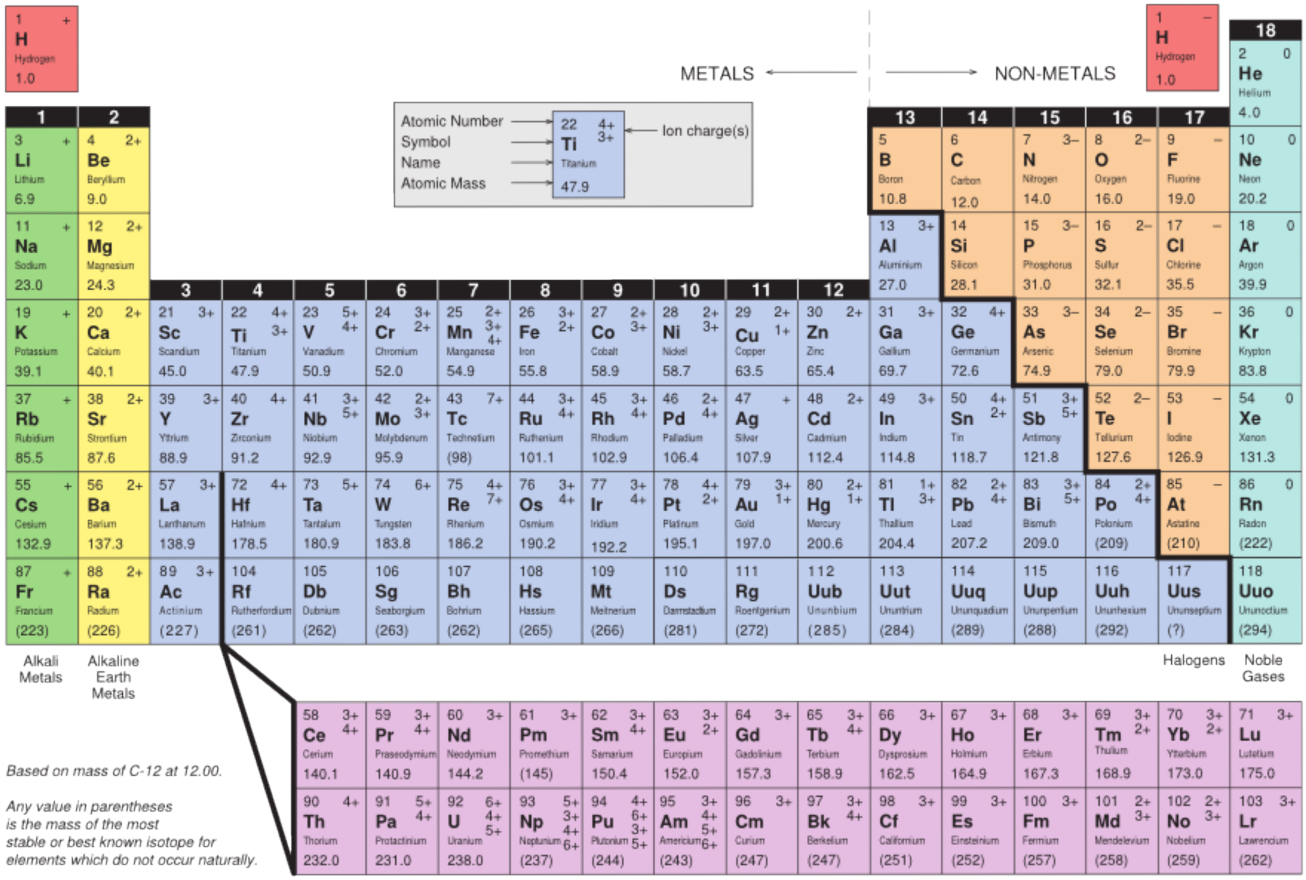
After recovering, Bohr went to the United States to join the Manhattan Project. His contribution, even by his own admission, was minimal. By the time he arrived the scientists already at work on the bomb had surpassed his knowledge. Still, the rescue mission likely saved Bohr from a concentration camp or outright execution.

He returned to Denmark after the war and died there in 1962.

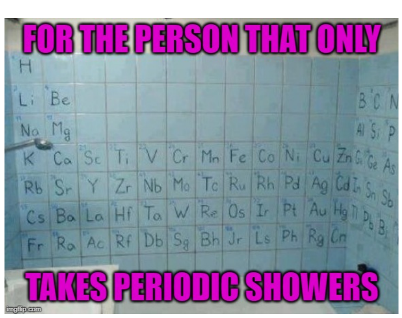
Bohr's time adventures read like a spy novel even though he provided little help to the development of the atomic bomb. There was one final, amusing indignity. The bottle of heavy water Bohr grabbed during his escape and so carefully smuggled to England turned out to be the wrong one. It contained only beer.



Lesson 3: The Periodic Table



In the periodic table, elements are listed in order by their atomic number.
Metals are on the left (the transition metals range from group 3 to group 12), non-metals are on the right, and the metalloids form a "staircase" toward the right side.



Rows of elements (across) are called periods.

Columns of elements are called groups, or families.

Group 1 = alkali metals

Group 2 = alkaline earth metals

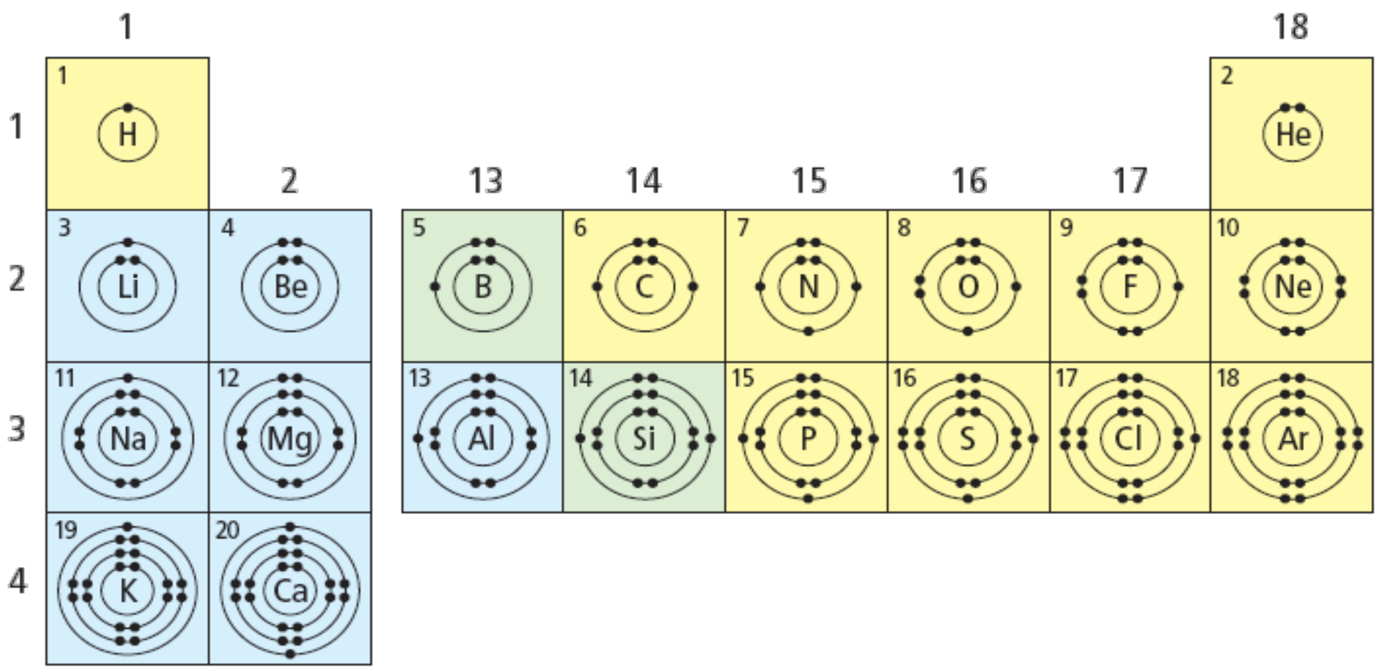
Group 17 = the halogens

Group 18 = noble gases

All elements in a family have similar properties and bond with other elements in similar ways.

This is because all the members of a family have the same number of electrons in their outermost electron orbital.

These electrons are called valence electrons.



Li, Na and K react in the same way and will form +1 charged ions.
F and Cl will react the same and form -1 ions.

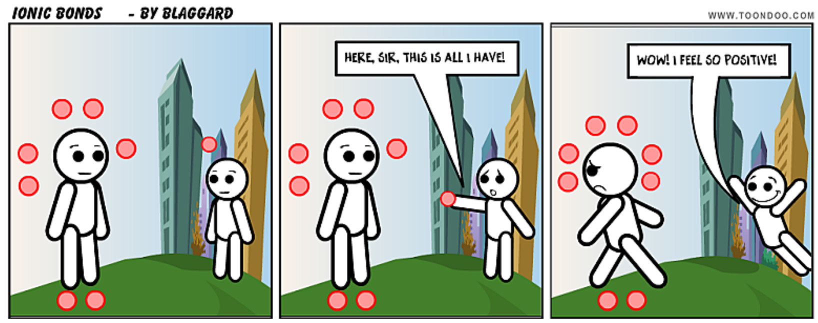
This is because all elements want to have a full outer orbital of electrons.

Atoms form bonds so that they can have full outer orbitals.

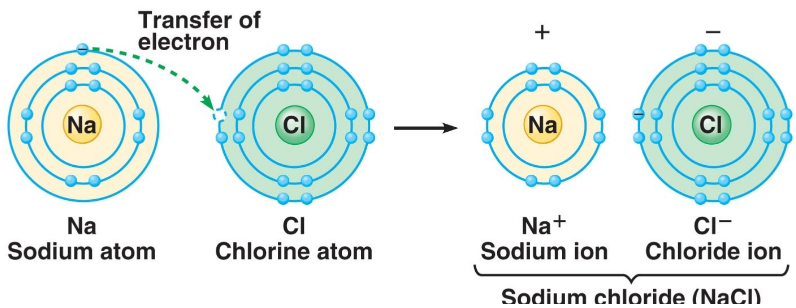
This is called the **Octet Rule**

Lesson 4: Ionic and Covalent Bonds

1) Ionic Bonds



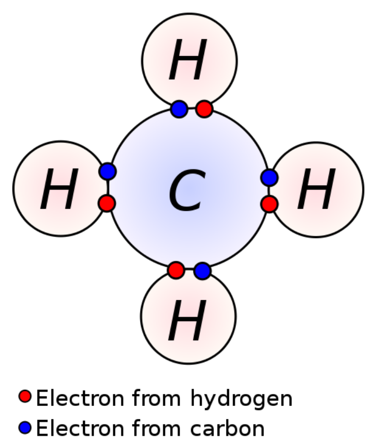
Metal atoms will lose valence electrons and non-metal atoms will gain these valence electrons. This process creates a positive metal ion and a negative non-metal ion. Their mutual attraction is called an **Ionic Bond.**

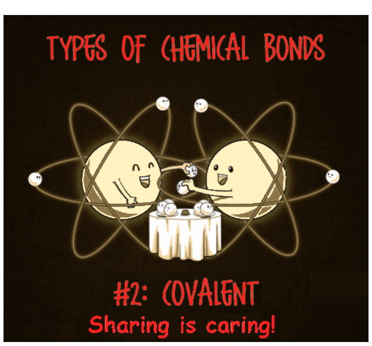


Metal plus Non-metal makes an Ionic Compound that is held together by an Ionic Bond.

2) Covalent Bonds

Non-metal atoms can share electrons to form **Covalent Bonds**





Non-Metal plus Non-metal makes a Covalent Compound that is held together by an Covalent Bond.

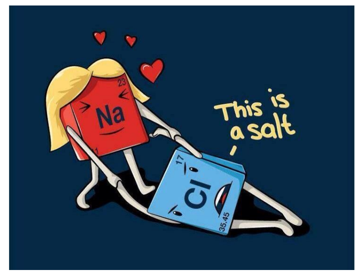
Lesson 5: Writing Ionic Formulae

When writing the formula for an ionic compound, the positive charges balance out the negative charges.

The ratio of positive:negative charges gives the proper formula.

The ratio is always written in reduced form.

Eg. 1: What is the formula for magnesium phosphide?



-magnesium is Mg^{2+} and phosphorous is P^{3-}

-lowest common multiple of 2 and 3 is 6

-need 3 Mg^{2+} ions to combine with 2 P^{3-} ions

-Which gives a formula of: **Mg_3P_2**

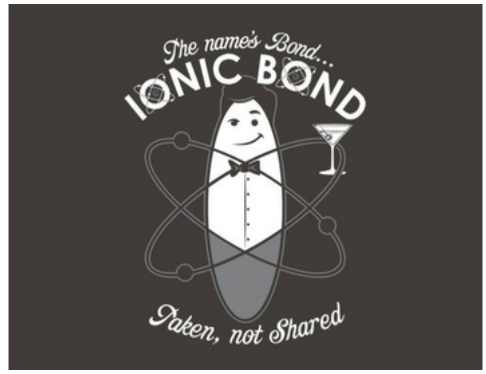
Eg. 2: Complete the following table of ionic compounds

	Cl^{-1}	O^{-2}	N^{-3}	OH^{-1}	SO_4^{-2}	PO_4^{-3}
Na^{+1}	$NaCl$	Na_2O	Na_3N	$NaOH$	Na_2SO_4	Na_3PO_4
Ag^{+1}						
Mg^{+2}						
Fe^{+3}						
Pb^{+4}						
V^{+5}						
Cr^{+6}						
Mn^{+7}						

Additional Practice

	F^{-1}	Br^{-1}	S^{-2}	O^{-2}	P^{-3}	MnO_4^{-1}	N^{-3}	SO_4^{2-}	OH^{-1}	PO_4^{-3}
Na^{+}										
Ca^{2+}										
Fe^{3+}										
K^{+}										
Sr^{2+}										
Al^{3+}										
Cs^{+}										
Cu^{2+}										
V^{5+}										
Ag^{+}										
Mg^{2+}										
Co^{3+}										
Cr^{3+}										
Mn^{6+}										

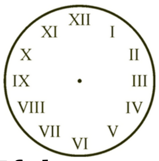
Lesson 6: Naming Ionic Compounds



When naming ionic compounds we need to first identify whether the metal ion is multivalent. Multivalent means that the ion can have different combining capacities or charges in different compounds.

The metal ions in the first two columns on the left (Alkali metals and Alkaline Earth metals) have only a +1 or +2 charge.

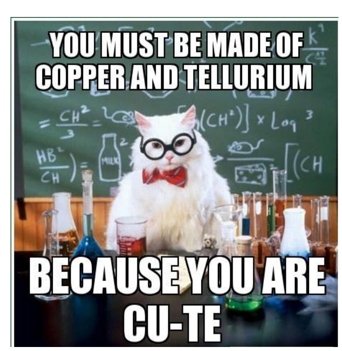
1	LiO	
2	NaCl	
3	MgF_2	
4	$BeBr_2$	
5	SrI_2	
6	Rb_2O	
7	Cs_3N	
8	K_3P	
9	Ca_3N_2	
10	BaS	
11	SrS	
12	Na_3N	
13	KCl	
14	$MgCl_2$	
15	BaI_2	
16	Rb_3P	
17	Sr_3P_2	
18	MgSe	
19	LiI	
20	RaTe	



Nearly all other metals on the chart are capable of being multivalent.

If the compound contains a metal that is multivalent your name must include brackets with the Roman numeral that represents the value of the charge on the metal ion.

1	$NiCl_2$	
2	$FeBr_2$	
3	$FeBr_3$	
4	CuI	
5	CuI_2	
6	Au_2O_3	
7	V_2O_5	
8	MnO_3	
9	Zr_3N_2	
10	CrS	
11	TiO_2	
12	TiO_3	
13	ScF_3	
14	$CoBr_3$	
15	MoP	
16	WAt_2	
17	OsO_2	
18	$HgCl$	
19	$ZnCl_2$	
20	$SnCl_4$	

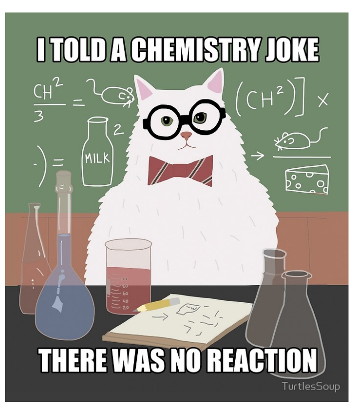


Some ions are made up of groups of atoms that join together and then are called something unique. These are called polyatomic ions.

When we named ions of single non-metal elements their names ended in ***–ide***. If we have a polyatomic ion in the compound the name does not change. (see the table of polyatomic ions)

1	LiOH	
2	$NaMnO_4$	
3	$MgSO_4$	
4	$Be(ClO)_2$	
5	$SrCr_2O_7$	
6	Rb_2CO_3	
7	Cs_3PO_4	
8	K_2SO_3	
9	$Ca_3(PO_4)_2$	
10	$Ba(NO_3)_2$	
11	$Sr(NO_2)_2$	
12	Na_3PO_4	
13	KCN	
14	$MgCrO_4$	
15	$Ba(CN)_2$	
16	$RbClO_2$	
17	$Sr(CH_3COO)_2$	
18	$Mg(HSO_4)_2$	
19	LiHS	
20	$Ra(HCO_3)_2$	

1		Sodium nitrate
2		Aluminum phosphate
3		Chromium (IV) iodide
4		Ammonium bromide
5		Strontium hypochlorite
6		Manganese (II) sulphate
7		Iron (II) carbonate
8		Nickel (II) hydroxide
9		Copper (II) sulphate
10		Calcium permanganate
11		Lithium cyanide
12		Barium iodide
13		Ammonium nitrite
14		Sodium bromide
15		Tungsten (IV) oxide
16		Magnesium hydroxide
17		Titanium (IV) sulphide
18		Chromium (IV) phosphate
19		Silver (I) carbonate
20		Beryllium chlorite



Additional Practice

Name the following			Provide the formula for the following		
1	NaI		21	Calcium Iodide	
2	CaS		22	Sodium Sulphide	
3	$SrCl_2$		23	Potassium Cyanide	
4	KNO_3		24	Rubidium Phosphate	
5	$Ba(CN)_2$		25	Vanadium (V) Oxide	
6	$TiCl_4$		26	Iron (III) Hydroxide	
7	$Fe(OH)_3$		27	Sodium Dichromate	
8	Mn_2O_3		28	Aluminum (III) Chloride	
9	VPO_4		29	Manganese (IV) Cyanide	
10	$K_2Cr_2O_7$		30	Lead (IV) Oxide	
11	$ZnSO_3$		31	Lithium Sulfite	
12	$NaCH_3COO$		32	Iridium (II) Nitride	
13	$AgNO_2$		33	Tungsten (IV) Carbide	
14	$Ni(ClO_4)_2$		34	Strontium Nitrite	
15	$Cr(HS)_3$		35	Iron (II) Bicarbonate	
16	$Cu(MnO_4)_2$		36	Magnesium Acetate	
17	$CaCO_3$		37	Cobalt (III) Hypochlorite	
18	OsO_4		38	Tin (IV) Nitrite	
19	$Ti_3(PO_3)_4$		39	Chromium (IV) Chromate	
20	MoP		40	Yttrium (II) Phosphite	

1	LiO		21	$NiCl_2$	
2	NaCl		22	$FeBr_2$	
3	MgF_2		23	$FeBr_3$	
4	$BeBr_2$		24	CuI	
5	SrI_2		25	CuI_2	
6	Rb_2O		26	Au_2O_3	
7	Cs_3N		27	V_2O_5	
8	K_3P		28	MnO_3	
9	Ca_3N_2		29	Zr_3N_2	
10		Barium sulphide	30		Chromium (II) sulphide
11		Strontium sulphide	31		Titanium (IV) oxide
12		Sodium nitride	32		Titanium (VI) oxide
13		Potassium chloride	33		Scandium (III) fluoride
14		Magnesium chloride	34		Cobalt (III) bromide
15		Barium iodide	35		Molybdenum (III) phosphide
16		Rubidium phosphide	36		Tungsten (II) astinide
17		Strontium nitride	37		Osmium (IV) oxide
18		Magnesium selenide	38		Mercury (I) chloride
19		Lithium iodide	39		Zinc (II) chloride
20		Radium telluride	40		Tin (IV) chloride

1	$LiOH$		21	$NaNO_3$	
2	$NaMnO_4$		22	$AlPO_4$	
3	$MgSO_4$		23	CrI_4	
4	$Be(ClO)_2$		24	NH_4Br	
5	$SrCr_2O_7$		25	$Sr(ClO)_2$	
6	Rb_2CO_3		26	$MnSO_4$	
7	Cs_3PO_4		27	$FeCO_3$	
8	$K_2C_2O_4$		28	$Ni(OH)_2$	
9	$Ca_3(PO_4)_2$		29	$CuSO_4$	
10		Barium nitrate	30		Iron (III) manganate
11		Strontium nitrite	31		Chromium (III) cyanide
12		Sodium phosphate	32		Barium iodide
13		Potassium cyanide	33		Ammonium nitrite
14		Manganese (II) chromate	34		Tantalum (I) bromide
15		Barium thiocyanate	35		Rhodium (I) fluoride
16		Silver (I) chlorite	36		Magnesium hydroxide
17		Titanium (IV) acetate	37		Titanium (II) oxide
18		Iron (III) sulphite	38		Niobium (II) oxalate
19		Iridium (II) hypochlorite	39		Nickel (II) carbonate
20		Potassium dichromate	40		Berrylium oxide

Lesson 7: Naming Covalent Compounds

Covalent compounds are made up of non-metal atoms only.

Eg. 1: What is the name of CCl_4?

As we did with ionic compounds we start by writing the names of both elements and then change the second element's name to end with –*ide*.

We then use the prefixes to indicate how many of each atom are within the molecule.

Which give us: **carbon tetrachloride**

One rule to remember is to never start a name with the *mono-* prefix.

Eg. 2: What is the name for P_2O_4?

Eg. 3: What is the name for OF_2?

Eg. 4: What is the name for CO_2?

1	mono
2	di
3	tri
4	tetra
5	penta
6	hexa
7	hepta
8	octa
9	nona
10	deca

Eg. 5: What is the name for CS_2?

Additional Practice

Name the following			Provide the formula for the following		
1	PI_3		21	Nitrogen dioxide	
2	CBr_4		22	Sulphur hexafluoride	
3	N_2O		23	Dinitrogen tetrasulphide	
4	NO		24	Sulphur dioxide	
5	N_2O_4		25	Bromine trifluoride	
6	P_4S_{10}		26	Phosphorus trichloride	
7	S_2F_8		27	Disulphur hexaoxide	
8	H_2O		28	Diiodine hexafluoride	
9	NI_3		29	Carbon monoxide	
10	PCl_5		30	Iodine difluoride	
11	SI_3		31	Phosphorous pentabromide	
12	N_2O_5		32	Sulphur trioxide	
13	SF_2		33	Oxygen difluoride	
14	CH_4		34	Nitrogen monoxide	
15	CS_2		35	Dihydrogen monosulphide	
16	$SeCl_2$		36	Chlorine trifluoride	
17	NH_3		37	Xenon hexafluoride	
18	CO		38	Sulphur tetrabromide	
19	CO_2		39	Iodine phosphide	
20	N_2O		40	Tribromine nitride	

Lesson 8: Chemical Equations

In chemical reactions reactants turn into new substances with new properties called products.

We need to write chemical reaction in two different ways:

1) A word equation

Copper metal + nitric acid → aqueous copper (II) nitrate + nitrogen dioxide gas + water

2) A symbolic equation

$$\mathbf{Cu_{(s)} + 4HNO_{3(aq)} \rightarrow Cu(NO_3)_{2(aq)} + 2NO_{2(g)} + 2H_2O_{(l)}}$$

Coefficients are the whole numbers found at the front of molecules in a balanced chemical equation.

State of matter

- Letters indicate the state of each compound.

(aq) = aqueous/dissolved in water

(s) = solid

(l) = liquid

(g) = gas

The law of conservation of mass.

In a chemical reaction matter is neither created nor destroyed, just rearranged. The total mass of the reactants equals the total mass of the products.

The number of atoms in the reactants is the same as the number of atoms in the products.

Because of this we when we write equations we must acknowledge this by accounting for the conservation of matter.

Antoine and Marie-Anne Lavoisier

Balancing chemical reactions

We balance chemical equations to make the total mass of reactants and products equal.

Starting with an unbalanced or skeletal equation we can **only** add or change the whole number coefficients found in front of the molecules.

Eg. 1: Balance the following skeletal equations

_____ K + _____ O_2 → _____ K_2O

_____ H_2 + _____ O_2 → _____ H_2O

_____ Fe + _____ Br_2 → _____ $FeBr_3$

_____ N_2 + _____ H_2 → _____ NH_3

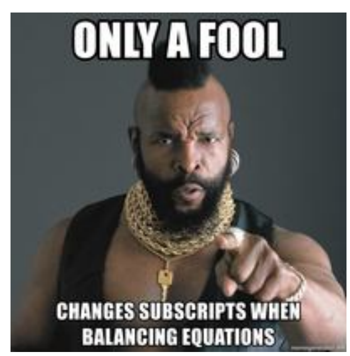
There are some special elements that when they are alone form into pairs or other arrangements. They are:

I_2, Br_2, Cl_2, F_2, O_2, N_2, H_2, S_8, P_4

Balancing equations from word equations

Write the balanced equation for the reaction between tin (IV) nitrate and potassium phosphate that produces tin (IV) phosphate and potassium nitrate

Start by writing the skeletal equation:



$Sn(NO_3)_4 + K_3PO_4 \rightarrow Sn_3(PO_4)_4 + KNO_3$

Then balance by adding the required coefficients:

_____ $Sn(NO_3)_4$ + _____ K_3PO_4 → _____ $Sn_3(PO_4)_4$ + _____ KNO_3

Balance the following:

_Cu + _O2 → _CuO

2Cu + _O2 → 2CuO

1) _____ Li + _____ Cl_2 → _____ LiCl

2) _____ NaI + _____ $AlCl_3$ → _____ NaCl + _____ AlI_3

3) _____ CH_4 + _____ O_2 → _____ CO_2 + _____ H_2O

4) _____ MgO → _____ Mg + _____ O_2

5) _____ NaN_3 → _____ Na + _____ N_2

6) _____ $Mg(ClO_4)$ + _____ Na → _____ $NaClO_4$ + _____ Mg

7) _____ C_3H_8 + _____ O_2 → _____ CO_2 + _____ H_2O

8) _____ H_2O_2 → _____ H_2O + _____ O_2

9) _____ $Se(NO_3)_2$ + _____ Na_2SO_4 → _____ $SeSO_4$ + _____ $NaNO_3$

10) _____ Fe + _____ $CuCl_2$ → _____ Cu + _____ $FeCl_3$

11) Lithium phosphate + magnesium sulphate → lithium sulphate + magnesium phosphate

12) Barium hydroxide + hydrochloric acid → water + barium chloride

13) Copper (II) nitrate + aluminum → copper + aluminum nitrate

14) Sulphur (S_8) + fluorine (F_2) → sulphur hexafluoride

Additional Practice

1) __ C_6H_6 + __ O_2 → __ H_2O + __ CO_2

2) __ NaI + __ $Pb(SO_4)_2$ → __ PbI_4 + __ Na_2SO_4

3) __ NH_3 + __ O_2 → __ NO + __ H_2O

4) __ $Fe(OH)_3$ → __ Fe_2O_3 + __ H_2O

5) __ HNO_3 + __ $Mg(OH)_2$ → __ H_2O + __ $Mg(NO_3)_2$

6) __ H_3PO_4 + __ NaBr → __ HBr + __ Na_3PO_4

7) __ C + __ H_2 → __ C_3H_8

8) __ CaO + __ MnI_4 → __ MnO_2 + __ CaI_2

9) __ Fe_2O_3 + __ H_2O → __ $Fe(OH)_3$

10) __ C_2H_2 + __ H_2 → __ C_2H_6

11) __ VF_5 + __ HI → __ V_2I_{10} + __ HF

12) __ OsO_4 + __ $PtCl_4$ → __ PtO_2 + __ $OsCl_8$

13) __ CF_4 + __ Br_2 → __ CBr_4 + __ F_2

14) __ Hg_2I_2 + __ O_2 → __ Hg_2O + __ I_2

15) __ $Y(NO_3)_2$ + __ $GaPO_4$ → __ YPO_4 + __ $Ga(NO_3)_2$

Lesson 9: Types of Chemical Reactions

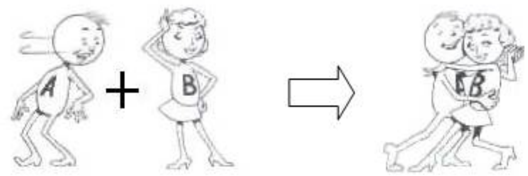
1) Synthesis Reactions

A synthesis reaction is where two or more atoms or molecules combine to form a single larger molecule.

$$A + B \rightarrow AB$$

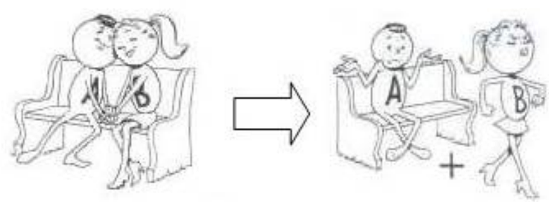
$$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$$

$$2Na_{(s)} + Cl_{2(g)} \rightarrow 2NaCl_{(s)}$$



2) Decomposition Reactions

A decomposition reaction is where a single larger molecule breaks apart to form two or more atoms or molecules.



$$AB \rightarrow A + B$$

$$2H_2O_{(g)} \rightarrow 2H_{2(g)} + O_{2(g)}$$

$$2NaCl_{(s)} \rightarrow 2Na_{(s)} + Cl_{2(g)}$$

3) Combustion Reactions

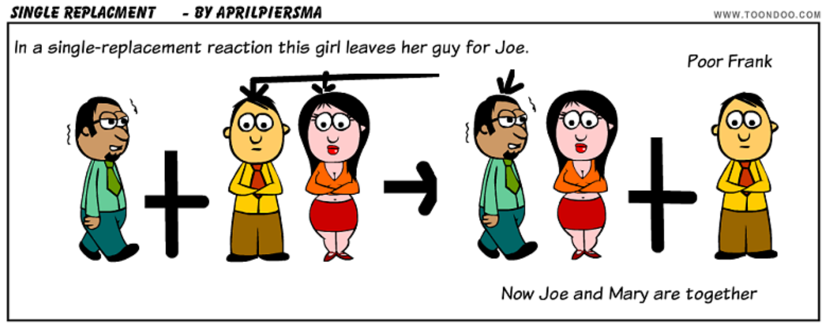
A combustion reaction is where O_2 combines with a hydrocarbon compound to produce CO_2 and H_2O.

$$C_3H_{8(g)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(g)}$$

$$C_6H_{12}O_{6(g)} + 6O_{2(g)} \rightarrow 6CO_{2(g)} + 6H_2O_{(g)}$$

4) Single Replacement Reactions

A single replacement reaction occurs when a single metal or non-metal takes the place of a similar metal or non-metal in a compound.



$$AX + Y \rightarrow AY + X$$

$$ZnF_{2(s)} + K_{(s)} \rightarrow KF_{(s)} + Zn_{(s)}$$

$$CuBr_{2(s)} + Cl_{2(g)} \rightarrow CuCl_{2(s)} + Br_{2(l)}$$

Eg. 1: Predict the products of the following single replacement reactions.

$AgNO_3 + Al \rightarrow$ __________ + ____________

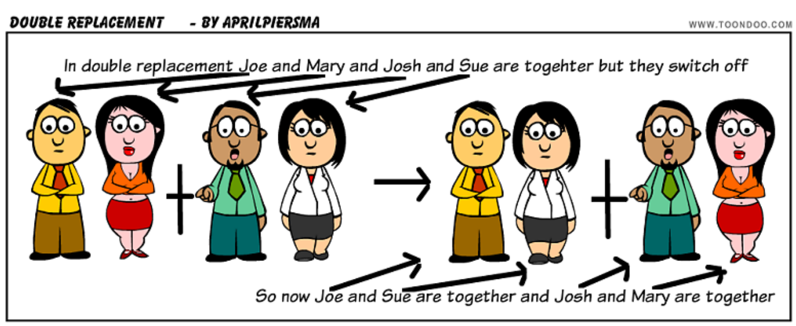
$CaCO_3 + Li \rightarrow$ __________ + ____________

$MgCl_2 + F_2 \rightarrow$ __________ + ____________

$PbBr_2 + Cl_2 \rightarrow$ __________ + ____________

5) Double Replacement Reactions

A double replacement reaction is when the ions on an ionic compound switch places and form two new combinations.



$$AX + BY \rightarrow AY + BX$$

$$Pb(NO_3)_{2(aq)} + MgCl_{2(aq)} \rightarrow PbCl_{2(aq)} + Mg(NO_3)_{2(aq)}$$

$$CuBr_{2(aq)} + KCl_{(aq)} \rightarrow CuCl_{2(aq)} + KBr_{(aq)}$$

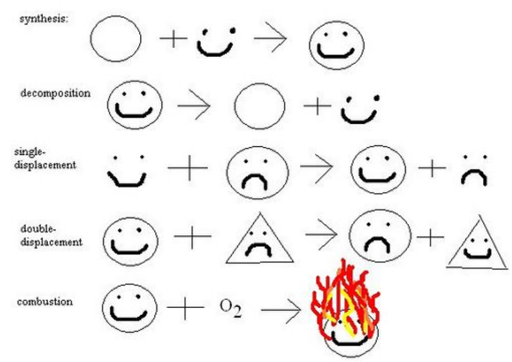
Eg. 2: Predict the products of the following double replacement reactions.

$AgNO_3 + KCl \rightarrow$ __________ + __________

$(NH_4)_2CO_3 + SrSO_4 \rightarrow$ __________ + __________

$SrBr_2 + MgSO_4 \rightarrow$ __________ + __________

$Cs_3PO_4 + Sr(OH)_2 \rightarrow$ __________ + __________

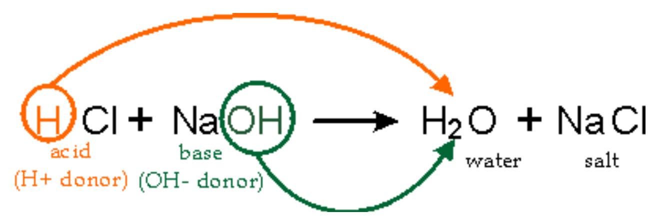


6) Acid Base Neutralization Reactions

An acid and a base react together to form a salt and water. Acids are compounds that start with H and release H^+ ions into the water. Bases are compounds that end with OH^-

$HY + XOH \rightarrow H_2O + XY$

$HCl + NaOH \rightarrow H_2O + NaCl$



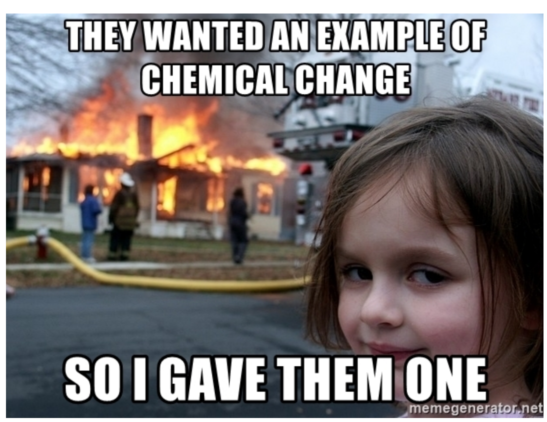
Eg. 3: Predict the products of the following acid base reactions.

$HCl + Sr(OH)_2 \rightarrow$ __________ + __________

$H_2SO_4 + LiOH \rightarrow$ __________ + __________

$H_3PO_4 + Ca(OH)_2 \rightarrow$ __________ + __________

$HF + Al(OH)_3 \rightarrow$ __________ + __________



Additional Practice: Identify the reaction type, then predict the products and balance the equations.

a. Combustion:	___C_6H_{12}	+	___O_2	$\rightarrow$
b. Combustion:	___C_4H_6	+	___O_2	$\rightarrow$
c. Combustion:	___$C_6H_{10}O_3$	+	___O_2	$\rightarrow$
1. Synthesis:	___Mg	+	___I_2	$\rightarrow$
2. Double replacement:	___$CuCl_2$	+	___H_2S	$\rightarrow$
3. Double replacement:	___NaOH	+	___$HClO_4$	$\rightarrow$
4. Decomposition:	___$CaCO_3$	$\rightarrow$		
5. Single replacement:	___HCl	+	___Zn	$\rightarrow$
6. ______________	___Na	+	___$MgCl_2$	$\rightarrow$
7. ______________	___$CaCl_2$	+	___K_2CO_3	$\rightarrow$
8. ______________	___K	+	___Cl_2	$\rightarrow$
9. ______________	___$BaCl_2$	+	___K_3PO_4	$\rightarrow$
10. ______________	___H_2SO_4	+	___KOH	$\rightarrow$
11. ______________	___$KClO_3$ $\rightarrow$			
12. ______________	___Al	+	___O_2	$\rightarrow$
13. ______________	___$Pb(NO_3)_2$	+	___KOH	$\rightarrow$
14. ______________	___H_2SO_4	+	___$BaCl_2$	$\rightarrow$

15. ______________	___Ca	+	___$AgCl \rightarrow$	
16. ______________	___H_3PO_4	+	___$FeBr_3$	$\rightarrow$
17. ______________	___Li	+	___N_2 $\rightarrow$	
18. ______________	___HCl	+	___$Mg(OH)_2$ $\rightarrow$	
19. ______________	___$Ag_2O \rightarrow$			
20. ______________	___$Al_2O_3 \rightarrow$			

Predicting Products Possible Quiz

For each of the following reactions, identify what type of reaction each is and then determine what the products of each will be. When you have predicted the products, balance the equation

Type:_____ 1) ___ C_8H_{18} + ___ $O_2 \rightarrow$

Type:_____ 2) ___ $Pb(NO_3)_2$ + ___ $K_2CrO_4 \rightarrow$

Type:_____ 3) ___ H_2 + ___ $S_8 \rightarrow$

Type:_____ 4) ___ $Cu(OH)_2$ + ___ $H_3PO_4 \rightarrow$

Type:_____ 5) ___ $AgNO_3$ + ___ $Na_2CO_3 \rightarrow$

Type:_____ 6) ___ Zn + ___ $CuCO_3 \rightarrow$

Type:_____ 7) ___ $NaCl \rightarrow$

Lesson 10: Acids and Bases

Definitions of Acid & Base

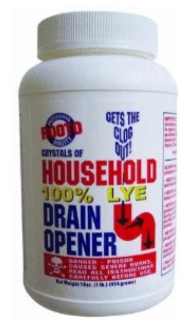
Acids and bases are very common. Acids are compounds whose formulae start with a H and when dissolved in water they produce H^{+1} ions.

Some common acids include HCl, HNO_3, H_2SO_4, H_3PO_4

Acids are found in many cleaning products, car batteries, and in soft drinks.

Bases are compounds whose formulae end in OH and when dissolved in water will produce OH^{-1} ions.

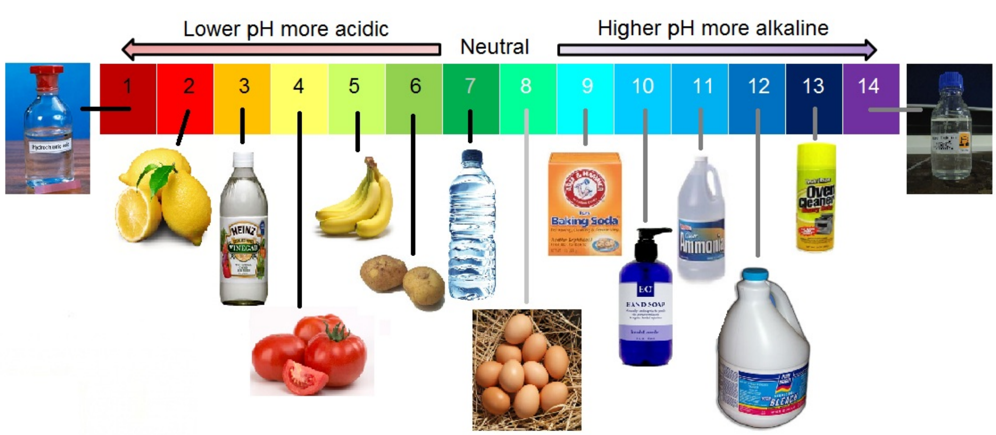
Some common bases include $NaOH$, $Ca(OH)_2$, NH_4OH



Bases are ingredients in oven and drain cleaner, antacids and laxatives. They are also used in the manufacture of soaps.

The pH scale

The pH scale is used to measure the relative amounts of acid or base in a solution. When the pH is 7 the solution is neutral.

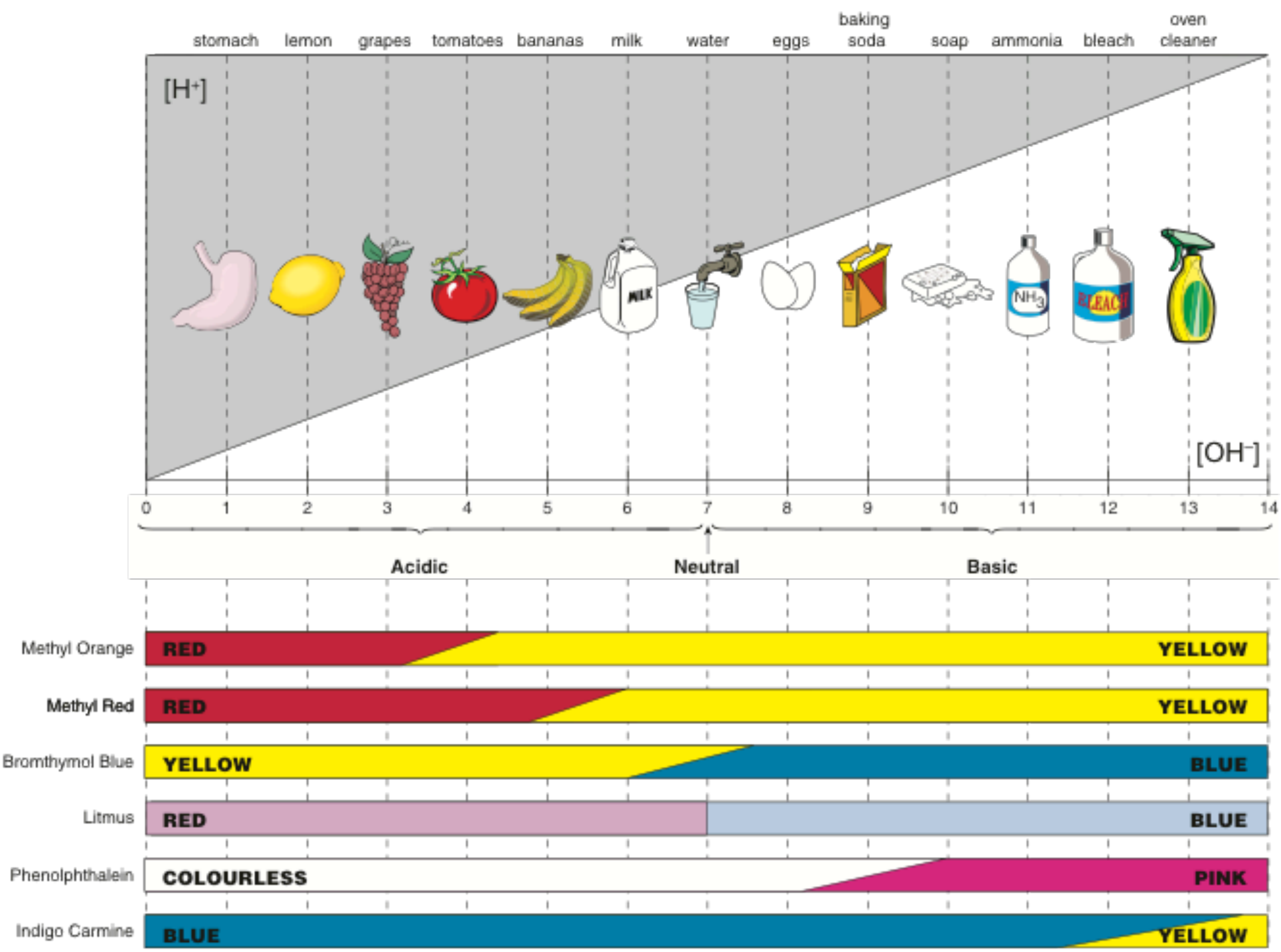


The pH scale is mathematically like the Richter scale for measuring the magnitude of earthquakes. For instance, a solution that has a pH of 3 is 10 times as acidic as a solution with a pH of 4. A solution that has a ph of 12 is 1000 times as basic as a solution that has a ph of 9.

Acid Base Indicators

An acid base indicator is a chemical that changes colour in the presence of acid or base, thus making it easy to see if a solution is acidic or basic.

Different indicators will change colour at different parts of the pH scale. This can be useful to estimate the exact pH of a solution.

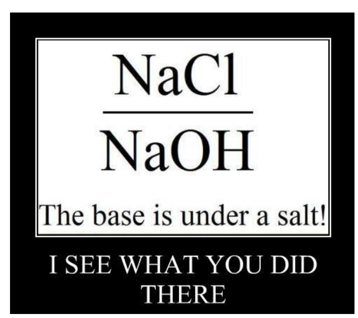


Properties of acids and Bases

Property	Acid	Base
Taste CAUTION: Never taste chemicals in the laboratory.	• Acids taste sour. Lemons, limes, and vinegar are common examples.	• Bases taste bitter. The quinine in tonic water is one example.
Touch CAUTION: Never touch chemicals in the laboratory with your bare skin.	• Many acids will burn your skin. Sulfuric acid (battery acid) is one example.	• Bases feel slippery. • Many bases will burn your skin. Sodium hydroxide (lye) is one example.
Indicator tests	• Acids turn blue litmus paper red. • Phenolphthalein is colourless in an acidic solution.	• Bases turn red litmus blue. • Phenolphthalein is colourless in slightly basic solutions and pink in moderate to strongly basic solutions.
Reaction with some metals, such as magnesium or zinc	• Acids corrode metals.	• No reaction
Electrical conductivity	• Conductive	• Conductive
pH	• Less than 7	• More than 7
Production of ions	• Acids form hydrogen (H^+) ions when dissolved in solution.	• Bases form hydroxide (OH^-) ions when dissolved in solution.

Metals from the Alkali metal and Alkaline Earth metal families will react with acids to produce hydrogen gas, $H_{2(g)}$.

Acids react with compounds that contain the carbonate ion to produce water and carbon dioxide.



Lesson 11: Organic Compounds

What does organic mean?

In chemistry an organic compound is one that is made of primarily carbon, hydrogen, oxygen and possibly a few other elements.

Carbon forms four strong covalent bonds with other carbon atoms to create large molecules that are the building blocks of all living things, plastics, medicines and fuels.

Hydrocarbons

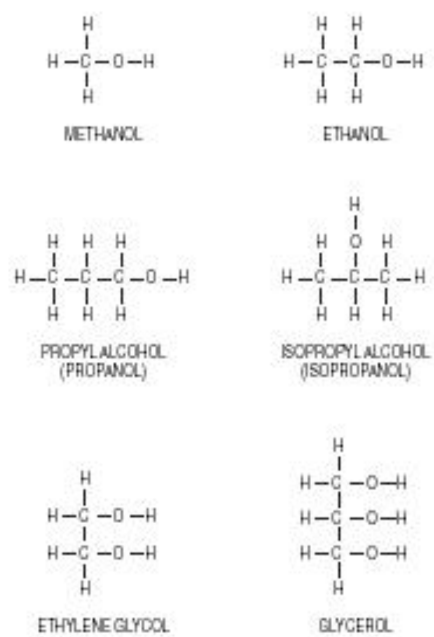
Hydrocarbons contain only carbon and hydrogen. An example is methane (CH_4) and ethane (C_2H_6) which together are the components of natural gas.

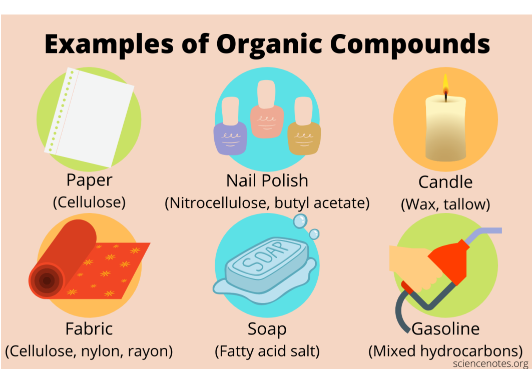
All hydrocarbons are combustible, with the smallest molecules being gasses at room temperature. Medium sized molecules are liquids and large molecules are solids.

Propane (C_3H_8) gas	Octane (C_8H_{18}) liquid	Paraffin wax ($C_{31}H_{64}$) solid

Alcohols

Alcohols are an example of a hydrocarbon that contains an oxygen atom.





Lesson 12: Factors Affecting the Rate of Chemical Reactions

Controlling the rate of a chemical reaction is vital to chemistry. There are several factors that affect the rate of chemical reactions.

1) Temperature

Temperature is a measure of the average speed or kinetic energy of molecules.

The faster (or hotter) that molecules are, the faster they will react. The colder a reaction is the slower it will react.

Putting food in a fridge slows the chemical reactions that spoil food, extending the safe lifespan of food.

2) Concentration

Concentration is a measure of how much of a chemical is present in a given volume. Concentration can be measured in grams per liter. (g/L)

Increasing the concentration increases the rate of the reaction and vice versa.

Natural gas will not explode if the concentration of oxygen gas is less than 12%. Most things burn due to the relatively high percentage of O_2 in the atmosphere (21%)

In World War II American aircraft carriers routinely purged their aircraft refueling lines with CO_2 so that in the event of enemy fire the aircraft fuel being carried would not explode. The Imperial Japanese aircraft carriers did not employ this technique and when attacked exploded and were more easily destroyed.

3) Surface Area

Chemical reactions occur when reactant molecules come into contact through collisions. Increasing the surface area will increase the rate of the reaction.

Surface area can be increased by chopping the reactant into small pieces or by grinding it into a powder.

Some examples of this principle include:

- Fuel injectors spray gas into the combustion chamber of an engine as a fine mist to speed the rate at which it burns as well as to help it burn evenly.
- It's easier to start a fire with kindling as it has a greater surface area.
- Flour will burn poorly but finely ground flour dispersed in air can burn very quickly.

4) Catalysts

A Catalyst is a chemical that that allows a reaction to proceed faster but is not consumed in the reaction.

Catalysts will lower the amount of energy required to break the bonds of reactant molecules.

Some examples of catalysts include:

- Biological catalysts are called enzymes. Saliva has enzymes that start the digestion of starches into sugars
- Automobiles have catalysts that convert harmful products of combustion into less harmful compounds.
- Platinum metal act as a catalyst in many reactions involving organic compounds.

A catalytic converter is a device installed in cars to decrease pollution.
Car exhaust passes through the catalytic converter before leaving the car.

Catalysts found in the honeycomb-shaped filters in the converter help to change many of the pollutants into less harmful substances.

- Poisonous carbon monoxide is changed into CO_2.
- Hydrocarbons are converted into CO_2 and H_2O.
- Nitrogen oxides are changed into N_2 and O_2.
  eg. $2N_2O_3 \rightarrow 2N_2 + 3O_2$