The Inorganic That You Don't Need to Know

Redox:

- Equation balanced
  - Calculate the oxidation number of each elements and ions
  - Calculate the number of electron transfer based on the change in oxidizing number and use this as the ratio for the calculation
  - Then balanced all the rest of equation number
  - For disproportion noticed that there must be a pair of change – to increase must be balanced by decrease in oxidizing number
- Reaction of Halide with conc. H_2SO_4

Reaction	Formula	Observation
Cl^-	H_2SO_4 + NaCl -> $NaHSO_4$ + HCl	Steamy fumes(HCl)
Br^-	H_2SO_4 + NaBr -> $NaHSO_4$ + HBr HBr + H_2SO_4 -> Br_2+SO_2+H_2O	Steamy fumes(HBr) Orange Brown Vapor(Br_2)
I^-	H_2SO_4 + NaI -> $NaHSO_4$ + HI AND 8HI + H_2SO_4 ->4I_2 + H_2S +4H_2O OR 6HI + H_2SO_4 -> 3I_2 + S+4H_2O	Purple vapor(I_2) Foul smell(H_2S) Yellow solid(S)

This is because X- are strong reducing agent and they have the ability to reduced others (S in this case)

This power increases down the group, therefore the S gets more and more reduced (from +6 -> +4 ->-2/0)

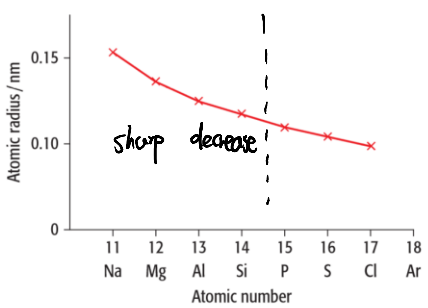
This could happen also because H_2SO_4 is a strong oxidizing agent, and that was not possible with non-oxidizing acid like H_3PO_4

The overall formula can be produced by adding the separate formula with equilibrium balanced

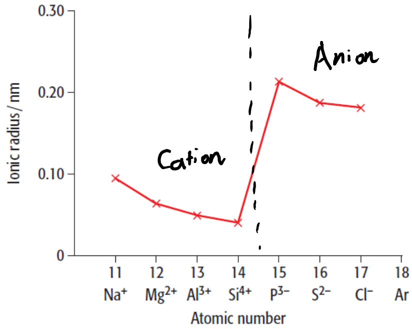
Period 3/Precocity:

- Physical properties
  - Atomic radius/Ionic radius

Atomic radius



Ionic radius

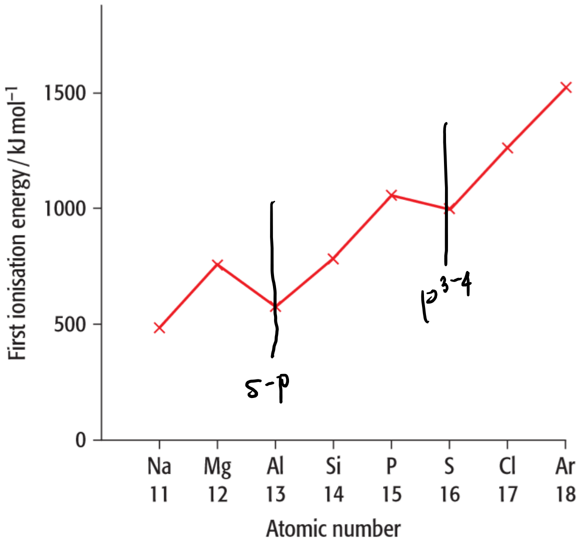


- Factor affecting atomic radius
  1. The number of shells of electron
  2. The effective nuclear charge cause by the shielding effect of the inner electron shell
  3. The attraction because of the nucleus charge

  You can answer by the form of argument like this:
  the increase attraction of the nucleus charge out weight the increase of distance between the nucleus and electron, since the shielding effect from the nucleus is constant so the atomic radius decrease
- Factor affecting ionic radius
  1. The charge of the ions(+/-)
  2. The effective nucleus charge
  3. The number of electron gain/loss

  If the electron loss electron, then the more it loss, the stronger the effective nucleus charge is and thus results in the smaller ionic radius
  If the electron gain electron, then the more it gain, the stronger the repusion between the electron it will be, and thus results in the larger ionic radius

■ First ionization energy

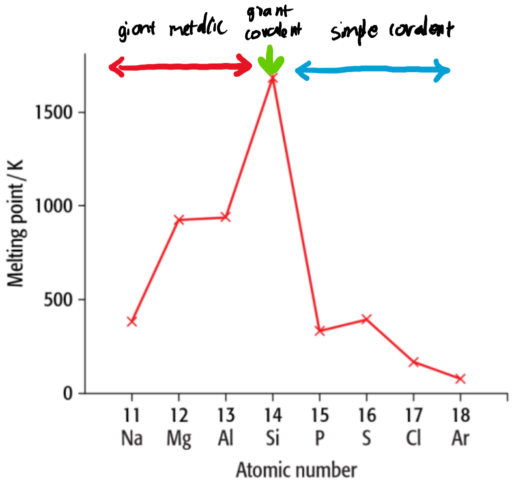


- Factor affecting the first ionization energy:
  1. Charge of the nucleus
  2. Distance between nucleus and the electron
  3. Shielding effect from the inner shell of electron
  4. Spin-pair repulsion[if applicable]

  You can answer by the form of argument like this:
  - the increase of the nucleus charge is out weight the increase in the distance between nucleus and electron, and the electron shells is constant, so the first ionization energy increase
  - for the decrease at p orbit: the electron shell increase from s to p therefore have higher shielding effect and distance, slightly reduce the first ionization energy

- for the decrease at p^{3-4}: the 3p orbital are all occupied by single electron at p3, and the addition of electron results in an electron pair which leads to the Spain pair repulsion and decrease the first ionization energy

■ M.P./B.P.



◆ The m.p. and b.p. are strongly related into the structure of elements

Elements	structure	Details of structure	Bond	IMF
Na	Gigantic metallic	Lattice	Metallic	Ionic
Mg	Gigantic metallic	Lattice	Metallic	Ionic
Al	Gigantic metallic	Lattice	Metallic	Ionic
Si	Gigantic covalent	lattice	Covalent	Covalent
P	Simple molecule	Red P_4(tetratomic)	Covalent	Van der Waals'
S	Simple molecule	Yellow S_8(Octaineatomic)	Covalent	Van der Waals'
Cl	Simple molecule	Green Cl_2(diatomic)	Covalent	Van der Waals'
Ar	Simple molecule	Ar(noble gas)	-	Van der Waals'

◆ The increase in m.p. in metallic is related

1. Higher charge density
2. More electron

These leads to stronger metallic bond

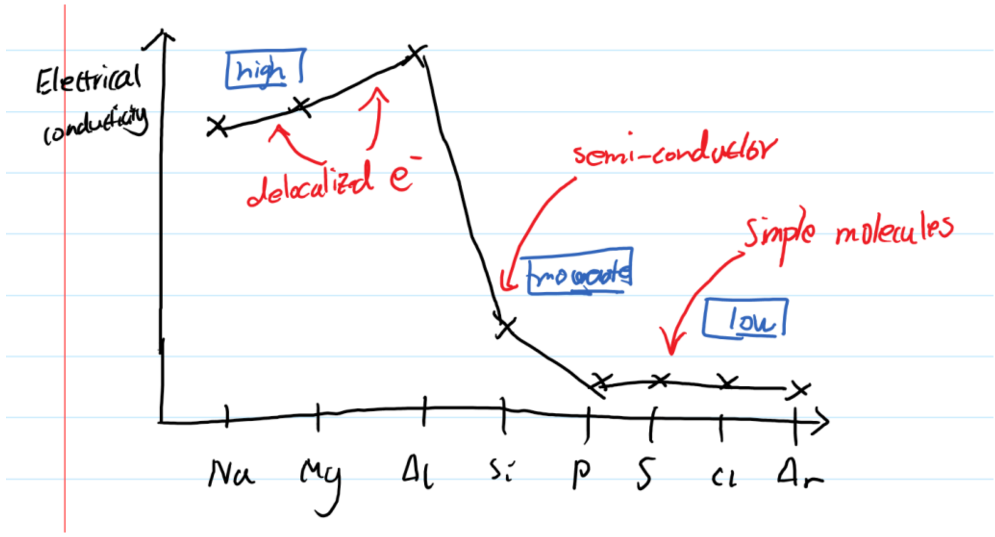
◆ The strongest m.p. in Si is related

1. Strong covalent bond in giant structure
2. Must break all if need to melt

◆ The variation in the rest is related to IMF

IMF is related to the number of electron and the size of molecules, which is directly related to the structure of the molecules

- Electroconductivity



- Electroconductivity is depends on the structure of the elements:
  - Na/Mg/Al are metallic ions with 'seas' of electron therefore have delocalized electron and is the strong conductor
  - Si is the gigantic covalent therefore be the semiconductor (although not strong as graphite)
  - All the rest are simple molecule and are insulator
- Chemical properties
  - Reaction with oxygen

Element	Observation	Formula
Na	Orange-yellow flame White product	$4Na + O_2 \rightarrow 2Na_2O$ (sodium oxide) $2Na + O_2 \rightarrow Na_2O_2$ (sodium peroxide)
Mg	Bright white flame White product	$2Mg + O_2 \rightarrow 2MgO$
Al	White flame White product/smoke	$4Al + 3O_2 \rightarrow 2Al_2O_3$
Si	Slowly burns when heat strongly White flame	$Si + O_2 \rightarrow SiO_2$
P	Yellow flame White smoke	$P_4 + 3O_2 \rightarrow P_4O_6$ $P_4 + 5O_2 \rightarrow P_4O_{10}$ (in excess oxygen)
S	Blue flame Colorless gas	$S + O_2 \rightarrow SO_2$
Cl	Does not react directly	-

  - Reaction with chlorine

Element	Observation	Formula
Na	Bright orange flame White product	$2Na + Cl_2$ -> $2NaCl$
Mg	Bright white flame White product	$Mg + Cl_2$ -> $MgCl_2$
Al	yellow flame pale yellow product	$4Al + 3Cl_2$ -> $2Al_2Cl_3$ (Sublime)
Si	Slowly react when passed with chlorine gas Colorless liquid	$Si + 2Cl_2$ -> $SiCl_4$
P	Yellow flame Mixtures of chlorides	$P_4 + 6Cl_2$ -> $4PCl_3$ $P_4 + 10Cl_2$ -> PCl_5
S [Does not include in syllabus]	Slowly react when passed with chlorine gas Orange liquid	$2S + Cl_2$ -> S_2Cl_2
Cl	No reaction	-

- Reaction with water
  - Sodium
    $Na + H_2O$ ->$NaOH + H_2$
  - Magnesium
    In cold water: $Mg + 2H_2O$ ->$Mg(OH)_2 + H_2$ (Slowly)
    In steam: $Mg + H_2O$ -> $MgO + H_2$ (Vigrously)
- Reaction of oxides with water

Element	Oxidation number	Structure	Observation	pH	Formula
Na	+1	Ionic	Dissolve exothermically	14	Na2O + H2O -> 2NaOH
Mg	+2	Ionic	Slight reaction	9	$MgO + 2H_2O$ -> $Mg(OH)_2 + H_2$
Al	+3	Giant Ionic with covalent	No reaction	-	-
Si	+4	Giant covalent	No reaction	-	-
P	+3 +5	Simple molecules	P_4O_6 reacts with cold water P_4O_{10} reacts violently	1-2 (phosphoric acid)	$P_4O_6 + 6H_2O$ -> $4H_3PO_3$ $P_4O_{10} + 6H_2O$ -> $4H_3PO_4$
S	+4 +6	Simple molecules	SO_2 dissolve readily SO_3 dissolve violently	1 0	$SO_2 + H_2O$ -> H_2SO_3 $SO_3 + H_2O$ -> H_2SO_4
Cl	+1 +4 +7	-	Does not react with water	-	-

- Amphoteric nature of Al_2O_3
  - It is a giant ionic with covalent characters so both basic and acidic behavior can be observed
  - With Acid: $Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + 3H_2O$
  - With Alkaline: $Al_2O_3 + 2NaOH + 3H_2O \rightarrow NaAl(OH)_4$ / ($Na^+ + Al(OH)_4^-$)
- Reaction of chloride

Element	structure	Oxidation number	Observation	pH	Formula
Na	Giant Ionic	+1	Dissolve	7	$NaCl \rightarrow Na^+ + Cl^-$
Mg	Giant Ionic with covalent	+2	Dissolve	6.5	$MgCl \rightarrow Mg^+ + Cl^-$
Al	Simple molecule with ionic	+3	Hydrolyses In droplet steamy fume might appeared	3	$AlCl_3 + 6H_2O \rightarrow [Al(H_2O)_6(OH)]^{2+} + H^+ + 3Cl^-$
Si	Simple molecule	+4	Hydrolyses	1-2	$SiCl_4 + 2H_2O \rightarrow SiO_2 + 4HCl$
P	Simple molecule	+3 +5	Hydrolyses	1-2	$PCl_3 + 3H_2O \rightarrow H_3PO_4 + HCl$
S [Not demand in syllabus]	Simple molecule	+1 +2 +4	Hydrolyses	1-2	$S_2Cl_2 + H_2O \rightarrow SO_2 + 4HCl + 3S$
Cl	-	-	No reaction	-	-

- An ionic chloride dissolve in H2O
  - The pH depends on the polarizing effect when if form complex in water
- Covalent Chlorides + H2O -> Acidic(steamy fume) – hydrolysis to produce HCl
  - Consider adding water to each side of the molecules and break them down(add Chlorine with H and other side with OH)
  - Then go for the most stable compound(SiO2, H_3PO_4)
  - Finally balanced the equation

Group 2(Alkaline Earth Metal):

- Physical Properties:
  - Atomic Radius: increase from up to down

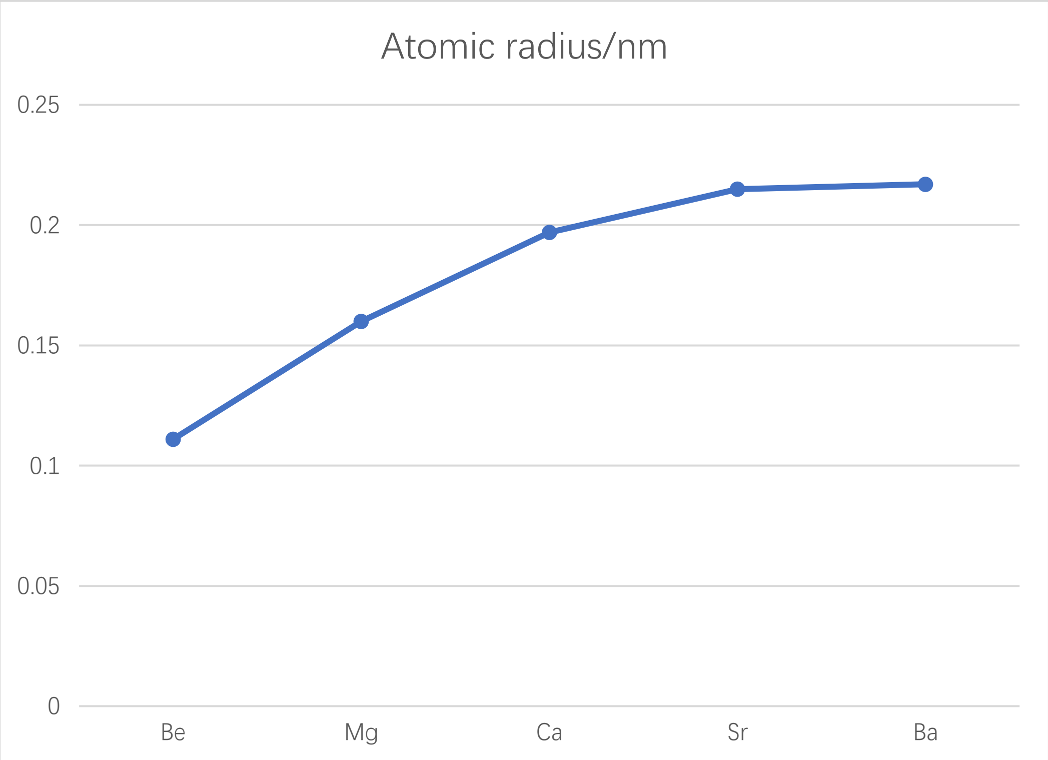
  the atomic radius increase could be explain by following factor:

  1. The number of shells of electron
  2. The effective nuclear charge cause by the shielding effect of the inner electron shell
  3. The attraction because of the nucleus charge

  You can answer by the form of argument like this:

  the increase attraction of the nucleus charge is out weight by the increase of shielding effect from the inner shell of electron, thus leading to the decrease of effective nuclear charge, and because the increase in the distance between nucleus and electron, so the atomic radius increase

	Be	Mg	Ca	Sr	Ba
Atomic radius/nm	0.111	0.160	0.197	0.215	0.217



■ Ionization Energy: decrease from up to down

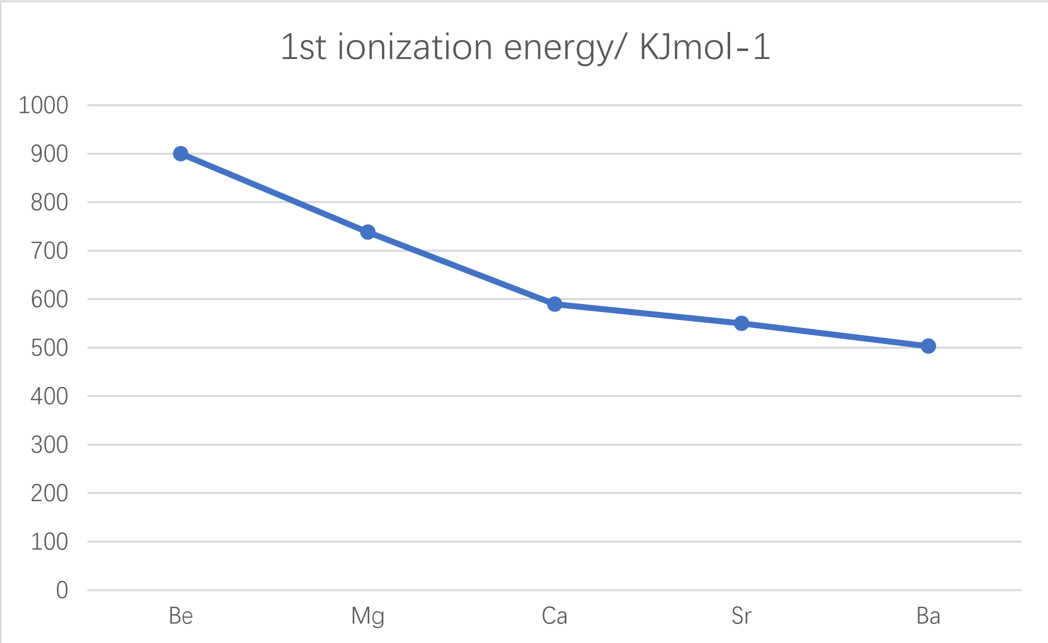
The decrease of ionization energy could be explain by the following factor:

1. Charge of the nucleus
2. Distance between nucleus and the electron
3. Shielding effect from the inner shell of electron

You can answer by the form of argument like this:

the increase of the nucleus charge is out weight by the increase of shielding effect from the inner shell of electron and the increase in the distance between nucleus and electron, so the first ionization energy decrease

	Be	Mg	Ca	Sr	Ba
1^{st} ionization energy/ $KJmol^{-1}$	900	738	590	550	503



■ Electronegativity: decrease from up to down

Electronegativity is the ability for an atom to attract the electron.

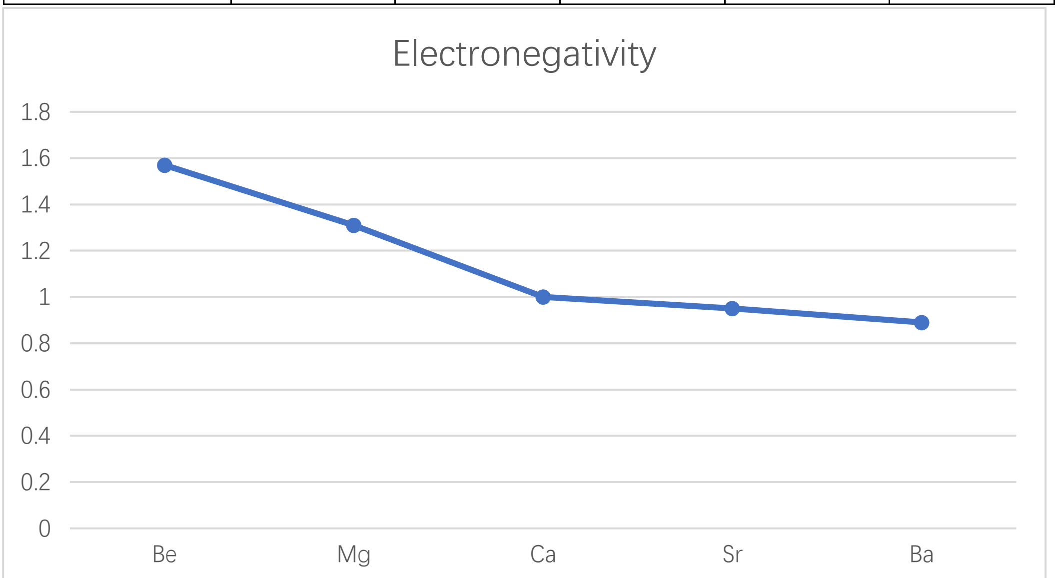
Electronegativity is explain by the following factor:

1. The size of the atom(atomic radius)
2. The attraction from the nucleus because

You can answer by the form of argument like this:

As the atomic radius increase the bonding pair is further away from the electron so the attraction for it is weaker, therefore the electronegativity decrease

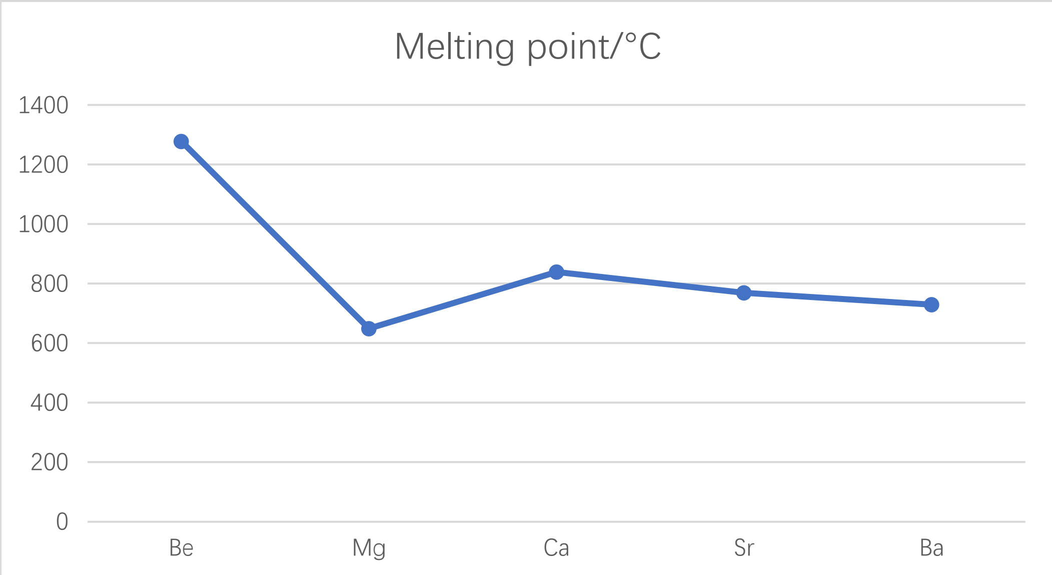
	Be	Mg	Ca	Sr	Ba
Electronegativity	1.57	1.31	1.00	0.95	0.89



■ Melting Point: decrease from up to down[Except for **Mg** which has an unusual low m.p.]

	Be	Mg	Ca	Sr	Ba
Melting	1278	649	839	769	729

point/°C					



- Chemical Properties
  - General properties
    - Reactive metals
    - Outer shell electron configuration ns^2
    - Only one oxidation state of +2
    - Strong reducing agent
  - Reaction with oxygen

Element	Observation	Formula	acidity
Be	Reluctant to burn, white flame	2Be + O2 ->2BeO	amphoteric
Mg	Burns easily with a bright white flame	2Mg+O2 ->2MgO	Basic
Ca	Difficult to ignite, flame tinged red	2Ca + O2 ->2CaO	Basic
Sr	Difficult to ignite, flame tinged red	2Sr + O2 ->2SrO Sr + O2 ->SrO_2 Notice Peroxide also formed	Basic
Ba	Difficult to ignied, flame tinged green	2Ba + O2 -> 2BaO Ba + O2 ->BaO_2 Notice Peroxide also formed	Basic

  - Reaction with water

Element	Observation	Formula	acidity
Be	No reaction	-	-
Mg	Reacts vigorously	Mg+$2H_2O$	Weak alkaline

	with steam but very slowly with water	->$Mg(OH)_2$ + H_2	pH 9-11
Ca	Reacts moderately forming the hydroxide	$Ca+2H_2O$ ->$Ca(OH)_2$ + H_2	Weak alkaline pH = 11
Sr	Reacts rapidly forming the hydroxide	$Sr+2H_2O$ ->$Sr(OH)_2$ + H_2	Alkaline pH =13
Ba	React vigorously forming the hydroxide	$Ba+2H_2O$ ->$Ba(OH)_2$ + H_2	Strong alkaline pH = 14

- Reaction with dilute acid

Element	Observation	Formula	acidity
Be	Reacts rapidly	Be+2HCl ->$BeCl_2$ + H_2	neutral
Mg	Reacts vigorously	Mg+2HCl ->$MgCl_2$ + H_2	neutral
Ca	Reacts vigorously	Ca+2HCl ->$CaCl_2$ + H_2	neutral
Sr	Reacts violently	Sr+2HCl ->$SrCl_2$ + H_2	neutral
Ba	React violently	Ba+2HCl ->$BaCl_2$ + H_2	neutral

- All group 2 metal reacts with dilute HCl or HNO_3, and it gets more vigorous down the group
- If H_2SO_4 is used, the reaction still happened, but since sulphate solubility decrease down the group, you will get white precipitate starting from Ca/Sr/Ba
- If the concentration of HNO_3 increase, then in moderate level it tends to give nitrogen oxide, and in concentrated level it tends to give nitrogen dioxide

- Reaction of oxides

Compound	Reaction with water	Reaction with dilute acids
BeO	No reaction	BeO+2HCl ->$BeCl_2$ + $2H_2O$
MgO	Apparently no change of the solid, pH of mixture is 9	$Mg(OH)_2$+2HCl ->$MgCl_2$ + $2H_2O$
CaO	Exothermic reaction, produce slightly soluble slaked lime, pH of the mixture is 12	CaO+2HCl ->$CaCl_2$ + $2H_2O$
SrO	Produce a colorless solution of pH 14	SrO+2HCl ->$SrCl_2$ + $2H_2O$
BaO	Produce a colorless solution of pH 14	BaO+2HCl ->$BaCl_2$ + $2H_2O$

- All group 2 oxides react with water in the general formula to give hydroxides $MO + H_2O \rightarrow M(OH)_2$
- For the reaction with HCl and HNO_3 all compound can react to form salts and water, but for H_2SO_4 the situation is complex as $SrSO_4$ and $BaSO_4$ are insoluble white percipitate

■ Reaction of hydroxides

Compound	Reaction with dilute acids
$Be(OH)_2$	$Be(OH)_2+2HCl \rightarrow BeCl_2 + 2H_2O$
$Mg(OH)_2$	$Mg(OH)_2+2HCl \rightarrow MgCl_2 + 2H_2O$
$Ca(OH)_2$	$Ca(OH)_2+2HCl \rightarrow CaCl_2 + 2H_2O$
$Sr(OH)_2$	$Sr(OH)_2+2HCl \rightarrow SrCl_2 + 2H_2O$
$Ba(OH)_2$	$Ba(OH)_2+2HCl \rightarrow BaCl_2 + 2H_2O$

- This is the typical reaction of acid – base reaction

■ Reaction of carbonates

Compound	Reaction with water	Reaction with dilute acids
$BeCO_3$	Insoluble in water	$BeCO_3 + 2HCl \rightarrow BeCl_2 + CO_2 + H_2O$
$MgCO_3$	Insoluble in water	$MgCO_3 + 2HCl \rightarrow MgCl_2 + CO_2 + H_2O$
$CaCO_3$	Insoluble in water	$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$
$SrCO_3$	Insoluble in water	$SrCO_3 + 2HCl \rightarrow SrCl_2 + CO_2 + H_2O$
$BaCO_3$	Insoluble in water	$BaCO_3 + 2HCl \rightarrow BaCl_2 + CO_2 + H_2O$

- All group 2 carbonates are insoluble in water
- They all react with dilute acids to give salts, water and carbon dioxide
- Because the decrease solubility of $SrSO_4$ and $BaSO_4$, they will prevent the reaction goes much further when react with H_2SO_4

■ Thermal decomposition of nitrates and carbonates

- The thermal stability of the compound is related to the ability for the cation to polarize the anion and results in the formation of oxides. The cation up the group is smaller, having a higher charge density, therefore have stronger polarizing effect and less thermal stability (this is not requiring by AS level)
- Nitrates

Element	Formula
Be	$2Be(NO_3)_2 \rightarrow 2BeO + 4NO_2 + O_2$
Mg	$2Mg(NO_3)_2 \rightarrow 2MgO + 4NO_2 + O_2$
Ca	$2Ca(NO_3)_2 \rightarrow 2CaO + 4NO_2 + O_2$
Sr	$2Sr(NO_3)_2 \rightarrow 2SrO + 4NO_2 + O_2$
Ba	$2Ba(NO_3)_2 \rightarrow 2BaO + 4NO_2 + O_2$

  - The thermal stability increases down the group, and the reaction gives out NO_2 as brown gas
  - Mg and Ca may form water crystal therefore dissolve into a colorless

solution before decomposing

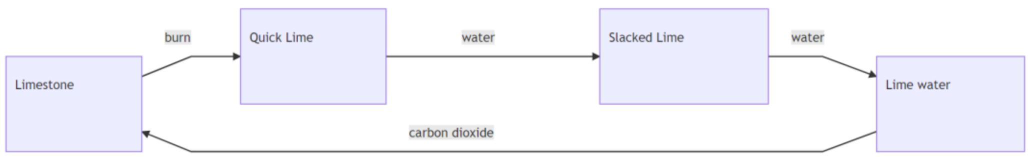
- Carbonates

Element	Formula
Be	$BeCO_3$ ->BeO + CO_2
Mg	$MgCO_3$ ->MgO + CO_2
Ca	$CaCO_3$ ->CaO + CO_2
Sr	$SrCO_3$ ->SrO + CO_2
Ba	$BaCO_3$ ->BaO + CO_2

- The thermal stability increase down the group

- Solubility of hydroxides and sulfates
  - They only demand the statement without explain because there is no simple explanation for it in AS level
  - The solubility for hydroxides increase down the group
  - The solubility for sulfates decrease down the group

- Application
  - Ca
    - Conversion between limes

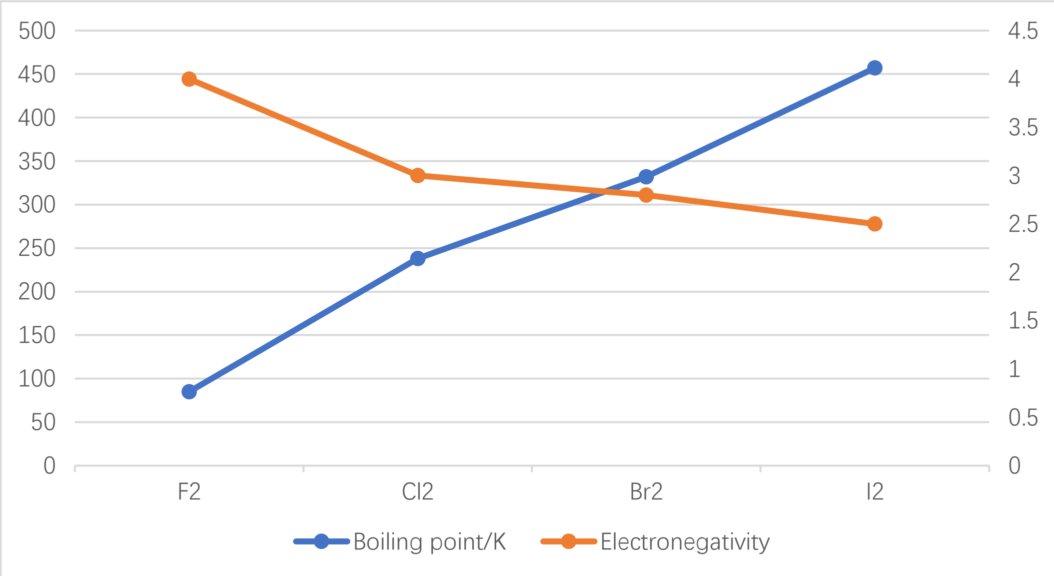


    - Lime(calcium carbonate) is used to make concrete by forming quick lime(Calium oxide) and marble(also calcium carbonate) is use as building material
      CaCO3 –(heat in rotating lime kilin)->CaO + CO_2
    - Slacked lime(calcium hydroxide) are used to increase the soil pH by neutralizing the acid(all of the lime can do it)
      $Ca(OH)_2$+2HCl ->$CaCl_2$ + $2H_2O$ -
  - Mg
    - MgO is used to make blast furnace lining because it is thermal insulator and has high mp(it is not acidic)
    - $Mg(OH)_2$ is used in toothpaste and indigestion tablets as anti-acid
      $Mg(OH)_2 + 2H^+ \rightarrow Mg^{2+} + 2H_2O$

Group 17(Halogen):

- Physical Properties

Element	Color	Boiling point/K	Electronegativity
F_2	Pale-yellow gas	85	4.0(strongest)
Cl_2	Yellow green gas	238	3.0
Br_2	Dark red liquid	332	2.8
I_2	Dark gray solid/ Purple Vapour	457	2.5



- The color intensity increases down the group
- The volatility decrease down the group

  1. Halogen are diatomic simple molecule
  2. Main IMF is Van der Vaal's force
  3. As the atomic size increase and electron number increase, the Van der Waal's force increase

- The electronegativity decrease down the group
  - As the atomic radius increase the bonding pair is further away from the electron so the attraction for it is weaker, therefore the electronegativity decrease

- Chemical Properties:
  - General properties
    - The reactivity decrease down the group because the electron are further apart from the nucleus, having more shielding effect therefore are less attractive for electrons
    - Halogens - diatomic molecules
    - Halogens elements are strong Oxidizing agent
    - Outer shell electron configuration = ns_2p_5
  - Elements
    - Reactions with hydrogen

Element	Observation	Formula
F	Explode under all condition (even at ~50K)	$F_2 + H_2 \rightarrow 2HF$
Cl	Explode under sunlight/bright light	$Cl_2 + H_2 \rightarrow 2HCl$
Br	Slow reaction, only happen on heating around ~400K	$Br_2 + H_2 \rightarrow 2HBr$
I	**Incomplete** reaction under heating around 1000K/platinum catalyst	$I_2 + H_2 \xleftrightarrow{reversible} 2HI$

	presents	

- Comparison between the reactions:
  - Extent of reaction decrease
  - Enthalpy change increase
  - The decrease in the extent of reaction is because of:
    1. The bond length increase down the group in X-X bond, therefore the activation energy decrease (F-F is special case because the distance between atoms is too small and the repulsion in electron is helping to break the bond)
    2. H-X bond length decrease down the group, the longer the bond length is the less energy it require to release to form, and this outweigh the energy require to break the bond(it is much more significant compare with the activation energy)

- Reaction of Halides
  - Except H-F, all of the halides are strong acids and can complete ionized
    - H-F can not complete ionized because of the strong bond energy of it
  - Thermal stability
    - the thermal stability decrease down the group: H-F is most stable and HI is least stable
    - This is because the bond energy of H-F is highest and H-I is lowest because H-F has shortest bond length and require more energy to break it, H-I has the longest bond length and require least energy to break it

	F	Cl	Br	I
H-X	562	431	366	299
C-X	467	346	290	228
Heating (putting red-hot glass rod into it) Observation	No reaction	No reaction	Evidence of Brownish coloration	Immediately purple vapor

  - Test for halides ions

Halide ion	Reaction with **acidified** $AgNO_{3(aq)}$	Observation with $NH_{3(aq)}$
Cl	White ppt.	Dissolve in dilute ammonia
Br	Cream ppt.	Dissolve with concentrated ammonia
I	Yellow ppt.	Does not dissolve

    - When added to NH3, Ag+ will form a complex and it is favor in RHS when NH_3 is conc.

$$2NH_3 + Ag^+ \xleftrightarrow{reversible} [Ag(NH_3)_2]^+_{(aq)}$$

    - However, this depends on the extent to which the AgX is soluble in water, because AgCl is mostly soluble, AgBr is partly soluble and AgI is insoluble in water, thus there is no complex formed in AgI but both formed in AgCl and AgBr

- Replacement reaction of ions:
  - The more reactive element will replace the less reactive element's ion in the ionic compound
  - $Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$
  - This is actually due to the different oxidizing power of the element:
    - Cl ->Br^-/I^-
    - Br ->I^-
- Reaction as oxidizing agent/reducing agent
  - Cl_2/Br_2 can oxidize $Fe^{2+}$to Fe^{3+}
    $Cl_2 + 2Fe^{2+} \rightarrow 2Fe^{3+} + 2Cl^-$
  - Fe^{3+} can oxidize I^- back to I_2
    $2Fe^{3+} + 2I^- \rightarrow I_2 + 2Fe^{2+}$
- Reaction with oxidizing acid [See Redox Section]
- Reaction with non-oxidizing acid
  - Non-oxidizing Acid(H_3PO_4) will only lead to the protonation of halide ions and seen the steamy fumes coming out of the reaction as $HX_{(g)}$ without any further oxidization happened
  - $H_3PO_4 + KX \rightarrow KH_2PO_4 + HX$
- Chlorine react with sodium hydroxide
  - In cold dilute NaOH:
    $Cl_2 + 2OH^- \rightarrow Cl^- + ClO^- + H_2O$
    Cl(0) converted to Cl^-(-1)
  - In hot, conc. NaOH:
    $3Cl_2 + 6OH^- \rightarrow 5Cl^- + ClO_3^- + 3H_2O$
    This is called **disproportion** of chlorine because the oxidation number of Cl(0) both increase to Cl(5+)and decrease to Cl(1-) in the reaction
    This is because at higher temperature the ClO^- will decompose into $2Cl^- + ClO_3^-$, which the chlorine gets disporpotion

- Application & Production
  - Chlorine produced by electrolysis of chloride
  - Bromine and iodine are produced using chlorine gas to oxidize the bromide and iodide ions presents in sea water
  - Pure Florine is hard to make because it will even make reaction with water
  - Chlorine is used in water purification because it has strong oxidizing power which can distrust the bacterial metabolism
    In water the following equilibrium happened:

    $Cl_2 + H_2O \xleftrightarrow{reversible} HCl + HClO$

    $HClO + H_2O \xleftrightarrow{reversible} H_3O^+ + OCl^-$

    Both Cl2 and HClO are oxidizing agent therefore have the ability to kill the bacteria

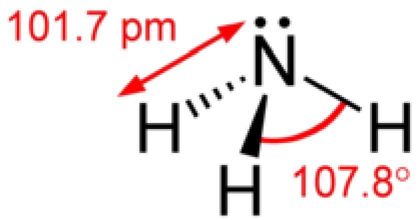
- NaOH and Cl can be used to make bleach(NaClO) which have cleaning effect and can wash toilets and 'kills' microorganism

  $Cl_2 + OH^- \xleftrightarrow{reversible} Cl^- + OCl^- + H_2O$

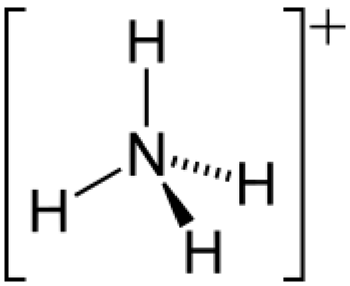
  Pale yellow bleach product is formed when the reaction used $Ca(OH)_2$
- Manufacture of PVC: hard and good thermal stability
- Manufacture of Halogenated hydrocarbons(CFC/PVC)
- AgBr used in photography
- $CClBrF_2$ as fire exhausters(inert)
- I_2 as mild antiseptic [solution of iodine in alcohol]

Nitrogen and Sulfur:

- Nitrogen
  - Lack of reactivity
    - Nitrogen is lack of reactivity because the N≡N bond is a triple covalent bond and have strong bond energy, therefore demanding high activation energy and results in the unreactive nature of Nitrogen
  - Structure and acidity
    - Ammonia(NH_3)



      - Pyramidal because of the lone pair on N
      - Bond angle 107°
      - Alkaline Gas
      - ability to form H-bond because of the strong electronegativity of N
      - $NH3 + H^+ \xleftrightarrow{reversible} NH_4^+$ (NH4+ is the conjugate acid to NH3 base)
    - Ammonium(NH_4^+)



      - Tetrahedral because of the dative covalent bond form with H
      - Can be displaced by warming with a strong base:
        $NH4^+ + OH^- \rightarrow NH_3 + H_2O$
  - Industrial application
    - Produce fertilizer

$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

- Produce nitric acid

  $2NO + O_2 \rightarrow 2NO_2$

  $2NO_2 \rightarrow 2N_2O_4$

  $3N_2O_4 + 2H_2O \rightarrow 4HNO_3$

  OR

  $2NO_2 + H_2O + 1/2O_2 \rightarrow 2HNO_3$

- Environmental consequence
  - Overusing nitrates will enter the water
  - Leads to Eutrophication (bloom of algae that cause environmental problem)
  - Potential harmful to human body
- Nitrogen oxides
  - These(NO_x) are produced when nitrogen react with oxygen in internal combustion engine
  - They have potential harmful effect to the environment by helping the formation of the SO_3 in air

    $SO_2 + NO_2 \rightarrow NO + SO_3$
  - Car engine can have catalytic converter (usually use platinum)to reduce these pollutants

    $2CO + 2NO \rightarrow 2CO_2 + N_2$
- Harbor process[removed from syllabus]
  - $N_2 + 3H_2$
  - 200 atm
  - Iron catalyst
  - 750K

- Sulfur
  - Formation of acid rain
    1. When sulfur contain fossil fuel is burnt in internal combustion engine: SO_2 is formed

       S + O2 ->SO2
    2. SO_2 reacted with O_2 in the air to produce SO_3(catalyst by NO_2 – homogenous catalyst)

       $2SO_2 + O_2 \rightarrow 2SO_3$
    3. SO_3 then react with water in the clouds to produce H_2SO_4, which formed the acid rain

       $H_2O + SO_3 \rightarrow H_2SO_4$
  - Harmful effect of the acid rain:
    - Plants(trees)
    - Rivers, streams, lakes(damage the food chain because the aquatic animals are sensitive to pH, and the reduce of food will lower the number of other number in the food chain)
    - Buildings, statues(marble), metal structures
  - Sulfuric Acid made of contact process[disappear from syllabus]
    - $SO_2 + O_2$

- Catalyst V_2O_5
- 1 atmosphere
- 450°C