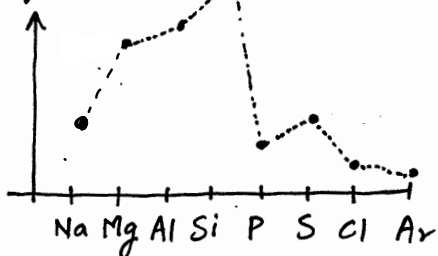


# PERIOD 3

## Melting Points



white solid

Na, Mg, Al → metallic bonds (high MP)

Si → macromolecular (very high MP)

$\left. \begin{matrix} P_4 \\ S_8 \\ Cl_2 \\ Ar \end{matrix} \right\}$  simple molecular (low MP)  
 (Temporary dipoles induced dipoles increase with size)

## Electricity Conduction

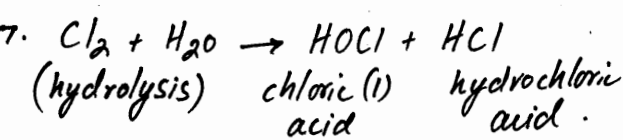
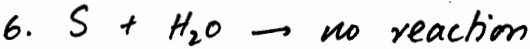
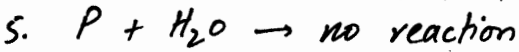
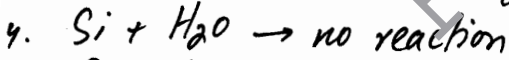
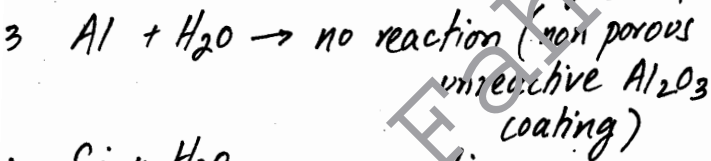
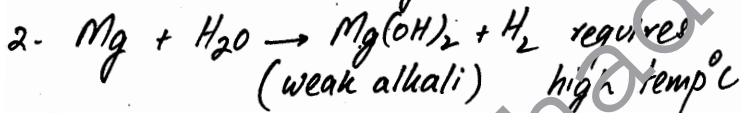
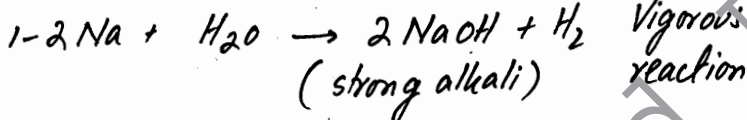
Na, Mg, Al → good conductors, metals

Si → semi conductors

S, P, Cl, Ar → non metals, poor conductors

colorless liquid

## Reactions with water



## Oxidation States

Na (+1)	$Na_2O, NaCl$
Mg (+2)	$MgO, MgCl_2$
Al (+3)	$Al_2O_3, AlCl_3$
Si (+4)	$SiO_2, SiCl_4$
P (+3, +5)	$P_4O_{10}, P_4O_6, PCl_5, PCl_3$
S (+4, +6)	$SO_2, SO_3$
Cl (-1, +1, +5)	$NaCl, NaClO, NaClO_3$

+7 in  $ClF_7$

## Oxides with water

- $Na_2O + H_2O \rightarrow 2NaOH$  strong alkali pH ≈ 13
- $MgO + H_2O \rightarrow Mg(OH)_2$  weak alkali pH: 8-10
- $Al_2O_3 + H_2O \rightarrow$  no reaction
- $SiO_2 + H_2O \rightarrow$  no reaction
- $P_4O_{10} + H_2O \rightarrow H_3PO_4$  (acidic)  
 $P_4O_6 + H_2O \rightarrow H_3PO_3$  (acidic)
- $SO_3 + H_2O \rightarrow H_2SO_4$  (acidic)  
 $SO_2 + H_2O \rightarrow H_2SO_3$  (acidic)

## Chlorides with water (hydrolysis)

- $NaCl + H_2O \rightarrow Na^+ + Cl^-$  (neutral) (aq) (aq)
  - $MgCl_2 + H_2O \rightarrow Mg(OH)_2 + HCl$  (pH=6.5) very slight hydrolysis (s) (aq)
  - $AlCl_3 + H_2O \rightarrow Al(OH)_3 + HCl$  (strongly strong hydrolysis (s) (aq) acidic)
  - $SiCl_4 + H_2O \rightarrow Si(OH)_4 + HCl$  (strongly strong hydrolysis (s) (aq) acidic)
  - $PCl_3 + H_2O \rightarrow H_3PO_3 + HCl$  (strongly acidic)  
 $PCl_5 + H_2O \rightarrow H_3PO_4 + HCl$  (strongly acidic)
- \*  $SiCl_4 / PCl_3 / PCl_5$  have rapid reaction releasing fumes/misty of  $HCl$  (g)

## Acid/Base nature of oxides/hydroxides

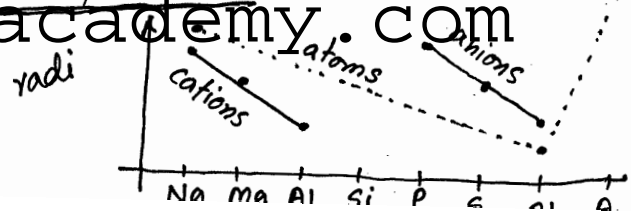
Basic:  $Na_2O/NaOH + HCl \rightarrow NaCl + H_2O$   
 $MgO/Mg(OH)_2 + HCl \rightarrow MgCl_2 + H_2O$

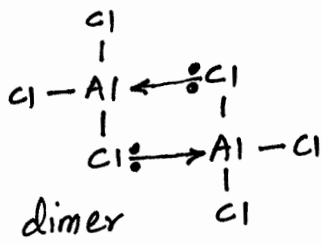
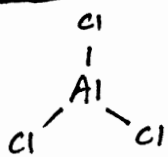
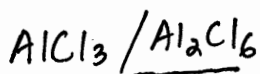
amphoteric:  
 $Al_2O_3/Al(OH)_3 + HCl \rightarrow AlCl_3 + H_2O$   
 $Al_2O_3/Al(OH)_3 + NaOH \rightarrow NaAlO_2 + H_2O$  (not/conc) sodium aluminate

weakly acidic:  
 $SiO_2 + NaOH \rightarrow Na_2SiO_3 + H_2O$  (hot/conc.) sodium silicate

acidic:  
 $P_4O_6 + NaOH \rightarrow Na_3PO_3 + H_2O$   
 $P_4O_{10} + NaOH \rightarrow Na_3PO_4 + H_2O$   
 $SO_2 + NaOH \rightarrow Na_2SO_3 + H_2O$   
 $SO_3 + NaOH \rightarrow Na_2SO_4 + H_2O$

## Atomic/ionic radii

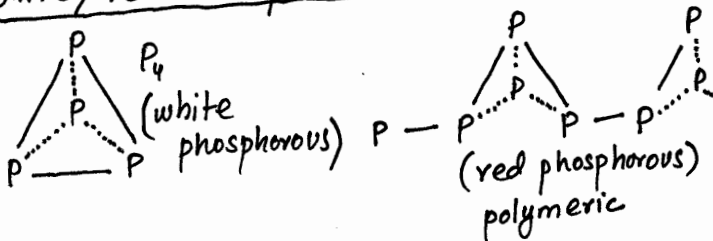




Period 3 Elements with Oxygen

1.  $4Na + O_2 \rightarrow 2Na_2O$  bright-yellow flame
2.  $2Mg + O_2 \rightarrow 2MgO$  bright-white flame
3.  $4Al + 3O_2 \rightarrow 2Al_2O_3$  bright-white flame  
( $Al_2O_3$  coating prevents fast combustion)
4.  $Si + O_2 \rightarrow SiO_2$  (slow reaction)
5.  $4P + 5O_2 \rightarrow P_4O_{10}$  vigorous, yellow flame  
white cloud of  $P_4O_{10}$
6.  $S + O_2 \rightarrow SO_2$  gentle blue flame

white/red Phosphorous

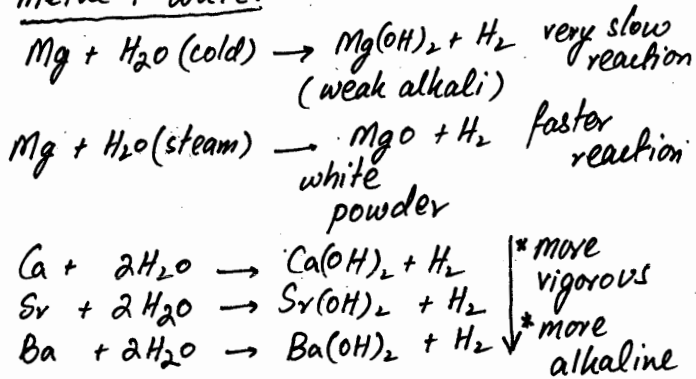


GROUP 2

- Be [He]  $2s^2$
- Mg [Ne]  $3s^2$
- Ca [Ar]  $4s^2$
- Sr [Kr]  $5s^2$
- Ba [Xe]  $6s^2$
- Ra [Rn]  $7s^2$

- \* Reactivity increases
- \* Reducing power decreases
- \* MP/BP decrease due to larger ionic radii/weaker metallic bonds
- \* Gp II metals have higher MP/BP/boiling points compared to Gp I but lower than other metals.

metal + water



\*  $Ca(OH)_2$  is partially soluble and will produce a white suspension

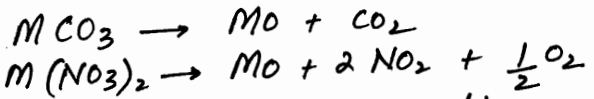
\* more soluble

\*  $CaO + H_2O \rightarrow Ca(OH)_2$  very exothermic some water boils,  $CaO$  cracks/hisses

\* BeO has the same properties as  $Al_2O_3$  unreactive and amphoteric/insoluble  $BeCl_2$  is also covalent like  $AlCl_3$

pH  $Mg(OH)_2, Ca(OH)_2, Sr(OH)_2, Ba(OH)_2$   
 $pH < 10$  more soluble  $pH > 10$  less soluble

Thermal decomposition/nitrates and carbonates



\*  $NO_2$  brown gas/toxic

\* thermal stability increases down the

group	$MgCO_3$	$540^\circ C$	[bunsen = $1000^\circ C$ flame]
	$CaCO_3$	$900^\circ C$	
	$SrCO_3$	$1280^\circ C$	
	$BaCO_3$	$1360^\circ C$	

down the group ionic radii increases, charge ( $2+$ ) density decreases, hence ion polarizing power decreases,  $CO_3^{2-}/NO_3^-$  less polarized down the group.

USES  $MgO$ : refractory lining (high melting points)

$CaCO_3$ : lime stone

- \* making of lime  $CaCO_3 \rightarrow CaO + CO_2$
- \* making steel/glass
- \* lime/limestone neutralizes acidic soil.
- \* make cement (lime mortar: Lime + sand + water)

Flame TESTS

1.  $2Mg + O_2 \rightarrow 2MgO$  white flame
2.  $2Ca + O_2 \rightarrow 2CaO$  brick red flame
3.  $2Sr + O_2 \rightarrow 2SrO$  red/scarlet flame
4.  $2Ba + O_2 \rightarrow 2BaO$  apple green flame



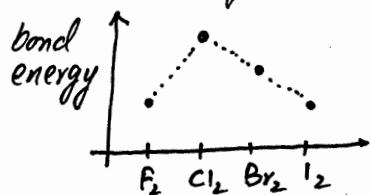
# Group 17 HALOGENS

## trends in volatility / color

- $F_2(g)$  very pale yellow
- $Cl_2(g)$  greenish yellow
- $Br_2(l)$  orange brown
- $I_2(s)$  blue black solid or purple vapour

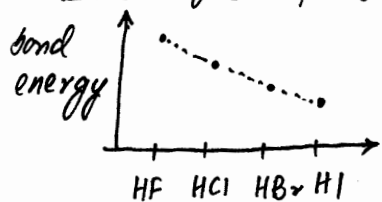
\* MP/BP increase as TdID increase due to larger size  
\* colors get darker

## Bond Strength



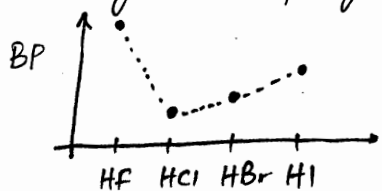
$X-X \rightarrow 2X$   
smaller atoms have stronger bonds  
except  $F_2$ , lone pair repulsion weakens bond

## Bond Strength of hydrogen halides



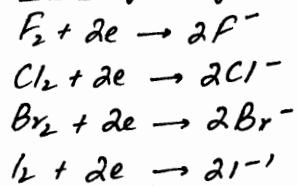
smaller atoms, stronger bonds, (H has no lone pairs hence no lone pair repulsion)

## Boiling Points of hydrogen halides



HF has hydrogen bonding whereas HCl, HBr, HI have permanent dipoles

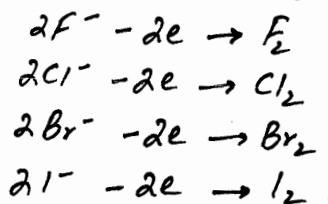
## Electronegativity / Oxidising ability



\* Electronegativity decreases  
\* weaker oxidizing agent (less easily reduced)

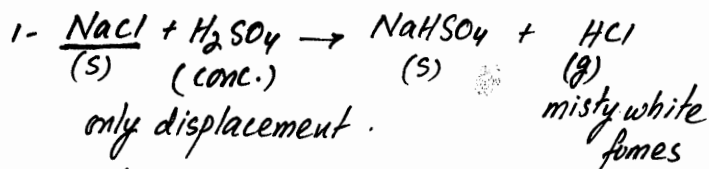
\* smaller atoms are less shielded and attract  $e^-$  strongly

## halide ions as reducing agents

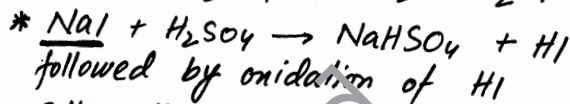
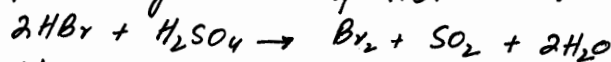
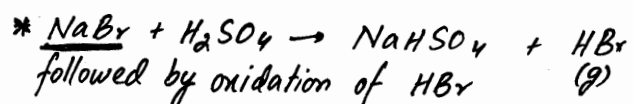


stronger reducing agents (get oxidized easily)  
(bigger ions, more shielding, lose  $e^-$  easily)

## Reaction of halide ions with concentrated sulfuric acid

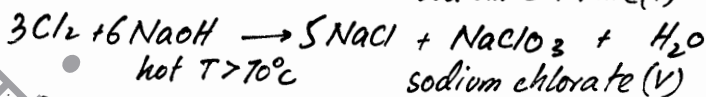
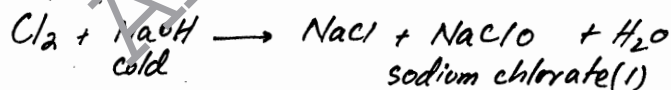


2. down the group  $Br^-$ ,  $I^-$  become good reducing agents, hence both displacement and redox occur

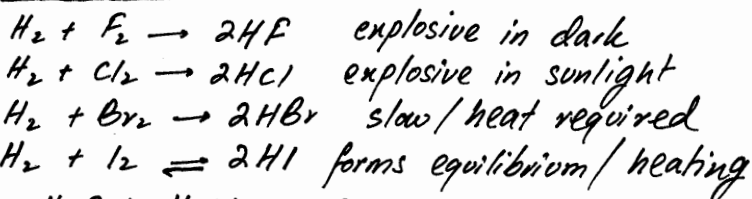


(Sulfur = yellow,  $H_2S$  = rotten eggs,  $I_2$  = purple)

## Disproportionation



## Reaction with $H_2$



$H-F > H-Cl > H-Br > H-I$   
thermal stability decreases

## TESTS of halide ions

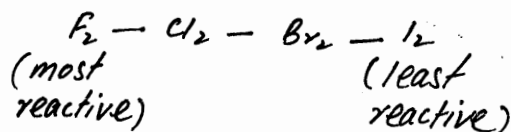
Add  $Ag^+$  followed by  $NH_3(aq)$

$Cl^-$ : white ppt, dissolves in dilute  $NH_3$

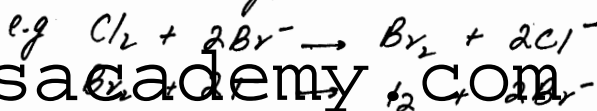
$Br^-$ : cream ppt, dissolves in conc.  $NH_3$

$I^-$ : yellow ppt, not soluble in  $NH_3$

## Reactivity

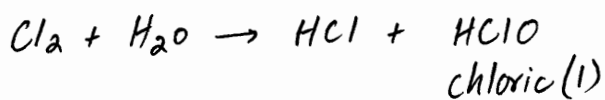


more reactive halogen displaces less reactive halogen



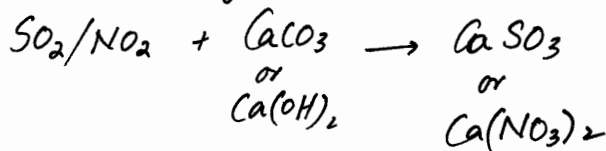
### Uses of halogens

- \* Cl<sub>2</sub> kills bacteria in water

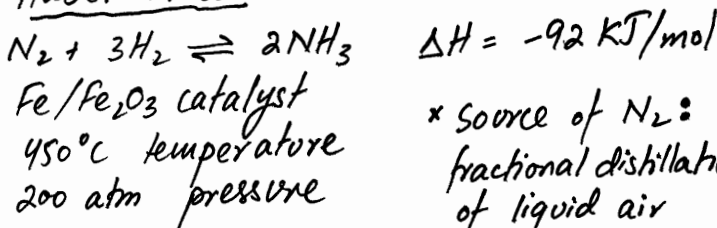


- \* NaClO bleaching agent (also kills bacteria)
- \* CFCs inert/volatile solvents/aerosols etc. (cause ozone depletion)

- \* flue gas desulfurization  
SO<sub>2</sub>/NO<sub>2</sub> gases from factories are neutralized by limestone/lime



### Haber Process



- \* source of N<sub>2</sub>: fractional distillation of liquid air
- \* source of H<sub>2</sub>: cracking of oil

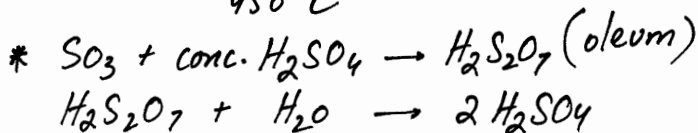
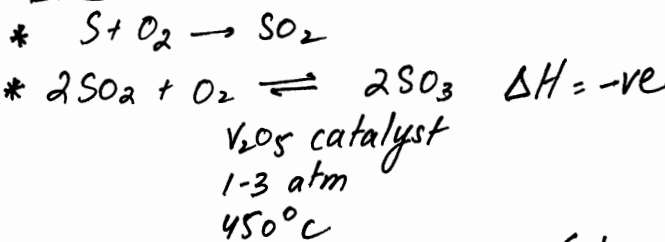
- \* Equilibrium favours products → low temperature, high pressure, NH<sub>3</sub> is removed.

(higher pressure increases economic cost, lower temperature reduces speed of reaction)

- \* Uses of NH<sub>3</sub>:

- 1- fertilizers (NPK)  
NH<sub>4</sub>NO<sub>3</sub>, (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>, (NH<sub>4</sub>)<sub>3</sub>PO<sub>4</sub>  
urea CO(NH<sub>2</sub>)<sub>2</sub>
- 2- formation of nitric acid
3. explosives, detergents, dyes

### Contact Process



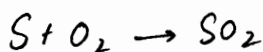
- Equilibrium in step 2 favours low temperature, high pressure

(higher pressure increases cost, lower temperature reduces rate of reaction)

- Uses: fertilizers, car batteries, paints

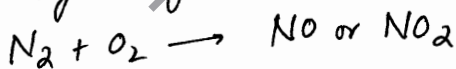
### Nitrogen and Sulfur

- \* 78% of atmosphere is N<sub>2</sub>  
N<sub>2</sub> is inert: N≡N is very strong.
- \* Sulfur is present in ZnS, fossil fuels such as coal and volcanoes

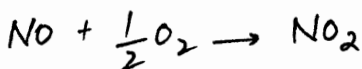
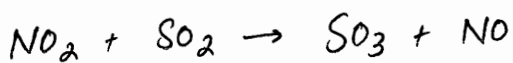


### Acid Rain

extreme temperatures (car engines and lightning strikes)



- \* NO<sub>2</sub> is an oxidizing agent and SO<sub>2</sub> is a reducing agent.

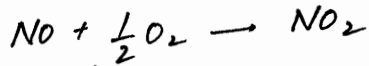


(NO<sub>2</sub> gets oxidized in air and acts as a catalyst)

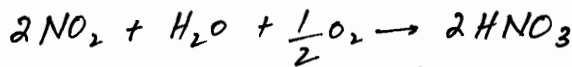
- \* acid rain causes corrosion of limestone buildings/metal structures, soil + water bodies become acidic, skin and eye irritation

## How do nitrates end up in soil

lightning  $N_2 + O_2 \rightarrow NO$  or  $NO_2$   
NO gets oxidized in air



$NO_2$  mixes with rain



plants absorb nitrates to make essential proteins

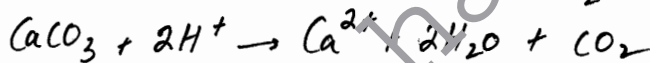
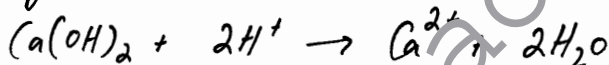
## Excess fertilizer / Eutrophication

gets washed away in rivers/lakes  
promotes algae growth, blocks sunlight, destroys marine plants, bacteria multiplies because of dead plants and consumes oxygen which destroys marine life/fish

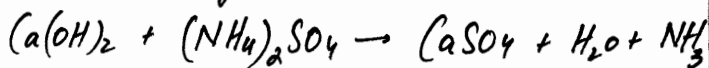
## Neutralizing acidic soils

lime  $Ca(OH)_2$  and limestone reduce  $(CaCO_3)$

acidity in soil



lime and fertilizers should not be added together.



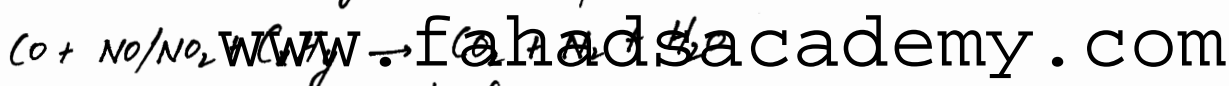
they react and release  $NH_3$  (g) which reduces "N" in soil.

## Catalytic Converter

car exhaust : CO incomplete combustion

$NO/NO_2$

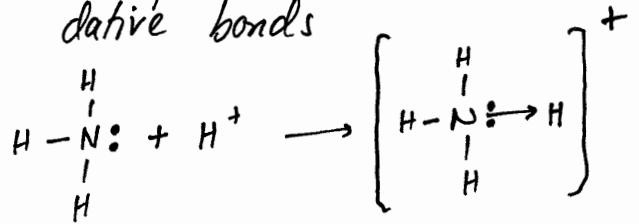
$C_xH_y$  unburnt fuel



\* honeycomb structure  
made of Pd/Pt catalyst

\*  $NH_3$  is basic

accepts protons/ $H^+$   
lone pair on N can form dative bonds



\* Extra Points

$NO$  is colorless

$NO_2$  is brown

•  $NO_2$  as an oxidizing agent plays important role in formation of  $O_3$ .