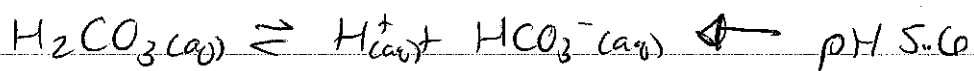
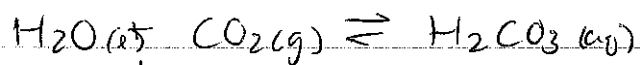


## 8.5 Acid Deposition

### Causes of Acid Deposition

Rain H<sub>2</sub>O naturally acidic due to CO<sub>2</sub>(g)



Acid rain  $\rightarrow$  soln  $<$  pH 5.6  $\therefore$  additional acids

Man contributors: oxides of nitrogen & sulfur



Secondary pollutant

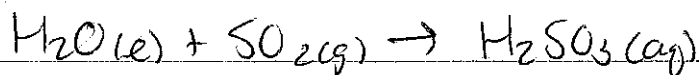
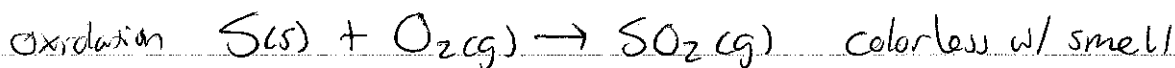
primary pollutants

### Acid deposition

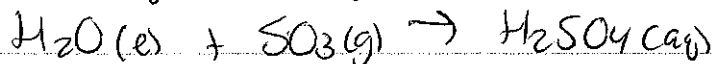
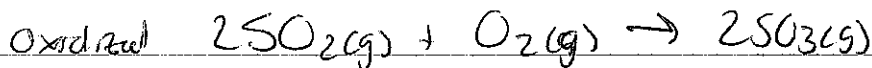
- 1) wet: rain, snow, sleet, hail, etc fall to ground as aq ppt
- 2) dry: acidifying particles, gases fall to ground as dust/smoke, later dissolve

### Sulfur oxides

produced from: coal, heavy oil, smelting  
(50%)



or

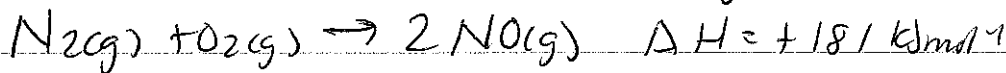


Several mechanisms:

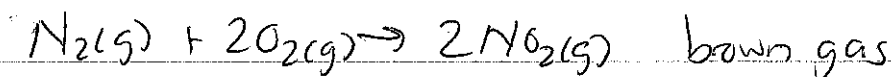
- photo-oxidation
- oxidation via metal particulates (Fe/Mn)
- $O_3$  or  $H_2O_2 \rightarrow$  free radicals
  - $HO + SO_2 \rightarrow \cdot HOSO_2$
  - $HOSO_2 + O_2 \rightarrow \cdot HO_2 + \boxed{SO_3}$

## Nitrogen Oxides

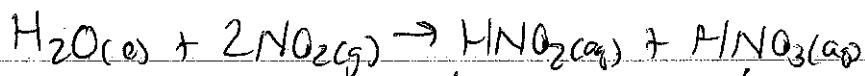
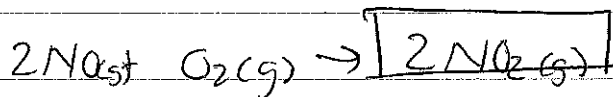
produced from: internal combustion engines



or

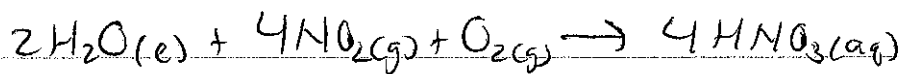


or



or

(nitrous acid) (nitric acid)



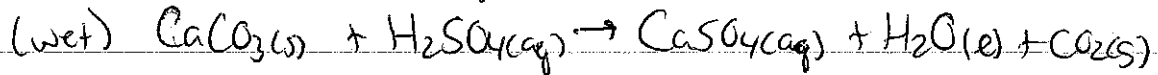
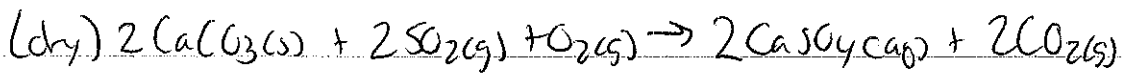
Mechanisms:

- photo-oxidation
- $O_3 + \cdot HO$  radicals
  - $HO + NO \rightarrow HNO_2$
  - $HO + NO_2 \rightarrow HNO_3$

# Effects of acid deposition

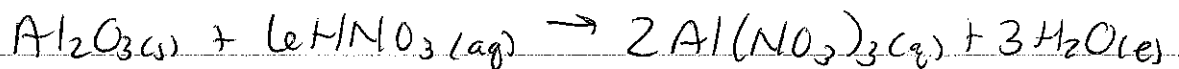
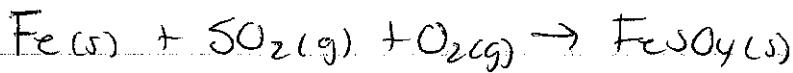
## Impact on materials

Marble / Limestone



- products more soluble  $\rightarrow$  wash away

Metals  $\rightarrow$  corrosion (rusting)



## Impact on plant life

- slower growth, injury, death
- causes leaching  $\rightarrow$  minerals ( $\text{Mg}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{K}^+$ ) to become soluble, wash away
- release toxic substances ( $\text{Al}^{3+}$ ), damage roots
- dry deposition  $\rightarrow$  block pores for gas exchange
- plants in more humid  $\rightarrow$  more exposure

## Impact on water

- dead zones: aquatic life cannot sustain under pH 5 releases  $Al^{3+}$  as pH lowers
- eutrophication: nitrates present in acid rain, over-fertilize water = algae bloom  $\rightarrow$  causes  $O_2$  depletion

## Impact on human health

- dry particulates can be inhaled  $\rightarrow$  lung problems
- corrosion of pipes  $\rightarrow$  leaching toxic metals ( $Al^{3+}$ ,  $Pb^{2+}$ ,  $Cu^{2+}$ ), to be ingested

## Responses to acid deposition

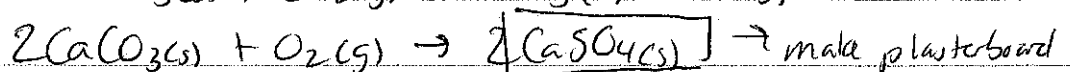
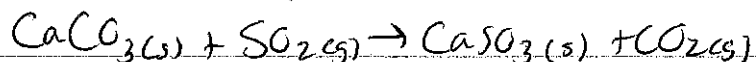
### Reduction of $SO_2$ emissions

#### 1) pre-combustion methods: removal/reduction

- metal sulfide  $\rightarrow$  crush coal & wash, Metal S. sinks
- hydrodesulfurization (HDS) catalytic process removes S from refined petroleum products, creates  $H_2S$   $\rightarrow$  converted to S, used in production of  $H_2SO_4$

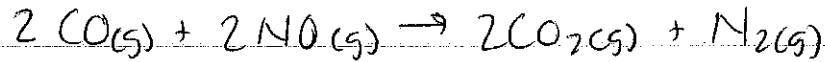
#### 2) post combustion

- flue-gas desulfurization  $\rightarrow$  removes 90% S in coal smoke



## Reduction of NO<sub>x</sub>

1) catalytic converter



2) lower temp comb

formation of NO reduced at low temps

circulate exhaust back into engine, lowers temp

## Other options

- reduce fossil fuel use
  - more efficient energy transfer, public transportation, renewable energy
- restoration of ecosystems
  - add CaO / CaCO<sub>3</sub> (lime) to neutralize acidiz soils