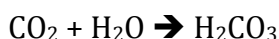


Acid Rain

1. What is it?

- a. acid precipitation
 - i. in Canada: acid rain, acid snow and acid smog (smoke & fog)
- b. occurs when oxides of sulfur and nitrogen mix with water in the atmosphere
- c. “normal” rain has a pH of 5.6 (from dissolved carbon dioxide)



- d. H_2CO_3 carbonic acid is a weak acid (5.6 is a high number remember that neutral is a pH of 7)
- e. acid rain has a pH less than 5.6

2. Chemicals Involved

- a. The two major chemicals involved are:
 - i. sulphur \rightarrow sulphur oxides
 - ii. nitrogen \rightarrow nitrogen oxides

Reactions involving sulphur

Order	Where it occurs	Reaction
1	sulphur combustion	$\text{S} + \text{O}_2 \rightarrow \text{SO}_2$
2	in air	$2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{SO}_3$
3	in water vapour	$\text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4$

*sulfuric acid is a strong acid aka it ionizes almost completely in water

Reactions involving nitrogen

Order	Where it occurs	Reaction
1	in car engines	$\text{N}_2 + \text{O}_2 + \text{heat} \rightarrow 2\text{NO}$
2	in air	$2\text{NO} + \text{O}_2 \rightarrow 2\text{NO}_2$
3	in water vapour	$2\text{NO}_2 + \text{H}_2\text{O} \rightarrow 2\text{HNO}_2 + \text{NO}$

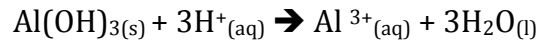
*nitrous acid is a strong acid aka it ionizes almost completely in water

3. Sources of sulphur and nitrogen

- a. sulphur
 - i. burning fossil fuels
 1. coal and petroleum contain some sulphur
 - ii. smelting metal ores (Cu, Ni, Pb, Zn)
 - iii. burning gas in cars
 - iv. natural sources: “sour” natural gas and volcanic eruptions
 - v.
- b. nitrogen
 - i. combustion in car engines
 - ii. natural sources: plant decay

4. Effects of acid rain

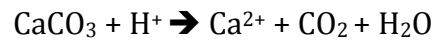
- a. irritates respiratory tract
- b. reduces plant growth
- c. decreases the pH of lakes and rivers
 - i. fish die when the pH is less than 4.5
- d. causes the leaching of metals – Mn, Cd, Al, Pb, Cu and Hg
 - i. examples of bioaccumulation of Al^{3+} in fish where a lake is affected by acid rain



- e. acid shock: a lake may become acid shocked when the pH of the runoff is low (can be up to 100 X more acidic)
- f. reduces the durability of concrete, marble and iron

5. Reduction

- a. reduce acidity in lakes by adding lime (CaCO_3)



- b. note: H^+ from H_2SO_4 or HNO_3
- c. scrubbers on smoke stacks
- d. use low sulphur fuels
- e. adopt tougher emission standards on cars and smelters