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 <u>sulfur</u> and <u>nitrogen</u> mix with <u>water</u> in the atmosphere
    c. "normal" rain has a pH of 5.6 (from dissolved carbon dioxide)

        $CO_2 + H_2O \rightarrow H_2CO_3$

    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 ➔ sulphur oxides
        ii. nitrogen ➔ nitrogen oxides

Reactions involving sulphur

Order	Where it occurs	Reaction
1	sulphur combustion	$S + O_2 \rightarrow SO_2$
2	in air	$2SO_2 + O_2 \rightarrow 2SO_3$
3	in water vapour	$SO_3 + H_2O \rightarrow H_2SO_4$

*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	$N_2 + O_2 + \text{heat} \rightarrow 2NO$
2	in air	$2NO + O_2 \rightarrow 2NO_2$
3	in water vapour	$2NO_2 + H_2O \rightarrow 2HNO_2 + NO$

*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

$$Al(OH)_{3(s)} + 3H^{+}_{(aq)} \rightarrow Al^{3+}_{(aq)} + 3H_2O_{(l)}$$

    e. acid shock: a lake may become acid shocked when the pH of the run off 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 ($CaCO_3$)

$$CaCO_3 + H^{+} \rightarrow Ca^{2+} + CO_2 + H_2O$$

    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