Acid Rain Wksht Answer Key

1. Natural rain has a pH of ~5.6 due to carbon dioxide combining with water vapor in the atmosphere to form carbonic acid.

$$CO_2(g) + H_2O(l) \rightarrow H_2CO_3(aq)$$

2. Burning coal produces sulfurous or sulfuric acid:

$$S(s) + O_2(g) \rightarrow SO_2(g)$$
$$SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq)$$
$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$
$$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$$

3. Internal combustion engines produce nitrous/nitric acid through combustion to produce NO_x compounds, which then combines with water vapor.
2 different ways to reduce NO_x emissions:
   - catalytic converters in vehicles to convert NO to N_2 and CO_2
   - low-temp combustion to reduce NO production by recirculating exhaust gases back into the engine

4. $CaCO_3(s) + 2HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + CO_2(g) + H_2O(l)$
$CaCO_3(s) + H_2SO_4(aq) \rightarrow CaSO_4(aq) + CO_2(g) + H_2O(l)$

5. - Leaching of metal ions in soil
   - Leaching of Al^{3+} ions into water, impacting aquatic life
   - Eutrophication (over-fertilizing bodies of water) due to nitrates in acid rain, which cause an increase in algal blooms
   - Sulfate/nitrate particulates can be inhaled by humans and irritate respiratory tract
   - Increase in water acidity due to runoff in bodies of water
   - Erosion of marble and limestone

6. Crushing coal and washing with water before combustion can reduce SO_2 emissions

7. $4HNO_3(aq) + Al(s) \rightarrow Al(NO_3)_3(aq) + NO(g) + 2H_2O(l)$

8. (a) SO_2 and NO
   (b) SO_2
   (c) ~~particulates can act as catalysts to produce~~ SO_2 can form other SO_x compounds. These react to form particulates.
   (d) SO_2: $CaO(s) + H_2SO_4(aq) \rightarrow CaSO_4(aq) + H_2O(l)$
   $CaO(s) + SO_2(g) \rightarrow CaSO_3(s)$

8. (c) NO comes from vehicle combustion.

$N_2(g) + O_2(g) \rightarrow 2NO(g)$

$N_2(g) + 2O_2(g) \rightarrow 2NO_2(g)$

$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$

$2NO_2(g) + H_2O(l) \rightarrow HNO_2(aq) + HNO_3(aq)$

$4NO_2(g) + 2H_2O(l) + O_2(g) \rightarrow 4HNO_3(aq)$

9. (a) Dry acid deposition (dust/smoke) occurs closer to the source of pollution compared to wet acid deposition (rain, snow, sleet, etc.)

9. (b) SO_2 and NO_x produced from burning of fossil fuels / combustion and released into the atmosphere. Oxidation and hydrolysis produce various acids in the atmosphere (H_2SO_3, H_2SO_4, HNO_2, HNO_3). Acids in clouds fall as precipitation.

10. • HO forms acid rain:

- $\cdot HO + NO \rightarrow HNO_2$
- $\cdot HO + NO_2 \rightarrow HNO_3$

• HO forms SO_3, which reacts w/ water to form sulfuric acid:

- $\cdot HO + SO_2 \rightarrow \cdot HOSO_2$
- $\cdot HOSO_2 + O_2 \rightarrow \cdot HO_2 + SO_3$