Why oxidation commonly leads to acidification

1. Oxidation removes electrons from atoms and thus increases the charge on those atoms.

2. Oxidation removes electrons from atoms and thus lessens the size of those atoms.

Examples:

Carbon	Sulfur	Nitrogen
C^{4-} -> C^{4+} (oxidation of methane)	S^{2-} -> S^{6+} (oxidation of sulfides)	N^{3-} -> N^{5+} (oxidation of ammonia)
C^{0} -> C^{4+} (e.g., biological respiration, or oxidation of plant matter or petroleum)	S^{4+} -> S^{6+} (oxidation of SO_2)	N^{4+} -> N^{5+} (oxidation of NO_2)

Combining Items 1 and 2:

3. Oxidation increases the ionic potential of atoms or ions (i.e., it increases the density of their positive charge).

Radii:

Carbon	Sulfur	Nitrogen
C^{4-} = 2.60Å	S^{2-} = 1.84Å	N^{3-} = 1.71Å
C^{0} = 0.77Å	S^{4+} = 0.37Å	
C^{4+} = 0.15Å	S^{6+} = 0.29Å	N^{5+} = 0.11Å

4. Cations of greater ionic potential more effectively attract negatively-charged ligand atoms.

$$\text{Ionic potential or density of charge} = \frac{\text{charge of ion}}{\text{radius of ion}} = \frac{z}{r}$$

$$\frac{z}{r} = \frac{4}{0.15} = 27 \qquad \frac{z}{r} = \frac{6}{0.29} = 21 \qquad \frac{z}{r} = \frac{5}{0.11} = 45$$

5. O^{2-} is by far the most abundant negatively-charged ligand atom, and it's produced when oxygen (as O_2, OH^0, or H_2O_2) serves as an oxidizing electron acceptor.

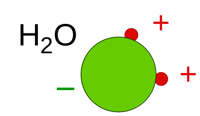
$CH_4 + 2O_2 \rightarrow H_2CO_3 + H_2O$

$NH_3 + 2O_2 \rightarrow HNO_3 + H_2O$

$H_2S + 2O_2 \rightarrow H_2SO_4$

$SO_2 + 2OH^0 \rightarrow H_2SO_4$

6. Maximally oxidized cations thus attract O^{2-}, like the O^{2-} of H_2O or OH^-.

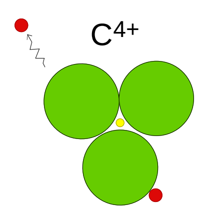


But conversely

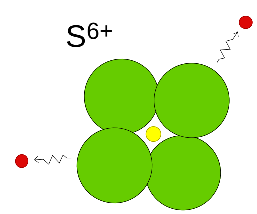
7. The positively charge of maximally oxidized cations repels the H^+ of H_2O or OH^-.

and

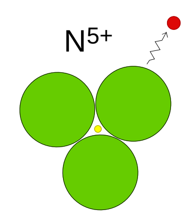
8. Release of H^+ (•) is acidity.



$H_2CO_3 \rightarrow HCO_3^- + H^+$



$H_2SO_4 \rightarrow SO_4^{2-} + 2H^+$



$HNO_3 \rightarrow NO_3^- + H^+$

As a result, natural oxidation in soils, both by respiration and by decay of soil organic matter, makes the carbonic acid that drives weathering. Meanwhile, anthropogenically driven oxidation promotes ocean acidification, acid rain, and acid mine drainage.