

5 • Reactions in Aqueous Solution

Oxidation Numbers & RedOx

Overview:

There are two kinds of reactions in the world, Oxidation-Reduction Reactions and Acid-Base Reactions. In a redox reaction, electrons are gained and electrons are lost.

Double Replacement Reactions are	_____	(redox/non-redox/either)
Single Replacement Reactions are	_____	(redox/non-redox/either)
Synthesis Reactions are	_____	(redox/non-redox/either)
Decomposition Reactions are	_____	(redox/non-redox/either)
Combustion Reactions are	_____	(redox/non-redox/either)

An important idea to help recognize oxidation-reduction reactions is to identify the oxidation number (or oxidation state) of an atom. The oxidation number is also called the “apparent charge.” Atoms in ionic compounds have charges and these are also the oxidation numbers. Atoms in molecular compounds can also have oxidation numbers, although they do not have charges.

Rules:

The oxidation number of:

Example:

- an element in the uncombined state is 0.
- a monatomic ion equals the charge on the ion.
- hydrogen is generally +1; in hydrides, -1.
- oxygen is generally -2; in peroxides, -1.
- elements other than oxygen and hydrogen in a neutral compound is such that the sum of the oxidation numbers for all atoms in the compound is 0.
- elements other than oxygen and hydrogen in a polyatomic ion is such that the sum of the oxidation numbers for all atoms in the ion equals the charge on the ion.

Practice:

Determine the oxidation number of the underlined element. Answers are given below:

1. <u>Ba</u> ²⁺	2. <u>N</u> ₂	3. <u>H</u> I	4. <u>O</u> ₂ ²⁻
5. Ag <u>Br</u>	6. <u>Cu</u> Cl ₂	7. H <u>N</u> O ₃	8. <u>Cl</u> O ₃ ⁻
9. <u>S</u> O ₃	10. Na ₂ <u>S</u> O ₃	11. Ba <u>Cr</u> O ₄	12. Ca <u>S</u> O ₄
1. +2	2. 0	3. +1	4. -1
5. -1	6. +2	7. +5	8. +5
9. +6	10. +4	11. +6	12. +6

Practice Problems from the Textbook

54. Determine the oxidation number of each element in the following ions or compounds:

- | | |
|--------------------------------|-----------------------------|
| a) BrO_3^- | d) CaH_2 |
| b) $\text{C}_2\text{O}_4^{2-}$ | e) H_4SiO_4 |
| c) F_2 | f) SO_4^{2-} |

55. Determine the oxidation number of each element in the following ions or compounds:

- | | |
|-------------------------------|---------------------------|
| a) SF_6 | d) N_2O_4 |
| b) H_2AsO_4^- | e) PCl_4^+ |
| c) UO_2^+ | f) XeO_4^{2-} |

56. Which of the following reactions is (are) oxidation-reduction reactions? Explain your answer briefly. classify the remaining reactions.

- $\text{Zn(s)} + 2 \text{NO}_3^-(\text{aq}) + 4 \text{H}^+(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + 2 \text{NO}_2(\text{g}) + 2 \text{H}_2\text{O(l)}$
- $\text{Zn(OH)}_2(\text{s}) + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{ZnSO}_4(\text{aq}) + 2 \text{H}_2\text{O(l)}$
- $\text{Ca(s)} + 2 \text{H}_2\text{O(l)} \rightarrow \text{Ca(OH)}_2(\text{s}) + \text{H}_2(\text{g})$

57. Which of the following reactions is (are) oxidation-reduction reactions? Explain your answer briefly. classify the remaining reactions.

- $\text{CdCl}_2(\text{aq}) + \text{Na}_2\text{S}(\text{aq}) \rightarrow \text{CdS(s)} + 2 \text{NaCl(aq)}$
- $2 \text{Ca(s)} + \text{O}_2(\text{g}) \rightarrow 2 \text{CaO(s)}$
- $\text{Ca(OH)}_2(\text{s}) + 2 \text{HCl(aq)} \rightarrow \text{CaCl}_2(\text{aq}) + 2 \text{H}_2\text{O(l)}$

58. In each of the following reactions, decide which reactant is oxidized and which is reduced. Designate the oxidizing agent and reducing agent.

- $2 \text{Mg(s)} + \text{O}_2(\text{g}) \rightarrow 2 \text{MgO(s)}$
- $\text{C}_2\text{H}_4(\text{g}) + 3 \text{O}_2(\text{g}) \rightarrow 2 \text{CO}_2(\text{g}) + 2 \text{H}_2\text{O(g)}$
- $\text{Si(s)} + 2 \text{Cl}_2(\text{g}) \rightarrow \text{SiCl}_4(\text{l})$

59. In each of the following reactions, decide which reactant is oxidized and which is reduced. Designate the oxidizing agent and reducing agent.

- $\text{Ca(s)} + 2 \text{HCl(aq)} \rightarrow \text{CaCl}_2(\text{aq}) + \text{H}_2(\text{g})$
- $\text{Cr}_2\text{O}_7^{2-}(\text{aq}) + 3 \text{Sn}^{2+}(\text{aq}) + 14 \text{H}^+(\text{aq}) \rightarrow 2 \text{Cr}^{3+}(\text{aq}) + 3 \text{Sn}^{4+}(\text{aq}) + 7 \text{H}_2\text{O(l)}$
- $\text{FeS(s)} + 3 \text{NO}_3^-(\text{aq}) + 4 \text{H}^+(\text{aq}) \rightarrow 3 \text{NO(g)} + \text{SO}_4^{2-}(\text{aq}) + \text{Fe}^{3+}(\text{aq}) + 2 \text{H}_2\text{O(l)}$