

III) Oxidation Numbers

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An **oxidation number is the real** (for atoms, ions, and ionic compounds) or apparent (for covalent compounds) **charge that a particle possesses**. It is very similar to 'combining capacity'. *(number of bonds an atom "wants" to form)*

What are oxidation numbers for the ionic compound NaCl?



What are the oxidation numbers for the covalent compound H₂O?

*assume ionic...and assign oxidation # H^+ , O^{2-}

Guidelines for Assigning Oxidation Numbers

When assigning oxidation numbers, the **guidelines must be followed IN ORDER**.

*The sum of the positive and negative charges must equal the overall charge of the substance.

A) For **neutral ATOMS**, the oxidation number is 0 *(atoms in elemental form, have no charge)*

Examples: Al 4×6 P₄ N₂ S₈
Oxidation #: 0 0 0 0

B) For **ions**, the oxidation number equals the charge. *any monatomic ions oxidation = ion charge*

Examples: Mn²⁺ Br⁻ S²⁻ Cu⁺ Al³⁺
oxidation #: +2 -1 -2 +1 +3

C) **Polyatomic ions can be assigned a total oxidation number**, which would be its **ionic charge**, or each element in the ion can be assigned its own oxidation number (part D will explain how this is done).

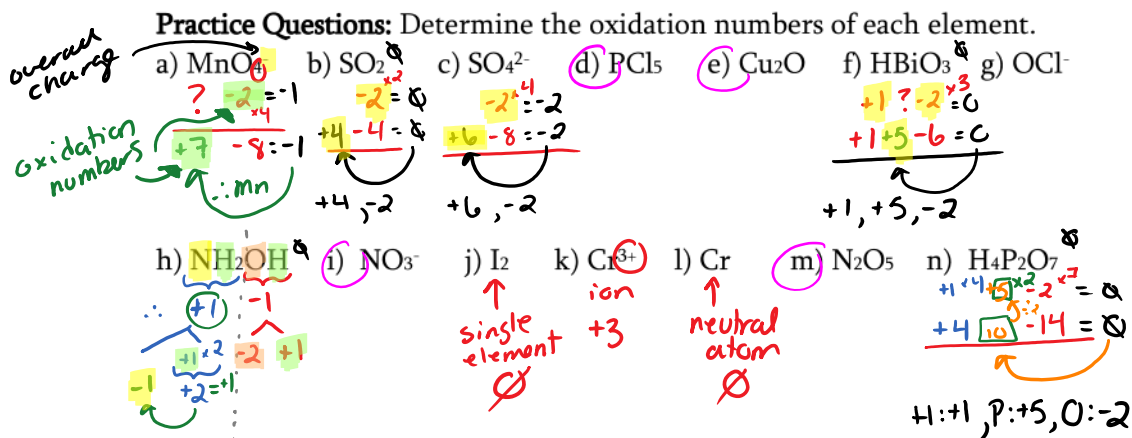
Find the TOTAL oxidation number: SO₄²⁻ PO₄³⁻

Handwritten diagram for SO4 2-: S is +6, 4 O's are -2 each. -2 + 1 = -1 (circled). Arrows point from the circled -1 to the overall -2 charge.

D) To assign individual elements an **oxidation number in a compound or polyatomic ion**, perform the following steps in order:

- 1) alkali metals are +1
- 2) alkaline earth metals are +2
- 3) Other metals with only one possible oxidation number (combining capacity)
- 4) oxygen is -2
- 5) hydrogen is +1 *(unless part of a metal hydride in which case -1)*
ex) CaH₂ Ca is +2, so each H is -1. *Handwritten: Ca + 2H, +2 + 2(-1) = 0, overall charge 0*
- 6) halogens are -1 (but can also be +1, +3, or +5 in certain compounds)
- 7) Lastly, assign any 'hard to predict' atoms that are left over. *Handwritten: +2 + x = 0*

*Since oxidation numbers are apparent for atoms in covalent compounds, sometimes an atom may have an oxidation number that's a fraction. *(very rare)*



How are oxidation numbers helpful?

* When an atom **undergoes oxidation** during a redox reaction, its oxidation number will **INCREASE** as it changes from reactant to product (it loses electrons, therefore it becomes more positive). *lose e^- → more \oplus*

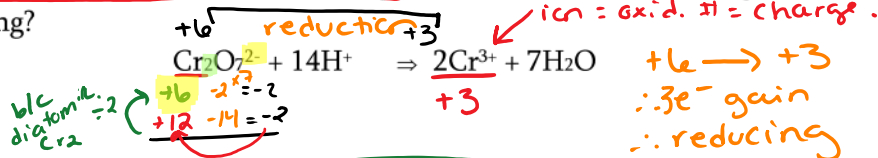
* When an atom **undergoes reduction** during a redox reaction, its oxidation number will **DECREASE** as it changes from a reactant to product (it gain electrons, therefore it becomes more negative). *gain e^- → more \ominus*

Assigning oxidation numbers to reactants and products in a chemical reaction is helpful in **determining whether the reaction is, in fact, a redox reaction**, and if so, **which reactant is oxidizing and which reactant is reducing**.

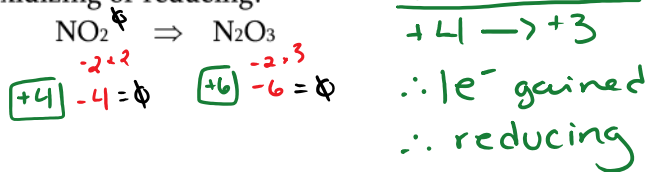
must have oxidation + reduction

Practice Questions

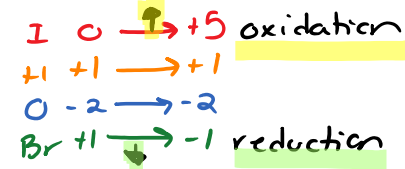
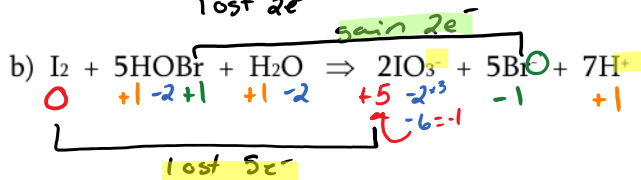
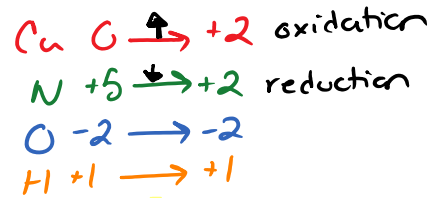
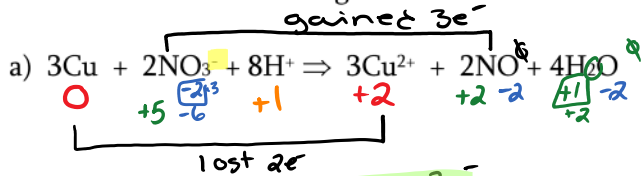
1. For the following half-reaction (with electrons not present), how does the oxidation number of chromium change? Is the chromium oxidizing or reducing?



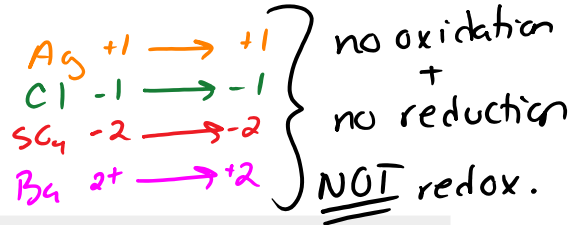
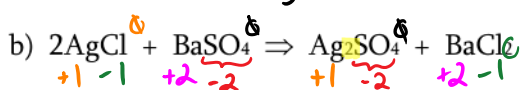
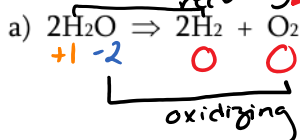
2. What happens to the oxidation # for nitrogen in the unbalanced half-reaction? Is nitrogen oxidizing or reducing?



3. Use oxidation numbers to identify which substance is oxidized and which is reduced in the following redox reactions.



4. Use oxidation numbers to determine whether the following reactions are redox reactions.



Assignment 2:

Read Hebden p.193-194,

- 1) Do Hebden p. 194 #3-6
- 2) For each unbalanced reaction, what is being oxidized and what is being reduced?
 - a) $\text{S}^{2-} + \text{ClO}_3^- \Rightarrow \text{Cl}^- + \text{S}$
 - b) $\text{Cl}_2 + \text{SO}_2 \Rightarrow 2\text{Cl}^- + \text{SO}_4^{2-}$
 - c) $\text{Mn}^{2+} + \text{HBiO}_3 \Rightarrow \text{Bi}^{3+} + \text{MnO}_4^-$
 - d) $\text{FeS} + \text{NO}_3^- \Rightarrow \text{NO} + \text{SO}_4^{2-} + \text{Fe}^{3+}$

3) Consider the following reaction:

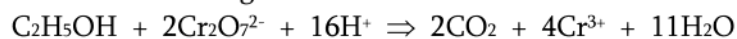


The species being oxidized is: (circle the correct response)

- A. H₂ B. H⁺ C. Zn D. Zn²⁺

- 4) When SO_4^{2-} reacts to form $\text{S}_2\text{O}_6^{2-}$, the sulfur atoms
- A. lose electrons and are reduced
 - B. gain electrons and are reduced
 - C. lose electrons and are oxidized
 - D. gain electrons and are oxidized
- 5) In a reaction, the oxidation number of Cr decreases by 3. This indicates that Cr is
- A. reduced
 - B. oxidized
 - C. neutralized
 - D. a reducing agent

- 6) Consider the following redox reaction:



Each carbon atom loses

- A. 2 electrons
- B. 4 electrons
- C. 6 electrons
- D. 12 electrons