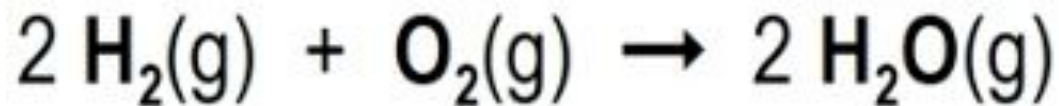# Lesson 2
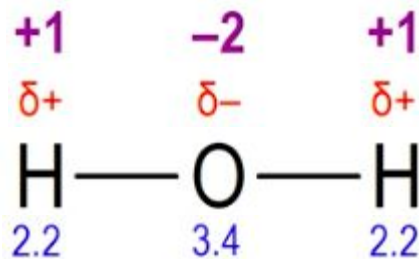# Oxidation Numbers

Learning Goals

❏ I will be able to determine the oxidation number for atoms.

❏ I will be able to analyse redox reactions based on changes in oxidation number.

$$2 \text{ H}_2(g) + \text{O}_2(g) \rightarrow 2 \text{ H}_2\text{O}(g)$$

Since water has covalent bonds. There is no gaining full electrons but there is a shift of electron density.

$$\begin{array}{ccc} +1 & -2 & +1 \\ \delta+ & \delta- & \delta+ \\ \text{H} & \text{O} & \text{H} \\ 2.2 & 3.4 & 2.2 \end{array}$$

H—O—H

Oxygen has a much higher electronegativity than the hydrogen.

Hydrogen has lost some electron density and a loss of electrons (oxidation) so hydrogen is being oxidized.

Oxygen is pulling electron density away from hydrogens → it's gaining electrons (reduction) so oxygen is being reduced.

Oxidation Numbers (Oxidation States)

Rules for Assigning Oxidation Numbers

1. atoms in elements ……………………………..O.N = 0

0

Fe

Br_2

O_3

~~Fe^{3+}~~

~~Br^-~~

~~H_2O~~

2. hydrogen in compounds ...............................O.N. = +1
   (except hydrides.................O.N. = −1)

+1

H_2O

C_2H_5OH

NH_4^+

−1

NaH
sodium hydride

AlH_3
aluminum hydride

3. oxygen in compounds...O.N. = −2
   (except peroxides...............O.N. = −1)

-2

H_2O

C_2H_5OH

NO_3^-

-1

H_2O_2
hydrogen peroxide

Na_2O_2
sodium peroxide

4. monatomic ions..O.N. = charge

$$\overset{+3}{Fe^{3+}}$$

$$NO_3^-$$

$$\overset{-1}{NH_4Br}$$

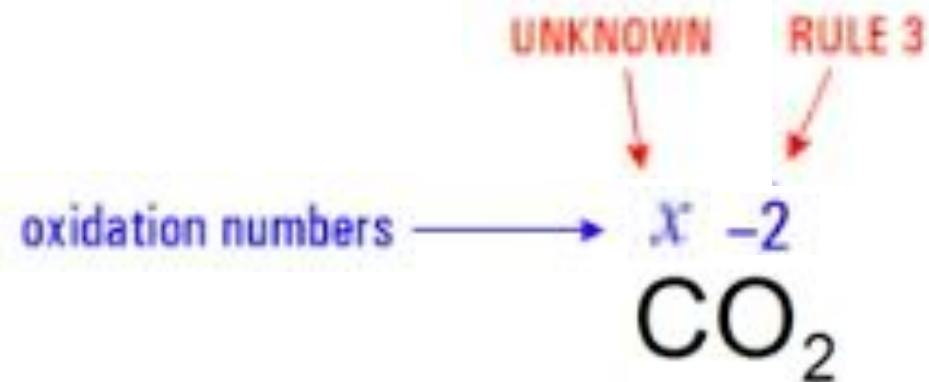$$NH_4^+$$

$$\overset{+1}{Na_2CO_3}$$

$$OH^-$$

Oxidation Numbers (Oxidation States)
Rules for Assigning Oxidation Numbers

1. atoms in elements ……………………………..O.N. = 0
2. hydrogen in compounds ………………………O.N. = +1
   (except hydrides…………….O.N. = –1)
3. oxygen in compounds……………………………O.N. = –2
   (except peroxides…………..O.N. = –1)
4. monatomic ions……………………………..O.N. = charge
5. ∑O.N. = charge on species

Example 1

What is the oxidation number for carbon in carbon dioxide?

UNKNOWN RULE 3

oxidation numbers ⟶ x -2

$$CO_2$$

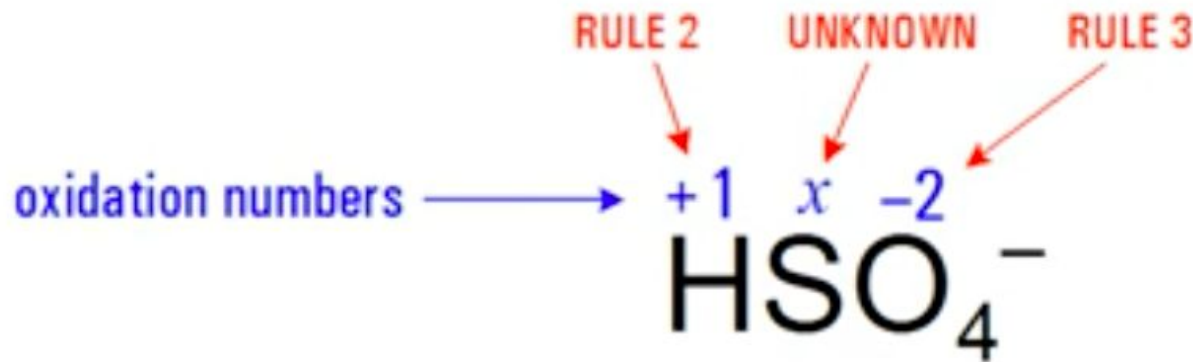RULE 5 ⟶ $x + 2(-2) = 0$

$$x - 4 = 0$$

$$x = +4$$

Therefore, the oxidation number for carbon in carbon dioxide is +4.

Example 2

What is the oxidation number for sulfur in a hydrogen sulfate ion?

RULE 2   UNKNOWN   RULE 3

oxidation numbers → $+1$ x -2
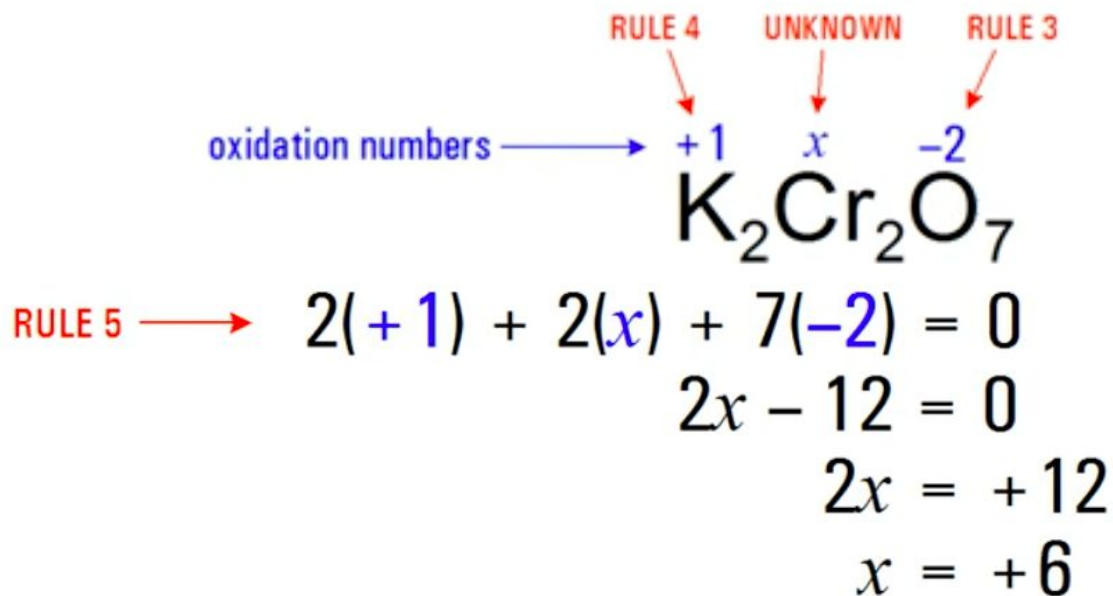
$$HSO_4^-$$

RULE 5 → $(+1) + x + 4(-2) = -1$

$$x - 7 = -1$$

$$x = +6$$

Therefore, the oxidation number for sulfur in hydrogen sulfate is +6.

Example 3

What is the oxidation number for chromium in potassium dichromate?

RULE 4   UNKNOWN   RULE 3

oxidation numbers $\longrightarrow$ +1 x -2

$$K_2Cr_2O_7$$

RULE 5 $\longrightarrow$ $2(+1) + 2(x) + 7(-2) = 0$
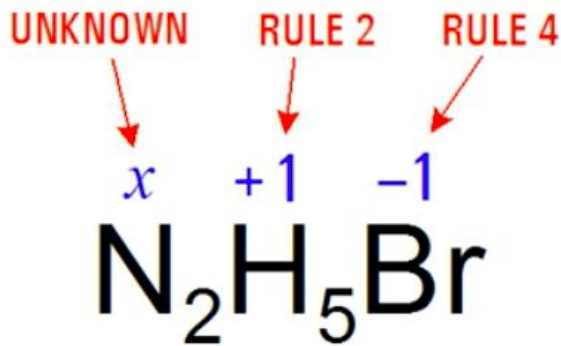
$$2x - 12 = 0$$
$$2x = +12$$
$$x = +6$$

Therefore, the oxidation number for chromium in potassium dichromate is +6.

LEARNING CHECK

What is the oxidation number for nitrogen in hydrazinium bromide, N_2H_5Br?

A. -4

B. -2

C. 0

D. $+2$

E. $+4$

UNKNOWN   RULE 2   RULE 4

$$\overset{x}{N_2}\overset{+1}{H_5}\overset{-1}{Br}$$
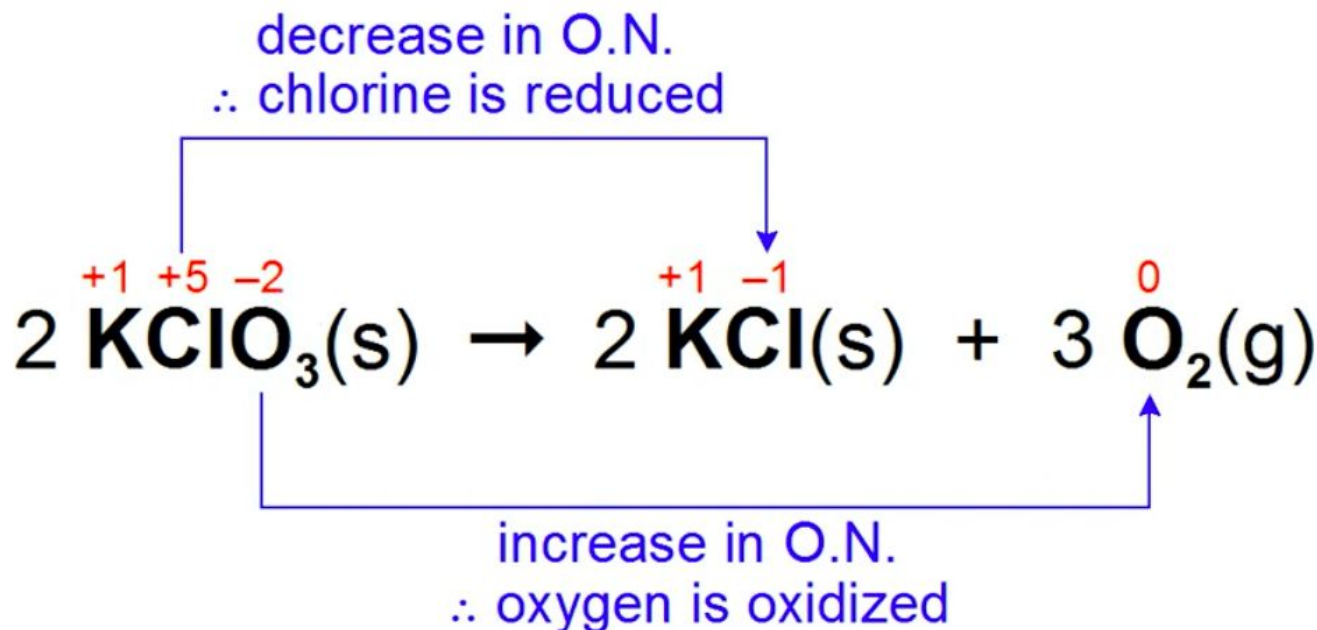
RULE 5 ⟶ $2(x) + 5(+1) + 1(-1) = 0$

$$2x + 4 = 0$$

$$2x = -4$$

$$x = -2$$

Example 4

Identify the element oxidized and the element reduced when potassium chlorate decomposes to potassium chloride and oxygen.

decrease in O.N.
∴ chlorine is reduced

$$\overset{+1\ +5\ -2}{2\ \textbf{KClO}_3\textbf{(s)}} \longrightarrow \overset{+1\ -1}{2\ \textbf{KCl(s)}} + \overset{0}{3\ \textbf{O}_2\textbf{(g)}}$$

increase in O.N.
∴ oxygen is oxidized

Success Criteria

❏   I can determine the oxidation number for atoms.
❏   I can analyse redox reactions based on changes
     in oxidation number.

WORK:
● Read **section 9.1** in textbook.
● Do questions **3, 4, 6** on **pages 607**
● Check your **answers** and review as necessary.