Oxidation-Reduction Reactions

Oxidation-Reduction Reactions

Acid-base reactions can be characterized as proton-transfer

oxidation-reduction reactions or redox, reactions are considered electron transfer reactions

Oxidation number

also called *oxidation state*

useful tool for understanding electron transfer in oxidation-reduction reactions

signifies the number of charges the atom would have in a molecule (or an ionic compound) if electrons were transfered completely.

Reference points for assigning oxidation numbers

(1) The oxidation number of an element is 0.

Na, Fe, Cl_2, F_2, P_4, ...

Reference points for assigning oxidation numbers

(2) The oxidation numbers in compounds of the metals in group 1A are always +1, those in group 2A are always +2, those in group 3A are +3.

Sodium is +1 NaCl

Calcium is +2 CaO

Aluminum is +3 Al_2O_3

Reference points for assigning oxidation numbers

(3) Oxygen has an oxidation number of -2 in most of its compounds.

Since the oxidation number of hydrogen of +1, each oxygen in H_2O_2 must have an oxidation number of -1.

Reference points for assigning oxidation numbers

(4) The oxidation number of hydrogen is usually +1.

Since the oxidation state of florine is -1, in all of its compounds, hydrogen must be +1 in HF. Likewise, the oxidation number of hydrogen is +1 in HCl, HBr, and HI.

Reference points for assigning oxidation numbers

A notable exception is that when hydrogen is bonded to a metal, the oxidation number of hydrogen is -1.

The compounds NaH and CaH_2 contain hydrogen in the -1 oxidation state.

Reference points for assigning oxidation numbers

(5) The halogens (fluorine, chlorine, bromine, and iodine) have an oxidation number of -1 in most of their compounds Fluorine always has an oxidation number of -1 in its compounds.

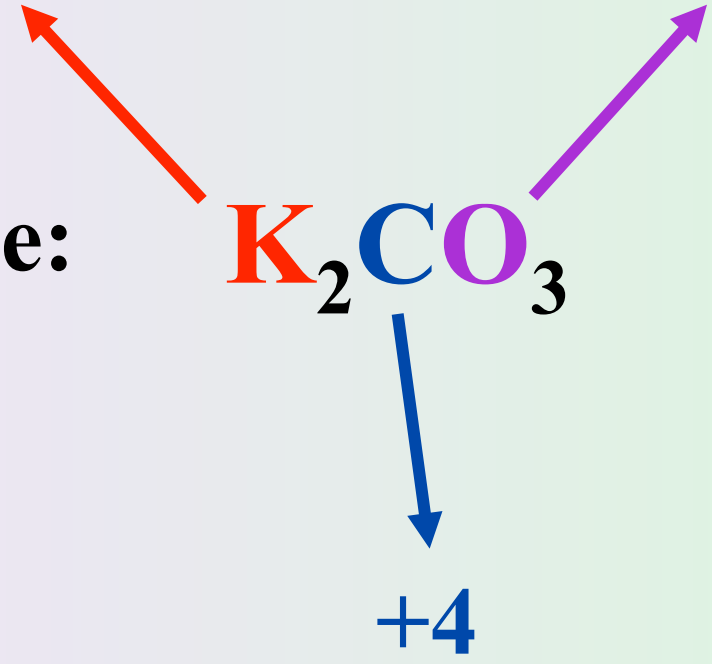
The oxidation number of bromine is -1 in NaBr, $CaBr_2$, $AlBr_3$, and $NiBr_2$.

Reference points for assigning oxidation numbers

(6) The sum of oxidation numbers in a neutral molecule must equal 0 .

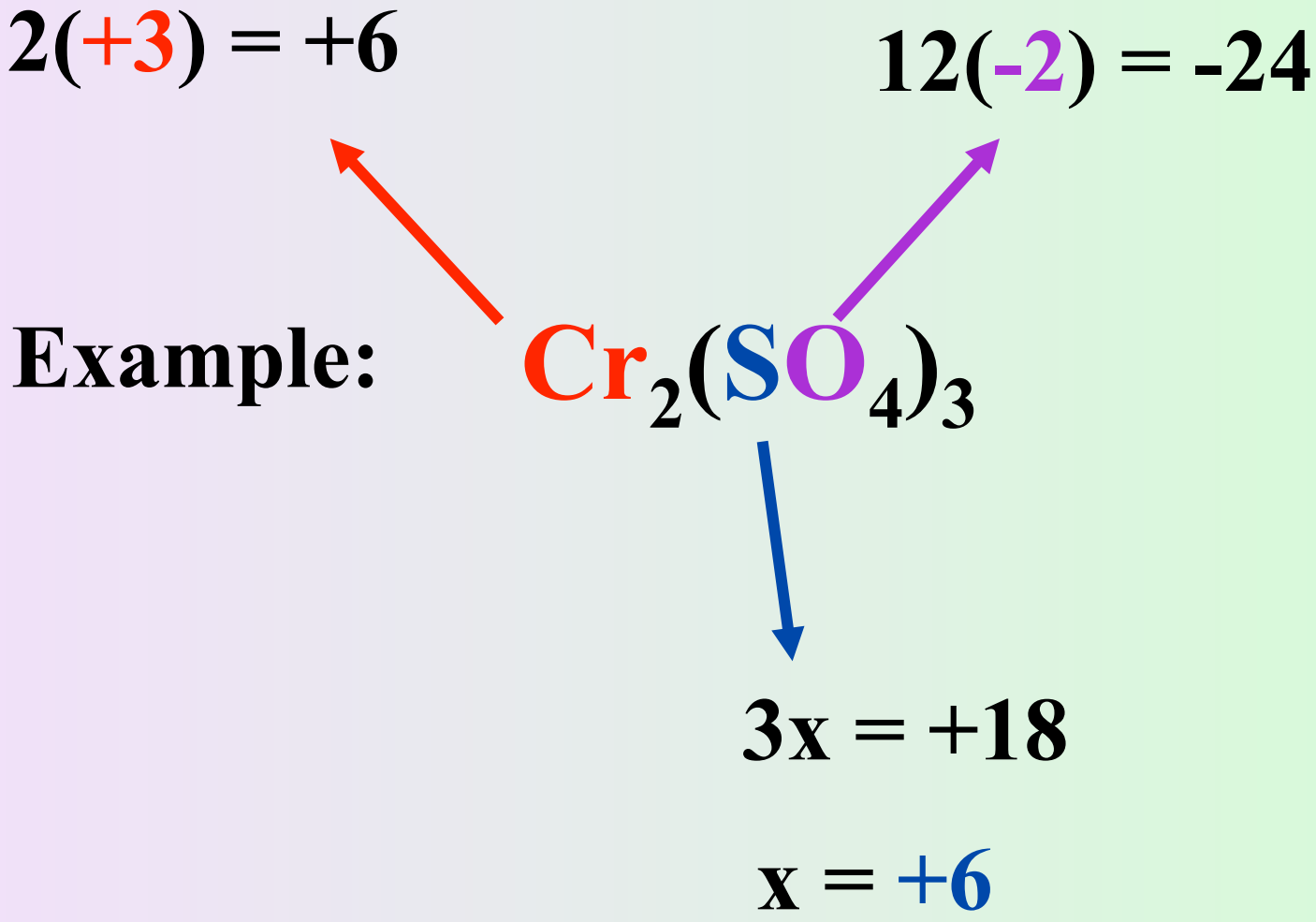
$2(+1) = +2$

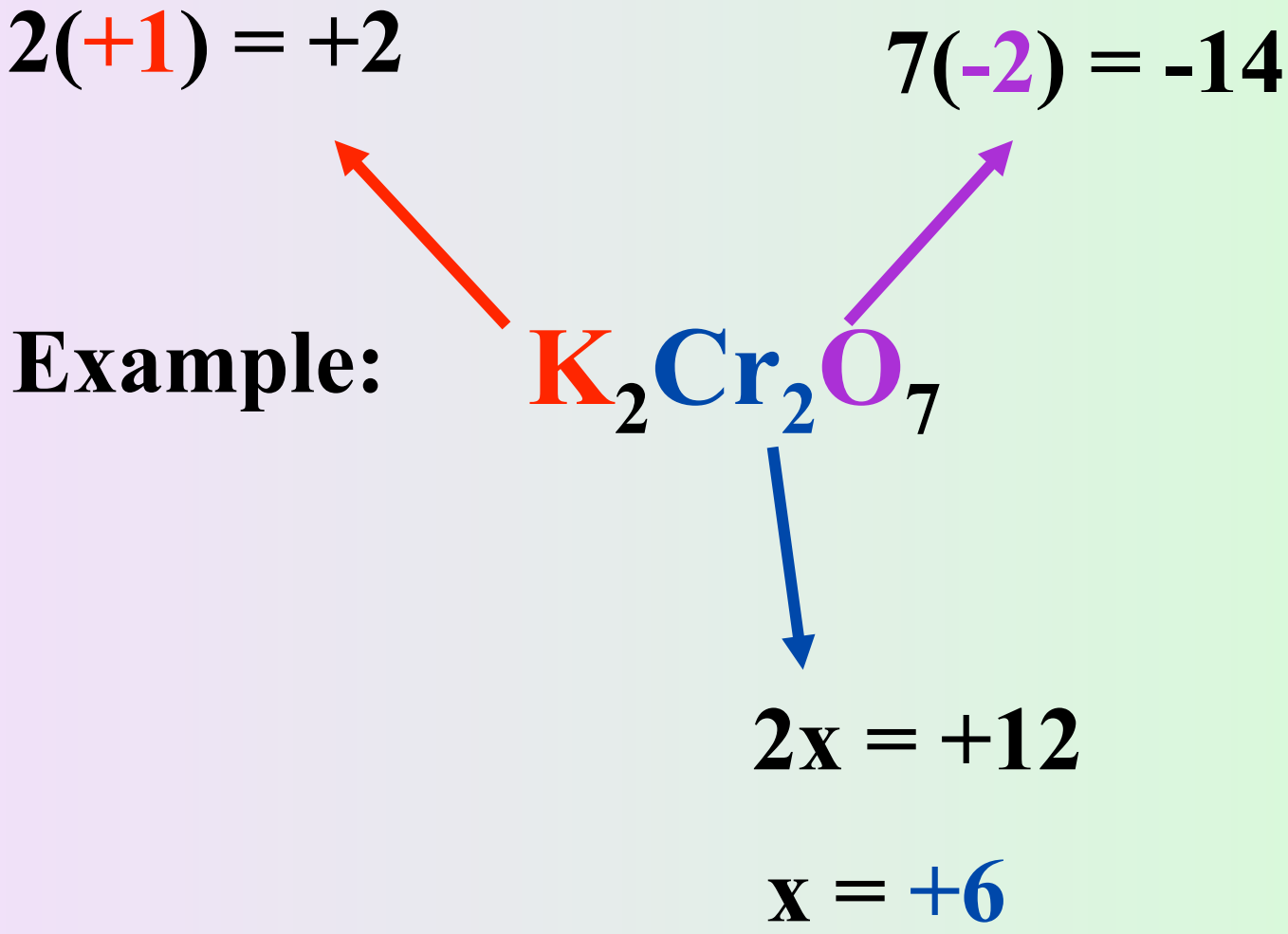
$3(-2) = -6$



Example: K_2CO_3

$+4$


2(+3) = +6
12(-2) = -24
Example:
$Cr_2(SO_4)_3$
3x = +18
x = +6


2(+1) = +2
7(-2) = -14
Example:
$K_2Cr_2O_7$
2x = +12
x = +6

Oxidation-Reduction Reactions

oxidation is an increase in oxidation state

loss of electrons from an atom or ion

reduction is a decrease in oxidation state

gain of electrons by atoms or ions

Oxidation-Reduction Reactions

oxidizing agent

gains electrons

reducing agent

gives up electrons

Types of Redox Reactions

combination

decomposition

displacement

- **of hydrogen**
- **of a metal**
- **of halogens**

Combination reactions

$$A + B \longrightarrow C$$

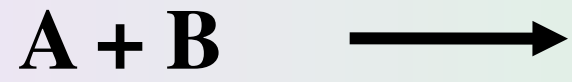
redox if A or B is an element

$$\overset{0}{S} + \overset{0}{O_2} \longrightarrow \overset{+4\ -2}{SO_2}$$

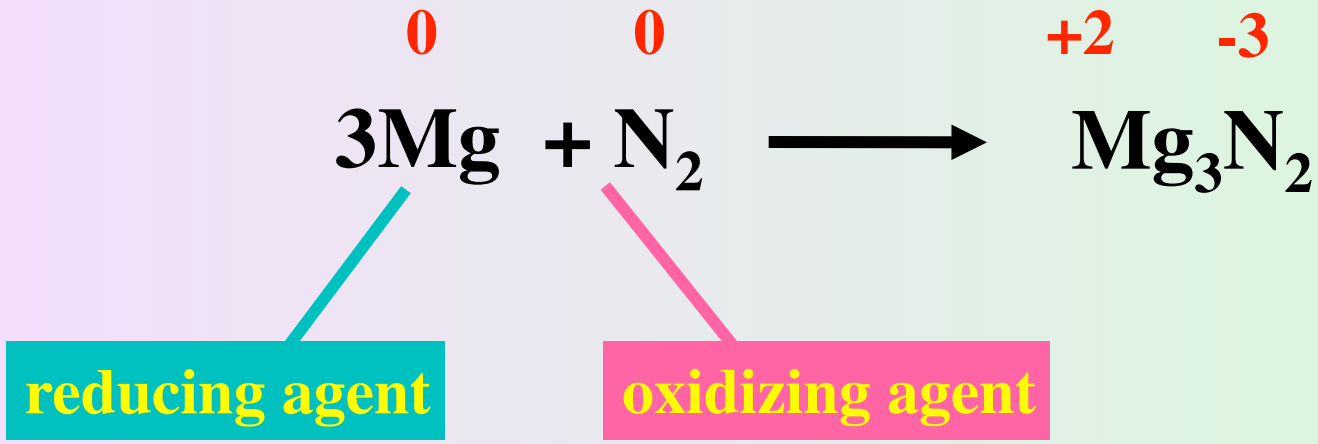
reducing agent

oxidizing agent

Combination reactions



redox if A or B is an element



Decomposition reactions

$$C \longrightarrow A + B$$

$$\overset{+2}{\underset{}{2HgO}} \overset{-2}{} \longrightarrow \overset{0}{\underset{}{2Hg}} + \overset{0}{\underset{}{O_2}}$$

oxidizing agent

reducing agent

Decomposition reactions

$$C \longrightarrow A + B$$

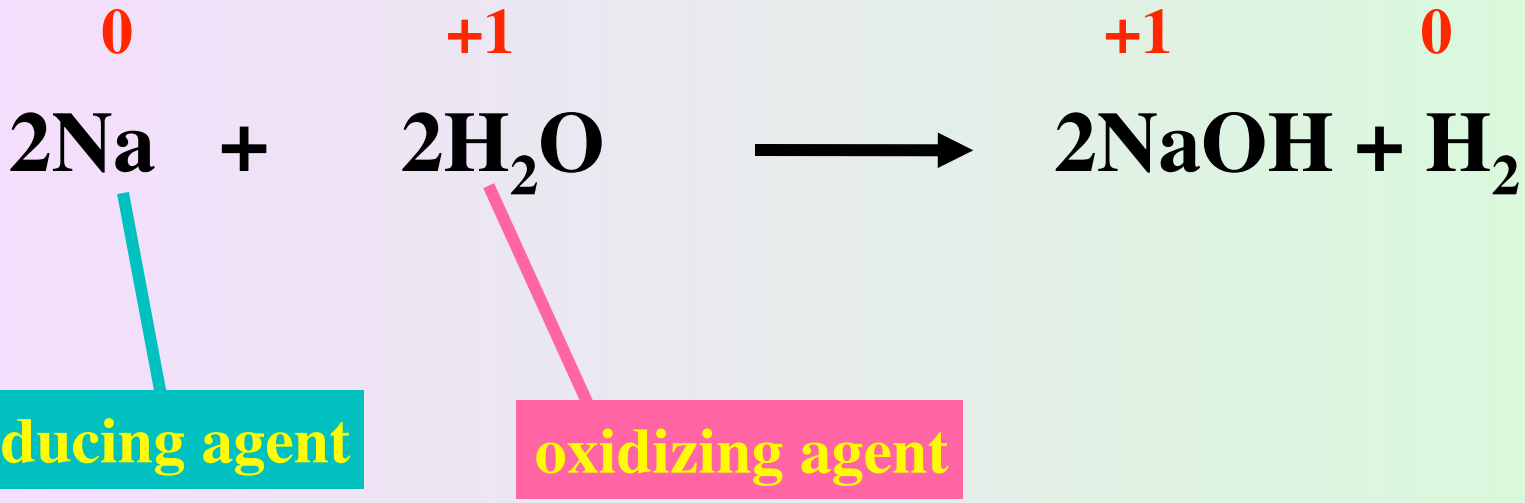
$$\overset{+5\ \ -2}{2KClO_3} \longrightarrow \overset{-1}{2KCl} + \overset{0}{3O_2}$$

oxidizing agent

reducing agent

Displacement reactions

of hydrogen



Displacement reactions

of metals

Displacement reactions

$$A + BC \longrightarrow AB + C$$

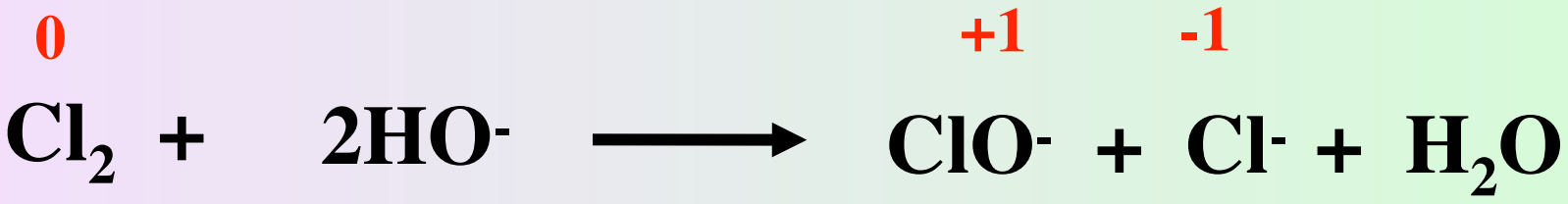
Of Halogens

$$\overset{0}{Cl_2} + \overset{-1}{KBr} \longrightarrow \overset{-1}{KCl} + \overset{0}{Br_2}$$

oxidizing agent

reducing agent

Disproportionation reactions



Classifying chemical reactions *(in high school chemistry)*

synthesis $A + B \longrightarrow AB$

decomposition $AB \longrightarrow A + B$

single replacement $AB + C \longrightarrow AC + B$

double replacement $AB + CD \longrightarrow AD + CB$

synthesis

two or more substances combine to produce a single (more complex) substance

(oxidation reduction reactions)

$$2H_2(g) + O_2(g) \longrightarrow 2H_2O(l)$$

$$CaO(s) + H_2O(l) \longrightarrow Ca(OH)_2(s)$$

decomposition

a single substance is broken down into two or more simpler substances

(oxidation reduction reactions)

single replacement reactions

a free element becomes an ion, and an ion in solution becomes a neutral atom

(oxidation reduction reactions)

$$Zn(s) + H_2SO_4(aq) \longrightarrow ZnSO_4(aq) + H_2(g)$$

$$Cu(s) + 2AgNO_3(aq) \longrightarrow 2Ag(s) + Cu(NO_3)_2(aq)$$

double replacement reactions

the cation of one aqueous compound replaces the cation in another aqueous compound

(precipitation reactions)

$$AgNO_3(aq) + NaCl(aq) \longrightarrow AgCl(s) + NaNO_3(aq)$$