Chemistry 12

Electrochemistry I

Name:
Date:
Block:

1. **Oxidation Numbers**
2. **Electron gain and loss**
3. **Agents**

Electrochemistry is the study of the interchange of chemical and electrical energy.

- Reactions with electron transfers are commonly called **oxidation-reduction reactions (redox reactions)**
- Not all reactions involve an electron transfer!

Oxidation Numbers

Oxidation number is the real or apparent **charge** of an atom or ion. Also called **"combining capacity".**

<u>Rules for Assigning Oxidation Numbers (simplified):</u>

1.

2.

3.

4.

5.

6.

7.

Hint!!

It might be helpful to break up a compound in a dissociation equation first!

Ex: $KMnO_4$ →

Ex: $Na_2Mo_2O_5$ →

Example: Assign the oxidation number of each atom in the following species

a) H_2O

b) AsO_4^{3-}

c) $Pb(NO_3)_2$

d) C_4H_{10}

e) $Al_2(SO_4)_3$

f) CO_3^{2-}

g) NH_4^+

h) $Na_2Cr_2O_7$

MORE PRACTICE!

Determine the oxidation number for **each atom** in the following compounds:

F_2	Fe_2O_3	$CaCO_3$	BrO_2^-
PbI_2	H_2	$S_2O_3^{2-}$	CN^-
ZnO	NH_4OH	P_4	Cs_2O_2
$S_2O_8^{2-}$	N_2H_4	MnO_4^-	PO_3^{3-}
N_2O_5	WBr_4	K_2S	SeO_3^{2-}
SF_6	NO_2	MnO_2^-	$Na_2Mo_2O_5$
$NaNO_3$	H_2CO	OH^-	Cl_2O
O_3	Ba_2XeO_4	PCl_3	P_2O_5
U_3O_8	Pb	$ZnBr_2$	$S_2O_3^{2-}$
$(NH_4)_2SeO_4$	CH_3OH	$LiAlH_4$	CH_3COO^-
$FeCl_3$	$(NH_4)_2C_2O_4$	BF_3	SiO_4^{4-}

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Electron gain and loss

Loss	Gain
• Oxidation number increases	• Oxidation number decreases
• Called "oxidation"	• Called "reduction"
L **E** **O**	**G** **E** **R**
O **I** **L**	**R** **I** **G**

$$Fe_{(s)} + Cu^{2+}_{(aq)} \rightarrow Fe^{2+}_{(aq)} + Cu_{(s)}$$

Practice:

Consider the following reaction:

$$2\ Al + Fe_2O_3 \rightarrow Al_2O_3 + 2\ Fe$$

Determine the oxidation numbers for each atom and write the value on top of the element in the reaction.

1. Are electrons gained or lost by each iron (III) ion? _____
    a. How many? _____
2. Are electrons gained or lost by each Al atom? _____
    a. How many? _____
3. How many electrons were transferred in total during the reaction? _____
4. What happened to the oxide ion, O^{2-} during the reaction?

The number of electrons _____ by the species being oxidized must always equal the number of electrons _____ by the species being reduced.

Practice:

1. Consider the following reactions. For each reaction:
   a) Determine the **oxidation number** for each of the atoms.
   b) Identify if the reaction is a **redox** reaction. (**red**uction/**ox**idation)

(1) $C + O_2 \rightarrow CO_2$

(2) $2CrO_4^{2-} + 2H^+ \rightarrow Cr_2O_7^{2-} + H_2O$

(3) $ZnCl_2 \rightarrow Zn^{+2} + 2Cl^-$

(4) $2\ NaI + Pb(NO_3)_2 \rightarrow PbI_2 + 2\ NaNO_3$

(5) $Cu + Ni^{2+} \rightarrow Cu^{2+} + Ni$

(6) $NH_3 + HCl \rightarrow NH_4Cl$

(7) $CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$

(8) $3\ I_2 + 3\ H_2O \rightarrow 6\ H^+ + 5\ I^- + IO_3^-$

(9) $Zn + Br_2 \rightarrow ZnBr_2$

(10) $H_2CO_3 \rightarrow H_2O + CO_2$

2. When MnO_4^{2-} undergoes **oxidation**, it may form:

A. MnO B. MnO_3 C. MnO_4^- D. Mn_2O_3

3. During the reaction, electrons transfer from:

$$MnO_4^- + 5\ Fe^{2+} + 8\ H^+ \rightarrow Mn^{2+} + 5\ Fe^{3+} + 4\ H_2O$$

A. Fe^{3+} to Fe^{2+} B. Fe^{2+} to MnO_4^- C. MnO_4^- to Fe^{2+} D. MnO_4^- to Mn^{2+}

Agents

Another way of looking at it is that one species ***causes*** the electron loss or gain. A species that is being oxidized causes the other species to gain electrons and be reduced.

$$MnO_4^- + 5\ Fe^{2+} + 8\ H^+ \rightarrow Mn^{2+} + 5\ Fe^{3+} + 4\ H_2O$$

A substance that is reduced acts as an _____ agent.

A substance that is oxidized acts as a _____ agent.

Practice:

a) Assign oxidation numbers to all atoms in the equation.
b) Indicate the oxidizing and reducing agents in each of the following reactions.

1. $C + O_2 \rightarrow CO_2$

Oxidizing agent (gets reduced): *Reducing Agent (gets oxidized):*

2. $4\ NH_3 + 7\ O_2 \rightarrow 4\ NO_2 + 6\ H_2O$

Oxidizing agent (gets reduced): *Reducing Agent (gets oxidized):*

3. $C + 2\ H_2 \rightarrow CH_4$

Oxidizing agent (gets reduced): *Reducing Agent (gets oxidized):*

4. $3\ Sr + 2\ FeBr_3 \rightarrow 2\ Fe + 3\ SrBr_2$

Oxidizing agent (gets reduced): *Reducing Agent (gets oxidized):*

5. $5\ CO + Cl_2O_5 \rightarrow 5\ CO_2 + Cl_2$

Oxidizing agent (gets reduced): *Reducing Agent (gets oxidized):*

6. $4\ PH_{3\ (g)} \rightarrow P_{4\ (g)} + 6\ H_{2\ (g)}$

Oxidizing agent (gets reduced): *Reducing Agent (gets oxidized):*

Worksheet
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