Announcements

No tutorial assignments in three weeks! Tutorial #3 will be posted on web by 10/19; the due date is 10/26.

Check the course web for

- **Answer keys of Tutorial Assignments**
- **Report Grading Guidelines and Prelab answers**
- **Recorded Grades**

When you report the flame colors, you should exclude the yellow/ orange color due to sodium contamination!!

What should be the correct flame colors?

$AgNO_3$	**Na_2CO_3**
HCl	**$CaCl_2$**
KOH	**Li_2SO_4**
$CuSO_4$	**$Ba(CH_3COO)_2$**

Chem 151 Lecture 4

EXP 3 Redox Reaction or Not?

A. Make nano-size Fe_3O_4 particles suspending in solution

B. Make a silver mirror from an Ag^+ solution

C. Reduction of VO_2^+ by zinc metal

Learn to:

- Identify a redox reaction
- Identify the oxidizing agents and the reducing agents
- Balancing redox reaction equations **(Net Ionic Equations)**

Oxidation State

The oxidation number is a bookkeeping device for the numbers of electrons gained or lost in an atom when it combines with other atoms to form a molecule.

The <u>possible</u> oxidation numbers of an atom can be derived from its ground state electron configuration.

e.g., Cl: [Ne] $3s^2$ $3p^5$

Its lowest possible O.N. is -1, highest possible O.N. is +7
Common O.N. are: -1, 0, +2, +5, and +7.
Any value between -1→ +7 is a possible O.N. of Cl.

e.g., Zn: The two stable O.N. are 0 and +2

e.g., Fe: The stable O.N. are 0, +2, and +3

e.g., V: The common O.N. are 0, +2, +3, +4, +5

The same element can have different O.N. in different compounds. This is because the O.N. of an atom depends on the other atoms in the molecule.

e.g. the O.N. of H in HCl is +1
the O.N. of H in NaH is –1
the O.N. of H in H_2 is zero.

How to assign oxidation numbers

1. **The O.N. of the more electronegative atom in a molecule is negative and the O.N. for the more electropositive atom is positive.**
2. **The O.N. of the atoms in free elements are always zero. The O.N. of a monatomic ion is the same as its charge.**

e.g. the O.N. of Al in a piece of Al metal is 0
the O.N. of Al in Al^{3+} is +3

3. **The algebraic sum of the O.N. of all atoms equals zero for an electrically neutral molecule, and equals the overall charge for an ionic species.**

e.g., NO_3^-

4. **Useful references for O.N. assignment**

- **With no exception**, the O.N. of alkali metals (Li, Na, K,…… etc.) in a compound are always +1. While the O.N. of the alkaline earth metals (Be, Mg, Ca, ···etc.) in a compound are always +2. The O.N. of fluorine in a compound is always -1.
- The O.N. of hydrogen is +1 in most compounds but is -1 in metal hydrides. The O.N. of oxygen is -2 in most compounds but is -1 in peroxides and -½ in superoxides. **Only group I elements forms peroxides and superoxides**.
- The polyatomic ions can also be used as references.

e.g., $In(NO_3)_3$ NO_3^- helps you assign as O.N. of In

Examples

Assign oxidation numbers to the atoms in each of the following molecules.

O.N. may not be an integer!

KO_2

H_2O_2

VO_2^+

VO_3^-

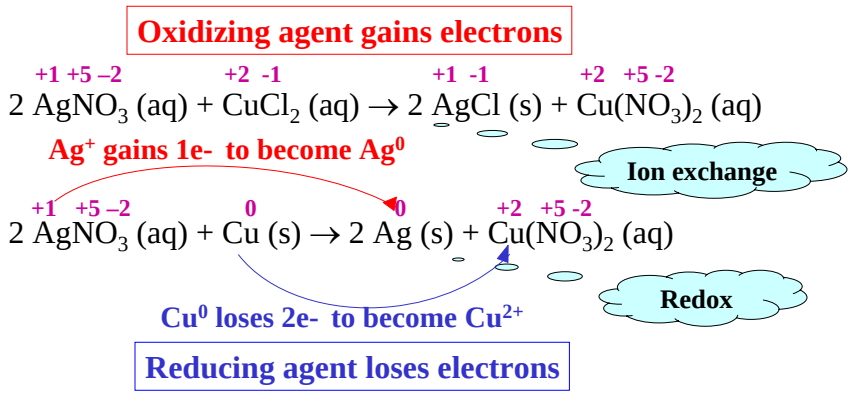
Fe_3O_4

Redox Reactions (reduction + oxidation)

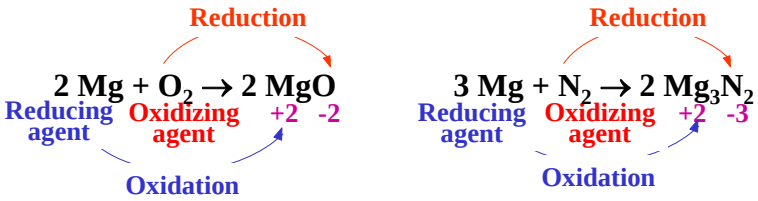
A redox reaction is defined as a reaction that involves transfer of electrons.

How does one know that electron transfer has occurred?

Ans. We know electron transfer has taken place if the oxidation number of an element has changed.



An Example to Remember



Oxidation is the process of losing e^- (LEO)

Reducing agent is being oxidized (O.N.↑)

e^-

When an element is at its lower O.N., it is a possible reducing agent; e.g. Cl^-, S^{2-}, and metals.

Reduction is the process of gaining e^- (GER)

Oxidizing agent is being reduced (O.N.↓)

When an element is at its higher O.N., it is a possible oxidizing agent; e. g. **Cl in ClO_4^-, Mn in MnO_4^-**

A redox reaction is a "tug of war" for electrons!

Some substances can act as an oxidizing agent or a reducing agent

For example, the oxygen in H_2O_2

H_2O **-2** ⟵ Reduction (Gains e^-) **-1** ⟶ oxidation (loses e^-) **0** O_2

Oxidation half-reaction $H_2O_2 \rightarrow O_2 + 2\,e^- + 2\,H^+$

Reduction half-reaction $2\,H^+ + H_2O_2 + 2\,e^- \rightarrow 2\,H_2O$

A half-reaction equation should be balanced

- **in mass (number of atoms of each element)**
- **in net charges**

Balancing a Redox Reaction

1. **Identify the species being oxidized and species being reduced.**
2. **Write the oxidation and reduction half-reactions.**
   a. **Balance all elements except O and H.**
   b. **Balance the number of electrons gained or lost.**
   c. **Balance the net charges by adding H^+ (acidic) or OH^- (basic).**
   d. **Balance the O and H by adding H_2O.**
3. **Make the number of e^- gained cancel the number of e^- lost.**
4. **Add the two half reactions to obtain a balanced overall equation.**

In basic solution NO_3^- + Al → NH_3 + $Al(OH)_4^-$

(+5) (0) (-3) (+3)

Oxidation Reaction $4\,OH^- + Al \rightarrow Al(OH)_4^- + 3\,e^-$

Reduction Reaction $6\,H_2O + NO_3^- + 8\,e^- \rightarrow NH_3 + 9\,OH^-$

Overall $18H_2O + 3NO_3^- + 8Al + 5OH^- \rightarrow 8Al(OH)_4^- + 3NH_3$

Many examples are available for balancing redox reactions

DQ#4 (Assigning O.N. and identifying oxidizing/reducing agents)
Pre-lab Practice 3A (O.N. and Balancing redox equations)
Pre-lab Practice 3B (Balancing redox equations)
in Lab Manual…….Exp. 3 Introduction

Balancing Redox Equation Workshop at 5 pm in LS250

Be prepared, Report 3 is challenging

Exp 3

Part A Synthesis of an Aqueous Ferrofluid

$$2\,FeCl_3 + FeCl_2 + 8\,NH_3(aq) + 4\,H_2O \rightarrow Fe_3O_4 + 8\,NH_4Cl$$

$$NH_3 + H_2O \rightleftharpoons NH_4OH$$

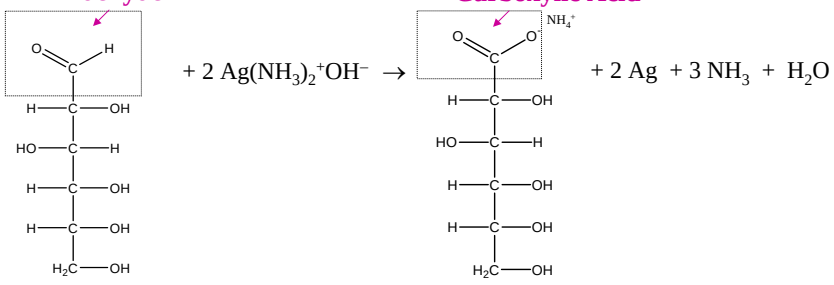
Part B The Silver Mirror Test (Tollen's test)

$$Ag^+ + OH^- \rightarrow AgOH$$

Tollen's Reagent

$$AgOH + 2\,NH_4OH \rightarrow [Ag(NH_3)_2]^+\,OH^- + 2\,H_2O$$

Aldehyde → Carboxylic Acid



Glucose → Gluconic Acid

Part C Progressive Reduction of Dioxovanadium(V) by Zinc Metal

Vanadate is VO_4^{3-}

VO_3^- Metavanadate

2 M H_2SO_4

$VO_3^- + 2\ H_3O^+ \rightarrow VO_2^+ + 3\ H_2O$

VO_2^+ Dioxovanadium(V)

Zn

VO^{2+} Oxovanadium(IV)

Zn

V^{3+} Vanadium(III)

Zn

V^{2+} Vanadium(II) $\xrightarrow{H_2O_2}$?

What is the gas?

As Zn metal is oxidized, what does it become?

Ans: