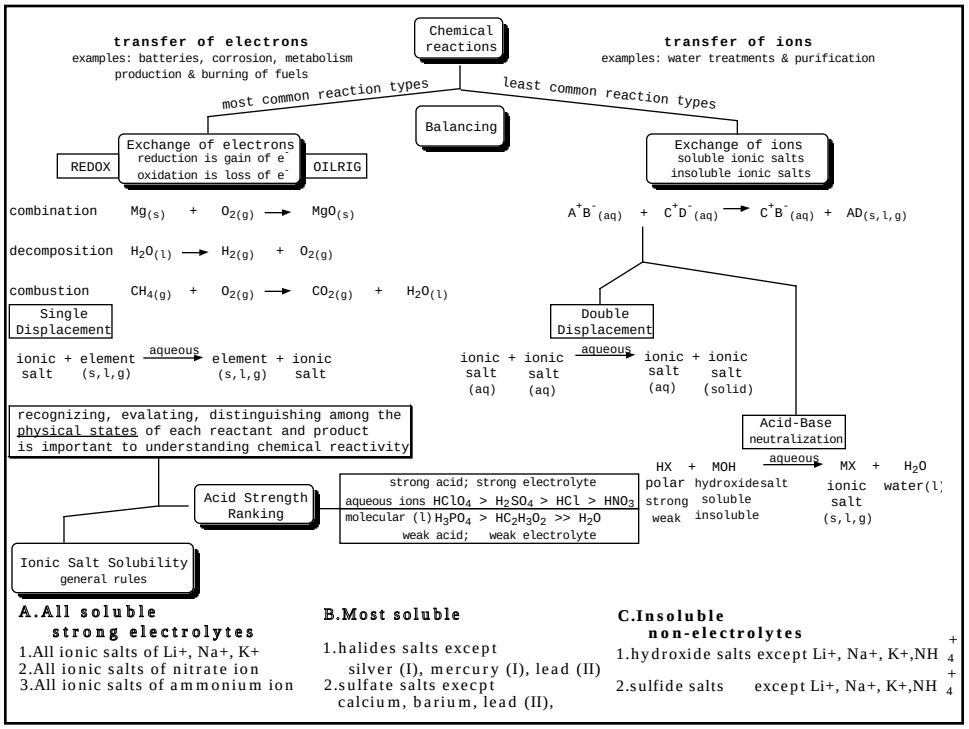
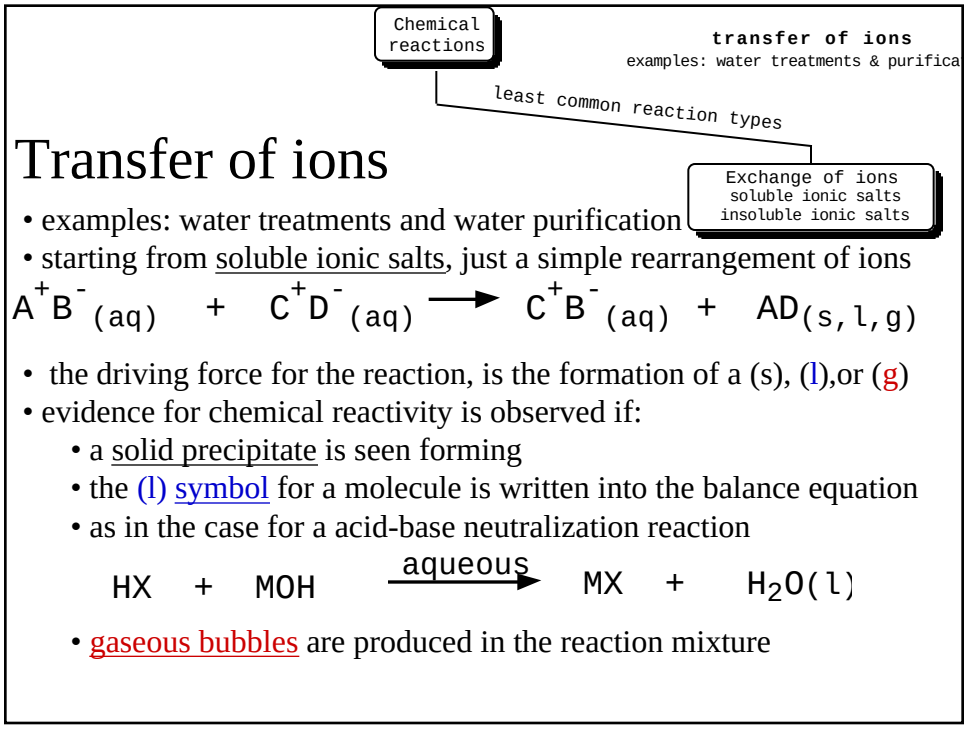

Chemical reactions
transfer of electrons
examples: batteries, corrosion, metabolism
production & burning of fuels
transfer of ions
examples: water treatments & purification
most common reaction types
least common reaction types
Balancing
Exchange of electrons
reduction is gain of e-
oxidation is loss of e-
REDOX
OILRIG
Exchange of ions
soluble ionic salts
insoluble ionic salts
combination Mg(s) + O2(g) → MgO(s)
decomposition H2O(l) → H2(g) + O2(g)
combustion CH4(g) + O2(g) → CO2(g) + H2O(l)
A+B-(aq) + C+D-(aq) → C+B-(aq) + AD(s,l,g)
Single Displacement
Double Displacement
ionic salt + element (s,l,g) aqueous element (s,l,g) + ionic salt
ionic salt (aq) + ionic salt (aq) aqueous ionic salt (aq) + ionic salt (solid)
recognizing, evalating, distinguishing among the physical states of each reactant and product is important to understanding chemical reactivity
Acid-Base neutralization
HX + MOH aqueous MX + H2O
polar hydroxide salt
strong soluble
weak insoluble
ionic salt (s,l,g)
water(l)
Acid Strength Ranking
strong acid; strong electrolyte
aqueous ions HClO4 > H2SO4 > HCl > HNO3
molecular (l) H3PO4 > HC2H3O2 >> H2O
weak acid; weak electrolyte
Ionic Salt Solubility
general rules
A.All soluble strong electrolytes
1.All ionic salts of Li+, Na+, K+
2.All ionic salts of nitrate ion
3.All ionic salts of ammonium ion
B.Most soluble
1.halides salts except silver (I), mercury (I), lead (II)
2.sulfate salts execpt calcium, barium, lead (II),
C.Insoluble non-electrolytes
1.hydroxide salts except Li+, Na+, K+,NH4+
2.sulfide salts except Li+, Na+, K+,NH4+


Chemical reactions
transfer of ions
examples: water treatments & purifica
least common reaction types
Exchange of ions
soluble ionic salts
insoluble ionic salts
Transfer of ions
• examples: water treatments and water purification
• starting from soluble ionic salts, just a simple rearrangement of ions
A+B-(aq) + C+D-(aq) → C+B-(aq) + AD(s,l,g)
• the driving force for the reaction, is the formation of a (s), (l),or (g)
• evidence for chemical reactivity is observed if:
• a solid precipitate is seen forming
• the (l) symbol for a molecule is written into the balance equation
• as in the case for a acid-base neutralization reaction
HX + MOH aqueous MX + H2O(l)
• gaseous bubbles are produced in the reaction mixture

Exchange of ions
soluble ionic salts
insoluble ionic salts

	Cu^{2+} SO_4^{2-} $CuSO_4$ (aq)	Na^+ NO_3^- $NaNO_3$ (aq)	H^+ Cl^- HCl (aq)	Ag^+ NO_3^- $AgNO_3$ (aq)	$2Na^+$ CO_3^{2-} Na_2CO_3 (aq)
Cu^{2+} SO_4^{2-} $CuSO_4$ (aq)		$Cu(NO_3)_{2\,(aq)}$ $Na_2SO_{4\,(aq)}$	$CuCl_{2\,(aq)}$ $H_2SO_{4\,(aq)}$	$Cu(NO_3)_{2\,(aq)}$ $Ag_2SO_{4\,(s)}$	$Cu(CO_3)_{2\,(s)}$ $Na_2SO_{4\,(aq)}$
Na^+ NO_3^- $NaNO_3$ (aq)			$NaCl_{\,(aq)}$ $HNO_{3\,(aq)}$	$NaNO_{3\,(aq)}$ $AgNO_{3(aq)}$	$Na_2CO_{3\,(aq)}$ $Cu(NO_3)_{2\,(aq)}$
H^+ Cl^- HCl (aq)				$HNO_{3\,(aq)}$ $AgCl_{\,(s)}$	$H_2CO_3 = CO_2 + H_2O$ $NaCl_{\,(aq)}$
Ag^+ NO_3^- $AgNO_3$ (aq)					$Ag_2CO_{3\,(s)}$ $NaNO_{3\,(aq)}$
$2Na^+$ CO_3^{2-} Na_2CO_3 (aq)					

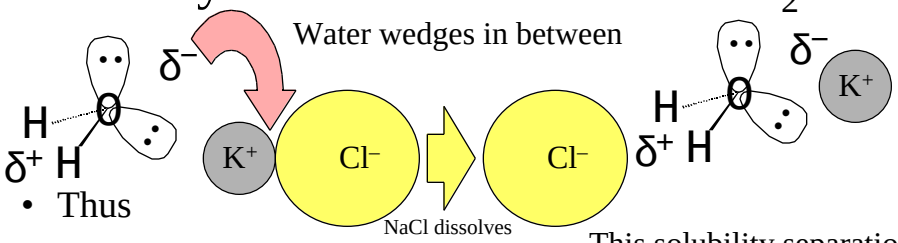
1. Write correct ions and ionic salt formulas
2. Apply solubility rules to determine if salts are Soluble (aq) or insoluble (s) in water

A. All soluble strong electrolytes
1. All ionic salts of Li^+, Na^+, K^+
2. All ionic salts of nitrate ion
3. All ionic salts of ammonium ion

B. Most soluble
1. halides salts except silver (I), mercury (I), lead (II)
2. sulfate salts except calcium, barium, lead (II),

C. Insoluble non-electrolytes
1. hydroxide salts except Li^+, Na^+, K^+, NH_4^+
2. sulfide salts except Li^+, Na^+, K^+, NH_4^+

Solubility Rules for Ionic Salts in H_2O



- Thus
- All ionic salts of group I ions,
  - Li^+, Na^+, K^+ are solubule in water
- All ionic salts of nitrate ion,
  - NO_3^- are solubule in water
- All ionic salts of ammonium ion,
  - NH_4^+ are solubule in water

This solubility separation is called solvation-dissociation

Acids

- often have H listed first in their chemical formula

- Strong Acids (strong electrolytes)

$HClO_4 > H_2SO_4 > HCl > HNO_3 >>$

$H^+ \ ClO_4^{-}{}_{(aq)} \quad 2H^+ \ SO_4^{2-}{}_{(aq)} \quad H^+ \ Cl^-{}_{(aq)} \quad H^+ \ NO_3^-{}_{(aq)}$

$H_3PO_4 > HC_2H_3O_2$
(l) (l)

Weak Acids
Weak Electrolytes
Stay as liquids
Stay molecular

Exchange of ions
soluble ionic salts
insoluble ionic salts

$A^+B^-{}_{(aq)} + C^+D^-{}_{(aq)} \rightarrow C^+B^-{}_{(aq)} + AD_{(s,l,g)}$

Double Displacement

ionic salt (aq) + ionic salt (aq) $\xrightarrow{\text{aqueous}}$ ionic salt (aq) + ionic salt (solid

$Ag^+ \ (NO_3)^- \ Na^+ \ Cl^- \rightarrow Ag^+ \ Cl^- \ Na^+ \ (NO_3)^-$

silver (I) nitrate + sodium chloride → silver (I) chloride + sodium nitrate

$Ag\ NO_{3(aq)} \quad Na\ Cl_{(aq)} \quad Ag\ Cl_{(s)} \quad Na\ NO_{3(aq)}$

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Double Displacement

ionic salt (aq) + ionic salt (aq) $\xrightarrow{\text{aqueous}}$ ionic salt (aq) + ionic salt (solid)

$Na^+ \ (PO_4)^{3-} \quad Ba^{2+} \ Cl^- \rightarrow Ba^{2+} \ (PO_4)^{3-} \quad Na^+ \ Cl^-$

soduim phosphate + barium chloride → barium phosphate + sodium chloride

$Na_3PO_{4(aq)} \quad BaCl_{2(aq)} \rightarrow Ba_3(PO_4)_{2\,(s)} \quad NaCl_{(aq)}$

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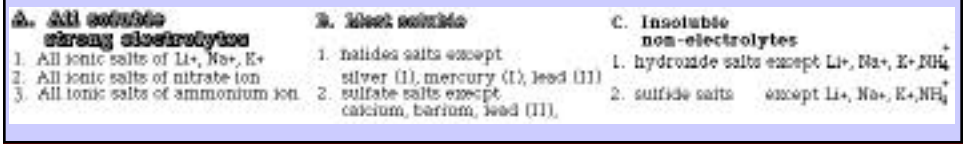

transfer of electrons

examples: batteries, corrosion, metabolism

production & burning of fuels

Chemical reactions

most common reaction types

REDOX | Exchange of electrons: reduction is gain of e^-; oxidation is loss of e^- | OILRIG

Transfer of electrons

- examples: batteries, corrosion, metabolism
- starting from an ionic salt and an element, an element and salt are produced.

ionic salt + element (s,l,g) $\xrightarrow{\text{aqueous}}$ element (s,l,g) + ionic salt

- the driving force for the reaction is the transfer of electrons which may result in the formation of a (s), (l),or (g)
- evidence for chemical reactivity is observed if:
  - a solid precipitate is seen forming
  - the (l) symbol for a molecule is written into the balance equation
  - as in the case for a acid-base neutralization reaction
  - gaseous bubbles are produced in the reaction mixture

Single Displacement

ionic salt + element (s,l,g) $\xrightarrow{\text{aqueous}}$ element (s,l,g) + ionic salt

$H^+ \ Cl^-$ hydrochloric acid + Mg magnesium metal → H_2 hydrogen gas + $Mg^{2+} Cl^-$ magnesium chloride

$HCl_{(aq)}$ + $Mg_{(s)}$ → $H_{2(g)}$ + $MgCl_{2(aq)}$

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1. hydroxide salts except Li^+, Na^+, K^+, NH_4^+
2. sulfide salts except Li^+, Na^+, K^+, NH_4^+

Single Displacement

ionic salt + element (s,l,g) $\xrightarrow{\text{aqueous}}$ element (s,l,g) + ionic salt

$Ag^+ NO_3^-$ hydrochloric acid + Cu copper metal → Ag silver metal + $Cu^{2+}NO_3^-$ sodium nitrate

$AgNO_{3(aq)}$ + $Cu_{(s)}$ → $Ag_{(s)}$ + $Cu(NO_3)_{2(aq)}$

1. Write correct ion and ionic salt formulas
2. Apply solubility rules to determine if salts are Soluble (aq) or insoluble (s) in water

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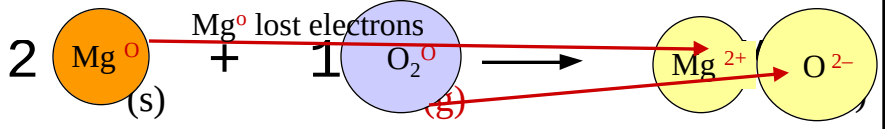
REDOX | Exchange of electrons: reduction is gain of e^-, oxidation is loss of e^- | OILRIG

combination $Mg_{(s)} + O_{2(g)} \rightarrow MgO_{(s)}$

What reactant was oxidized?

What reactant was reduced?



Mg^o lost electrons

magnesium metal solid

oxygen gas

magnesium oxide solid ionic salt

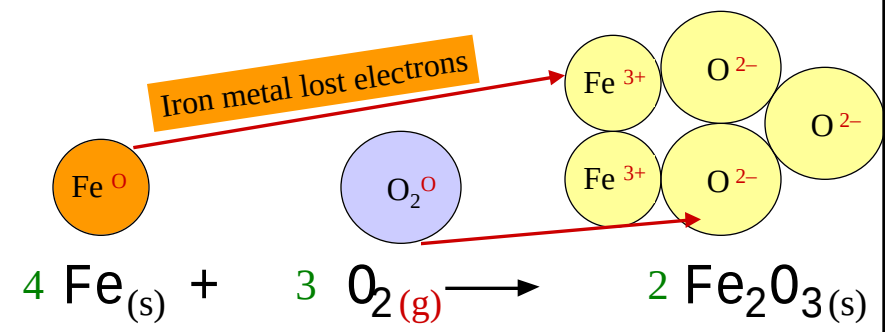
Oxygen gained electrons

REDOX | Exchange of electrons: reduction is gain of e^-, oxidation is loss of e^- | OILRIG

combination $Mg_{(s)} + O_{2(g)} \rightarrow MgO_{(s)}$

What reactant was oxidized?

What reactant was reduced?



$4\ Fe_{(s)} + 3\ O_{2\,(g)} \rightarrow 2\ Fe_2O_{3\,(s)}$

iron metal solid

oxygen gas

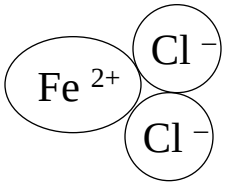
iron (III) oxide solid TM ionic salt

Oxygen gained electrons

Combination - Synthesis (the REDOX process defined)

iron metal chlorine gas forms iron (II) chloride

$1\ Fe_{(s)} + 1Cl_{2(g)} \longrightarrow 1\ FeCl_{2\,(s)}$



Analyzing the half reactions

$1\ Fe^{o} \longrightarrow 1\ Fe^{2+} + 2e^{-}$ Oxidation OIL

$1\ Cl_2^{\,o} + 2e^{-} \longrightarrow 2Cl^{-}$ Reduction RIG

the electrons on the reactant side cancel the electrons on the product side

$1\ Fe_{(s)} + 1\ Cl_{2(g)} \longrightarrow 1\ FeCl_{2\,(s)}$