

CHAPTER 7
REACTIONS IN AQUEOUS
SOLUTIONS

7

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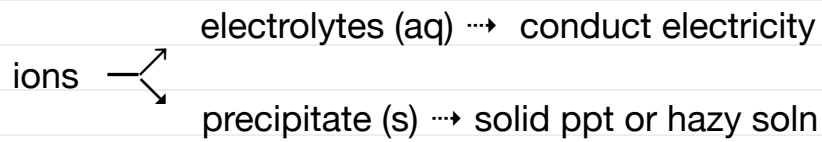
7 TYPES OF CHEMICAL REACTIONS

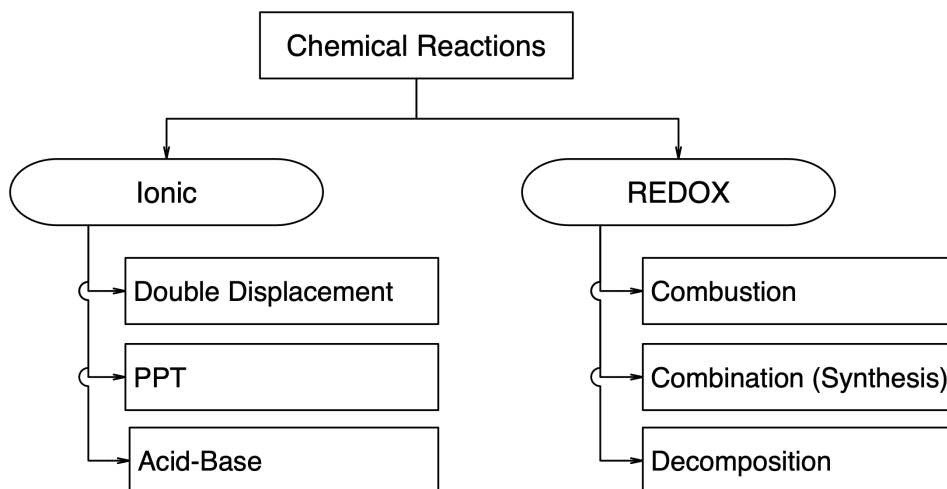
Indications a Reaction has Occurred



Electrolysis & Ionic Compound Degredation into Ions

Electrolysis – uses water to break compounds into ions





IONIC reactions occur between ionic compounds

↳ recall, ionic compound is usually a Metal + Nonmetal

↳ or another way of putting it: a Type I or Type II compound

REDOX reactions are reactions between covalent compounds

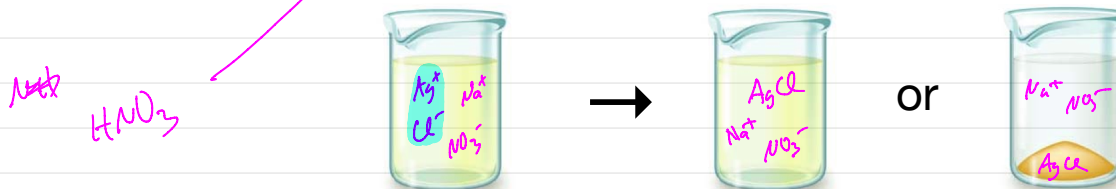
↳ reactions between Type III compounds

[1] Double Displacement

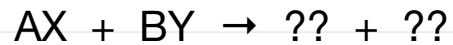
- Also known as a METATHESIS reaction
- Common vernacular is the PARTNER SWAP reaction
- Essentially, cations exchange their associated anions with each other
- Falls under the class of IONIC reactions
 - ↳ Ionic Compound = a Metal + a Nonmetal
 - ↳ Ionic Compound = Type I or Type II compound



for example . . .



Predicting ionic reaction products



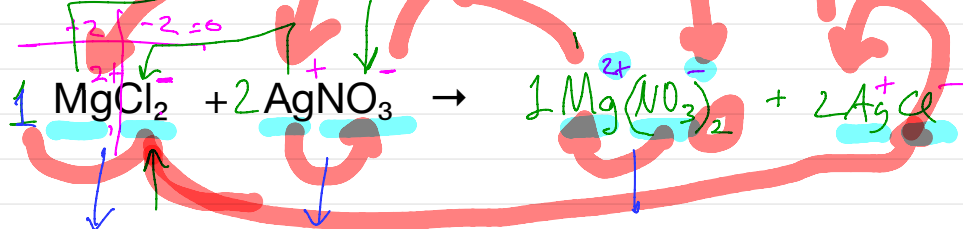
- ✓ (1) Pair (elements)
- ✓ (2) CHG neutral (compounds)
- ✓ (3) BCE (equation)

Given 2 Ionic Reactants: Procedure for Predicting Correct Molecular Equation

- (1) Pair (elements)
- (2) CHG neutral (compounds on Product-side)
- (3) BCE (entire chemical equation)

- ✓ (1) Pair (elements)
- ✓ (2) CHG neutral (compounds)
- ✓ (3) BCE (equation)

Molecular →

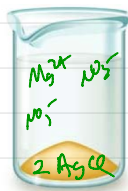
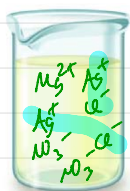
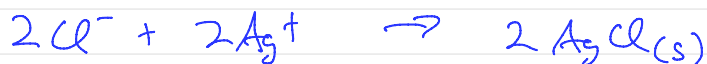


Solubility table

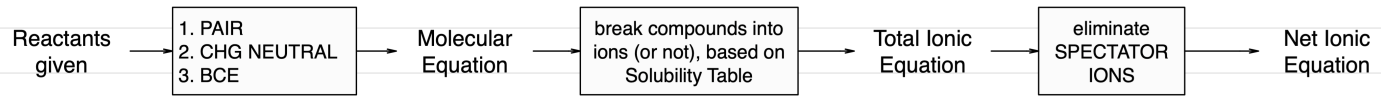
Total Ionic →



Net Ionic →



Spectator Ion — ion which does NOT participate in the chemical reaction; i.e., it is the same on both the Reactant and Product sides of the equation.



Solubility Tables

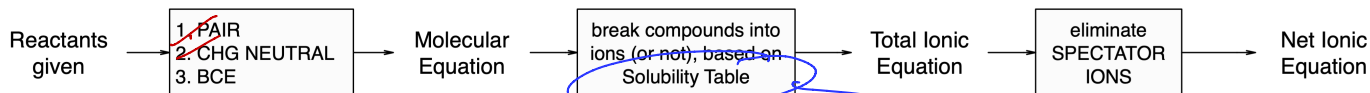
Solubilities of Common Ionic Compounds in Water

<p>Soluble compounds contain</p> <ul style="list-style-type: none"> group 1 metal cations (Li^+, Na^+, K^+, Rb^+, and Cs^+) and ammonium ion (NH_4^+) <ul style="list-style-type: none"> the halide ions (Cl^-, Br^-, and I^-) the acetate ($\text{C}_2\text{H}_3\text{O}_2^-$), bicarbonate ($\text{HCO}_3^-$), nitrate ($\text{NO}_3^-$), and chlorate ($\text{ClO}_3^-$) ions <ul style="list-style-type: none"> the sulfate (SO_4^{2-}) ion 	<p>Exceptions to these solubility rules include</p> <ul style="list-style-type: none"> halides of Ag^+, Hg_2^{2+}, and Pb^{2+} sulfates of Ag^+, Ba^{2+}, Ca^{2+}, Hg_2^{2+}, Pb^{2+}, and Sr^{2+}
<p>Insoluble compounds contain</p> <ul style="list-style-type: none"> carbonate (CO_3^{2-}), chromate (CrO_4^{2-}), phosphate (PO_4^{3-}), and sulfide (S^{2-}) ions <ul style="list-style-type: none"> hydroxide ion (OH^-) 	<p>Exceptions to these insolubility rules include</p> <ul style="list-style-type: none"> compounds of these anions with group 1 metal cations and ammonium ion hydroxides of group 1 metal cations and Ba^{2+}

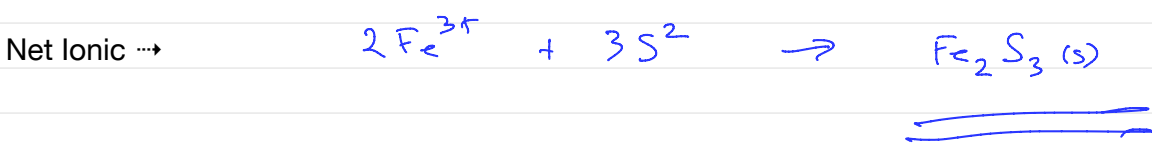
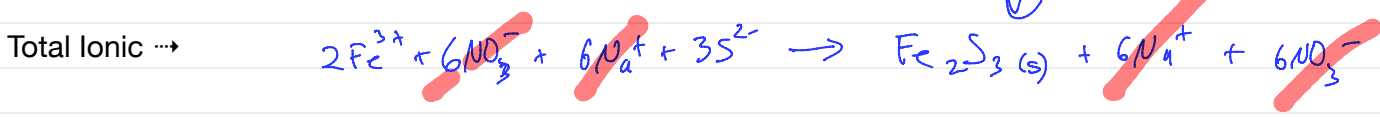
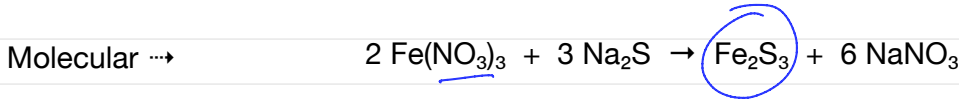
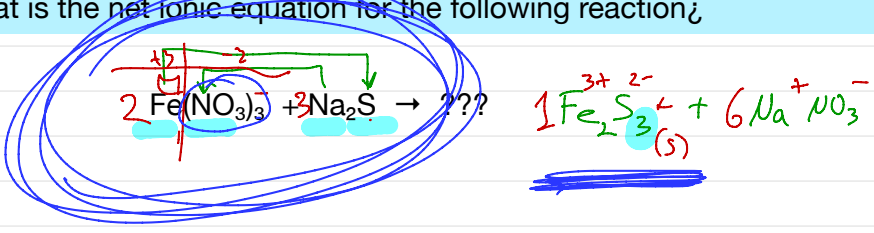
Table 4.1

	Ion	Ion Formula	Soluble	Insoluble	Exceptions
1	sodium ion	Na^+	✓		
2	potassium ion	K^+	✓		
3	ammonium	NH_4^+	✓		
4	nitrate	NO_3^-	✓		
5	acetate	AcO^-	✓		
6	halogen ion	Cl^- , Br^- , I^-	✓		salts with... Ag^+ , Hg_2^{2+} , Pb^{2+}
7	sulfate	SO_4^{2-}	✓		salts with... Ba^{2+} , Ca^{2+} , Pb^{2+} , Hg^{2+}
8	sulfide	S^{2-}		✓	salts with... Na^+ , K^+ , NH_4^+ , Mg_2^+ , Ca_2^+
9	carbonate	CO_3^{2-}		✓	salts with... Na^+ , K^+ , NH_4^+
10	phosphate	PO_4^{3-}		✓	salts with... Na^+ , K^+ , NH_4^+
11	arsenate	AsO_4^{3-}		✓	salts with... Na^+ , K^+ , NH_4^+
12	oxide	O^{2-}		✓	salts with... Group 1 & 2 metals
13	hydroxide	HO^-		✓	strong bases

Memorize "5 Always-soluble" ions?



(EX) Using the "5 Always Solubles" to quickly work a problem
 ¿What is the net ionic equation for the following reaction¿



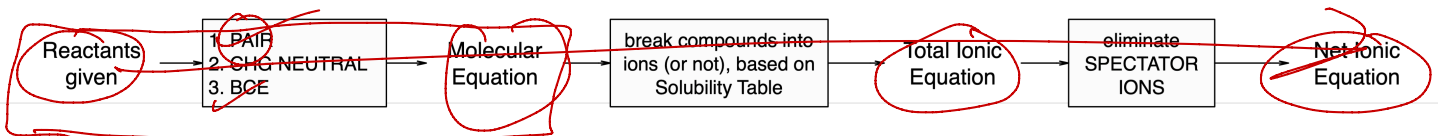
#76
 #72 When start - wrong

Skill you must have to be successful on next exam:

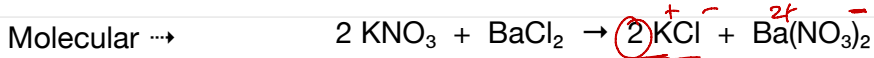
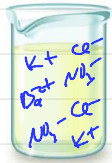
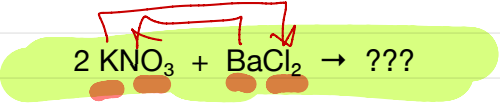
¿Could you have worked the above problem, had you only been given the Reactants, and not the Molecular Equation . . . that is, had you only been given:



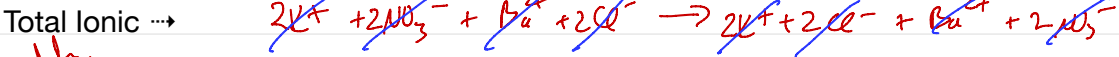
Wed, Oct 2



(EX) ¿What is the net ionic equation for the following reaction?



soluble in water



insoluble



EAST
hard "think" work

Not all chemicals, when mixed together, react!

[2] Precipitation Reactions

- As illustrated above
- Often, these are the result of ionic reactions; however, any type of reaction which give a precipitate is a precipitation reaction.
- To solve these problems, one either needs a solubility table, or to know the solubility rules for the reaction materials.

	Ion	Ion Formula	Soluble	Insoluble	Exceptions
1	sodium ion	Na ⁺	✓		
2	potassium ion	K ⁺	✓		
3	ammonium	NH ₄ ⁺	✓		
4	nitrate	NO ₃ ⁻	✓		
5	acetate	AcO ⁻	✓		
6	halogen ion	Cl ⁻ , Br ⁻ , I ⁻	✓		salts with... Ag ⁺ , Hg ₂ ²⁺ , Pb ²⁺
7	sulfate	SO ₄ ²⁻	✓		salts with... Ba ²⁺ , Ca ²⁺ , Pb ²⁺ , Hg ²⁺
8	sulfide	S ²⁻		✓	salts with... Na ⁺ , K ⁺ , NH ₄ ⁺ , Mg ²⁺ , Ca ²⁺
9	carbonate	CO ₃ ²⁻		✓	salts with... Na ⁺ , K ⁺ , NH ₄ ⁺
10	phosphate	PO ₄ ³⁻		✓	salts with... Na ⁺ , K ⁺ , NH ₄ ⁺
11	arsenate	AsO ₄ ³⁻		✓	salts with... Na ⁺ , K ⁺ , NH ₄ ⁺
12	oxide	O ²⁻		✓	salts with... Group 1 & 2 metals
13	hydroxide	HO ⁻		✓	strong bases

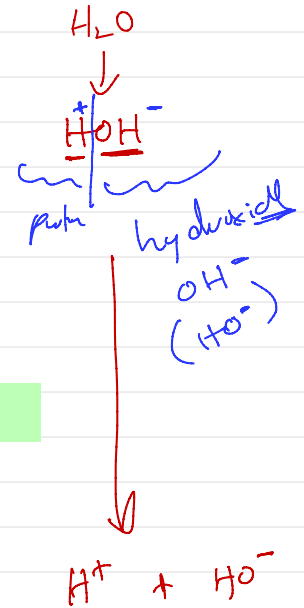
[3] Acid-Base Reactions

Definitions: What is an Acid, and what is a Base?

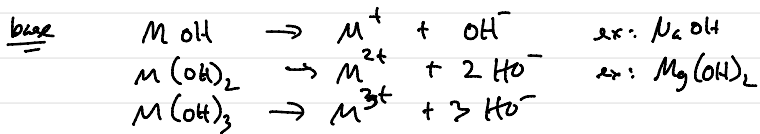
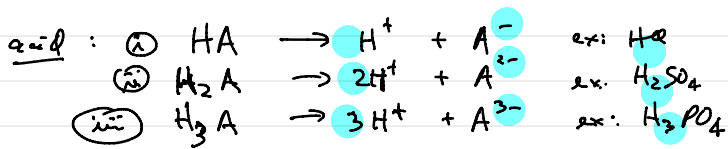
acid-base reaction — $\left. \begin{array}{l} \text{hydrogen ion} \\ \text{proton} \\ \text{hydronium ion} \end{array} \right\} \begin{array}{l} \text{H}^+ \\ \\ \text{H}_3\text{O}^+ \end{array}$ is transferred

Arrhenius acid — donates H^+ in water $\text{HA} \rightarrow \text{A}^- + \text{H}^+$

Arrhenius base — donates OH^- in water $\text{MOH} \rightarrow \text{M}^+ + \text{OH}^-$

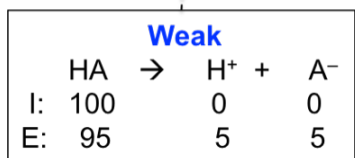
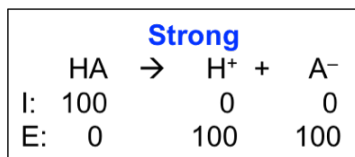


Representations of Acids and Bases: Generic Formulas



Strong vs. Weak Acids

- strong — dissociates 100%
- weak — “ < 100%



8 STRONG BASES

Hydroxides of ...

- ① Li
- ② Na
- ③ K
- ④ Rb
- ⑤ Cs
- ⑥ Ba
- ⑦ Sr
- ⑧ Ca

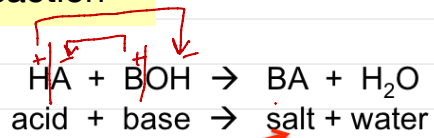
7 STRONG ACIDS

- ① HNO₃
- ② H₂SO₄
- ③ HClO₄
- ④ HClO₃
- ⑤ HCl
- ⑥ HI
- ⑦ HBr

[NOTE: For the most part, we will limit equations of acid-base reactions to those involving Strong Acids... acid-base reactions involving Weak Acids are much more difficult to work with, and beyond the scope of this class.]

Generic Acid-Base Reaction

general
reaction

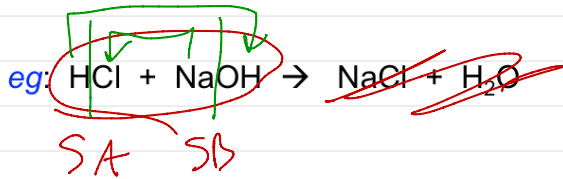


SALT = cation other than H^+ + anion other than HO^-

NaCl = table salt

MgSO_4 = epsom salt

NOMENCLATURE = Type I and Type II



Acid-Base Reaction is a type of Double Displacement

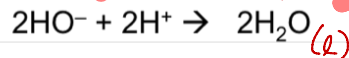
Molecular:



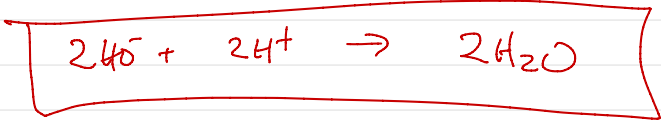
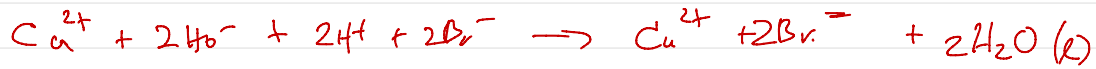
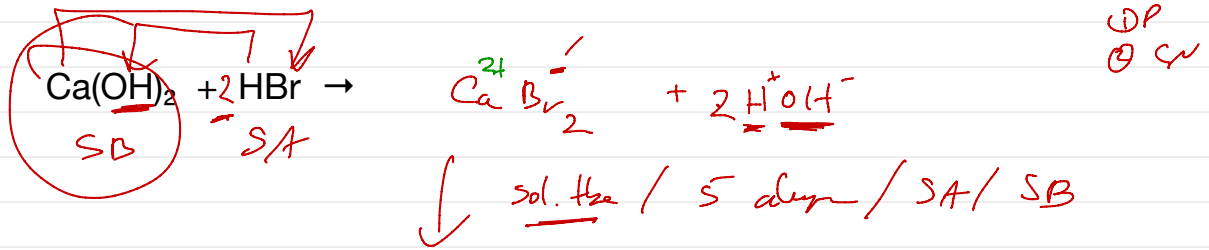
Total Ionic:



Net Ionic:

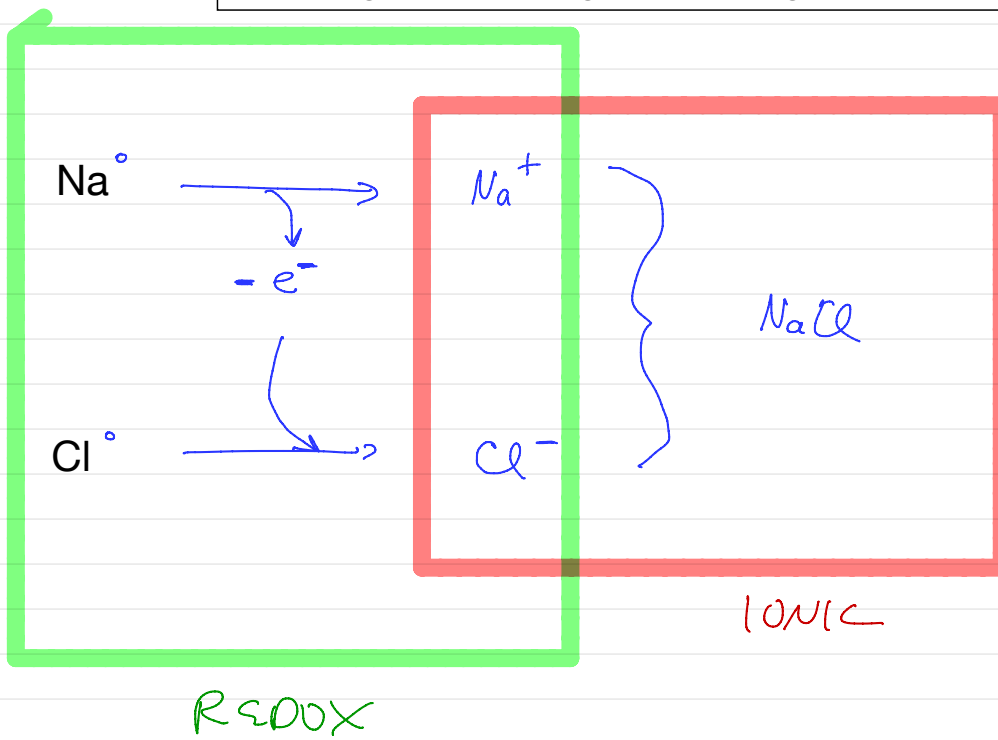


Practice Problem: Predict the products, and write balanced (i) molecular, (ii) total ionic, and (iii) net ionic equations.

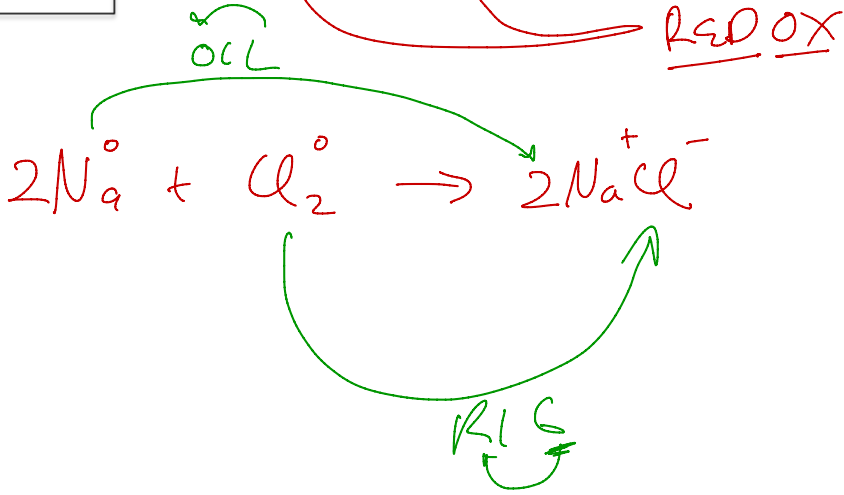
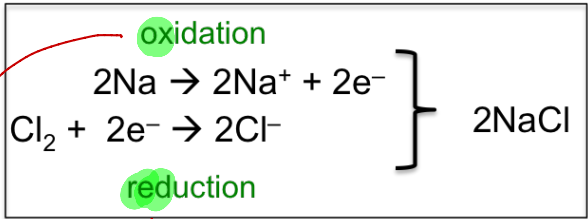
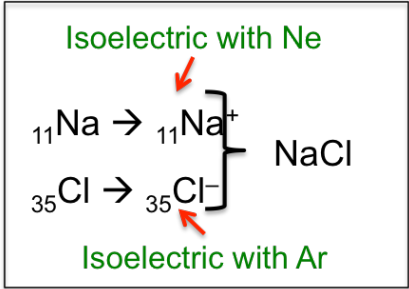


[4] REDOX Reactions

“Long Live the King” – the King’s Court story redux

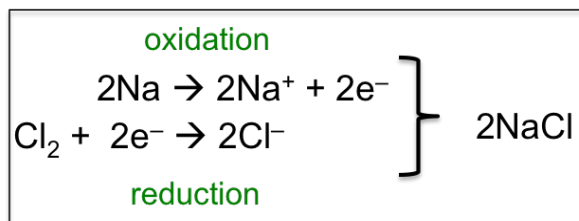


Half Reactions



Best Mnemonic Device Ever . . .

¿How to tell which half reaction is Oxidation, and which is Reduction



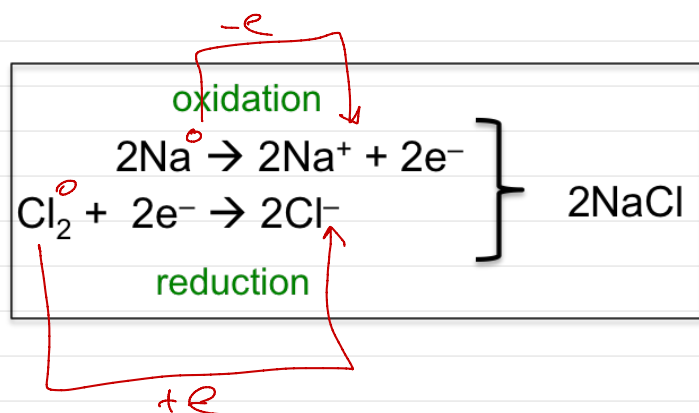
OIL
RIG

Agency

“AGENTS” (facilitates an action)

- Oxidizing agent (OXIDANT) = species that causes something else to become oxidized ... it is, itself, reduced.
- Reducing agent (REDUCTANT) = species that causes something else to become reduced... it is, itself, oxidized.

OIL
RIG



Mon Oct 7

Rules for Assigning Oxidation Numbers ("Charge")

A formalization of what you already know

1. The oxidation number of an atom in an elemental substance is zero.
2. Oxidation numbers for common NONmetals are usually assigned as follows:
 - Hydrogen: +1 when combined with nonmetals, -1 when combined with metals
 - Oxygen: -2 in most compounds
 - Halogens: -1 in most compounds
3. GROUP 1 = +1
4. GROUP 2 = +2
5. GROUP 3 = usually +3
6. Transition metals - Type I / Type II rules as guidance



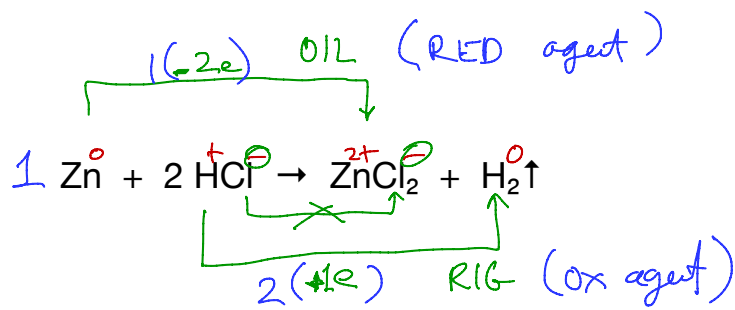
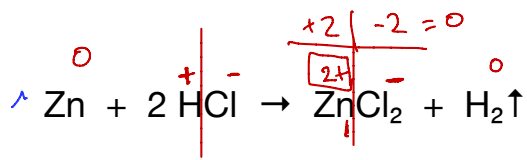
4 Types of REDOX questions

(EX) CLASSIFY REACTION

For the following reaction, answer the following:

- (1) Is this reaction a redox?
- (2) What is oxidized? (or, What is reduced?)
- (3) What is oxidizing agent? (or, What is reducing agent?)
- (4) How many electrons are transferred

OIL
RIG

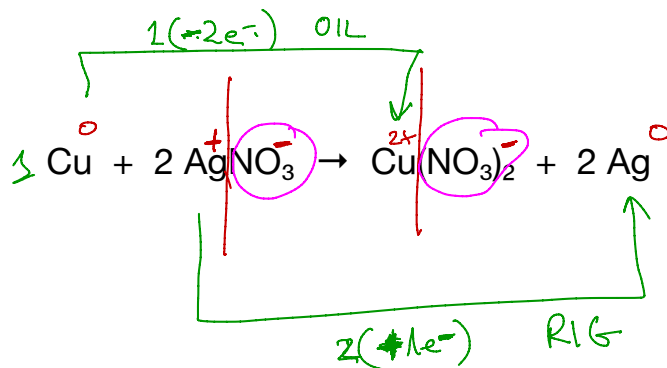


- (a) 1
- (b) 2 ✓
- (c) 3 ✓
- (d) 4
- (e) none of the above

(EX) CLASSIFY REACTION

¿For the following reactionS, answer the following:

- (1) Is this reaction a redox?
- (2) What is oxidized? (or, What is reduced?)
- (3) What is oxidizing agent? (or, What is reducing agent?)
- (4) How many electrons are transferred



[5] Combustion Reactions

- A special class of REDOX reaction

- For purposes of this class, a COMBUSTION reaction is one in which a compound reacts with elemental OXYGEN to produce an "OXIDE"

(EX) Combustion (redox) Reaction

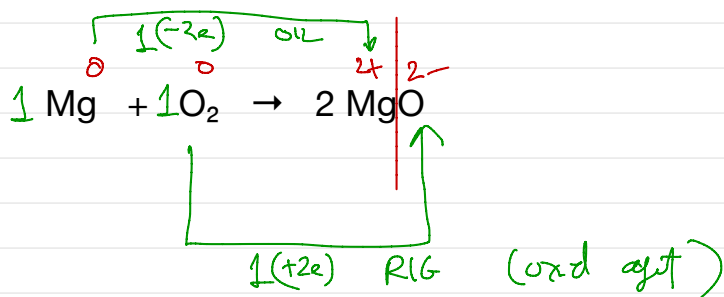
For the following reaction, answer the following:

(1) Is this reaction a redox? ✓

(2) What is oxidized? (or, What is reduced?) ✓

(3) What is oxidizing agent? (or, What is reducing agent?) ✓

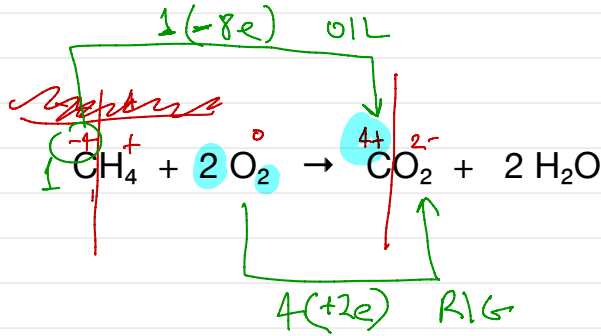
(4) How many electrons are transferred



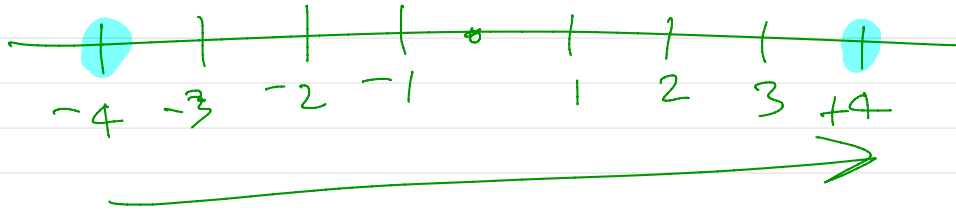
(EX) Hydrocarbon Combustion Reaction

For the following reaction, answer the following:

- (1) Is this reaction a redox?
- (2) What is oxidized? (or, What is reduced?)
- (3) What is oxidizing agent? (or, What is reducing agent?)
- (4) How many electrons are transferred



, C₄

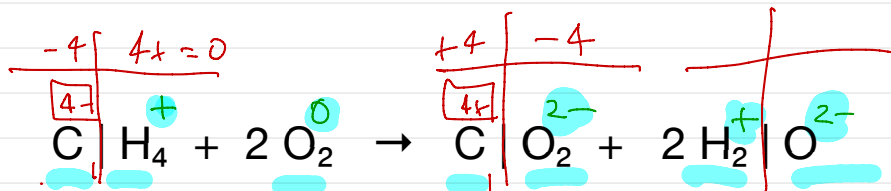


¿How do I determine the oxidation number (ON) of the carbon's?

To determine the ON for each element in a compound . . .

- treat each compound as if it has two pieces: a positive (cation) piece, and a negative (anion) piece.
- you must know the charge of one of the two “pieces” to calculate the other. You can usually figure one of them out by either looking at a periodic chart, or knowing the rules in the Oxidation Number list.
- once you know the charge on one of the two pieces, back-calculate the other until the compound of interest is Charge Neutral.

(essentially, you calculate in a manner analogous to the way you determine the Roman Numeral when naming a Type II compound)



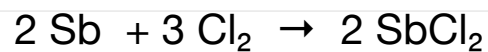
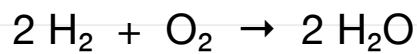
Procedure summary:

Identify the charge on one part of the compound, then “back-calculate” the other part.

[6] Synthesis Reactions

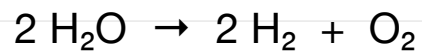
More → Fewer

aka Combination Rxn.



[7] Decomposition Reactions

Fewer → More

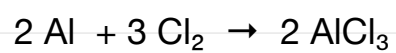


(EX) Classification of Reactions

¿Classify the following reactions ...



redox; combustion



syn; redox



dbl displ; ppt

My Cheatsheet

