

Know: Nomenclature (including names of polyatomic ions)

Solubility rules

Which elements are diatomic (HOFBrINCl and also At)

Charges of common transition metal ions

Fe is +2 or 3; Pb is +2 or 4; Sn is +2 or +4; Cu is +1 or 2; Ni is +2 or 3; Cr is +2, 3, or 6;

A halogen is an element from 7A

Types of Reactions: (UCE Rounds in parenthesis.)

1. **Combustion**

2. **Synthesis (or Combination)** (Round 2)

3. **Decomposition** (Round 2)

4. **Single Displacement** (Round 3)

5. **Double Displacement** (Round 4 – 6)

6. **Organic Reactions** (Round 1)

7. **Hydrolysis** (Round 7)

8. **Redox** (Round 11)

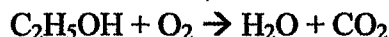
9. **Electrolysis** (Round 12)

10. **Complex ion reactions** (Round 13)

1. **Combustion** – results in forming the oxide of the elements of the compound

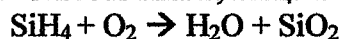
a) Hydrocarbons or alcohols combine with oxygen to form CO₂ and H₂O

Ex. Ethanol is burned in air



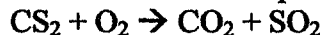
b) Nonmetallic hydrides (a hydride is a compound with a H⁻ anion) combine with oxygen to form nonmetal oxides and water

Ex. Gaseous silane, SiH₄, is burned in oxygen.



c) Nonmetallic sulfides combine with oxygen to form nonmetal oxides and sulfur dioxide

Ex. Carbon disulfide vapor is burned with excess oxygen



d) Ammonia combines with limited oxygen to produce NO and H₂O and with excess oxygen to produce NO₂

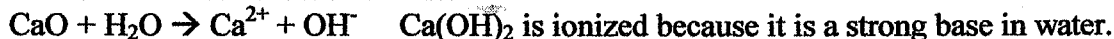
Ex. Ammonia is ignited in a closed container with limited air



2. **Synthesis (or Combination)** (UCE Round 2) – two reactants result in a single product

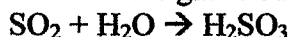
a) Metal oxide + water → base

Ex. Solid calcium oxide is added to water



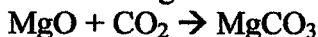
b) Nonmetal oxide + water → ternary acid

Ex. Sulfur dioxide gas is bubbled through water



c) Metal oxide + nonmetal oxide → ternary salt

Ex. Powdered magnesium oxide is added to a container of carbon dioxide



X 3. **Decomposition** (UCE Round 2) – one reactant becomes several products

a) Metallic hydroxide → metal oxide + water

Ex. Magnesium hydroxide is heated

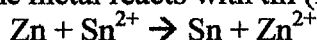


- b) Ternary acid \rightarrow nonmetal oxide + water
Ex. Sulfuric acid is heated
 $\text{H}_2\text{SO}_4 \rightarrow \text{SO}_2 + \text{H}_2\text{O}$
- c) Ternary salt \rightarrow metal oxide + nonmetal oxide
Ex. Sodium nitrate is strongly heated
 $\text{NaNO}_3 \rightarrow \text{Na}_2\text{O} + \text{NO}_2$
- d) Metallic chlorates \rightarrow metallic chlorides + oxygen
Ex. Potassium chlorate is heated
 $\text{KClO}_3 \rightarrow \text{KCl} + \text{O}_2$
- e) Electrolysis decomposes compound into its elements
Ex. A current of electricity is passed through water
 $\text{H}_2\text{O} \rightarrow \text{H}_2 + \text{O}_2$
- f) Hydrogen peroxide \rightarrow water + oxygen
Ex. Hydrogen peroxide is heated slightly
 $\text{H}_2\text{O}_2 \rightarrow \text{H}_2\text{O} + \text{O}_2$
- g) Metallic carbonates \rightarrow metal oxides + carbon dioxide
Ex. Copper (II) carbonate is heated
 $\text{CuCO}_3 \rightarrow \text{CuO} + \text{O}_2$
- h) Ammonium carbonate \rightarrow ammonia (NH_3) + water + carbon dioxide
 $(\text{NH}_4)_2\text{CO}_3 \rightarrow \text{NH}_3 + \text{H}_2\text{O} + \text{CO}_2$

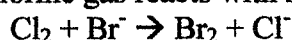
**4. Single displacement (UCE Round 3) – One element is displaced by another element
(metals displace metals and nonmetals displace nonmetals)**

Examples:

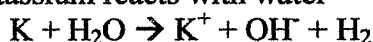
Zinc metal reacts with tin (II) sulfate solution



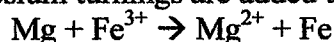
Chlorine gas reacts with sodium bromide solution



Potassium reacts with water



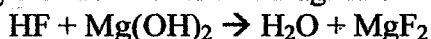
Magnesium turnings are added to a solution of iron (III) chloride



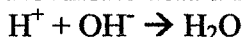
5. Double Displacement (a.k.a. Metathesis) (UCE Round 4–6) General Formula: $\text{AB} + \text{CD} \rightarrow \text{AD} + \text{CB}$

a) Neutralization – Acid + Base \rightarrow Water + Salt

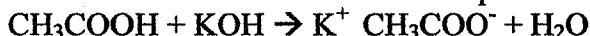
Ex. Hydrofluoric acid and magnesium hydroxide solutions are mixed (Weak Acid – Weak Base)



Ex. Hydrochloric acid and sodium hydroxide solutions are mixed. (Strong Acid – Strong Base)

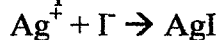


Ex. Acetic acid solutions reacts with solid potassium hydroxide

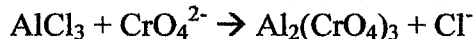


b) Precipitation – forming an insoluble product i.e. $\text{Ag}^+ + \text{Cl}^- \rightarrow \text{AgCl}$

Ex. Aqueous solutions of silver nitrate and sodium iodide are mixed



Ex. Solid aluminum chloride is added to an aqueous solution of potassium chromate

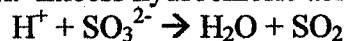


c) Gas Forming – produces a gas **Know:** $\text{H}_2\text{CO}_3 \rightarrow \text{H}_2\text{O} + \text{CO}_2$ and $\text{H}_2\text{SO}_3 \rightarrow \text{H}_2\text{O} + \text{SO}_2$

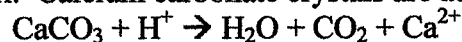
Ex. A solution of hydrofluoric acid is mixed with solid magnesium carbonate



Ex. Excess hydrochloric acid solution is added to a solution of potassium sulfite.

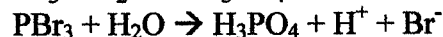
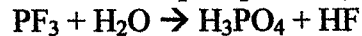


Ex. Calcium carbonate crystals are added to a solution of hydrochloric acid

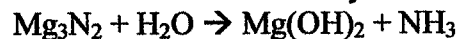


- Less common examples

- Phosphorus halides (i.e. PF_3) react with water to make an acid of phosphorus (H_3PO_4) and a binary acid containing hydrogen (i.e. HF)



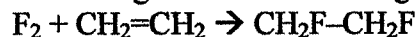
- Group 1A and 2A nitrides (i.e. Mg_3N_2) react with water to make the metallic hydroxide (i.e. $\text{Mg}(\text{OH})_2$) and ammonia (NH_3)



6. Organic Reactions (Round 1)

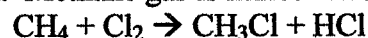
a) Addition reaction – hydrogen or halogen is added to a compound with a multiple bond. The hydrogen or halogen breaks the multiple bond and bonds with the carbon compound.

Ex. Fluorine gas is bubbled through ethene.



b) Substitution reaction – when an atom (often a halogen) is added

Ex. Methane gas is mixed with chlorine gas.



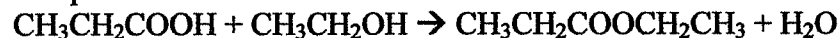
c) Organic Combustion reaction – when an organic compound reacts with oxygen gas (O_2) to produce water (H_2O) and carbon dioxide (CO_2)

Ex. Ethane burns in air.



d) Esterification reaction – when a carboxylic acid ($\text{R}-\text{COOH}$) is combined with an ($\text{R}'-\text{OH}$) alcohol to make an ester ($\text{R}-\text{COO}-\text{R}'$) and water (H_2O)

Ex. Propanoic acid is reacted with ethanol



7. Hydrolysis (UCE Round 7) – compounds reacting with water

Watch for soluble salts that contain anions of weak acids (the anion is a conjugate base) or cations of weak bases (the cation is a conjugate acid).

Examples:

1.0 M sodium acetate is added to water



Solid ammonium chloride is added to water



8. Redox – (a.k.a. oxidation-reduction) (UCE Round 11) – change in charges (oxidation state)

Keywords to look for:

- Common oxidizers or reducers (on tables below)
- “acidified” or “acid added”

Less common things to look for:

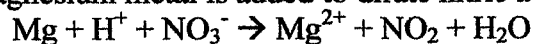
- Hydrides of 1A and Ca, Ba, or Sr dissolve in water to make hydroxides and H₂ gas.
i.e. $\text{NaH} + \text{H}_2\text{O} \rightarrow \text{Na}^+ + \text{OH}^- + \text{H}_2$ or $\text{BaH}_2 + \text{H}_2\text{O} \rightarrow \text{Ba}^{2+} + \text{OH}^- + \text{H}_2$
- One element can be both oxidized and reduced

Common Oxidizers	What they produce
MnO ₂ in acid solution	Mn ²⁺
MnO ₄ ⁻ in acid solution	Mn ²⁺
MnO ₄ ⁻ in neutral or basic solution	MnO ₂
Cr ₂ O ₇ ²⁻ in acid	Cr ³⁺
HNO ₃ , concentrated	NO ₂
Halogens, diatomic i.e. F ₂	Halide ions i.e. F ⁻
H ₂ SO ₄ , hot, concentrated	SO ₂

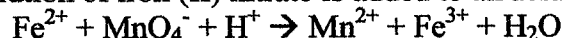
Common Reducers	What they produce
Metal element	Metal ion
Halide ions	Halogens, diatomic
Sulfite (SO ₃ ²⁻)	Sulfate (SO ₄ ²⁻)
Nitrite (NO ₂ ⁻)	Nitrate (NO ₃ ⁻)
H ₂ O ₂	O ₂
C ₂ O ₄ ²⁻	CO ₂

Examples:

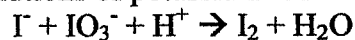
Magnesium metal is added to dilute nitric acid



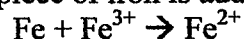
Solution of iron (II) nitrate is added to an acidified solution of potassium permanganate



Solutions of potassium iodide, potassium iodate, and dilute sulfuric acid are mixed



A piece of iron is added to a solution of iron (III) sulfate



Solid lithium hydride is placed in water



9. Electrolysis (Round 12) – where an electric current is passed through a solution and one kind of ion is oxidized and another kind of ion is reduced.

Reductions:

A cation may be reduced to its metal.



Water can be reduced to hydrogen and hydroxide.

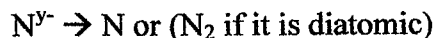


Which will happen?

- Transition (B-groups) metal ions are easier to reduce than water, so if you have a transition metal in water, the metal ions will be reduced to the solid neutral metal.
- Representative (A-groups) metal ions are harder to reduce than water, so if you have a representative metal in water the water will be reduced and the representative metal will stay as ions.

Oxidations:

An anion may be oxidized to its nonmetal.



Water can be oxidized to oxygen and hydrogen ions.



Which will happen?

- It is easier to oxidize chloride, bromide, and iodide to their ions than it is to oxidize water, so if any of these three are in water their ions will be produced.
- However, fluorine and all of the polyatomic ions are harder to oxidize than water, so if only these ions are in water the water will be oxidized instead of the ions

Ex. Aqueous calcium chloride is electrolyzed.

What could be reduced: Ca^{2+} and H_2O

Ca^{2+} is an A-group (and therefore harder to reduce than water) so the H_2O will be reduced to H_2

What could be oxidized?

Cl^- and $\text{H}_2\text{O} \rightarrow \text{Cl}^-$ is easier to oxidize than H_2O so, Cl^- will be oxidized to Cl_2

Rxn: $\text{H}_2\text{O} + \text{Cl}^- \rightarrow \text{H}_2 + \text{OH}^- + \text{Cl}_2$

Ex. Aqueous zinc sulfate is electrolyzed.

What could be reduced: Zn^{2+} and $\text{H}_2\text{O} \rightarrow \text{Zn}^{2+}$ is easier so, $\text{Zn}^{2+} \rightarrow \text{Zn}$

What could be oxidized? SO_4^{2-} and $\text{H}_2\text{O} \rightarrow \text{H}_2\text{O}$ is easier so, $\text{H}_2\text{O} \rightarrow \text{O}_2 + \text{H}^+$

Rxn: $\text{Zn}^{2+} + \text{H}_2\text{O} \rightarrow \text{Zn} + \text{O}_2 + \text{H}^+$

Ex. Molten calcium phosphide is electrolyzed. (Note: Molten means liquid. There is no water present!)

What could be reduced: $\text{Ca}^{2+} \rightarrow$ no other choices so, $\text{Ca}^{2+} \rightarrow \text{Ca}$

What could be oxidized? $\text{P}^{3-} \rightarrow$ no other choices so, $\text{P}^{3-} \rightarrow \text{P}$

Rxn: $\text{Ca}_3\text{P}_2 \rightarrow \text{Ca} + \text{P}$

10. Complex ion reactions (UCE Round 13) – a reaction where a coordinate compound and a ligand react to make a complex ion

- a) The formation of a Complex occurs when you add excess source of ligand to transition metal. Keywords such as “excess” and “concentrated” of compounds containing ligands indicates a formation of a complex ion.

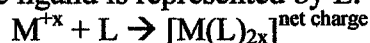
Complex ions are compounds where ligands are bonded to a central atom that is a transition metal (or Al).

Ligands are normally OH^- or NH_3 or Cl^- (but could also be CN^- (cyanide) and SCN^- (thiocyanate)). In the complex, the number of ligands is normally twice the charge of the metal ion.

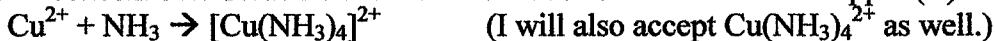
General Form:

where the transition metal (or Al) is represented by M

and the ligand is represented by L.



Ex. A concentrated solution of ammonia is added to a solution of copper (II) chloride



- b) Breakup of complex by adding an acid which makes a metal ion and the species that is formed when hydrogen ions from the acid reacts with the ligand

Ex. Tetrammine copper (II) ions are reacted with nitric acid

