PREDICTING REACTIONS AP STYLE

You will write a net ionic equation given a description of the reactants. One point is awarded for writing the correct reactants and two points for writing the correct products. Remember to write reactants and products in net ionic form. You do not need to balance the equation. In all cases a reaction does occur.

KNOW:

1. Nomenclature
2. Solubility rules
3. Which elements are diatomic

A. Double displacement.

- **Precipitation → forming an insoluble product**
- **Neutralization → acid + base → salt + water**
- **Gas forming → carbonic acid in solution forms water and carbon dioxide and sulfurous acid will decompose into water and sulfur dioxide**
- **If a nonelectrolyte is formed from a double displacement reaction a reaction occurs. Phosphorus halides react with water to produce an acid of phosphorus (phosphorous acid or phosphoric acid) and a binary acid containing a halogen. Group I&II nitrides react with water to produce the metallic hydroxide and ammonia**
- **Metallic carbides will react with water to form metallic hydroxide and C_2H_2**

Examples:

aqueous solutions of silver nitrate and sodium iodide are mixed

$Ag^+_{(aq)} + I^-_{(aq)} \rightarrow AgI_{(s)}$

solid aluminum chloride is added to an aqueous solution of potassium chromate

$AlCl_{3(s)} + CrO_{4\,(aq)} \rightarrow Al_2(CrO_4)_{3(s)}$

solutions of hydrochloric acid and sodium hydroxide are mixed

$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$

acetic acid reacts with solid potassium hydroxide

$CH_3COOH_{(aq)} + KOH_{(aq)} \rightarrow CH_3COO^-_{(aq)} + H_2O_{(l)}$

hydrofluoric acid reacts with solid silicon dioxide.

$HF + SiO_2 \rightarrow SiF_4 + H_2O$

phosphorus tribromide is added to water
$PBr_3 + H_2O \rightarrow H_3PO_3 + H^+ + Br^-$

calcium carbonate crystals are added to a solution of hydrochloric acid
$CaCO_{3(s)} + H^+_{(aq)} \rightarrow H_2O_{(l)} + CO_{2(g)} + Ca^{2+}_{(aq)}$

excess hydrochloric acid solution is added to a solution of potassium sulfite.
$H^+ + SO_3^{2-} \rightarrow H_2O + SO_2$

B. Single displacement may also be redox replacement: ⟶ a more reactive element can displace a less reactive element with similar properties in a compound. (metals displace metals and nonmetals displace nonmetals)

Examples:
zinc metal reacts with tin (II) sulfate solution
$Zn(s) + Sn^{2+}_{(aq)} \rightarrow Sn_{(s)} + Zn^{2+}_{(aq)}$

chlorine gas reacts with sodium bromide solution
$Cl_{2(g)} + Br^-_{(aq)} \rightarrow Br_2 + Cl^-_{(aq)}$

potassium metal reacts with water
$K + H_2O \rightarrow K^+ + OH^- + H_2$

magnesium turnings are added to a solution of iron(III) chloride
$Mg + Fe^{3+} \rightarrow Fe + Mg^{2+}$

C. Combination or synthesis ⟶ two reactants result in a single product

- **Metal oxide + water → metallic hydroxide (base)**
- **Nonmetal oxide + water → nonbinary acid**
- **Metal oxide + nonmetal oxide → nonbinary salt**

Examples :
solid calcium oxide is added to water
$CaO_{(s)} + H_2O_{(l)} \rightarrow Ca(OH)_{2(aq)}$ (some text consider calcium hydroxide as a strong base but on the most recent AP test it was treated as a weak base)

sulfur dioxide gas is bubbled through water
$SO_{2(g)} + H_2O_{(l)} \rightarrow H_2SO_{3(aq)}$

powdered magnesium oxide is added to a container of carbon dioxide
$MgO_{(s)} + CO_{2(g)} \rightarrow MgCO_{3(s)}$

D. Decomposition → one reactant becomes several products

- **Metallic hydroxide → metal oxide + water**
- **Nonbinary acid → nonmetal oxide + water**
- **Nonbinary salt → metal oxide + nonmetal oxide**
- **Metallic chlorates → metallic chlorides + oxygen**
- **Electrolysis decompose compound into elements (water in dilute acids or solutions of dilute acids)**
- **Hydrogen peroxide → water + oxygen**
- **Metallic carbonates → metal oxides + carbon dioxide**
- **Ammonium carbonate → ammonia, water and carbon dioxide.**

Examples:
a current of electricity is passed through water
$H_2O \rightarrow H_2 + O_2$

potassium chlorate is heated
$KClO_3 \rightarrow KCl + O_2$

hydrogen peroxide is catalytically decomposed
$H_2O_2 \rightarrow H_2O + O_2$

calcium carbonate is heated
$CaCO_3 \rightarrow CaO + CO_2$

sulfurous acid decomposes
$H_2SO_3 \rightarrow H_2O + SO_2$

magnesium hydroxide decomposes
$Mg(OH)_2 \rightarrow MgO + H_2O$

E. Hydrolysis ⟶ compound reacting with water.

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

Examples:
0.1 M sodium acetate is added to water
$CH_3COO^-_{(aq)} + H_2O \rightarrow CH_3COOH_{(aq)} + OH^-_{(aq)}$

solid ammonium chloride is added to water
$NH_4Cl + H_2O \rightarrow NH_{3(aq)} + H_3O^+_{(aq)} + Cl^-_{(aq)}$

F. Reactions of coordinate compounds and complex ions Remember ligands are bonded (coordinate covalent) to a central atom that is usually a transitional metal ion. The most frequently occurring ligands are hydroxide and ammonia. Review coordinate compounds nomenclature. The number of ligands attached to the central ion is often twice the oxidation number of the central metal ion.

- **Complex formation by adding excess source of ligand to transitional metal of highly charged metal ion such as Al^{3+}**
  Keywords such as "excess" and "concentrated" of compounds containing common ligands indicates formation of a complex ions. $AgNO_3$ + HCl forms the white precipitate, AgCl, but with excess, concentrated HCl, the complex ion, $AgCl_2^-$, will form.
- **Breakup of complex by adding an acid → metal ion and the species formed when hydrogen from the acid reacts with the ligand**

Examples:
tetraammine copper II ions are reacted with nitric acid
$Cu(NH_3)_4^{2+} \rightarrow NH_4^+ + Cu^{2+}$

a concentrated solution of ammonia is added to a solution of copper(II) chloride.
$Cu^{2+} + NH_3 \rightarrow Cu(NH_3)_4^{2+}$

G. Lewis acid base reactions ⟶ formation of coordinate covalent bond

Example:
the gases boron trifluoride and ammonia are mixed
$BF_3 + NH_3 \rightarrow BF_3NH_3$

H. redox ⟶ change in oxidation state ⟶ a reaction between an oxidizer and a reducer.

Recognized:

- **Familiarization with important oxidizers and reducers**
- **"added acid" or "acidified"**
- **an oxidizer reacts with a reducer of the same element to produce the element at intermediate oxidation state**

- **When the hydrides of an alkali metal (Family 1), Ca, Ba, or Sr dissolve in water, hydroxides will form and $\underline{H_2 \text{ gas}}$ is released.**

- **OXIDIZERS:**

MnO_4^- in acid	Mn^{2+}
MnO_2 in acid	Mn^{2+}
MnO_4^- in neutral or basic solution	MnO_2
$Cr_2O_7^{2-}$ in acid	Cr^{3+}
HNO_3 concentrated	NO_2
HNO_3 dilute	NO
H_2SO_4, hot, concentrated	SO_2
Metal ic ions	Metal ous ions
Halogens diatomic	Halide ions
Na_2O_2	NaOH
$HClO_4$	Cl^-
H_2O_2	H_2O

- **REDUCERS:**

Halide ions	Halogens
Metal element	Metal ion
Sulfite	Sulfate
Nitrite	Nitrate
Halogen element in dilute basic solution	Hypohalite ion an halide ion
Halogen element in concentrated basic solution	Halite ion
Metal ous ion	Metallic ion
H_2O_2	O_2
$C_2O_4^{2-}$	CO_2

Examples:
magnesium metal is added to dilute nitric acid
$Mg + H^+ + NO_3^- \rightarrow Mg^{2+} + NO + H_2O$

solution of iron (II) nitrate is added to an acidified solution of potassium permanganate
$Fe^{2+} + MnO_4^- + H^+ \rightarrow Mn^{2+} + Fe^{3+} + H_2O$

solutions of potassium iodide, potassium iodate and dilute sulfuric acid are mixed
$I^- + IO_3^- + H^+ \rightarrow I_2 + H_2O$

a piece of iron is added to a solution of iron (III) sulfate
$Fe + Fe^{3+} \rightarrow Fe^{2+}$

solid lithium hydride is placed in water
$LiH + H_2O \rightarrow Li^+ + OH^- + H_2$

I. **Combustion** ⟶ results in forming the oxide of the elements of the compound

- **Hydrocarbons or alcohols combine with oxygen to form carbon dioxide and water.**
- **Ammonia combines with limited oxygen to produce NO and water and with excess oxygen to produce NO_2 and water.**
- **Nometallic hydrides combine with oxygen to form oxides and water.**
- **Nonmetallic sulfides combine with oxygen to form oxides and sulfur dioxide.**

Examples:
gaseous silane, SiH_4, is burned in oxygen.
$SiH_4 + O_2 \rightarrow H_2O + SiO_2$

carbon disulfide vapor is burned in excess oxygen.
$CS_2 + O_2 \rightarrow CO_2 + SO_2$

ethanol is burned completely in air.
$C_2H_5OH + O_2 \rightarrow CO_2 + H_2O$