Synthesis (combination)

- A synthesis reaction occurs when two or more substances combine chemically to form a single compound.
- Consider the following three synthesis reactions:

1) $2\ Mg_{(s)} + O_{2(g)} \rightarrow 2\ MgO_{(s)}$

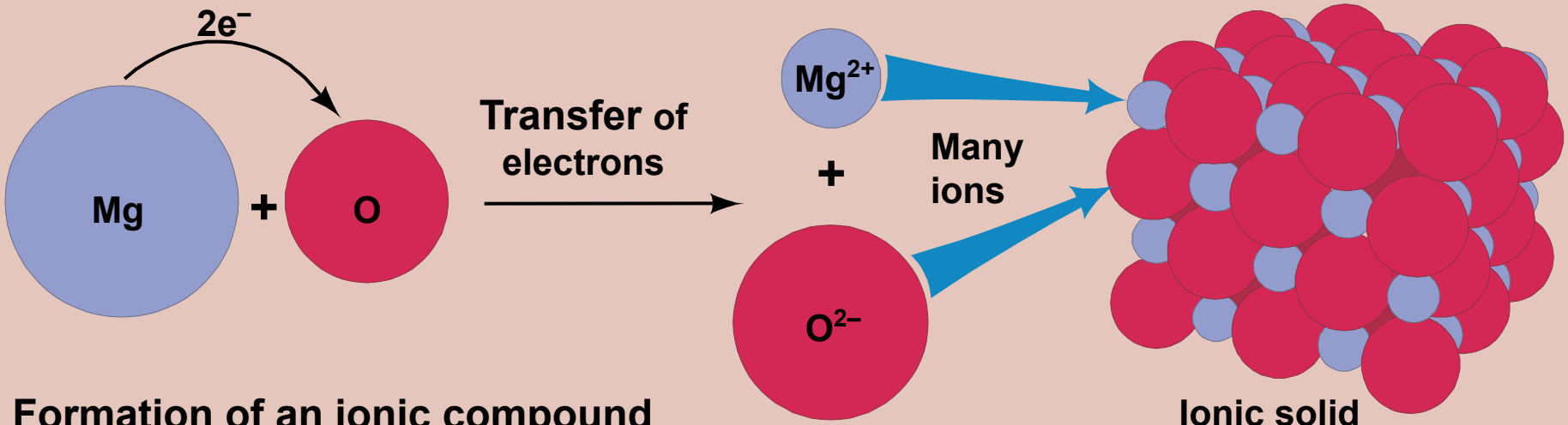
(for the following, predict the products and balance the equations)

2) $\_\_\ H_{2(g)} + \_\_\ Cl_{2(g)} \rightarrow$

3) $\_\_\ K_{(s)} + \_\_\ Cl_{2(g)} \rightarrow$

The redox process in compound formation

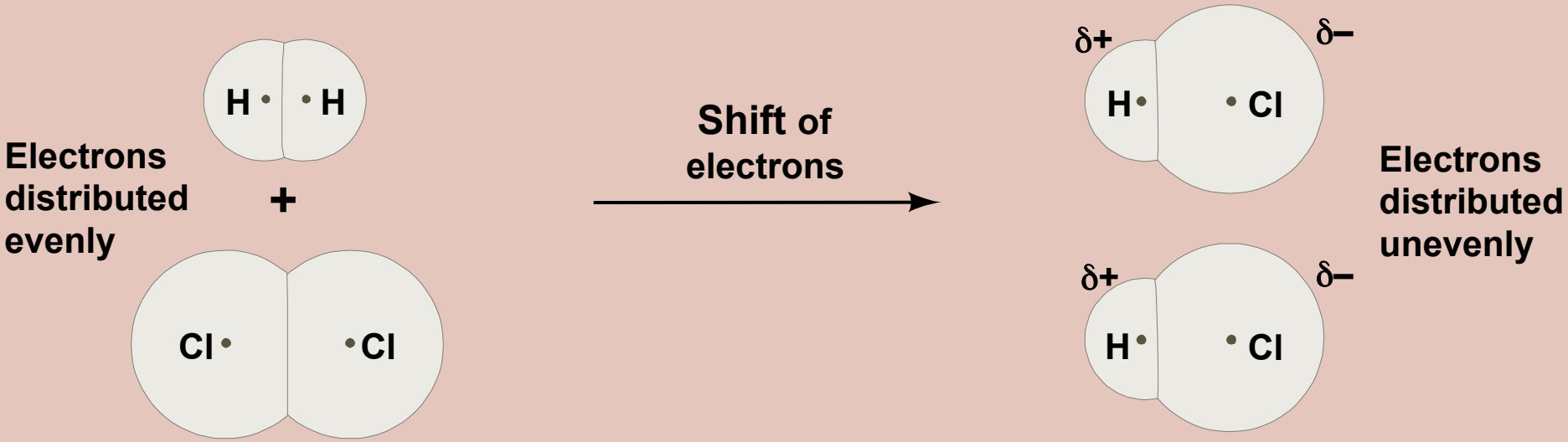
$$2\ Mg_{(s)} + O_{2(g)} \rightarrow 2\ MgO_{(s)}$$



A Formation of an ionic compound

The redox process in compound formation

Reaction of hydrogen and chlorine



Formation of a covalent compound

Decomposition Reactions

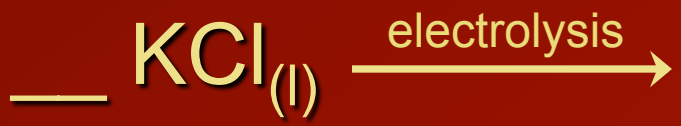
- A decomposition reaction is a reaction in which one compound breaks down into two or more substances.

Decomposition into elements:

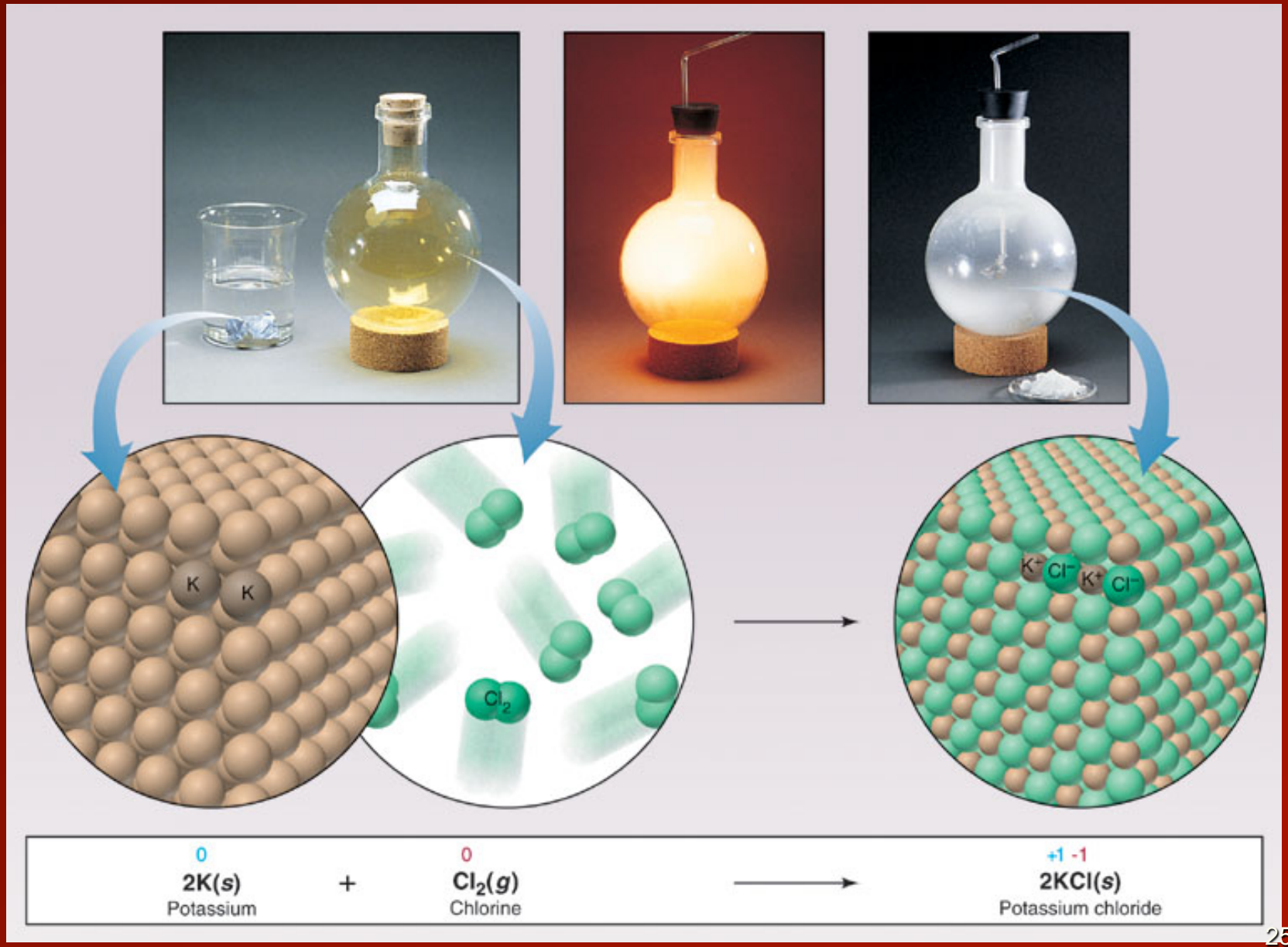
- Thermal Decomposition:

- Electrolytic Decomposition: electrical energy drives the oxidation-reduction reactions

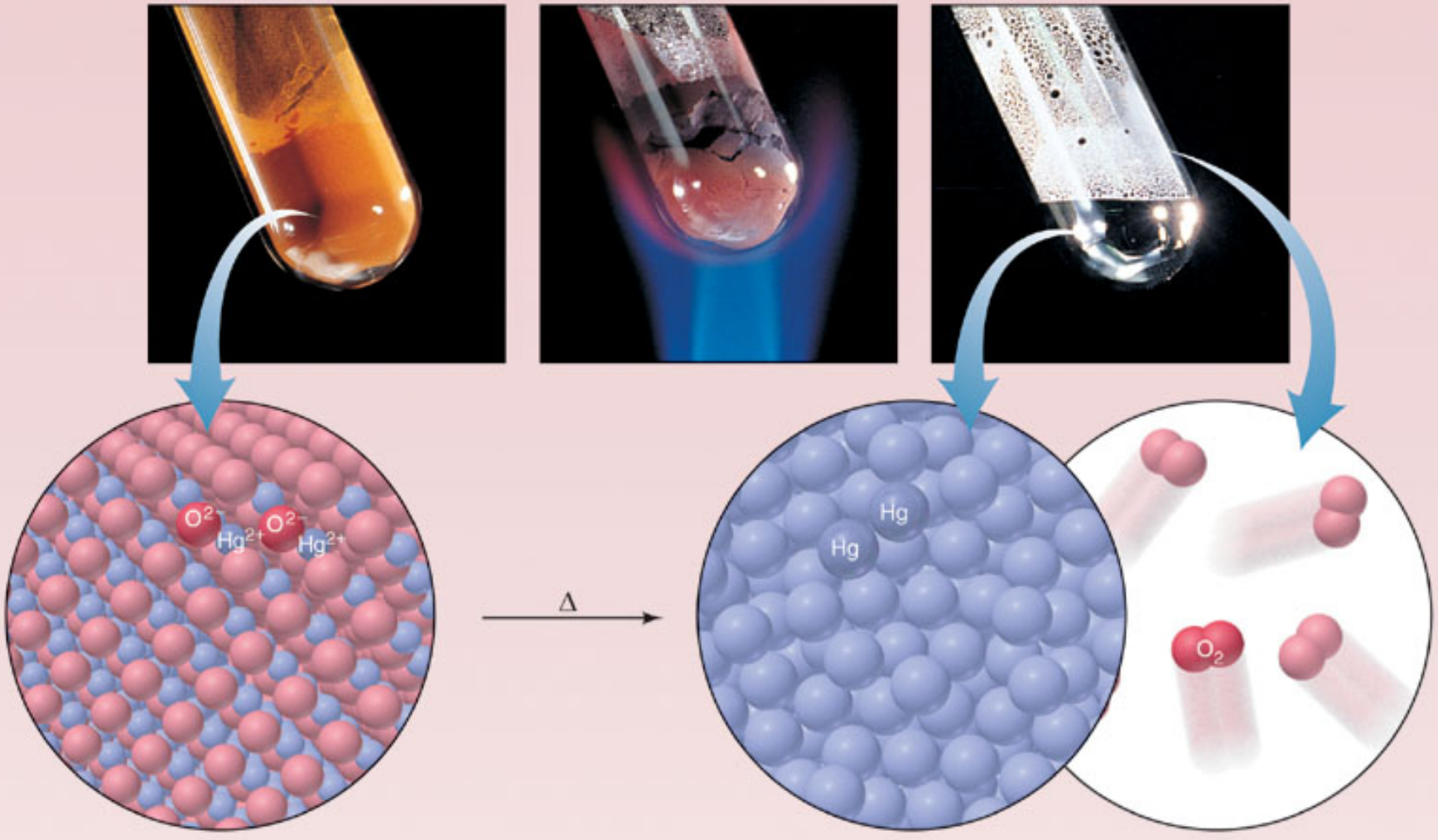
Predict products & balance:



Formation of potassium chloride



Thermal decomposition of mercury (II) oxide



$$\overset{+2\ \ -2}{2HgO(s)} \xrightarrow{\Delta} \overset{0}{2Hg(l)} + \overset{0}{O_2(g)}$$

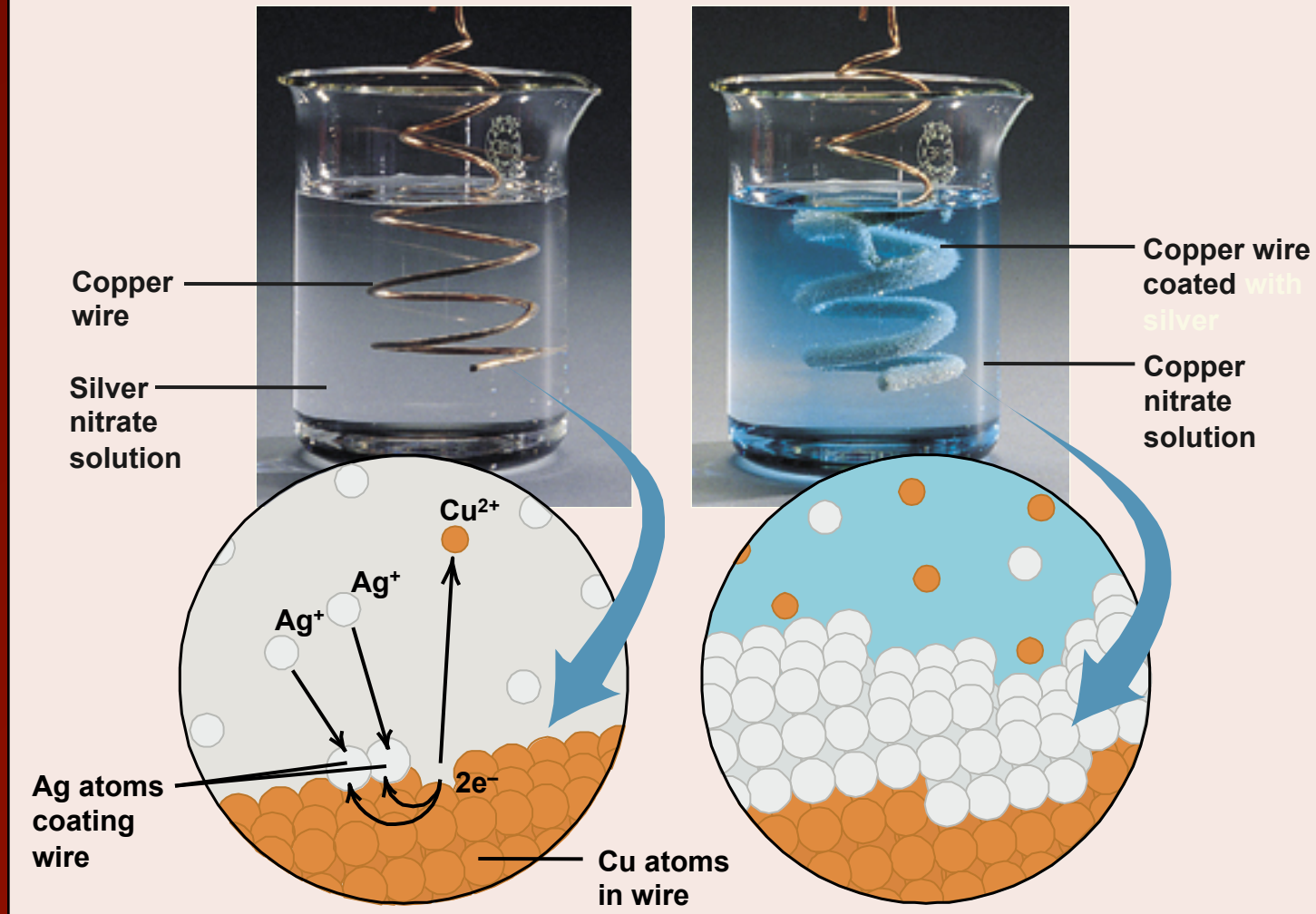
Mercury(II) oxide → Mercury + Oxygen

Single Replacement Reactions

- A single replacement reaction is a reaction in which one element replaces another element in a compound.

- Consider the reaction that occurs when a copper wire is placed into a solution containing copper nitrate.

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



$$\overset{+1}{2AgNO_3}(aq) + \overset{0}{Cu}(s) \longrightarrow \overset{+2}{Cu(NO_3)_2}(aq) + \overset{0}{2Ag}(s)$$

Single Replacement Reactions

- Not all possible single replacement reactions will occur.
- It depends on the reactivity of the element that is trying to displace the element in the compound.
- In order for a single replacement reaction to take place, the free element that is replacing the element in the compound must be higher in the activity series.

Reactivity Series

Metals

MOST Reactive

Lithium (Li)
Potassium (K)
Barium (Ba)
Calcium (Ca)
Sodium (Na)
Magnesium (Mg)
Aluminum (Al)
Manganese (Mn → Mn^{2+})
Zinc (Zn)
Chromium (Cr → Cr^{3+})
Iron (Fe → Fe^{2+})
Cadmium (Cd)
Cobalt (Co → Co^{2+})
Nickel (Ni → Ni^{2+})
Tin (Sn → Sn^{2+})
Lead (Pb → Pb^{2+})
Hydrogen (H_2)
Copper (Cu → Cu^{2+})
Silver (Ag)
Mercury (Hg → Hg^{+})
Platinum (Pt → Pt^{2+})
Gold (Au → Au^{3+})

LEAST Reactive

Nonmetals

MOST Reactive

Fluorine (F_2)
Oxygen (O_2)
Chlorine (Cl_2)
Bromine (Br_2)
Iodine (I_2)

LEAST Reactive

Note:

All reactivities are for the most common ion formed.In the cases of elements that can form more than one ion, the ion indicated is the most common ion.

Single Replacement Reactions

- *Predict whether or not the following reactions will occur:* (Refer to the reactivity series.)

- SR and net ionic equations: *Write the molecular, ionic, and net ionic equations for the reaction of magnesium metal with hydrochloric acid.*

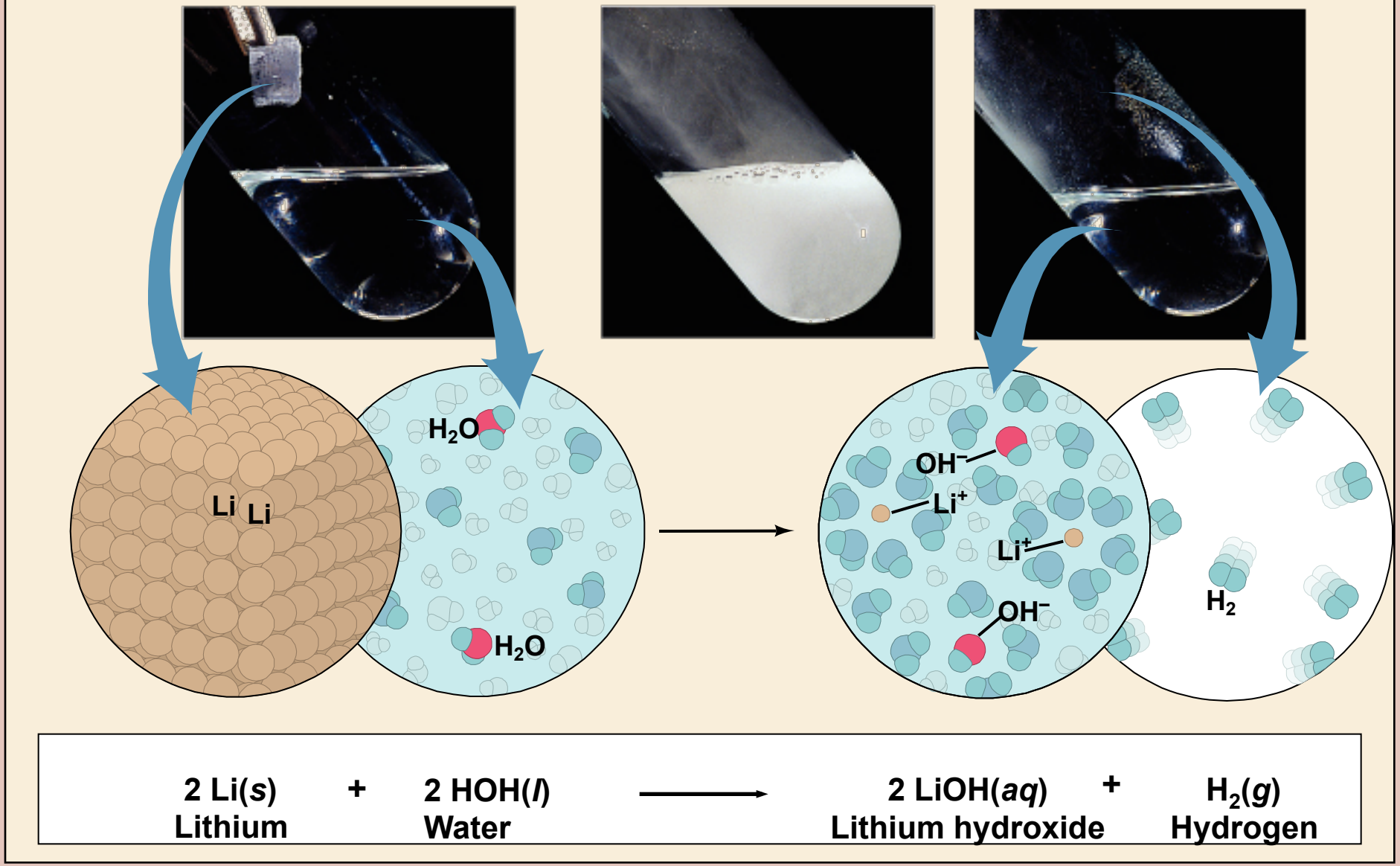
Single Replacement Reactions

- When water reacts with a reactive metal, treat it as an H^+ ion and an OH^- to predict its reactivity.

- Predict the products for and balance the following chemical reaction:

$$\_\_\ Li_{(s)} + \_\_\ HOH_{(l)} \rightarrow$$

Reaction of lithium with water



2 Li(*s*)	+	2 HOH(*l*)	⟶	2 LiOH(*aq*)	+	H_2(*g*)
Lithium		Water		Lithium hydroxide		Hydrogen

Combustion Reactions of Hydrocarbons & Carbohydrates

- In a complete combustion reaction of a compound containing C and H, or C, H, and O, the compound is burned in oxygen gas.
- The products of a complete combustion of a hydrocarbon are carbon dioxide and water.
- ***Special balancing rule for combustion:***
  Balance Carbon first, Hydrogen second, and Oxygen last. CHECK.

Combustion Reactions of Hydrocarbons & Carbohydrates

Steps in writing a Complete, Balanced Chemical Equation:

- ***Step 1:***

  Write the correct formula for the ***reactants*** with ***state symbols.***

- ***Step 2:***

  Determine the ***type*** of reaction that would likely occur.

- ***Step 3:***

  Predict what ***products*** would form if a reaction occurs.

  - If a *double replacement reaction*, use the solubility chart to see if a solid will form. (Unless acid-base, in which case water is the driving force of the reaction.)
  - If a *single replacement reaction*, use the activity chart to see if a reaction will occur.

Steps in writing a Complete, Balanced Chemical Equation:

- *Step 4:*

  Write correct ***formulas*** for the products based on charges (if ionic).

- *Step 5:*

  Determine the correct ***states*** for the products.

- *Step 6:*

  Balance the equation.

Determining the TYPE of Reaction

- If the reaction has two elements as reactants, then it is likely a SYNTHESIS reaction.
- If one reactant only, then the reaction is likely a DECOMPOSITION reaction.
- If one reactant is an ionic compound and the other reactant is an element, then the reaction is likely a SINGLE REPLACEMENT reaction.
- If both reactants are ionic compounds, then the reaction is likely a DOUBLE REPLACEMENT reaction.
- If one reactant is a hydrocarbon (C,H) or carbohydrate (CHO), and O_2 gas is available, then the reaction is likely a COMBUSTION reaction.

Predicting States of Matter

Elements

- Mercury (Hg) and Bromine (Br_2) are the only elemental LIQUIDS at STP (standard temperature and pressure).
- All Metals (except Hg) and metalloids are SOLIDS in their elemental states at STP.
- C, P, S, Se, and I_2 are SOLID non-metals at STP.
- The other non-metals are GASES in their elemental forms at STP.

Ionic Compounds

- Ionic compounds are generally SOLIDS at room temperature if there is no water around.
- If water is available:
  - Ionic compounds that are soluble in water will be AQUEOUS.
  - Ionic compounds that are ***not*** soluble in water will be SOLIDS.
- In electrolytic decomposition reactions, ionic compounds must be melted (LIQUIDS).

Other Compounds

- Acids will be aqueous.
- Non-metal oxides (*e.g.* CO_2, SO_3) are generally gases at STP.
- Water is a liquid.

  (Unless at high temperature, as in a combustion, where it is generally a gas).