Activity (Reactivity) Series

Unit: Chemical Reactions

NGSS Standards/MA Curriculum Frameworks (2016): HS-PS1-2

Mastery Objective(s): (Students will be able to…)

- Use the activity series to predict whether or not a single replacement reaction will occur.

Success Criteria:

- Prediction is correct about whether or not a reaction occurs.
- Cation & anion are correct if reaction does occur.
- Products have correctly balanced charges.

Tier 2 Vocabulary: product, replacement, activity

Language Objectives:

- Explain how you can tell using the activity series whether or not a reaction will occur.

Notes:

In the reaction between aluminum metal and copper (II) chloride:

$$Al\,(s) + CuCl_2\,(aq) \longrightarrow AlCl_3\,(aq) + Cu\,(s) + \text{heat} \qquad (1)$$

the beaker got hot. This means the reaction gave off heat, which was lost to the surroundings (the water that the chemicals were dissolved in, the beaker, the air, your hand). Once the energy was given off, the chemicals didn't have enough energy to go the other direction. In other words, the reverse reaction does not happen:

$$Cu\,(s) + AlCl_3\,(aq) \longrightarrow \text{no reaction} \qquad (2)$$

Is it possible to predict which direction the reaction will go?

For single replacement reactions, there is a list, called the activity series, (or reactivity series), which lists metals in order from most reactive to least, based on how much energy they give off when they lose electrons to form a positive ion. A metal that's higher on the list can replace anything lower on the list (because more energy is given off), but a metal that's lower on the list doesn't have enough energy to replace one that's higher up.

Use this space for summary and/or additional notes:

Activity (Reactivity) Series

Metal	Ion		Reacts With	Method of Extraction
Cs	Cs^+	increasing reactivity	cold H_2O, dilute acids, O_2	electrolysis
Rb	Rb^+			
K	K^+			
Na	Na^+			
Li	Li^+			
Sr	Sr^{2+}			
Ca	Ca^{2+}			
Mg	Mg^{2+}		steam, dilute acids, O_2	
Be	Be^{2+}			
Al	Al^{3+}			
Mn	Mn^{2+}			
Zn	Zn^{2+}			metal oxide reduction with carbon or CO_2; smelting with coke
Cr	Cr^{3+}			
Fe	Fe^{2+}			
Cd	Cd^{2+}			
Co	Co^{2+}		dilute acids, O_2	
Ni	Ni^{2+}			
Sn	Sn^{2+}			
Pb	Pb^{2+}			
H_2	H^+		O_2	
Cu	Cu^{2+}			
Cu	Cu^+			
Hg	Hg^{2+}			heat or physical extraction
Ag	Ag^+			
Au	Au^{3+}		some strongly oxidizing acids	
Pt	Pt^{2+}			

To answer the original question, notice that aluminum is higher than copper on the activity series. This means aluminum can replace copper:

$$Al\,(s) + CuCl_2\,(aq) \rightarrow AlCl_3\,(aq) + Cu\,(s) + \text{heat}$$

but copper can't replace aluminum:

$$Cu\,(s) + AlCl_3\,(aq) \rightarrow \text{no reaction}$$

Use this space for summary and/or additional notes:

Homework Problems

For each of the following single replacement reactions:

a) Check the activity series to see whether the reaction happens.

b) If the reaction happens, predict the products. If the reaction does not happen, write "N.R." ("No Reaction").

1. $K\,(s) + H_2O \rightarrow$

2. $Pb\,(s) + Zn(CH_3COO)_2\,(aq) \rightarrow$

3. $Al\,(s) + Fe_2O_3\,(s) \xrightarrow[\Delta]{}$

4. $AgNO_3\,(aq) + Ni\,(s) \rightarrow$

5. $Ag\,(s) + H_2SO_4\,(aq) \rightarrow$

6. $NaBr\,(aq) + I_2\,(s) \rightarrow$

7. $Ca\,(s) + MgSO_4\,(aq) \rightarrow$

8. $Ca\,(s) + HCl\,(aq) \rightarrow$

9. $Mg\,(s) + HNO_3\,(aq) \rightarrow$

10. $CuCl_2\,(aq) + Hg\,(\ell) \rightarrow$

11. $Na\,(s) + H_2O\,(\ell) \rightarrow$

Use this space for summary and/or additional notes: