

1. Most metals have high thermal and electrical conductivities, high luster, malleability, and ductility, whereas nonmetals usually have low thermal and electrical conductivities, low luster, low malleability, and low ductility. In addition, relative to nonmetals, metals have low ionization potentials and low electron affinities.
2. Ionization energy is the energy required to remove an electron from an atom in the gaseous state.
3. Electron affinity is the energy produced when an electron is added to a species in the gas phase and is the inverse of the ionization energy in a physical sense, but the values are not just of opposite sign because you are considering slightly different processes; in each case, they differ by one electron.
4. An oxidation must always be accompanied by a reduction because the species being oxidized must transfer an electron to some other species that is reduced. The electron cannot just be given up to free space.
5. By systematically observing the displacement reactions among metals and their cations, it is possible to determine the relative oxidation potentials of the metals. The metal with the lower reduction potential will reduce a cation of a metal with a higher reduction potential.
6. $2\text{Mg} + \text{O}_2 \longrightarrow 2\text{MgO}$; $\text{Zn} + 2\text{HCl} \longrightarrow \text{ZnCl}_2 + \text{H}_2$;
 $\text{Zn} + \text{Cu}^{2+} \longrightarrow \text{Zn}^{2+} + \text{Cu}$.

7.

Oxidized	Reduced:
I ⁻	Cl ₂
H ₂	W ⁴⁺
Ca	H
Al	O ₂

8.

Li
Cr
cd

Name _____ Desk _____

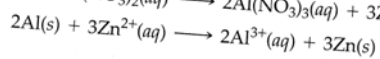
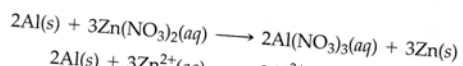
Date _____ Laboratory Instructor _____

REPORT SHEET | EXPERIMENT
Activity Series | 15

A. Reactions of Metals with Acid

Metal	Reaction with HCl	Observation	Equations
Ca	Yes	Ca all dissolved with very vigorous evolution of H ₂ gas; colorless solution	$\text{Ca}(s) + 2\text{HCl}(aq) \longrightarrow \text{CaCl}_2(aq) + \text{H}_2(g)$ $\text{Ca}(s) + 2\text{H}^+(aq) \longrightarrow \text{Ca}^{2+}(aq) + \text{H}_2(g)$
Cu	No	No reaction	_____
Mg	Yes	Mg dissolved, but more slowly than Ca, to produce a colorless solution with H ₂ gas evolution	$\text{Mg}(s) + 2\text{HCl}(aq) \longrightarrow \text{MgCl}_2(aq) + \text{H}_2(g)$ $\text{Mg}(s) + 2\text{H}^+(aq) \longrightarrow \text{Mg}^{2+}(aq) + \text{H}_2(g)$
Fe	Yes	Very, very slow reaction with evolution of some H ₂ gas	$\text{Fe}(s) + 2\text{HCl}(aq) \longrightarrow \text{FeCl}_2(aq) + \text{H}_2(g)$ $\text{Fe}(s) + 2\text{H}^+(aq) \longrightarrow \text{Fe}^{2+}(aq) + \text{H}_2(g)$
Sn	Yes	Extremely slow evolution of H ₂	$\text{Sn}(s) + 2\text{HCl}(aq) \longrightarrow \text{SnCl}_2(aq) + \text{H}_2(g)$ $\text{Sn}(s) + 2\text{H}^+(aq) \longrightarrow \text{Sn}^{2+}(aq) + \text{H}_2(g)$
Zn	Yes	Zn dissolved to produce colorless solution with H ₂ gas evolution	$\text{Zn}(s) + 2\text{HCl}(aq) \longrightarrow \text{ZnCl}_2(aq) + \text{H}_2(g)$ $\text{Zn}(s) + 2\text{H}^+(aq) \longrightarrow \text{Zn}^{2+}(aq) + \text{H}_2(g)$
Example: Co	Yes, slowly	Gas evolved; solution turned blue	$\text{Co}(s) + 2\text{HCl}(aq) \longrightarrow \text{CoCl}_2(aq) + \text{H}_2(g)$ $\text{Co}(s) + 2\text{H}^+(aq) \longrightarrow \text{Co}^{2+}(aq) + \text{H}_2(g)$

Example:



Complete equation	Net ionic equation
$\text{Ca}(s) + \text{Mg}(\text{NO}_3)_2(aq) \longrightarrow \text{Ca}(\text{NO}_3)_2(aq) + \text{Mg}(s)$	$\text{Ca} + \text{Mg}^{2+} \longrightarrow \text{Ca}^{2+} + \text{Mg}$
$\text{Ca}(s) + \text{Zn}(\text{NO}_3)_2(aq) \longrightarrow \text{Ca}(\text{NO}_3)_2(aq) + \text{Zn}(s)$	$\text{Ca} + \text{Zn}^{2+} \longrightarrow \text{Ca}^{2+} + \text{Zn}$
$\text{Ca}(s) + \text{Fe}(\text{NO}_3)_2(aq) \longrightarrow \text{Ca}(\text{NO}_3)_2(aq) + \text{Fe}(s)$	$\text{Ca} + \text{Fe}^{2+} \longrightarrow \text{Ca}^{2+} + \text{Fe}$
$3\text{Ca}(s) + 2\text{Fe}(\text{NO}_3)_3(aq) \longrightarrow 3\text{Ca}(\text{NO}_3)_2(aq) + 2\text{Fe}(s)$	$3\text{Ca} + 2\text{Fe}^{3+} \longrightarrow 3\text{Ca}^{2+} + 2\text{Fe}$
$2\text{Ca}(s) + \text{SnCl}_4(aq) \longrightarrow 2\text{CaCl}_2(aq) + \text{Sn}(s)$	$2\text{Ca} + \text{Sn}^{4+} \longrightarrow 2\text{Ca}^{2+} + \text{Sn}$
$\text{Ca}(s) + \text{CuSO}_4(aq) \longrightarrow \text{CaSO}_4(aq) + \text{Cu}(s)$	$\text{Ca} + \text{Cu}^{2+} \longrightarrow \text{Ca}^{2+} + \text{Cu}$
$\text{Mg}(s) + \text{Zn}(\text{NO}_3)_2(aq) \longrightarrow \text{Mg}(\text{NO}_3)_2(aq) + \text{Zn}(s)$	$\text{Mg} + \text{Zn}^{2+} \longrightarrow \text{Mg}^{2+} + \text{Zn}$
$\text{Mg}(s) + \text{Fe}(\text{NO}_3)_2(aq) \longrightarrow \text{Mg}(\text{NO}_3)_2(aq) + \text{Fe}(s)$	$\text{Mg} + \text{Fe}^{2+} \longrightarrow \text{Mg}^{2+} + \text{Fe}$
$3\text{Mg}(s) + 2\text{Fe}(\text{NO}_3)_3(aq) \longrightarrow 3\text{Mg}(\text{NO}_3)_2(aq) + 2\text{Fe}(s)$	$3\text{Mg} + 2\text{Fe}^{3+} \longrightarrow 3\text{Mg}^{2+} + 2\text{Fe}$
$2\text{Mg}(s) + \text{SnCl}_4(aq) \longrightarrow 2\text{MgCl}_2(aq) + \text{Sn}(s)$	$2\text{Mg} + \text{Sn}^{4+} \longrightarrow 2\text{Mg}^{2+} + \text{Sn}$
$\text{Mg}(s) + \text{CuSO}_4(aq) \longrightarrow \text{MgSO}_4(aq) + \text{Cu}(s)$	$\text{Mg} + \text{Cu}^{2+} \longrightarrow \text{Mg}^{2+} + \text{Cu}$
$\text{Zn}(s) + \text{Fe}(\text{NO}_3)_2(aq) \longrightarrow \text{Zn}(\text{NO}_3)_2(aq) + \text{Fe}(s)$	$\text{Zn} + \text{Fe}^{2+} \longrightarrow \text{Zn}^{2+} + \text{Fe}$
$3\text{Zn}(s) + 2\text{Fe}(\text{NO}_3)_3(aq) \longrightarrow 3\text{Zn}(\text{NO}_3)_2(aq) + 2\text{Fe}(s)$	$3\text{Zn} + 2\text{Fe}^{3+} \longrightarrow 3\text{Zn}^{2+} + 2\text{Fe}$
$2\text{Zn}(s) + \text{SnCl}_4(aq) \longrightarrow 2\text{ZnCl}_2(aq) + \text{Sn}(s)$	$2\text{Zn} + \text{Sn}^{4+} \longrightarrow 2\text{Zn}^{2+} + \text{Sn}$
$\text{Zn}(s) + \text{CuSO}_4(aq) \longrightarrow \text{ZnSO}_4(aq) + \text{Cu}(s)$	$\text{Zn} + \text{Cu}^{2+} \longrightarrow \text{Zn}^{2+} + \text{Cu}$
$2\text{Fe}(s) + \text{SnCl}_4(aq) \longrightarrow 2\text{FeCl}_2(aq) + \text{Sn}(s)$	$2\text{Fe} + \text{Sn}^{4+} \longrightarrow 2\text{Fe}^{2+} + \text{Sn}$
$\text{Fe}(s) + \text{CuSO}_4(aq) \longrightarrow \text{FeSO}_4(aq) + \text{Cu}(s)$	$\text{Fe} + \text{Cu}^{2+} \longrightarrow \text{Fe}^{2+} + \text{Cu}$
$\text{Sn}(s) + \text{CuSO}_4(aq) \longrightarrow \text{SnSO}_4(aq) + \text{Cu}(s)$	$\text{Sn} + \text{Cu}^{2+} \longrightarrow \text{Sn}^{2+} + \text{Cu}$

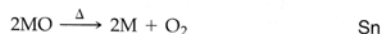
C. Relative-Activity Series

Most reactive

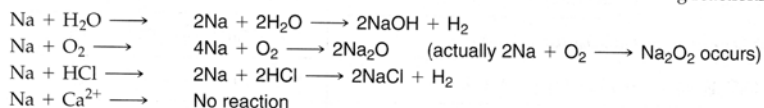
Least reactive

1. Ca 2. Mg 3. Zn 4. Fe 5. Sn 6. Cu**QUESTIONS**

- Which of these six metals should be the most reactive toward oxygen? Ca
- Which of the oxides would be expected to be thermally unstable and decompose according to the equation?



- Sodium is slightly less reactive than calcium. Predict the outcome of the following reactions:



- Which is more reactive, Fe^{2+} or Fe^{3+} , and why?

Fe^{3+} has more chemical potential than Fe^{2+} , and it reacted faster and to a greater extent with Zn. The emf for the half reaction $\text{Fe}^{3+} + 3\text{e}^- \longrightarrow \text{Fe}$ is greater than the emf for the half reaction $\text{Fe}^{2+} + 2\text{e}^- \longrightarrow \text{Fe}$. Therefore, Fe^{3+} is a stronger oxidizing agent than Fe^{2+} .

- From the data in Table B, rank the activity of aluminum.

Because aluminum does not replace magnesium ion, it is less reactive than magnesium. It does replace zinc ion and is therefore more reactive than zinc. Hence, the order of reactivity is $\text{Mg} > \text{Al} > \text{Zn}$.

- For each of the following reactions, indicate which substance is oxidized and which is reduced. Which substance is the oxidizing agent and which is the reducing agent?

	<i>Substance oxidized</i>	<i>Substance reduced</i>	<i>Oxidizing agent</i>	<i>Reducing agent</i>
$2\text{Al}(s) + 3\text{Cl}_2(g) \longrightarrow 2\text{AlCl}_3(s)$	<u>Al</u>	<u>Cl_2</u>	<u>Cl_2</u>	<u>Al</u>
$8\text{H}^+(aq) + \text{MnO}_4^-(aq) + 5\text{Fe}^{2+}(aq) \longrightarrow$				
$5\text{Fe}^{3+}(aq) + \text{Mn}^{2+}(aq) + 4\text{H}_2\text{O}(l)$	<u>Fe^{2+}</u>	<u>MnO_4^-</u>	<u>MnO_4^-</u>	<u>Fe^{2+}</u>
$\text{FeS}(s) + 3\text{NO}_3^-(aq) + 4\text{H}^+(aq) \longrightarrow$				
$3\text{NO}(g) + \text{SO}_4^{2-}(aq) + \text{Fe}^{3+}(aq) + 2\text{H}_2\text{O}(l)$	<u>FeS</u>	<u>NO_3^-</u>	<u>NO_3^-</u>	<u>FeS</u>