

Single Displacement Reactions and Relative Reactivity

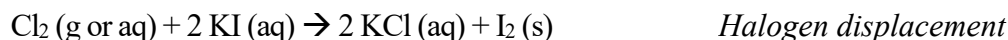
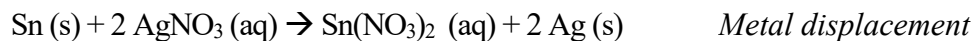
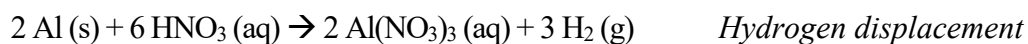
In your text (Chang and Goldsby 7th Ed) : Chapter 4: end of Section 4.4; Fig. 4.1 4, Activity Series

Background:

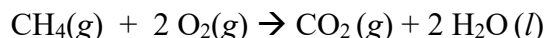
Recall from the last experiment (Exp. 5, Writing Chemical Equations) that one method of classifying reactions emphasizes the **form** of the reaction:

Combination (or synthesis)	$A + B \rightarrow AB$
Decomposition	$AB \rightarrow A + B$
Single displacement (or substitution)	$A + BX \rightarrow AX + B$
Double displacement (or metathesis)	$AB + CD \rightarrow AD + CB$

In this experiment, we will focus on **single displacement (or substitution or single replacement) reactions**, $A + BX \rightarrow AX + B$, where one element is replaced (displaced) by another in a compound. Examples are given below.



Note that all of these reactions are specific types of **oxidation-reduction (redox) reactions**. Oxidation-reduction or redox reactions involve electron transfers from one species to another, making one species more positive and the other species more negative. This is the case in all three reactions above. Oxidation-reduction can also occur between molecular substances when there is no electron transfer happening. However, bonding electrons can shift away or towards an atom within the molecule, making the atom more partially positive or more partially negative. One example for this kind of redox reaction is the burning of methane in your gas stove:



In all redox reactions, the species with a stronger attraction to electrons can “pull” electrons away from another species, thus oxidizing the other species and itself being reduced. The species with stronger attraction to electrons are called oxidizing agent, and species being oxidized is called the reducing agent.

How well an atom attracts the electrons can be roughly quantify by how difficult it is to remove an electron from the atom using a unit-less, relative value called **ELECTRONEGATIVITY**. The higher the electronegativity, the stronger attraction to electrons by the nucleus of the atom. Electronegativity generally increases going left to right and bottom to top on the periodic table, as the metallic character of the elements decreases, as shown in Fig. 1. Cesium is the least electronegative non-radioactive element, and fluorine is the most electronegative. Elements from the opposite of the periodic table i.e. metals and non-metals, have large differences in electronegativity therefore tend to make ionic compounds, because the more electronegative

element is able to remove one or more electrons from the less electronegative element, and the resulting species are stable cations (the metals) and stable anions (the non-metals). This electron transfer process is the mechanism for many oxidation-reduction reactions. Electronegativity is useful for predicting bond polarity and is useful for assigning oxidation numbers in polyatomic species.

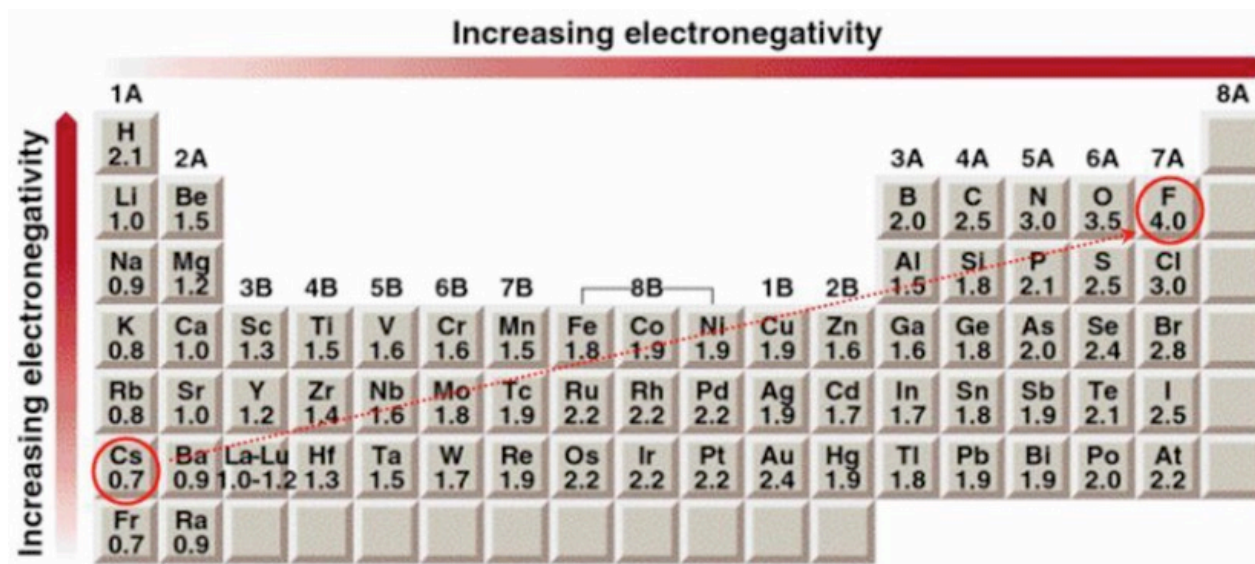
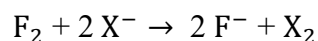


Fig. 1 Electronegativity of elements

As can be seen in Fig. 1, the trends in electronegativity are *general*, and small differences are not particularly useful in making predictions. There are not strong trends *within* the metals, but there are large differences in electronegativity between metals and non-metals, and when going down non-metal groups. The relative reactivity of halogens can be understood by the trend in electronegativity in group 7A.

The relative reactivity of one element with respect to another can be established in a series of experiments, by mixing the element of one with the ionic form of the other and vice versa, and seeing which combination reacts. The species with a greater attraction to electrons will remove electrons from the species with a lower attraction to electrons, and some sign of chemical change (gas formation, color change, etc.) will be observed.

For example, a series of **halogen displacement** reactions can be performed, and the halogens can then be ranked by their **relative reactivity**, in this case their increasing ability to gain electrons. Halogens under ambient conditions form stable diatomic molecules of the form X_2 and stable anions of the form X^- (aq). If $X = \text{Cl}, \text{Br}, \text{or I}$, their reaction with fluorine can be expected to be:



Oxidation number of atoms in each species: 0 -1 -1 0

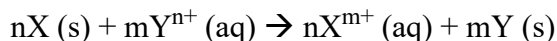
Fluorine, the most electronegative species in the group, “pulls” electrons over from X^- , so each F atom is reduced to F^- , and F_2 therefore is the oxidizing agent (it causes the oxidation of X^- to X_2

when an electron of X^- are “pulled” away from it.) If the reverse experiment was run, $X_2 + 2 F^-$, no reaction would be expected, since X is much less electronegative than fluorine, therefore cannot remove electrons from F^- . We will apply this understanding of halogen displacement reaction to compare and rank the relative reactivity of the rest of the halogens in group 7A.

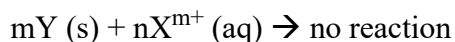
In a similar fashion, metals and their respective cations can be tested against each other in **metal displacement** reactions, and then be ranked by their **relative reactivity**, in this case their increasing ability to *lose* electrons. This might seem to be the reverse of the halogens, but the common thread is the increasing ability to react, producing the ionic form as a product. Halogens form anions, so the reactivity increases with the ability to *gain* electrons and hence become anions. Metals form cations, so the reactivity increases with the ability to *lose* electrons and hence become cations.

Since many metals can react with strong acids to reduce H^+ to H_2 gas, both **hydrogen displacement** and **metal displacement** reactions are used to rank metals by their relative activities. Testing metals with respect to their reactivity with acid divide the test group into two sections. Additionally, broad classifications are based on the reaction with water at various temperatures. More reactive metals will react with both acid and steam, and the most reactive metals will react with acid, steam and even cold water, in all cases producing as one of the products.

The metals can also be sorted with respect to each other, in tests analogous to the halogen/halide reactions used to rank the reactivity of the halogens. For arbitrary metals X and Y, the metal displacement reaction tests will be solid metal vs. a solution of a metallic salt, of the form:



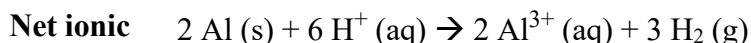
If the above reaction does take place, there will be no reaction when the species are reversed, i.e. when X^{m+} is the ion and Y is in its reduced form, the solid metal:



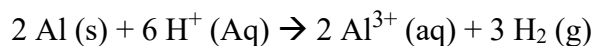
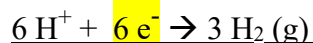
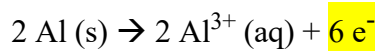
We deduce from this data that metal X is the more reactive than metal Y and is placed higher on the activity scale.

Example of **hydrogen displacement**, ranking a metal with respect to its reactivity to acid

If aluminum, Al (s), a silvery-white metal, is placed in a solution of transparent, colorless HCl (aq), the resulting products are a colorless solution of aluminum chloride, $AlCl_3$ (aq) and bubbles of colorless hydrogen H_2 (g). As the solution warms, H_2 bubbles out of the solution, and the surface of the Al changes and erodes. If there is sufficient HCl, all of the Al will “disappear” (completely consumed by the acid). The reaction can be written in molecular or net ionic form:

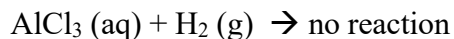


The spectator ion is Cl^- (aq), and a total of 6 electrons are transferred, 3 from each of the Al atoms and one to each of the H^+ ions, as shown in the half-reactions:



Al metal loses electrons and is oxidized to Al^{3+} . Hydrogen ions (H^{+}) gain electrons and are reduced to H_2 . Al is the *reducing agent*, and H^{+} is the *oxidizing agent*.

The reverse of this reaction does not occur:



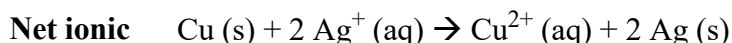
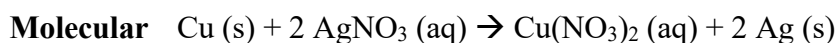
From this data we can tell that Al metal is more reactive (or active) than H_2 and hence is placed higher on the activity scale than the hydrogen/acid (H_2/H^{+}) reaction pair.

If a metal is less active than H^{+} , no reaction will occur when the metal is added to a strong acid, but care must be taken that the reaction is observed for a sufficiently long time before making the judgment of reaction or no reaction. Evidence of a reaction will be bubbling (the formation of H_2), change in the appearance of the metal surface, the erosion of the metal as it dissolves into solution, and the evolution of heat. Active metals will react with strong acids at different rates, with some of these metals causing vigorous bubbling and steam formation due to the rapid release of H_2 and heat, and other metals generating heat and gas much more slowly, with the erosion of the metal not being particularly noticeable.

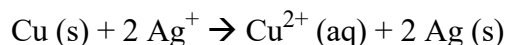
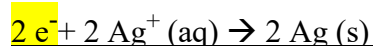
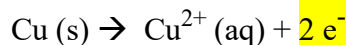
Example of *metal displacement* ranking a metal with respect to its reactivity to another metal

If reddish-gold metallic copper, Cu (s) , is placed in a colorless silver nitrate solution, $\text{AgNO}_3 \text{(aq)}$, the products formed are blue copper (II) nitrate solution, $\text{Cu(NO}_3)_2 \text{(aq)}$, and metallic silver Ag (s) .

The reaction can be written in molecular or net ionic form:

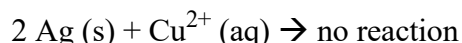


The spectator ion is $\text{NO}_3^{-} \text{(aq)}$, and a total of 2 electrons are transferred, 2 from each of the Cu atoms and one to each of the Ag^{+} ion, as shown in the half-reactions:



Cu metal loses electrons and is oxidized to $\text{Cu}^{2+} \text{(aq)}$ and silver ions $\text{Ag}^{+} \text{(aq)}$ gain electrons and are reduced to silver atoms in silver metal, Ag (s) . Cu is the *reducing agent*, and Ag^{+} is the *oxidizing agent*.

The reverse of this reaction does not occur:



We gather from this data that Cu metal is more active (or reactive) than Ag and hence is placed higher on the activity scale than the Ag/Ag⁺ reaction pair.

WARNING ABOUT FALSE POSITIVES

Small, highly charged cations can form acidic solutions, due to their interaction with water. This background acidity means that some metal-metallic cation tests will also have the competing acid-metal reaction taking place.

If **only** the appearance of H₂ gas and the disappearance of some or all of the original metal is observed, those results are due to the acid-metal reaction, and **no reaction** is taking place due to the metal-metallic cation interaction.

Conversely, if the metal-metallic cation reaction **is** occurring in the presence of background acidity, both reactions will occur at the same time. Bubbles of H₂ gas will form and some of the metal will get smaller **and** the deposition of a different metal and/or a change in the color of the metallic solution will occur.

Overview of the Procedure

In Part I of this experiment, you will establish the reactivity of three halogens. Aqueous solutions of Cl₂, Br₂, and I₂ will be mixed one by one with aqueous solutions of Cl⁻, Br⁻ and I⁻. The anions are delivered to the reaction via their pairing with nonreactive spectator ions, such as Na⁺ or K⁺. There will be nine mixtures:

Cl ₂ /Cl ⁻	Cl ₂ /Br ⁻	Cl ₂ /I ⁻
Br ₂ /Cl ⁻	Br ₂ /Br ⁻	Br ₂ /I ⁻
I ₂ /Cl ⁻	I ₂ /Br ⁻	I ₂ /I ⁻

Once the test solutions are mixed, the reaction products (if any) will be extracted into hexane (or pentane), an organic solvent. The three halogens, Cl₂, Br₂, I₂, each has distinctive color in hexane (or pentane), which will be used to deduce what, if any, reaction took place.

In Part II of the experiment, you will establish a relative reactivity series for zinc (Zn), iron (Fe), copper (Cu), and hydrogen (H₂). You will determine the order from observations of chemical changes occurring when single replacement reactions of these metals and their metallic ions are carried out, and the reaction of the solid metals with an acid solution, HCl (aq).

Procedure

WEAR YOUR GOGGLES AT ALL TIMES; WEAR GLOVES WHEN HANDLING HALOGEN SOLUTIONS AND HEXANE (OR PENTANE)

Chemical Hazards

Hexane (or pentane) – flammable

Halogens solutions – corrosive, toxic

0.5 M copper (II) sulfate – toxic and irritant

0.5 M iron (II) sulfate - toxic

6 M hydrochloric acid – toxic and corrosive

WASTE DISPOSAL: Use **a large beaker** from your drawer as the **waste beaker** on your bench throughout the experiment. Put **a large watch glass** on the beaker to reduce evaporation of certain substances. Dispose all reaction mixtures in the test tubes and the first rinse of the test tubes into this beaker. When you finish all parts of the experiment, empty the beaker into the waste disposal jar in the hood by the door.

START ALL REACTIONS IN PART II FIRST. Some reactions may take long time for changes to be observed. Record any immediate changes, and leave the test tubes on the side. Check for additional changes in these test tubes while carrying out the reactions in Part I.

PART I: Reactivity of Halogens

Part Ia: In the halogens, group 7A, some of the molecular forms (Cl_2 , Br_2 , I_2) have similar colors in aqueous solution. However, they have three distinct colors when dissolved in hexane (or pentane), so that property CAN be used for identification. We will first examine the color of *just* the Cl_2 , Br_2 , and I_2 in water (no mixture with halides), before and after extraction into hexane (or pentane).

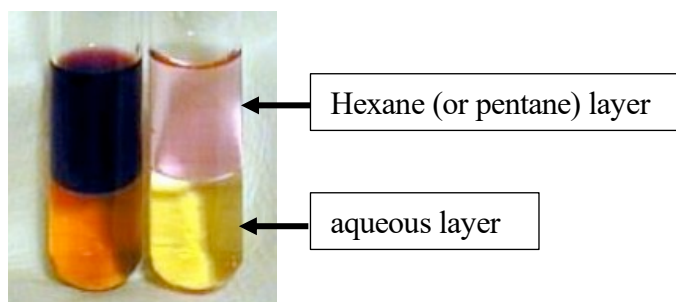
Note: The word clear does not describe a solution with no color. Clear only means transparent or see through. The word to describe no color is COLORLESS.

1. Take three clean test tubes and put about 1–2 mL (1–2 eyedroppers full) of Cl_2 (aq) in the first tube, about 1–2 mL of Br_2 (aq) in the second tube, and about 1–2 mL of I_2 (aq) in the third tube. Record the colors observed in the first row of Table 1 in Data Sheet I. This exercise is to convince yourself that observing the colors in the aqueous phase will not be adequate for identification.
2. Add about 1–2 mL of hexane (or pentane) to each of the three aqueous samples of Cl_2 , Br_2 , and I_2 in the test tubes in step 1. Do not shake the samples yet. Record any color observed in *just* the hexane (or pentane) layer (the top layer) in the second row of the table.

The next step is to get an idea of the range of the intensity of hue that might be observed after reaction mixtures are extracted into hexane (or pentane), since this will depend on concentration. Suppose a species looks blue when extracted into hexane (or pentane). If there is only a small concentration in the hexane (or pentane) phase, it might look so faintly pale blue as to appear colorless. (Viewing with a white paper behind helps in seeing faint hues.) If extracted further, the concentration will increase, and the color could go from light blue, to bright blue, to deep dark blue to nearly blue-black as more and more of the species is extracted into the hexane (or pentane) layer. Hexane (or pentane) is less dense than water and is not soluble in water, so when hexane (or pentane) is put in the test tube with an aqueous solution, it will float on **TOP**. Compounds soluble in hexane (or pentane) will slowly move across the hexane (or pentane)/water interface, thus any color observed in the hexane (or pentane) layer will initially be very pale.

- To increase the extraction into hexane (or pentane) (i.e. increase the concentration), put *on* gloves, cover the top of the test tube with the small squares of aluminum foil (or parafilm) supplied, press *tightly* with a gloved thumb or finger, and shake vigorously. The two immiscible liquids will form an emulsion (small droplets of hexane (or pentane) dispersed throughout the water), making the sample look somewhat opaque. This emulsion very quickly breaks, with the water phase dropping to the bottom and the hexane (or pentane) phase floating to the top. However, there was increased hexane (or pentane)/water surface area during the dispersion, and more Cl_2 , Br_2 , or I_2 will be extracted into the hexane (or pentane). Any color in the lower aqueous layer will get paler, and the color in the upper, hexane (or pentane) layer will get darker. Go through several shake/observe cycles so you can see how the color of each species in hexane (or pentane) depends on concentration. Record your final observation of the darkest characteristic color for Cl_2 , Br_2 , and I_2 in hexane (or pentane) (TOP layer) in the final row of Table 1, and the first row of Table 2 on the next page. Be mindful that these are not necessarily the darkest or lightest values that might be observed.

Figure 2. Example of color range observable for a compound as a function of solvent and concentration. The test tube on the left has high concentration and the one on the right low concentration.



Part Ib: Now you are ready to mix each halogen (Cl_2 , Br_2 , and I_2) with aqueous solution of each halides (Cl^- , Br^- and I^-) and extract molecular halogen into the hexane (or pentane) to determine whether a reaction has occurred.

- Nine reaction mixtures will be made. As in Part I, be methodical, doing one COLUMN at a time. For the first column, fill three test tubes each with about 1–2 mL of one of the three halides solutions, Cl^- , Br^- and I^- . To each test tube, use an eyedropper to *slowly* add about an equal volume of an aqueous solution of Cl_2 . If a reaction takes place, sometimes there is an obvious change before the reaction product is extracted in hexane (or pentane), but sometimes not.
- Now, add about 1–2 mL of hexane (or pentane) to each tube. Cover the tube with an aluminum foil square (or parafilm) and, with gloves on, cover the top *tightly* with a thumb or finger, and shake vigorously. Let the hexane (or pentane) and water separate. If there is an obvious color in the hexane (or pentane) layer, record that color in the appropriate box on the table. If there is no color in the hexane (or pentane), or if you are unsure, shake the sample vigorously several times, letting the hexane (or pentane)/water separate each time, and view the tube with a white paper behind it. If there is color in the hexane (or pentane), it will get darker with each shake/observe cycle. Record the color (if any) in the TOP, HEXANE (OR PENTANE) layer in the appropriate grid box of Table 2 in Data Sheet I.
- From the color of the hexane (or pentane) layer recorded in each grid box, deduce if there is reaction or no reaction. Write down R for reaction and NR or no reaction.

PART II: Reactivities of metals and hydrogen

1. Observing the Appearance of Metals and Solutions of Their Metallic Salts

Before starting the reactions, take Data Sheet II to the hoods to make observations of the solutions: copper(II) sulfate, CuSO_4 (aq), iron(II) sulfate, FeSO_4 (aq), zinc sulfate, ZnSO_4 (aq), and HCl (aq). Obtain from the front of the lab the metal pieces (Zn, Cu and Fe), and make observations. Record the appearance of all the materials which will be used in Table 1, so that any signs of chemical reaction (change in color, phase, temperature, etc.) when they are combined will be apparent.

2. Reacting Metals with Hydrochloric Acid

For this section, record the observations on Data Sheet II Table 2. Take three test tubes, add about 2 mL of 6 M HCl to each. Take a small piece of each metal (Zn, Cu, Fe), about 4 cm long, sand the surface to remove surface oxides, and *immediately* place each metal in its separate test tube containing HCl . Record any immediate changes that you see. Leave the test tubes aside to observe any additional changes over time while starting reactions in the next part.

Base on your observation, determine whether a reaction occurred. Write R or NR in the third column of Table 2.

3. Reacting Metals with Solutions of Metallic Salts

For this section, record the observations in Data Sheet II Table 3. Take two test tubes, add 6 mL of 0.5 M ZnSO_4 to each. Take a small piece of Cu and Fe, about 4 cm long, sand the surface clean, and *immediately* place each metal in its separate test tube containing ZnSO_4 (aq). Record any immediate changes that you see. Leave the test tubes aside to observe any additional changes over time while starting reactions in the next part.

Repeat the same procedure for metals Zn and Cu in 0.5 M FeSO_4 solution and for metals Zn and Fe in 0.5 M CuSO_4 solution, observing and recording any changes.

Note: if you suspect that an oxide layer is preventing or significantly slowing a reaction, try dipping the metal into acid until it starts to bubble, then immediately transfer it to the metallic cation solution. **Do this only after consultation with and permission from your instructor.**

Base on your observation, determine whether a reaction occurred. Write R or NR in the fourth column of Table 3.

4. Conclusions

At home, on Data Sheet III, use your experimental observations in Part I to arrange the three halogens (Cl_2 , Br_2 , I_2) in the order of increasing reactivity, and the three element (Cl, Br, I) in the order of increasing electronegativity. Also use your experimental observations in Part II to arrange the three metals and H_2 in the order of increasing relative reactivity. Provide your reasoning to the three rankings based on your **observations in this experiment**.

Pre-Laboratory Assignment

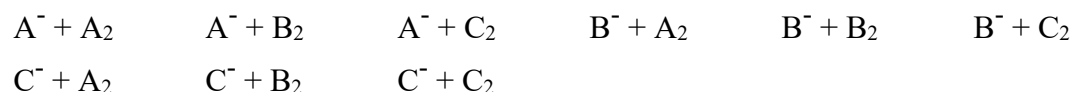
1. The following made-up reaction pattern is similar to the halogens/halides experiment:

As shown in the table below, the molecular species (A_2 , B_2 , C_2) have similar colors in aqueous solutions, so those colors cannot be used for identification. However, they have three distinct colors (yellow, red, green) in hexane (or pentane) that CAN be used.

Grading	
Pre-Lab	_____/19
Data	_____/60
Post-lab	_____/21
Safety (deduction)	- ____
Legibility (deduction)	- ____
Tardiness (deduction)	- ____
TOTAL	_____/100

COLOR	A^-	B^-	C^-	A_2	B_2	C_2
In water	colorless	colorless	colorless	Lt. blue	Lt. blue	Blue-green
In hexane (or pentane)	Insoluble, colorless	Insoluble, colorless	Insoluble, colorless	Green	Yellow	Red

Nine reaction mixtures are made:



The reaction products, if any, are extracted into hexane (or pentane) and *that* color is used to deduce if a reaction took place. Take the test mixture $A^- + B_2$ for an example: If no reaction takes place, the characteristic yellow color of B_2 will be observed in the hexane (or pentane) layer. If element B is more electronegative, atoms of B_2 will be able to pull electrons away from A^- ions, oxidizing it to A_2 . There will be a reaction $2 A^- + B_2 \rightarrow 2 B^- + A_2$, and the characteristic green color of A_2 will be observed after extraction into hexane (or pentane).

Mixture grid. Color of reaction products extracted into the hexane (or pentane) layer.

	A_2	B_2	C_2
A^-	Green _____	Yellow _____	Green _____
B^-	Yellow _____	Yellow _____	Yellow _____
C^-	Green _____	Yellow _____	Red _____

- a) Determine whether a reaction occurred for each combination in the grid. Write *NR for No Reaction* or *R for Reaction* on the line.

b) Rank the elements (A, B, C) in order of increasing electronegativity:

Least electronegative Intermediate Most electronegative

c) Rank the molecular species (A_2 , B_2 , C_2) in order of oxidizing strength:

Strongest oxidizing agent Intermediate Weakest oxidizing agent

2. For the reaction $2 \text{Al (s)} + 3 \text{Sn}^{2+} \text{(aq)} \rightarrow 2 \text{Al}^{3+} \text{(aq)} + 3 \text{Sn (s)}$

a) _____ is being oxidized; _____ is the oxidizing agent.

b) Write the two half-reactions:

oxidation half reaction: _____

reduction half reaction: _____

c) How many electrons are being transferred from the oxidized species to the reduced species? _____

3. A student did experiments to establish the relative reactivity of metallic Cr, Pt, and Pb, with the following results:

- i. Both Cr and Pb metals reacted with 6 M HCl, but Pt metal did not.
- ii. There was no reaction between $\text{PbSO}_4 \text{(aq)}$ and Pt metal.
- iii. There was a reaction between $\text{PbSO}_4 \text{(aq)}$ and Cr metal.

a) What can be concluded from result i)?

b) What can be concluded from result ii)?

c) What can be concluded from result iii)?

d) Rank the three metals and hydrogen in order of relative reactivity:

_____ > _____ > _____ > _____
Most reactive Least reactive

DATA SHEET I

Instructor's Initials: _____

For the halogen/halides, only the molecular species (Cl_2 , Br_2 , and I_2) are colored in water or in hexane (or pentane). Record your observations of the colors of Cl_2 , Br_2 , and I_2 in water. Then add hexane (or pentane) to each tube and record the color in the hexane (or pentane) layer BEFORE shaking. Finally, shake vigorously several times, letting the phases separate between each step, to observe the effect of concentration/degree of extraction on the characteristic colors of Cl_2 in hexane (or pentane), Br_2 in hexane (or pentane) and I_2 in hexane (or pentane). Also write the colors observed in the last row here to the first row in Part IIb.

Table 1 Color of halogen in hexane (or pentane)

	Cl_2	Br_2	I_2
Color in water			
Color in hexane (or pentane) <u>Before</u> shaking			
Color in hexane (or pentane) <u>After</u> shaking			

Copy the colors in the last row to the first row Table 2 on the next page.

DATA SHEET I

Instructor's Initials: _____

The characteristic colors of in hexane (or pentane), in hexane (or pentane), and in hexane (or pentane) recorded in the first row are an aid in determining whether a redox reaction takes place when each molecular halogen/halide pair is mixed and the product is extracted into hexane (or pentane). If no reaction takes place, the color will be the same all the way down a given column.

Mix the indicated molecular halogen with the indicated halide for each box. Then add hexane (or pentane), shake vigorously, and note the color of the **HEXANE (OR PENTANE)** layer.

Deduce whether a reaction took place and note NR or R (No Reaction or Reaction)

Table 2 Color of mixture of halogen and halides in hexane (or pentane)

Color in hexane (or pentane), <u>after</u> shaking, from table in Data Sheet 1a			
<div> <div>Molecular Halogens</div> <div>Halides</div> </div>	Cl_2 (aq)	Br_2 (aq)	I_2 (aq)
Cl^- (aq)			
Br^- (aq)			
I^- (aq)			

DATA SHEET II

Instructor's Initials: _____

Table 1: Observing the Appearance of Metals and Solutions of their Metallic Salts

Metal	Appearance	Metallic salt solutions	Appearance
Zn		ZnSO ₄	
Cu		CuSO ₄	
Fe		FeSO ₄	

Hydrochloric acid, HCl, appearance: _____

Table 2 Reacting Metals with Hydrochloric Acid

Metal	Observations	R or NR
Zn		
Cu		
Fe		

Table 3 Reacting Metals with Solutions of Metallic Salts

Metal	Solution of metallic salt	Observations	R or NR
Cu	ZnSO ₄		
Fe	ZnSO ₄		
Zn	FeSO ₄		
Cu	FeSO ₄		
Zn	CuSO ₄		
Fe	CuSO ₄		

DATA SHEET III Conclusions

1. Arrange the three halogens (Cl_2 , Br_2 , I_2) in the order of their increasing RELATIVE REACTIVITY:

Least reactive < < Most reactive

Use your recordings in Data Sheet I Table 2 to provide reasoning for the ranking:

2. Arrange the three element, Cl, Br, and I, in the order of their increasing ELECTRONEGATIVITY:

Least electronegative < < Most electronegative

Use your recordings in Data Sheet I Table 2 to provide reasoning for the ranking:

3. Arrange the three metals and hydrogen in order of their increasing relative reactivity:

Least reactive < _____ < _____ < _____ Most reactive

Use your recordings in Data Sheet II Table 2 and 3 to provide reasoning for the ranking:

Post-Laboratory Questions

1. Write the net ionic equations for the reactions between the halogens and halides that did occur in Part I of the experiment (those you wrote down R in Data Sheet I Table 2). For each reaction, identify the species being oxidized and the one being reduced.

Reaction 1:

Net ionic equation: _____

_____ is being oxidized; _____ is being reduced

Reaction 2:

Net ionic equation: _____

_____ is being oxidized; _____ is being reduced

Reaction 3:

Net ionic equation: _____

_____ is being oxidized; _____ is being reduced

Continue in the space below if more reactions were observed:

2. Write the molecular and the net ionic equations for the reactions that did occur in Part II of the experiment (those you wrote down in Data Sheet II Table 2 and Table 3). For each reaction, write the oxidation and reduction half reactions.

Reaction 1

Molecular equation

Net ionic equation

ox. half reaction

red. half reaction

Reaction 2

Molecular equation

Net ionic equation

ox. half reaction

red. half reaction

Reaction 3

Molecular equation

Net ionic equation

ox. half reaction

red. half reaction

Reaction 4

Molecular equation

Net ionic equation

ox. half reaction

red. half reaction

Reaction 5

Molecular equation

Net ionic equation

ox. half reaction

red. half reaction

Attach an additional sheet if more reactions were observed.