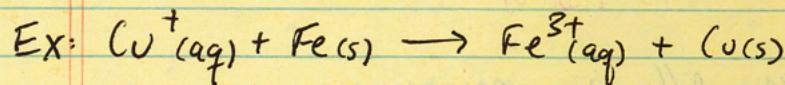


(3)

## Redox Reactions : Types of Reactions

Def: An oxidative-reduction (redox) reaction is a chemical reaction where a transfer of electrons occurs between 2 species.



Electrons transferred from Fe  $\rightarrow$  Cu. How can we formalize this to reactions where this may not be obvious?

Def: Oxidation states/numbers describe the degree of oxidation of an atom in a chemical species. More practically, they are the hypothetical charge that an atom would have if all bonds to atoms of different elements were 100% ionic.

Remark: Oxidation states are typically integers ( $\mathbb{Z}$ ), though rational oxidation states exist (as averages in a compound)

Remark: The sum of oxidation states in a compound should equal the overall charge of the compound. Neutral species have a total oxidation sum of 0. Ionic species sum to their charge.

### Rules of Assigning Oxidation States:

1) Oxidation state of an individual atom is 0.

2) Group 1 elements have oxidation states of +1. Group 2 elements are +2.

3) The oxidation state of F is -1 in compounds

4) Hydrogen typically has a +1 oxidation number.

5) Oxygen typically has a +2 oxidation number.

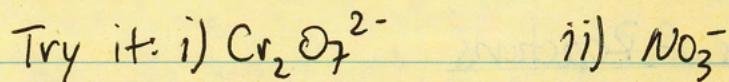
Examples: a)  $\text{Fe}(\text{s})$ , 0

b)  $\text{O}_2(\text{g})$ , 0

c)  $\text{Fe}_2\text{O}_3(\text{g})$ , Fe is +3, O is -2

$$2(+3) + 3(-2) = 0 ?$$

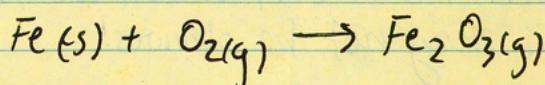
(4)



$$\text{Cr is } +6 \text{ since} \\ 2(+6) + 2(-2) = -2$$

$$\text{N is } +5 \text{ since} \\ +5 + 3(-2) = -1$$

So let's ~~possibly~~ examine the following reaction:



The initial oxidation states are:

$$\begin{aligned} \text{Fe : O} & \} \text{ from before.} \\ \text{O : O} & \end{aligned}$$

Now, the product, Fe has +3 and Oxygen is -2.

So Fe lost electrons and Oxygen gained electrons. Motivates:

Def: During the course of a chemical reaction, if a compound or species loses electrons, we say it has been oxidized. If it gains electrons than it is said to be reduced.

So Fe was oxidized & O was reduced during the course of the reaction.

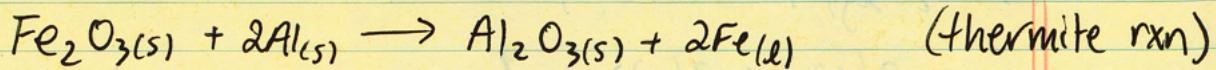
Can use OIL RIG or LEO the lion says GER to remember.

Def: The compound or species that accepts electrons is called the oxidizing agent (causes other species to be ~~red~~ oxidized). Similarly, if it donates electrons, it is called the reducing agent (causes other species to be reduced).

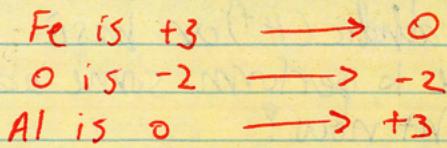
So Fe oxidized but reducing agent.

And O reduced but oxidizing agent.

Okay, let's try it: identify the oxidation states of all elements and determine the oxidizing & reducing agent.

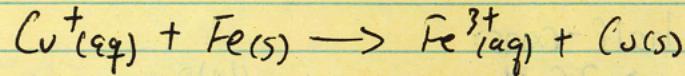


(5)



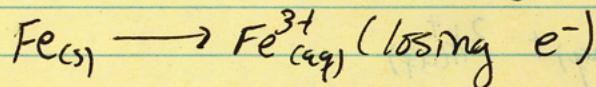
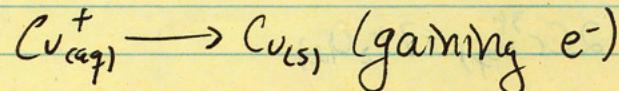
So Fe gained  $e^- \Rightarrow$  reduced  $\therefore$  thus oxidizing agent  
 Al lost  $e^- \Rightarrow$  oxidized  $\therefore$  thus reducing agent

Now how can we balance redox reactions? From the beginning we had

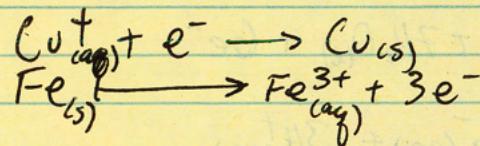


This isn't balanced because the left has a +1 overall charge and the right has a +3 overall charge. We must have charges be equal (cannot create nor destroy charge!)

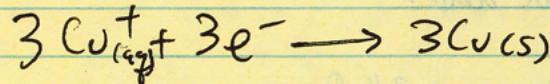
Well, we have



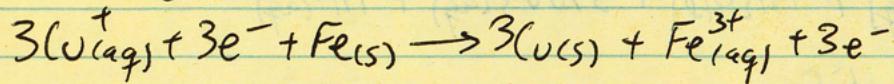
We can write these half-reactions:



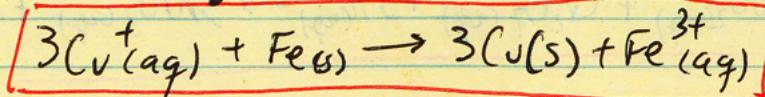
Want total charge conservation, so multiply by 3 to get



Then adding the half-reactions:



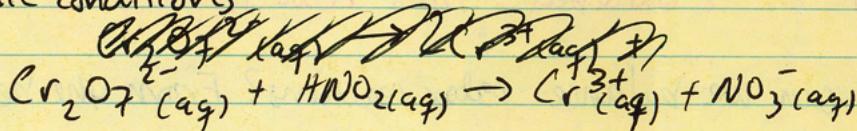
The  $e^-$  cancel leaving:



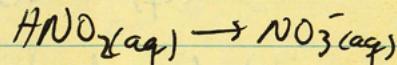
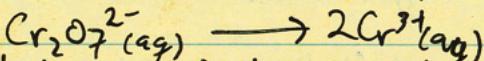
(6)

What we just experienced was balancing half-reactions in a neutral solution. If we were in an acidic ( $H^+$ ) or basic environment ( $OH^-$ ), we would have to perform some additional steps. Don't worry about this right now!

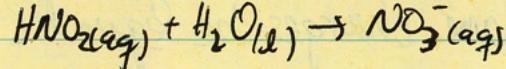
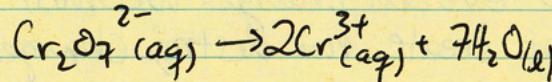
Ex: In acidic conditions



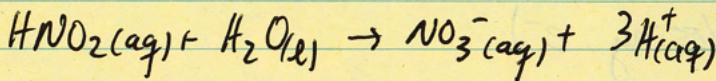
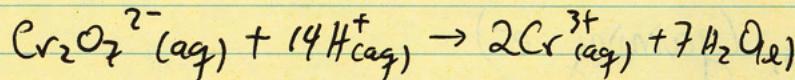
Start with half-rexns:



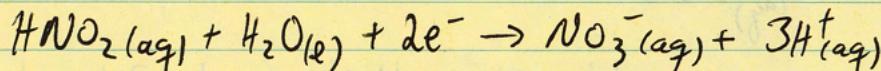
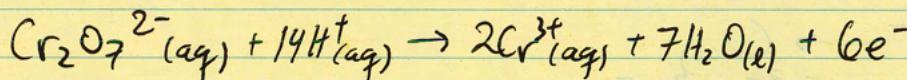
1) Add  $H_2O$  to balance O's.



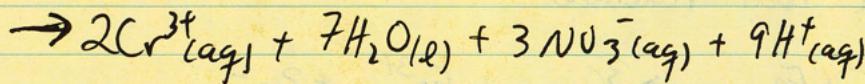
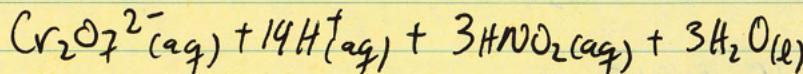
2) Balance H's via  $H^+$  (acidic environment).



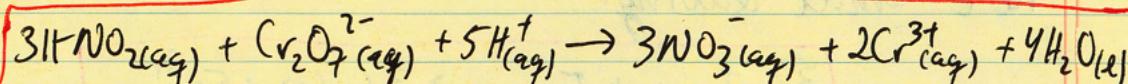
3) Balance charges using  $e^-$ :



4) Multiply so  $e^-$  cancel and add:

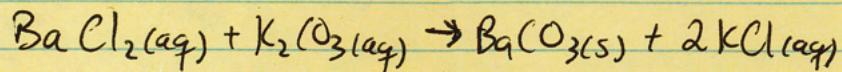


5) Cancel / Simplify



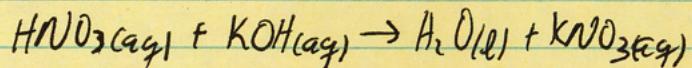
So what we have talked about so far are redox reactions, but we can classify other types of reactions

### i) Precipitation

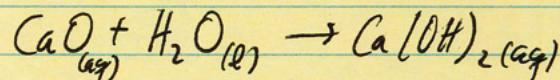


The  $\text{Ba}(\text{O}_3)$  is insoluble in water & falls out of solution. Easy to identify precipitation type reactions since they will form a solid from liquid or aqueous reagents.

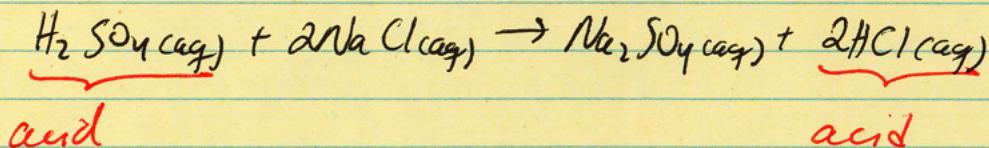
### ii) Acid - Base



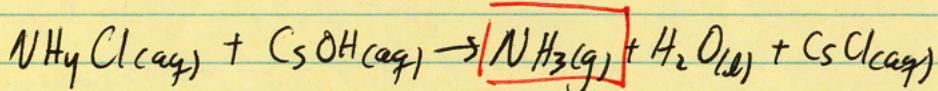
Usually identified by formation of water + salt. What is given above is a neutralization type reaction. Also have hydration of acid/base anhydrides to form acid/bases



and acid/base displacement:



### iii) Gas Evolution (Not Part of lab)



Formation of gas (hence the name).