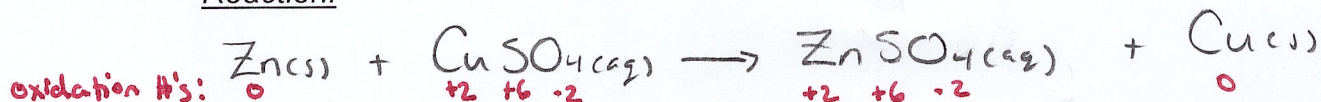


Using Half-Reactions to Balance Redox Reactions

- **Half-reactions** are equations that describe the changes in only the compound that is oxidized or only the compound that is reduced
 - Half-reactions are still balanced reactions (both atoms and charges), but also show the loss or gain of electrons
 - An ionic or net ionic equation should never show the electron loss or gain.
- Consider the reaction of zinc with copper(II) sulphate

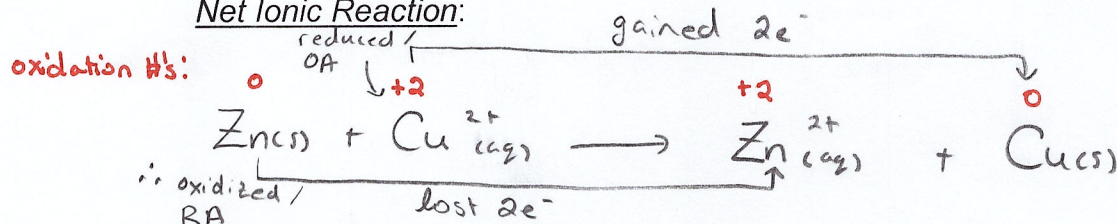
Reaction:



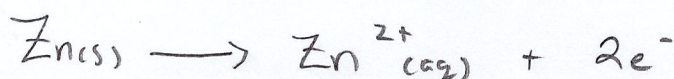
Ionic Reaction:



Net Ionic Reaction:



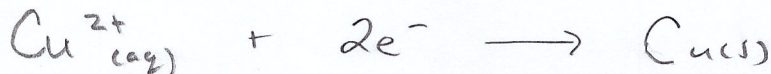
Oxidation Half-Reaction:



* both atoms & charges are balanced *

Zinc atoms (Zn) are converted into zinc ions (Zn²⁺) by losing two electrons

Reduction Half-Reaction:



Copper(II) ions (Cu²⁺) are converted into copper atoms (Cu) by gaining 2 electrons.

- Most redox reactions that we have seen so far can be balanced just by inspection (ie. our usual way of balancing any chemical reaction)
 - However, some reactions are more difficult to balance and we need a method/procedure for balancing redox reactions
 - A common technique is to use half-reactions

BALANCING REDOX EQUATIONS THAT OCCUR IN ACIDIC

- Some redox reactions take place in acidic conditions and the hydrogen ions ($H^+_{(aq)}$) must be account for in the balanced redox reaction
 - Several steps are needed just to balance the half-reactions for acidic conditions (outlined in the first box)
 - Once the two half-reactions are balanced, it is necessary to balance the entire redox reaction (outlined as review in second box)

BALANCING HALF-REACTIONS OCCURRING IN ACIDIC SOLUTIONS

Step 1 Write the unbalanced half-reactions showing the reactants and products.

Step 2 Balance any atoms other than oxygen and hydrogen atoms first.

Step 3 Balance any oxygen atoms by adding water molecules.

Step 4 Balance any hydrogen atoms by adding hydrogen ions.

Step 5 Balance the charges by adding electrons.

BALANCING EQUATIONS USING HALF-REACTIONS

Step 1 Multiply one or both half-reactions by a number that will allow each half-reaction to have the same number of electrons. Lowest common multiple is best.

Step 2 Add the balanced half-reactions together.

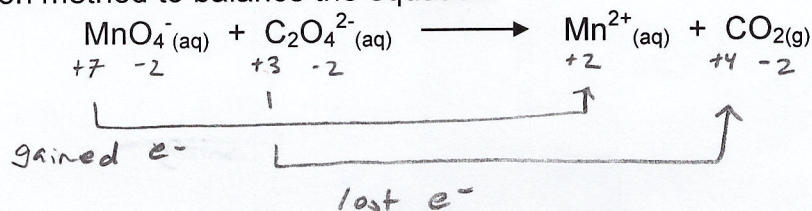
Step 3 Cancel out electrons and any other atoms/molecules that are the same on opposite sides of the reaction.

Step 4 If spectator ions were removed, add them back to the equation.

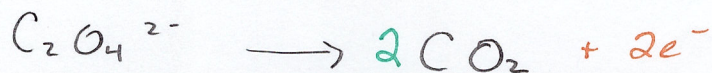
easier to keep them in

EXAMPLES

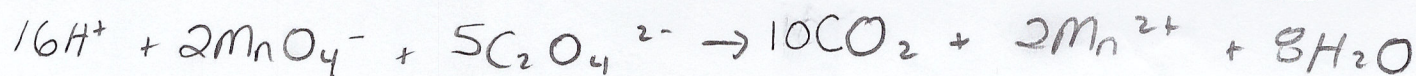
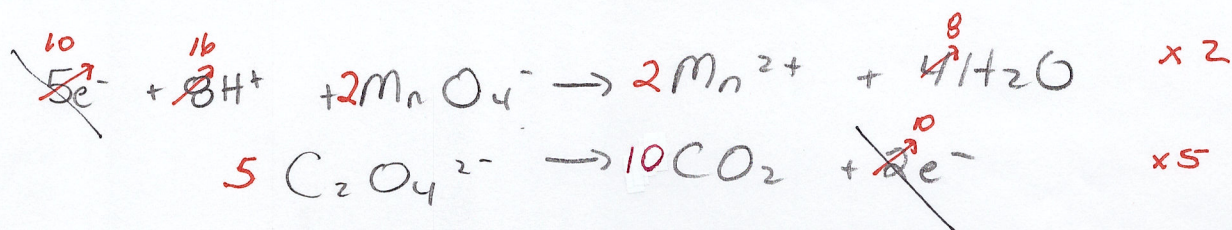
1. The unbalanced equation for the reaction between permanganate ions, MnO_4^- (aq), and oxalate ions, $\text{C}_2\text{O}_4^{2-}$ (aq), in acidic conditions is shown below. Use half-reaction method to balance the equation.



reduction
half-rxn



oxidation
half-rxn



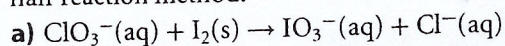
total charge: +4

total charge: +4

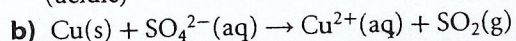
charge & atoms are balanced.

PRACTICE PROBLEMS

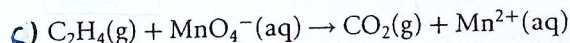
1.) Balance the following redox reactions using the half reaction method.



(acidic)

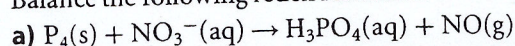


(acidic)

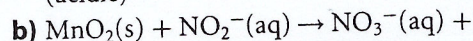


(acidic)

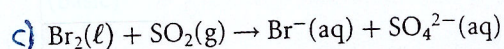
2.) Balance the following redox reactions:



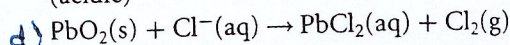
(acidic)



(acidic)

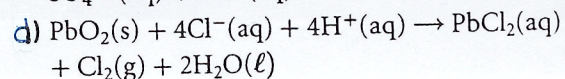
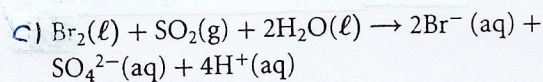
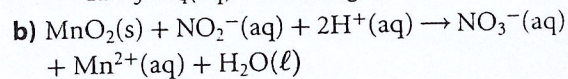
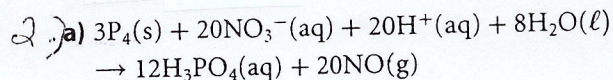
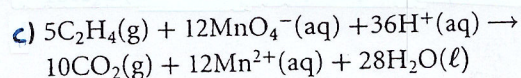
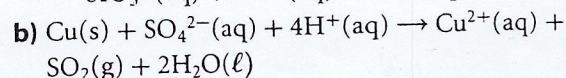
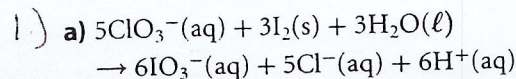


(acidic)



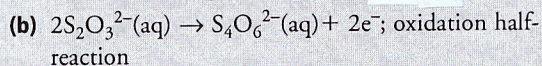
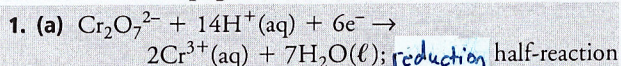
(acidic)

Solutions

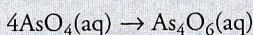


Section 12.2 Review Answers

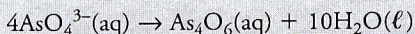
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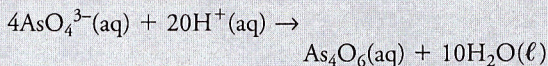
(c) Arsenic is reduced, so this is a reduction half-reaction. First balance the atoms other than oxygen and hydrogen.



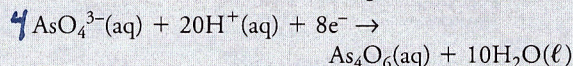
Add water to balance the oxygen atoms.



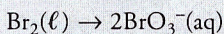
Add hydrogen ions (acidic solution) to balance the hydrogen atoms.



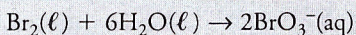
Add electrons to balance the charges on both sides.



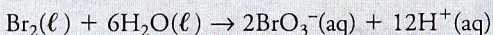
(d) Bromine is oxidized, so this is an oxidation half-reaction. First balance the atoms other than oxygen and hydrogen.



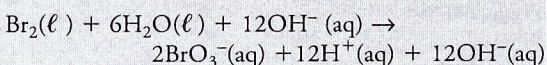
Add water to balance the oxygen atoms.



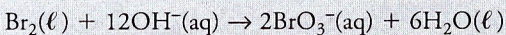
Add hydrogen ions (acidic solution) to balance the hydrogen atoms.



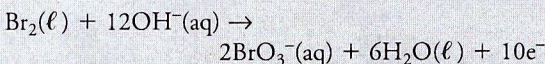
Adjust for basic conditions by adding hydroxide ions to both sides.



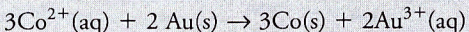
Combine hydrogen and hydroxide ions and cancel any water found on both sides of the equation.



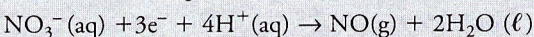
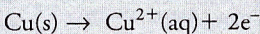
Add electrons to balance the charges on both sides.



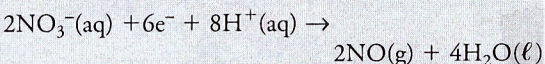
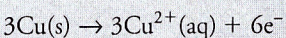
2. (a) Balance this equation by balancing charge:



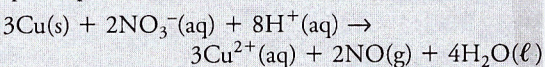
(b) Under acidic conditions, the balanced half-reactions are:



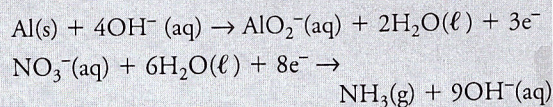
Write half-reactions with the LCM.



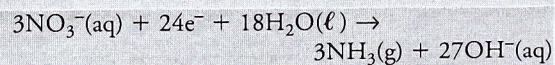
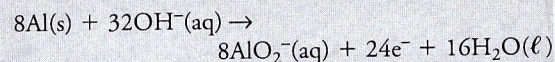
Add half-reactions, remove electrons and chemical species present on both sides:



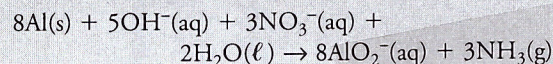
(c) Under basic conditions, the balanced half-reactions are:



Write half-reactions with the LCM.



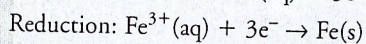
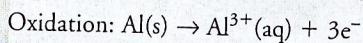
Add half-reactions, remove electrons and chemical species present on both sides:



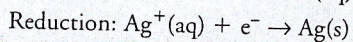
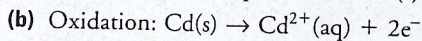
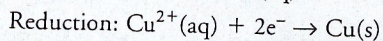
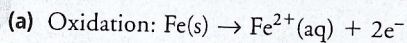
Answers to Questions for Comprehension

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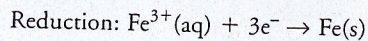
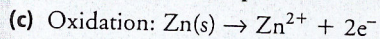
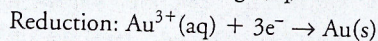
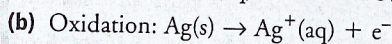
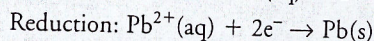
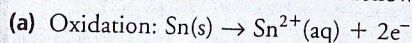
Q9. The balanced half-reactions are as follows:



Q10. The balanced half-reactions are as follows:



Q11. The balanced half-reactions are as follows:



Answers to Practice Problems 1-2

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For full solutions to the practice problems, visit www.albertachemistry.ca, Online Learning Centre, Instructor Edition, Full Solutions.

