

Sample Problems

1. Redox reactions (look at the change in oxidation states)
 - a. Na is oxidized ($\text{Na}^0 \rightarrow \text{Na}^+$), making it the reducing agent
S is reduced ($\text{S}^0 \rightarrow \text{S}^{-2}$), making it the oxidizing agent
 - b. Al is oxidized ($\text{Al}^0 \rightarrow \text{Al}^{+3}$), making it the reducing agent
O is reduced ($\text{O}_2^0 \rightarrow 2\text{O}^{-2}$), making it the oxidizing agent
2. Redox reactions (look at the change in oxidation states)
 - a. oxidization ($\text{Li}^0 \rightarrow \text{Li}^+$) ... increase in oxidation state
 - b. oxidation ($2\text{I}^- \rightarrow \text{I}_2^0$) ... increase in oxidation state
 - c. reduction ($\text{Zn}^{+2} \rightarrow \text{Zn}^0$) ... decrease in oxidation state
 - d. reduction ($\text{Br}_2^0 \rightarrow 2\text{Br}^-$) ... decrease in oxidation state

Lesson Check Answers

3. Oxidation is the gain of oxygen. Reduction is the loss of oxygen.
 4. Oxidation is the loss of electrons. Reduction is the gain of electrons.
 5. Salts and acids produce conductive solutions that make electron transfer easier.
 6. The species reduced is the oxidizing agent. The species oxidized is the reducing agent.
7. The oxidizing agent gets reduced (decreased oxidation state/gain e^-); the reducing agent gets oxidized (increased oxidation state/lose e^-)
 - a. Cl_2^0 is likely to get reduced to 2Cl^{-1} by gaining $e^- \rightarrow$ oxidizing agent
 - b. K is likely to get oxidized to K^+ by losing $e^- \rightarrow$ reducing agent
 - c. Ag^+ is likely to get reduced to Ag^0 by gaining $e^- \rightarrow$ oxidizing agent

8 & 9.

The oxidizing agent gets reduced (decreased oxidation state/gain e-); the reducing agent gets oxidized (increased oxidation state/lose e-)

- a. Na is oxidized ($\text{Na}^0 \rightarrow \text{Na}^+$) by losing an e-; reducing agent
Br₂ is reduced ($\text{Br}_2^0 \rightarrow 2\text{Br}^-$) by gaining 2 e-; oxidizing agent
- b. H₂ is oxidized ($\text{H}_2^0 \rightarrow 2\text{H}^+$) by losing 2 e-; reducing agent
Cl₂ is reduced ($\text{Cl}_2^0 \rightarrow 2\text{Cl}^-$) by gaining 2 e-; oxidizing agent
- c. Li is oxidized ($\text{Li}^0 \rightarrow \text{Li}^+$) by losing an e-; reducing agent
F₂ is reduced ($\text{F}_2^0 \rightarrow 2\text{F}^-$) by gaining 2 e-; oxidizing agent
- d. S is oxidized ($\text{S}^0 \rightarrow \text{S}^{+2}$) by losing 2 e-; reducing agent
Cl₂ is reduced ($\text{Cl}_2^0 \rightarrow 2\text{Cl}^-$) by gaining 2 e-; oxidizing agent
- e. N₂ is oxidized ($\text{N}_2^0 \rightarrow \text{N}^{+4}$) by losing 4 e-; reducing agent
O₂ is reduced ($\text{O}_2^0 \rightarrow \text{O}^{-2}$) by gaining 2 e-; oxidizing agent
- f. Mg is oxidized ($\text{Mg}^0 \rightarrow \text{Mg}^{+2}$) by losing an e-; reducing agent
Cu is reduced ($\text{Cu}^{+2} \rightarrow \text{Cu}^0$) by gaining 2 e-; oxidizing agent

Sample Problems

FIGURE 20.8 0, +6, +3

10. a. S, +3; O, -2
b. Na, +1; O, -1
c. P, +5; O, -2
d. N, +5; O, -2
11. a. +5 b. 0 c. +7 d. +1

12 & 13.

The oxidizing agent gets reduced (decreased oxidation state/gain e-); the reducing agent gets oxidized (increased oxidation state/lose e-)

- a. H₂ is oxidized ($\text{H}_2^0 \rightarrow 2\text{H}^+$) by losing 2 e-; reducing agent
O₂ is reduced ($\text{O}_2^0 \rightarrow \text{O}^{-2}$) by gaining 2 e-; oxidizing agent

- b. O_2 is oxidized ($O^{-2} \rightarrow O_2^0$) by losing $2e^-$; reducing agent
 N is reduced ($N^{+5} \rightarrow N^{+8}$) by gaining $2e^-$; oxidizing agent

FIGURE 20.9 The oxidation number of silver changes from +1 to 0; the oxidation number of copper changes from 0 to +2.

- 14. a.** N in NH_4^+ is oxidized (-3 to 0); H is unchanged; N in NO_2^- is reduced ($+3$ to 0); O is unchanged.
b. Pb is reduced ($+4$ to $+2$); O is unchanged; H is unchanged; I is oxidized (-1 in HI to 0 in I_2).
- 15. a.** N in NH_4^+ is the reducing agent; N in NO_2^- is the oxidizing agent.
b. Pb is the oxidizing agent; I is the reducing agent.

FIGURE 20.11 The oxidation number of potassium changes from 0 to +1, so this is a redox reaction. The oxidation number of zinc changes from 0 to +2, so this is a redox reaction.

Lesson Check Answers

- 16.** The oxidation number is the charge a bonded atom would have if the electrons in the bond were assigned to the more electronegative element.
- 17.** An increase in oxidation number indicates oxidation; a decrease in oxidation number indicates reduction.
- 18.** For a polyatomic ion, the sum of the oxidation numbers must equal the ionic charge of the ion.
- 19. a.** Na, oxidized; Cl_2 , reduced
b. I, oxidized; N, reduced
c. S, oxidized; N, reduced
d. Pb, oxidized and reduced
- 20. a.** Na reducing agent, Cl_2 oxidizing agent
b. N in HNO_3 oxidizing agent, I in HI reducing agent
c. N in HNO_3 , oxidizing agent; S in H_2S , reducing agent
d. Pb in $PbSO_4$, oxidizing-reducing agent

19 & 20.

The oxidizing agent gets reduced (decreased oxidation state/gain e⁻); the reducing agent gets oxidized (increased oxidation state/lose e⁻)

- a. Na is oxidized ($\text{Na}^0 \rightarrow \text{Na}^+$) by losing an e⁻; reducing agent
Cl₂ is reduced ($\text{Cl}_2^0 \rightarrow 2\text{Cl}^-$) by gaining 2 e⁻; oxidizing agent
- b. I is oxidized ($2\text{I}^- \rightarrow \text{I}_2^0$) by losing an 2 e⁻; reducing agent
N is reduced ($\text{N}^{+5} \rightarrow \text{N}^{+2}$) by gaining 3e⁻; oxidizing agent
- c. S is oxidized ($\text{S}^- \rightarrow \text{S}^0$) by losing an 2 e⁻; reducing agent
N is reduced ($\text{N}^{+5} \rightarrow \text{N}^{+2}$) by gaining 3e⁻; oxidizing agent
- d. **Pb⁺²SO₄** is oxidized and reduced
Pb is oxidized ($\text{Pb}^{+2} \rightarrow \text{Pb}^{+4}$) by losing an e⁻; reducing agent
Pb is reduced ($\text{Pb}^{+2} \rightarrow \text{Pb}^0$) by gaining 2 e⁻; oxidizing agent

Sample Problems

21a. This is a redox reaction.

Mg is oxidized ($\text{Mg}^0 \rightarrow \text{Mg}^{+2}$) by losing 2 e⁻; reducing agent
Br₂ is reduced ($\text{Br}_2^0 \rightarrow 2\text{Br}^-$) by gaining 2 e⁻; oxidizing agent

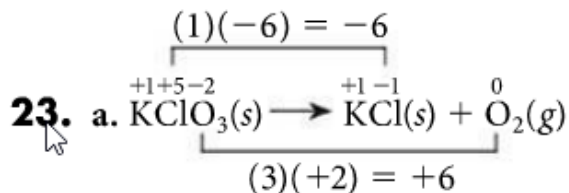
21b. This is NOT a redox reaction. No element changes oxidation state.

22a. This is NOT a redox reaction. No element changes oxidation state.

22b. This is a redox reaction.

H₂ is oxidized ($\text{H}_2^0 \rightarrow 2\text{H}^+$) by losing 2 e⁻; reducing agent
Cu is reduced ($\text{Cu}^{+2} \rightarrow \text{Cu}^0$) by gaining 2 e⁻; oxidizing agent

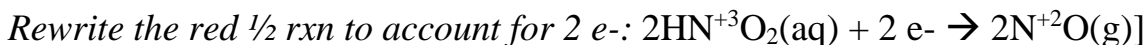
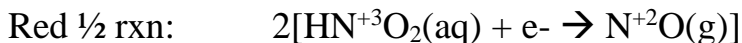
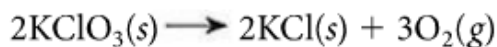
23 – 26. You may balance using either the oxidation-number method or the half reaction method.



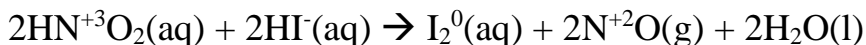
One K atom must be reduced for every 3 oxygen atoms oxidized.



Balance by inspection; put the coefficient 3 in front of O_2 , and the coefficient 2 in front of KClO_3 and KCl :



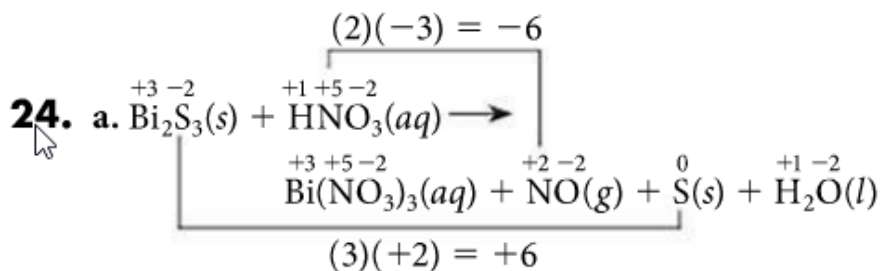
Balance overall equation (spectator ions) involving O, H.



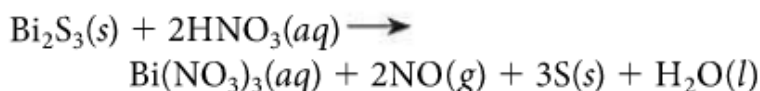
Cl^{+5} was reduced to Cl^{-1} ... that is an overall -6 drop.

O^{-2} was oxidized to O_2^0 ... that is an overall +2 increase.

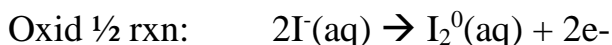
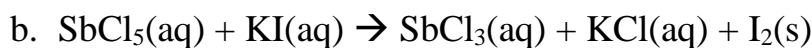
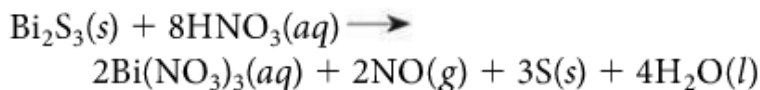
To account for the oxidation difference, use a common multiple.



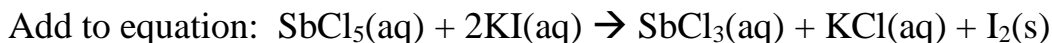
2 N atoms must be reduced for every 3 sulfur atoms oxidized.



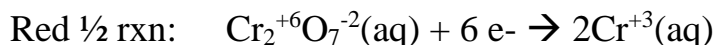
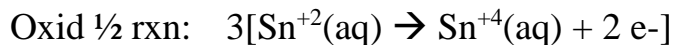
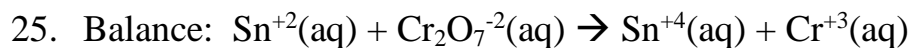
Balance by inspection; put the coefficient 2 in front of $\text{Bi}(\text{NO}_3)_3$, the coefficient 8 in front of HNO_3 , and the coefficient 4 in front of H_2O :



Both $\frac{1}{2}$ rxns involve 2 e^- without changing coefficients



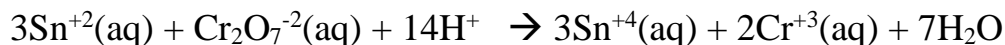
Balance overall equation (spectator ions) involving K, Cl.



Rewrite the oxid $\frac{1}{2}$ rxn to account for 6 e^- : $3\text{Sn}^{+2}(aq) \rightarrow 3\text{Sn}^{+4}(aq) + 6e^-$



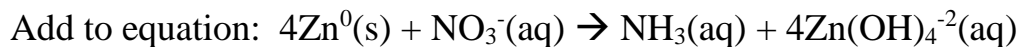
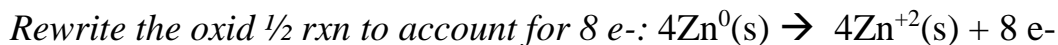
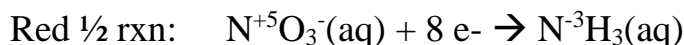
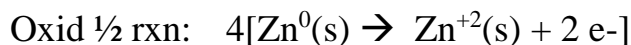
Balance overall equation (spectator ions) involving O, H. Since the reaction is acidic (H^+ ions) and aqueous (H_2O), we add those elements in.



N^{+5} was reduced to N^{+2} ... that is an overall -3 drop.

S^{-2} was oxidized to S^0 ... that is an overall +2 increase.

To account for the oxidation difference, use a common multiple.



Balance overall equation (spectator ions) involving O, H. Since the reaction is basic (OH^- ions) and aqueous (H_2O), we add those elements in.

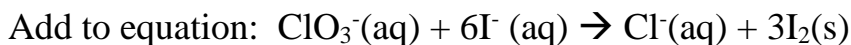
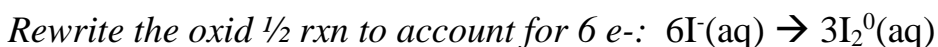
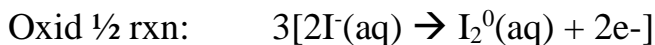


Lesson Check Answers

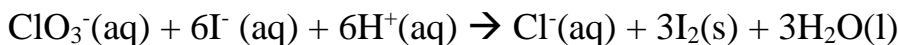
27. Reactions in which electrons are transferred from one reacting species to another (redox reactions) and reactions that do not involve a transfer of electrons.

28. The oxidation-number-change method and the half-reaction method.

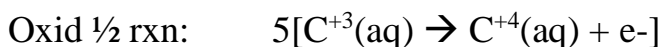
29 – 30. You may balance using either the oxidation-number method or the half reaction method.



Balance overall equation (spectator ions) involving O, H. Since the reaction is acidic (H^+ ions) and aqueous (H_2O), we add those elements in.



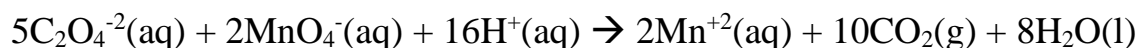
The acid (H^+ ions) are with I^- ions on the reactant side.



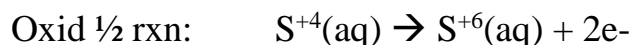
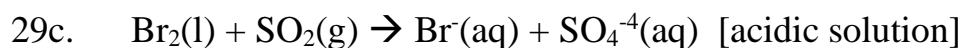
Rewrite the oxid $\frac{1}{2}$ rxn to account for 5 e⁻: $5\text{C}^{+3}(\text{aq}) \rightarrow 5\text{C}^{+4}(\text{aq}) + 5\text{e}^-$

Add to equation: $5\text{C}_2\text{O}_4^{-2}(\text{aq}) + 2\text{MnO}_4^-(\text{aq}) \rightarrow 2\text{Mn}^{+2}(\text{aq}) + 10\text{CO}_2(\text{g}) \dots$
note that we had to double the amount of Carbons based on the equation. Therefore, we have to double the amount of manganese as well $\rightarrow 10 \text{e}^-$

Balance overall equation (spectator ions) involving O, H. Since the reaction is acidic (H^+ ions) and aqueous (H_2O), we add those elements in.



The acid (H^+ ions) are with MnO_4^- ions on the reactant side.



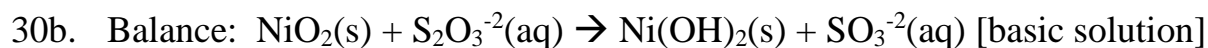
Both $\frac{1}{2}$ rxn involve 2 e⁻ without changing coefficients

Balance overall equation (spectator ions) involving O, H. Since the reaction is acidic (H^+ ions) and aqueous (H_2O), we add those elements in.



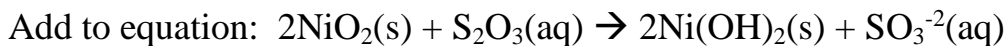
The acid (H^+ ions) are with Br^- ions on the product side.

30a. You do NOT have to answer 30a.



Both $\frac{1}{2}$ rxn involve 2 e⁻ without changing coefficients

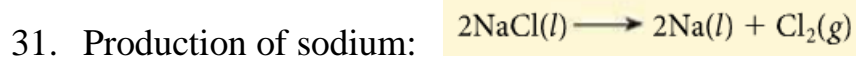
Note that we had to double the amount of Sulfur based on the equation. Therefore, we have to double the amount of Nickel as well $\rightarrow 4 \text{e}^-$



Balance overall equation (spectator ions) involving O, H. Since the reaction is basic (OH^- ions) and aqueous (H_2O), we add those elements in.

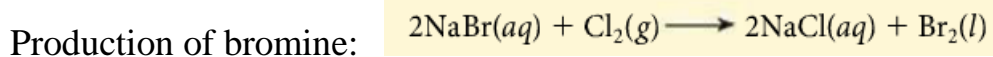


The base (OH^- ions) are with the H^+ ions of water on the reactant side.



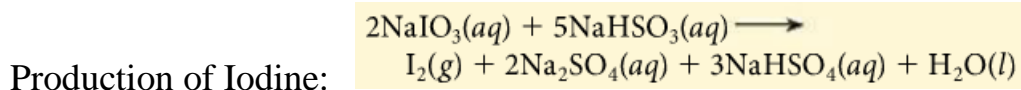
Cl_2 is oxidized ($2\text{Cl}^- \rightarrow \text{Cl}_2^0$) by losing 2 e-; reducing agent

Na is reduced ($\text{Na}^+ \rightarrow \text{Na}^0$) by gaining an e-; oxidizing agent



Br^- is oxidized ($2\text{Br}^- \rightarrow \text{Br}_2^0$) by losing 2 e-; reducing agent

Cl_2 is reduced ($\text{Cl}_2^0 \rightarrow 2\text{Cl}^-$) by gaining 2 e-; oxidizing agent



S^{+4} is oxidized ($\text{S}^{+4} \rightarrow \text{S}^{+6}$) by losing 2 e-; reducing agent

I^{+5} is reduced ($2\text{I}^{+5} \rightarrow \text{I}_2^0$) by gaining 10 e-; oxidizing agent