

CHAPTER REVIEW

For more practice, go to the Problem Bank in Appendix D.

Oxidation and Reduction

SECTION 1 REVIEW

- a. Distinguish between the processes of oxidation and reduction.
b. Write an equation to illustrate each process.
- Which of the following are redox reactions?
 - $2\text{Na} + \text{Cl}_2 \longrightarrow 2\text{NaCl}$
 - $\text{C} + \text{O}_2 \longrightarrow \text{CO}_2$
 - $2\text{H}_2\text{O} \longrightarrow 2\text{H}_2 + \text{O}_2$
 - $\text{NaCl} + \text{AgNO}_3 \longrightarrow \text{AgCl} + \text{NaNO}_3$
 - $\text{NH}_3 + \text{HCl} \longrightarrow \text{NH}_4^+ + \text{Cl}^-$
 - $2\text{KClO}_3 \longrightarrow 2\text{KCl} + 3\text{O}_2$
 - $\text{H}_2 + \text{Cl}_2 \longrightarrow 2\text{HCl}$
 - $\text{H}_2\text{SO}_4 + 2\text{KOH} \longrightarrow \text{K}_2\text{SO}_4 + 2\text{H}_2\text{O}$
 - $\text{Zn} + \text{CuSO}_4 \longrightarrow \text{ZnSO}_4 + \text{Cu}$
- For each oxidation-reduction reaction in the previous question, identify what is oxidized and what is reduced.

PRACTICE PROBLEMS

- Each of the following atom/ion pairs undergoes the oxidation number change indicated below. For each pair, determine whether oxidation or reduction has occurred, and then write the electronic equation indicating the corresponding number of electrons lost or gained.
 - $\text{K} \longrightarrow \text{K}^+$
 - $\text{S} \longrightarrow \text{S}^{2-}$
 - $\text{Mg} \longrightarrow \text{Mg}^{2+}$
 - $\text{F}^- \longrightarrow \text{F}_2$
 - $\text{H}_2 \longrightarrow \text{H}^+$
 - $\text{O}_2 \longrightarrow \text{O}^{2-}$
 - $\text{Fe}^{3+} \longrightarrow \text{Fe}^{2+}$
 - $\text{Mn}^{2+} \longrightarrow \text{MnO}_4^-$
- Identify the following reactions as redox or nonredox:
 - $2\text{NH}_4\text{Cl}(aq) + \text{Ca}(\text{OH})_2(aq) \longrightarrow 2\text{NH}_3(aq) + 2\text{H}_2\text{O}(l) + \text{CaCl}_2(aq)$
 - $2\text{HNO}_3(aq) + 3\text{H}_2\text{S}(g) \longrightarrow 2\text{NO}(g) + 4\text{H}_2\text{O}(l) + 3\text{S}(s)$
 - $[\text{Be}(\text{H}_2\text{O})_4]^{2+}(aq) + \text{H}_2\text{O}(l) \longrightarrow \text{H}_3\text{O}^+(aq) + [\text{Be}(\text{H}_2\text{O})_3\text{OH}]^+(aq)$
- Arrange the following in order of increasing oxidation number of the xenon atom: CsXeF_8 , Xe , XeF_2 , XeOF_2 , XeO_3 , and XeF .

- Determine the oxidation number of each atom indicated in the following:
 - H_2
 - H_2O
 - Al
 - MgO
 - Al_2S_3
 - HNO_3
 - H_2SO_4
 - $\text{Ca}(\text{OH})_2$
 - $\text{Fe}(\text{NO}_3)_2$
 - O_2

Balancing Redox Equations

SECTION 2 REVIEW

- Label the following half-reactions as either reduction or oxidation half-reactions.
 - $\text{H}_2\text{S} \longrightarrow \text{S} + 2e^- + 2\text{H}^+$
 - $\text{SO}_2 + 4e^- + 2\text{H}_2\text{O} \longrightarrow \text{S} + 4\text{OH}^-$
 - $\text{ClO}_3^- + 6\text{H}^+ + 6e^- \longrightarrow \text{Cl}^- + 3\text{H}_2\text{O}$
 - $\text{Mn}(\text{CN})_6^{4-} \longrightarrow \text{Mn}(\text{CN})_6^{3-} + e^-$
- What are the oxidation states of the elements that changed oxidation states in the half-reactions in the above question?
- Balance the equation for the following reaction in a basic solution. Give balanced equations for both half-reactions and the balanced equation for the overall reaction.
 $\text{KMnO}_4 + \text{NaIO}_3 \longrightarrow \text{MnO}_2 + \text{NaIO}_4$

PRACTICE PROBLEMS

- For each requested step, use the half-reaction method to balance the oxidation-reduction equation below. (Hint: See Sample Problem A.)
 $\text{K} + \text{H}_2\text{O} \longrightarrow \text{KOH} + \text{H}_2$
 - Write the ionic equation, and assign oxidation numbers to all atoms to determine what is oxidized and what is reduced.
 - Write the equation for the reduction, and balance it for both atoms and charge.
 - Write the equation for the oxidation, and balance it for both atoms and charge.
 - Multiply the coefficients of the oxidation and reduction equations so that the number of electrons lost equals the number of electrons gained. Add the two equations.
 - Add species as necessary to balance the overall formula equation.

12. Use the method in the previous problem to balance each of the reactions below.
- $\text{HI} + \text{HNO}_2 \longrightarrow \text{NO} + \text{I}_2 + \text{H}_2\text{O}$
 - $\text{FeCl}_3 + \text{H}_2\text{S} \longrightarrow \text{FeCl}_2 + \text{HCl} + \text{S}$
13. Balance the equation for the reaction in which hot, concentrated sulfuric acid reacts with zinc to form zinc sulfate, hydrogen sulfide, and water.
18. Arrange the following in order of decreasing oxidation number of the nitrogen atom: N_2 , NH_3 , N_2O_4 , N_2O , N_2H_4 , and NO_3^- .
19. Balance the following redox equations:
- $\text{SbCl}_5 + \text{KI} \longrightarrow \text{KCl} + \text{I}_2 + \text{SbCl}_3$
 - $\text{Ca}(\text{OH})_2 + \text{NaOH} + \text{ClO}_2 + \text{C} \longrightarrow \text{NaClO}_2 + \text{CaCO}_3 + \text{H}_2\text{O}$
20. Balance the following equations in basic solution:
- $\text{PbO}_2 + \text{KCl} \longrightarrow \text{KClO} + \text{KPb}(\text{OH})_3$
 - $\text{KMnO}_4 + \text{KIO}_3 \longrightarrow \text{MnO}_2 + \text{KIO}_4$
 - $\text{K}_2\text{MnO}_4 \longrightarrow \text{MnO}_2 + \text{KMnO}_4$
21. Balance the following equations in acidic solution:
- $\text{MnO}_4^- + \text{Cl}^- \longrightarrow \text{Mn}^{2+} + \text{HClO}$
 - $\text{NO}_3^- + \text{I}_2 \longrightarrow \text{IO}_3^- + \text{NO}_2$
 - $\text{NO}_2^- \longrightarrow \text{NO} + \text{NO}_3^-$

Oxidizing and Reducing Agents

SECTION 3 REVIEW

14. a. Identify the most active reducing agent among all common elements.
 b. Why are all of the elements in its group in the periodic table very active reducing agents?
 c. Identify the most active oxidizing agent among the common elements.
15. Use **Table 3** to identify the strongest and weakest reducing agents among the substances listed within each of the following groupings:
- Ca, Ag, Sn, Cl^-
 - Fe, Hg, Al, Br^-
 - F^- , Pb, Mn^{2+} , Na
16. Use **Table 3** to respond to each of the following:
- Would Al be oxidized by Ni^{2+} ?
 - Would Cu be oxidized by Ag^+ ?
 - Would Pb be oxidized by Na^+ ?
 - Would F_2 be reduced by Cl^- ?
 - Would Br_2 be reduced by Cl^- ?

MIXED REVIEW

17. Identify the following reactions as redox or nonredox:
- $\text{Mg}(s) + \text{ZnCl}_2(aq) \longrightarrow \text{Zn}(s) + \text{MgCl}_2(aq)$
 - $2\text{H}_2(g) + \text{OF}_2(g) \longrightarrow \text{H}_2\text{O}(g) + 2\text{HF}(g)$
 - $2\text{KI}(aq) + \text{Pb}(\text{NO}_3)_2(aq) \longrightarrow \text{PbI}_2(s) + 2\text{KNO}_3(aq)$
 - $\text{CaO}(s) + \text{H}_2\text{O}(l) \longrightarrow \text{Ca}(\text{OH})_2(aq)$
 - $3\text{CuCl}_2(aq) + 2(\text{NH}_4)_3\text{PO}_4(aq) \longrightarrow 6\text{NH}_4\text{Cl}(aq) + \text{Cu}_3(\text{PO}_4)_2(s)$
 - $\text{CH}_4(g) + 2\text{O}_2(g) \longrightarrow \text{CO}_2(g) + 2\text{H}_2\text{O}(g)$

CRITICAL THINKING

22. **Interpreting Graphics** Given the activity table below, determine whether a reaction will occur or not. If the reaction will occur, give the products.

Reducing Agents	L	L ⁺
↑	M	M ⁺
	P	P ⁺
	T	T ⁺
		↓
		Oxidizing Agents

- L and M^+
 - P and M^+
 - P and T^+
23. **Drawing Conclusions** A substance has an element in one of its highest possible oxidation states. Is this substance more likely to be an oxidizing agent or a reducing agent? Explain your reasoning.

- 24. Drawing Conclusions** Use **Table 3** to decide if a redox reaction would occur between the two species, and if so, write the balanced equation. Explain your reasoning.
- Cl_2 and Br_2
 - Sn^{2+} and Zn
- 25. Drawing Conclusions** An element that disproportionates must have at least how many different oxidation states? Explain your reasoning.



USING THE HANDBOOK

- 26.** Several reactions of aluminum are shown in the common reactions section for Group 13 of the *Elements Handbook*. Use these reactions to answer the following:
- Which of the five reactions shown are oxidation-reduction reactions? How do you know?
 - For each redox reaction you listed in item **a**, identify what is oxidized and what is reduced.
 - Write half-reactions for each equation you listed in item **a**.
- 27.** Aluminum is described in Group 13 of the *Elements Handbook* as a self-protecting metal. This property of aluminum results from a redox reaction.
- Write the redox equation for the oxidation of aluminum.
 - Write the half-reactions for this reaction, and show the number of electrons transferred.
 - What problems are associated with the buildup of aluminum oxide on electrical wiring made of aluminum?

RESEARCH & WRITING

- 28.** Oxidizing agents are used in the cleaning industry. Research three different oxidizing agents used in this area, and write a report on the advantages and disadvantages of these compounds.
- 29.** Oxidizing and reducing agents play important roles in biological systems. Research the role of one of these agents in a biological process. Write a report describing the process and the role of oxidation and reduction.

ALTERNATIVE ASSESSMENT

- 30.** Boilers are used to convert water to steam in electric power plants. Dissolved oxygen in the water promotes corrosion of the steel used in boiler parts. Explain how dissolved oxygen is removed from the water in boilers.
- 31. Performance** For one day, record situations that show evidence of oxidation-reduction reactions. Identify the reactants and the products, and determine whether there is proof that a chemical reaction has taken place.