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5 • Reactions in Aqueous Solution

Oxidation Numbers & Redox

Overview:
There are two kinds of reactions in the world: Oxidation-Reduction Reactions and Acid-Base Reactions. In a redox reaction, electrons are gained and electrons are lost.

- Double Replacement Reactions are _____ (redox/non-redox/other)
- Single Replacement Reactions are _____ (redox/non-redox/other)
- Synthesis Reactions are _____ (redox/non-redox/other)
- Decomposition Reactions are _____ (redox/non-redox/other)
- Combustion Reactions are _____ (redox/non-redox/other)

An important idea to help recognize oxidation-reduction reactions is to identify the oxidation number (or oxidation state) of an atom. The oxidation number is also called the "apparent charge". Atoms in ionic compounds have charges and these are also the oxidation numbers. Atoms in molecular compounds can also have oxidation numbers, although they do not have charges.

- Rules:**
The oxidation number of:
Example:
- an element in the uncombined state is 0.
 - a monatomic ion equals the charge on the ion.
 - hydrogen is generally +1; in hydrides, -1.
 - oxygen is generally -2; in peroxides, -1.
 - elements other than oxygen and hydrogen in a neutral compound is such that the sum of the oxidation numbers for all atoms in the compound is 0.
 - elements other than oxygen and hydrogen in a polyatomic ion is such that the sum of the oxidation numbers for all atoms in the ion equals the charge on the ion.

Practice:
Determine the oxidation number of the underlined element. Answers are given below:

1. Ba <u>l</u>	2. B <u>s</u>	3. H <u>I</u>	4. O <u>2</u>
5. Ag <u>H</u>	6. Cu <u>Cl</u>	7. H <u>N</u> O	8. C <u>O</u>
9. S <u>O</u>	10. Na <u>S</u> O	11. Ba <u>Cr</u> O	12. C <u>S</u> O
1. +2	2. 0	3. +1	4. -1
5. -1	6. +2	7. +5	8. +5
9. +6	10. +4	11. +6	12. +6

Regents Review Redox Worksheet Mr. Beauchamp

1. What is the oxidized number of chlorine in the chlorate ion, ClO_3^- ?

A. +8
B. +2
C. +1
D. +6

2. What is the oxidation number assigned to oxygen in KMnO_4 ?

A. +1
B. +2
C. +3
D. +4

3. Which change occurs when Fe^{3+} is reduced?

A. The Fe^{3+} gains electrons and its oxidation number increases.
B. The Fe^{3+} gains electrons and its oxidation number decreases.
C. The Fe^{3+} loses electrons and its oxidation number increases.
D. The Fe^{3+} loses electrons and its oxidation number decreases.

4. Given the balanced ionic equation representing a reaction:

$$2\text{Al}^{3+}(\text{aq}) + 3\text{Mg}(\text{s}) \rightarrow 3\text{Mg}^{2+}(\text{aq}) + 2\text{Al}(\text{s})$$

In this reaction, electrons are transferred from:

A. Al to Mg^{2+}
B. Al^{3+} to Mg
C. Mg to Al
D. Mg^{2+} to Al

5. Half-reactions can be written for systems all:

A. electro-lytic cells
B. neutralization reactions
C. redox and non-redox
D. oxidation and reduction reactions

6. In an oxidation-reduction reaction, reduction is defined as the:

A. loss of protons
B. gain of protons
C. loss of electrons
D. gain of electrons

7. In which reaction are electrons transferred from one reactant to another reactant?

A. $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$
B. $\text{AgNO}_3(\text{aq}) + \text{KCl}(\text{aq}) \rightarrow \text{AgCl}(\text{s}) + \text{KNO}_3(\text{aq})$
C. $\text{HCl}(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow \text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
D. $\text{H}_2\text{O}_2(\text{aq}) + \text{H}^+(\text{aq}) \rightarrow 2\text{H}_2\text{O}(\text{l})$

8. Which balanced equation represents a redox reaction?

A. $\text{AgNO}_3 + \text{NaCl} \rightarrow \text{AgCl} + \text{NaNO}_3$
B. $\text{KCl} + \text{H}_2\text{CO}_3 \rightarrow \text{KHCO}_3 + \text{HCl}$
C. $\text{CaO} + \text{CO}_2 \rightarrow \text{CaCO}_3$
D. $\text{HCl} + \text{KOH} \rightarrow \text{KCl} + \text{H}_2\text{O}$

9. Which metal reacts spontaneously with a solution containing zinc ions?

A. magnesium
B. nickel
C. copper
D. silver

10. Which reaction is an example of an oxidation-reduction reaction?

A. $\text{AgNO}_3 + \text{KCl} \rightarrow \text{AgCl} + \text{KNO}_3$
B. $\text{Cu} + 2\text{AgNO}_3 \rightarrow \text{Cu(NO}_3)_2 + 2\text{Ag}$
C. $2\text{KOH} + \text{H}_2\text{SO}_4 \rightarrow \text{K}_2\text{SO}_4 + 2\text{H}_2\text{O}$
D. $\text{BaCO}_3 + 2\text{HCl} \rightarrow \text{BaCl}_2 + 2\text{H}_2\text{CO}_3$

11. Given the reaction:

$$2\text{Al}(\text{s}) + \text{Fe}_2\text{O}_3(\text{s}) \xrightarrow{\text{heat}} \text{Al}_2\text{O}_3(\text{s}) + 2\text{Fe}(\text{s})$$

Which species undergo reduction?

A. Al
B. Fe
C. Al^{3+}
D. Fe^{3+}

12. According to Reference Table J, which of these metals will react most readily with 1.0 M HCl to produce H_2 gas?

A. Cu
B. K
C. Mg
D. Zn

13. Given the balanced equation representing a redox reaction:

$$2\text{Al} + 3\text{Cu}^{2+} \rightarrow 2\text{Al}^{3+} + 3\text{Cu}$$

Which statement is true about this reaction?

A. Half Al loses $2e^-$ and each Cu^{2+} gains $2e^-$.
B. Half Al loses $3e^-$ and each Cu^{2+} gains $2e^-$.
C. Each Al³⁺ gains $2e^-$ and each Cu loses $3e^-$.
D. Each Al³⁺ gains $3e^-$ and each Cu loses $2e^-$.

14. Given the redox reaction:

$$\text{Cu}^{2+} + \text{Al} \rightarrow \text{Cu} + \text{Al}^{3+}$$

In the reaction take place, there is a transfer of:

A. electrons from Al to Cu^{2+}
B. electrons from Cu^{2+} to Al
C. protons from Al to Cu^{2+}
D. protons from Cu^{2+} to Al

15. Which half-reaction correctly represents reduction?

A. $\text{Ag} \rightarrow \text{Ag}^+ + e^-$
B. $\text{Fe} \rightarrow 2\text{Fe}^{2+} + 2e^-$
C. $\text{Ni}^{2+} + e^- \rightarrow \text{Ni}$
D. $\text{Zn}^{2+} + e^- \rightarrow \text{Zn}$

16. Which equation shows conservation of both mass and charge?

A. $\text{Cl}_2 + \text{Br}^- \rightarrow 2\text{Cl}^- + \text{Br}_2$
B. $\text{Cu} + 2\text{Ag}^+ \rightarrow 2\text{Cu}^{2+} + \text{Ag}$
C. $2\text{A} + \text{O}_2 \rightarrow 2\text{A}^{2+} + \text{O}_2$
D. $\text{Fe} + 19\text{H}^+ \rightarrow \text{Fe}^{2+} + \text{H}_2$

17. Which half-reaction can occur at the anode in a voltaic cell?

A. $\text{Zn}^{2+} + 2e^- \rightarrow \text{Zn}$
B. $\text{Cu} + 2\text{e}^- \rightarrow \text{Cu}^{2+}$
C. $\text{Zn} \rightarrow \text{Zn}^{2+} + 2e^-$
D. $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + e^-$

Name: _____

Worksheet – ASSIGNING OXIDATION NUMBERS

Oxidation Number Rules:

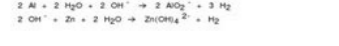
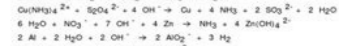
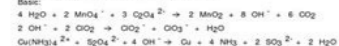
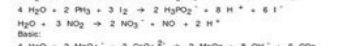
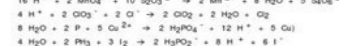
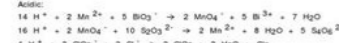
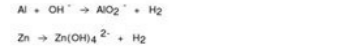
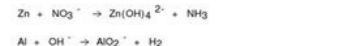
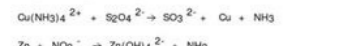
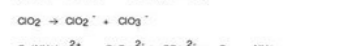
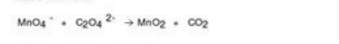
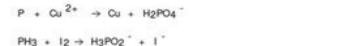
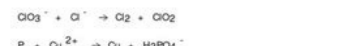
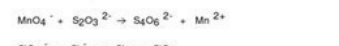
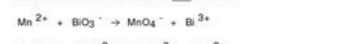
- The oxidation number of any pure element is 0.
- The oxidation number of a monatomic ion equals that charge on the ion.
- The more electronegative element in a binary compound is assigned the number equal to the charge it would have if it were an ion.
- The oxidation number of fluorine in a compound is always -1.
- Oxygen has an oxidation number of -2 unless it is combined with F, in which it is +1 or +2, or it is in peroxide (such as H_2O_2 or Na_2O_2), in which it is -1.
- Hydrogen is +1, unless combined with a metal, and then it is -1.
- In compounds, Group 1 is +1, Group 2 is +2, and Aluminum is +3.
- The sum of the oxidation numbers of all atoms in a neutral compound is 0.
- The sum of the oxidation numbers in a polyatomic ion equals the charge of the ion.

Part A: In the following questions, give the oxidation number of the indicated atoms/ion:

- | | |
|---|--|
| 1. N in N_2O_5 _____ | 16. C in CH_4 _____ |
| 2. S in H_2SO_4 _____ | 17. Mn in MnO_2 _____ |
| 3. C _____ | 18. S in SO_3^{2-} _____ |
| 4. C in CO _____ | 19. Mg^{2+} _____ |
| 5. Na in NaCl _____ | 20. Cl ⁻ _____ |
| 6. H in H_2O _____ | 21. O_2 _____ |
| 7. Ba in BaCl ₂ _____ | 22. P ₄ _____ |
| 8. N in NO_2^- _____ | 23. Na in Na_2S _____ |
| 9. S in Al_2S_3 _____ | 24. S in H_2S _____ |
| 10. S in HSO_4^- _____ | 25. Ca^{2+} _____ |
| 11. Cl in $\text{Fe}(\text{ClO}_2)_3$ _____ | 26. C in CN^- _____ |
| 12. Fe in $\text{Fe}(\text{ClO}_2)_3$ _____ | 27. H in OH^- _____ |
| 13. N in NO_2^- _____ | 28. Mn in KMnO_4 _____ |
| 14. Cu^{2+} _____ | 29. I in $\text{Mg}(\text{IO}_3)_2$ _____ |
| 15. Zn^{2+} _____ | 30. C in $\text{C}_2\text{O}_4^{2-}$ _____ |

Balancing Redox Reactions Worksheet 1

Balance each redox reaction in acid solution.



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