Student Worksheet for Chemical Redox Reactions

Attempt to work the following practice problems after working through the sample problems in the videos. Answers are given on the last page(s).

Rules for Oxidation Numbers:

1. Oxygen always has an oxidation number of -2, except in peroxides

Then, it has an oxidation number of -1.

2. Hydrogen always has an oxidation number of +1, except when bonded to other elements in Column 1.

Then, it assumes a -1 charge.

3. Most atoms obtain their octet charge based on electrons gained or lost.

4. When the oxidation number is unknown, the formula:

$$X + Known\ Oxidation\ Numbers\ = Charge\ on\ Molecule$$

can be used, where X is the atom(s) that you are solving for oxidation.

Steps in Redox Equations:

1. Separate the half reactions.

2. Add e's to balance the half reactions.

3. Note: Sometimes it is easier to proceed the same as acidic conditions, as long as the H^+ cancel each other out.

In acidic solutions:

a. Add H_2O to balance the Oxygen.

b. Add H^+ to balance the Hydrogen.

In basic solutions:

a. Add ^-OH to both sides of the equation to balance the proton (H^+) charge.
b. Combine H^+ and ^-OH on the reactant side to form H_2O.

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1. Assign oxidation numbers to each of the elements in $C_6H_{12}O_6$.

C: ___________________________

H: ____________________________

O: ____________________________

2. Assign oxidation numbers to each of the elements in $K_2Cr_2O_7$.

Cr: ____________________________

K: ____________________________

O: ____________________________

3. In the following synthesis reaction, annotate the atomic change in oxidation between reactants and products.

$$6\ CO_2 + 6\ H_2O \longrightarrow C_6H_{12}O_6 + 6\ O_2$$

4. In the following chemical displacement reaction, annotate the atomic change in oxidation between reactants and products.

$$2\ NaOH + H_2SO_4 \longrightarrow 2\ H_2O + SO_4^{2-} + 2\ Na^+$$

5. What is the difference, and how do you determine which reagent is the oxidizing reagent and which is the reducing agent?

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6. In the following displacement reaction, identify which is the oxidizing reagent and which is the reducing agent.

$NaH + CO_2H \longrightarrow H_2 + CO_2^- + Na^+$

7. In the following decomposition reaction, identify which is the oxidizing reagent and which is the reducing agent.

$H_2O_2 + K_2MnO_4 \longrightarrow 2\ KOH + O_2 + MnO_2$

8. Identify the half reactions in the following decomposition reaction:

$Cu_2O_3 + 3CO \longrightarrow 2Cu^{3+} + 3\ CO_2$

9. Identify the half reactions in the following decomposition reaction in acidic conditions:

$K_2Cr_2O_7 + I^- \longrightarrow 2\ Cr^{3+} + I_2 + 7\ H_2O$

10. Complete the redox reaction steps for the following reaction in a neutral solution.

$Zn + Cu^{3+} \longrightarrow Zn^{2+} + Cu$

11. Complete the redox reaction steps for the following reaction in a neutral solution.

$CH_4 + CO_2 \longrightarrow CO + H_2O$

12. Complete the redox reaction steps for the following reaction in an acidic solution.

$MnO_4^- + Br^- \longrightarrow Mn^{2+} + Br_2$

13. Complete the redox reaction steps for the following reaction in an acidic solution.

$Cr_2O_7^{2-} + NaCl \longrightarrow Cr^{3+} + Cl_2 + Na^+$

14. Complete the redox reaction steps for the following reaction in a basic solution.

15. Complete the redox reaction steps for the following reaction in a basic solution.

$Pb + ClO_2^- \longrightarrow PbO + Cl_2$

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16. Show the redox steps for the following combustion/synthesis reaction.

$N_2 + O_2 \longrightarrow N_2O$

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X +1 -2

1. Assign oxidation numbers to each of the elements in $C_6H_{12}O_6$.

C: _____0_________________

Using #4 from Page 1, C is unknown, but $C_6H_{12}O_6$ is neutral.

6X + 12(+1) + 6(-2)= 0. Solve for X.

6X + 12 – 12= 0

H: ____+1___________________

6X = 0

X= 0

O: ____-2___________________

+1 X -2

2. Assign oxidation numbers to each of the elements in $K_2Cr_2O_7$.

Cr: ____+6___________________

Same approach as before.

2X + 2(+1) + 7(-2) = 0

K: _____+1__________________

2X +2 -14 = 0

2X + 2 = 14

2X = 12

O: _____-2___________________

X = +6

3. In the following synthesis reaction, annotate the atomic change in oxidation between reactants and products.

O changes from -2 to 0 = oxidation

+4 -4 =0 +2-2=0 0 +12-12=0

C changes from +4 to 0 = reduction

+4 -2 +1-2 0 +1 -2 0

$6\ CO_2 + 6\ H_2O \longrightarrow C_6H_{12}O_6 + 6\ O_2$

H does not change

4. In the following chemical displacement reaction, annotate the atomic change in oxidation between reactants and products.

+2+6 -8 = 0 +2-2=0 6-8=-2 +1

+1 -2 +1 +1+6-2 +1 -2 +6-2 +1

$2\ NaOH + H_2SO_4 \longrightarrow 2\ H_2O + SO_4^{2-} + 2\ Na^+$

5. What is the difference, and how do you determine which reagent is the oxidizing reagent and which is the reducing agent?

After assigning oxidation numbers to each of the compounds, the compound with the atom that gets reduced is the oxidizing agent. This happens because electrons are transferred between reactants. Hence, when an atom gets reduced (accepts an electron), it oxidizes the other reactant.

Likewise, the reactant that gets oxidized is the reducing agent because by giving up its electron, the other reagent is able to be reduced.

6. In the following displacement reaction, identify which is the oxidizing reagent and which is the reducing agent.

$NaH + CO_2H \longrightarrow H_2 + CO_2^- + Na^+$

The Na does not change charge, but the H changes from -1 to 0 (oxidation) making it the reducing reagent and CO_2H the oxidizing reagent.

7. In the following decomposition reaction, identify which is the oxidizing reagent and which is the reducing agent.

$H_2O_2 + K_2MnO_4 \longrightarrow 2\ KOH + O_2 + MnO_2$

The O of the peroxide changes from -1 to 0 (oxidation) making it the reducing reagent. The Mn changes from +6 to +4 (reduction) making it the oxidizing reagent.

8. Identify the half reactions in the following decomposition reaction:

$Cu_2O_3 + 3CO \longrightarrow 2Cu^{3+} + 3\ CO_2$

$Cu_2O_3 \longrightarrow 2\ Cu^{3+}$

$3\ CO \longrightarrow 3\ CO_2$

9. Identify the half reactions in the following decomposition reaction in acidic conditions:

$K_2Cr_2O_7 + I^- \longrightarrow 2\ Cr^{3+} + I_2 + 7\ H_2O$

$K_2Cr_2O_7 \longrightarrow 2\ Cr^{3+}$

$I^- \longrightarrow I_2$

10. Complete the redox reaction steps for the following reaction in a neutral solution.

$Zn + Cu^{3+} \longrightarrow Zn^{2+} + Cu$

$Zn \longrightarrow Zn^{2+} + 2$ e's

$3\ Zn \longrightarrow 3\ Zn^{2+} + 6$ e's

$Cu^{3+} + 3$e's $\longrightarrow Cu$

$2\ Cu^{3+} + 6$ e's $\longrightarrow 2\ Cu$

$\boxed{3\ Zn + 2\ Cu^{3+} \longrightarrow 3\ Zn^{2+} + 2\ Cu}$

11. Complete the redox reaction steps for the following reaction in a neutral solution.

$CH_4 + CO_2 \longrightarrow CO + H_2O$

$CH_4 \longrightarrow CO$

$CH_4 + H_2O \longrightarrow CO + 6\ H^+ + 6$ e's

$CO_2 \longrightarrow CO$

$CO_2 + 2H^+ + 2$ e's $\longrightarrow CO + H_2O$

$3CO_2 + 6H^+ + 6$ e's $\longrightarrow 3\ CO + 3\ H_2O$

$\boxed{CH_4 + 3\ CO_2 \longrightarrow 4\ CO + 2\ H_2O}$

12. Complete the redox reaction steps for the following reaction in an acidic solution.

$MnO_4^- + Br^- \longrightarrow Mn^{2+} + Br_2$

$MnO_4^- \longrightarrow Mn^{2+}$

$MnO_4^- \longrightarrow Mn^{2+} + 4\ H_2O$

$8H^+ + 5$ e's $+ MnO_4^- \longrightarrow Mn^{2+} + 4\ H_2O$

$16H^+ + 10$e's $+ 2\ MnO_4^- \longrightarrow 2\ Mn^{2+} + 8\ H_2O$

$Br^- \longrightarrow Br_2$

$2\ Br^- \longrightarrow Br_2 + 2$ e's

$10\ Br^- \longrightarrow 5\ Br_2 + 10$ e's

$\boxed{16\ H^+ + 2\ MnO_4^- + 10\ Br^- \longrightarrow 5\ Br_2 + 2\ Mn^{2+} + 8\ H_2O}$

13. Complete the redox reaction steps for the following reaction in an acidic solution.

$Cr_2O_7^{2-} + NaCl \longrightarrow Cr^{3+} + Cl_2 + Na^+$

$Cr_2O_7^{2-} \longrightarrow 2\ Cr^{3+}$

$Cr_2O_7^{2-} \longrightarrow 2Cr^{3+} + 7\ H_2O$

$14\ H^+ + 6$ e's $+ Cr_2O_7^{2-} \longrightarrow 2\ Cr^{3+} + 7\ H_2O$

$2\ NaCl \longrightarrow Cl_2$

$2\ Cl^- \longrightarrow Cl_2 + 2$ e's

$6\ Cl^- \longrightarrow 3\ Cl_2 + 6$ e's

$\boxed{14\ H^+ + Cr_2O_7^{2-} + 6\ Cl^- \longrightarrow 2\ Cr^{3+} + 7\ H_2O + 3\ Cl_2}$

14. Complete the redox reaction steps for the following reaction in a basic solution.

$ClO_4 + 2\ N_2O \longrightarrow Cl^- + 2\ N_2O_3$

$ClO_4^- \longrightarrow Cl^-$

$ClO_4^- \longrightarrow Cl^- + 4\ H_2O$

$8\ H^+ + 8$ e's $+ ClO_4^- \longrightarrow Cl^- + 4\ H_2O$

$2\ N_2O \longrightarrow 2\ N_2O_3$

$2\ N_2O + 4\ H_2O \longrightarrow 2\ N_2O_3$

$2\ N_2O + 4\ H_2O \longrightarrow 2\ N_2O_3 + 8\ H^+ + 8$e's

$\boxed{ClO_4^- + 2\ N_2O \longrightarrow Cl^- + 2\ N_2O_3}$

15. Complete the redox reaction steps for the following reaction in a basic solution.

$Pb + ClO_2^- \longrightarrow PbO + Cl_2$

$Pb \longrightarrow PbO$

$ClO_2^- \longrightarrow Cl_2$

$Pb + H_2O \longrightarrow PbO + 2\ H^+ + 2e's$

$2\ ClO_2^- \longrightarrow Cl_2 + 4\ H_2O$

$8\ H^+ + 6\ e's + 2\ ClO_2^- \longrightarrow Cl_2 + 4\ H_2O$

$3\ Pb + 3\ H_2O \longrightarrow 3\ PbO + 6\ H^+ + 6\ e's$

$2\ ClO_2^- + 6\ e's + 8\ H^+ \longrightarrow Cl_2 + 4\ H_2O$

$3\ Pb + 2\ ClO_2^- + 2\ H^+ \longrightarrow 3\ PbO + Cl_2 + H_2O$

Add 2 ^-OH to **both** sides, and combine the H^+ and ^-OH to make water. Then, cancel terms on both sides of the reaction arrow again.

$3\ Pb + 2\ ClO_2^- + 2\ H_2O \longrightarrow 3\ PbO + Cl_2 + H_2O + 2\ ^-OH$

$\boxed{3\ Pb + 2\ ClO_2^- + H_2O \longrightarrow 3\ PbO + Cl_2 + 2\ ^-OH}$

16. Show the redox steps for the following combustion/synthesis reaction.

$N_2 + O_2 \longrightarrow N_2O$

The first thing to note with combustion reactions is that the half reactions are split per atom and e's assigned based on the change of oxidation state of the atom (see after the solution). Reviewing the rules on Page 1 and the reaction given, you will note the following oxidations:

0 +1

$N_2 \longrightarrow N_2O$

$N_2 \longrightarrow 2\ N^+ + e'$

$2\ N_2 \longrightarrow 4\ N^+ + 2\ e's$

0 -2

$O_2 \longrightarrow N_2O$

$O_2 + 2\ e' \longrightarrow 2\ O^{2-}$

$2\ N_2 + O_2 + 2\ e's \longrightarrow 4\ N^+ + 2\ O^{2-} + 2\ e's$

$\boxed{2\ N_2 + O_2 \longrightarrow 2\ N_2O}$

The reason that combustion reactions use the change in oxidation per atom is because you could have used the total electrons, but it simplifies to the same. In this example, N going changing from a 0 oxidation to 2 +1 oxidation numbers, gives you a total of 2. Likewise, O changing from 0 oxidation to 2 -2 oxidation numbers, gives you a total of 4. The 2:4 ratio explained here is the same as the 1:2 simplified ratio used to solve the problem. Thus, if you proceed with the 2:4, you will reach the same answer after simplification.