Dougherty Valley HS Chemistry
Redox – Oxidation Numbers

Worksheet #1

Name: **Period:** **Seat#:**

Directions: Use the rules for Assigning Oxidation numbers to determine the oxidation number assigned to each element in each of the given formulas. The rules are at the bottom of the page.

Q #	Formula	Oxidation #'s	
1)	**Cl_2**	Cl	
2)	**Cl^-**	Cl	
3)	**Na**	Na	
4)	**Na^+**	Na	
5)	**KCl**	K	Cl
6)	**H_2S**	H	S
7)	**CaO**	Ca	O
8)	**H_2O**	H	O
9)	**NO_3^-**	N	O
10)	**NO_2**	N	O
11)	**$Cr_2O_7^{2-}$**	Cr	O
12)	**O_2**	O	
13)	**NH_3**	N	H
14)	**CaH_2**	Ca	H
15)	**SO_4^{2-}**	S	O

Q #	Formula	Oxidation #'s		
16)	**Na_2O**	Na	O	
17)	**HNO_3**	H	N	O
18)	**$CaCl_2$**	Ca	Cl	
19)	**PO_4^{3-}**	P	O	
20)	**MnO_2**	Mn	O	
21)	**K_3PO_4**	K	P	O
22)	**Fe_2O_3**	Fe	O	
23)	**KNO_2**	K	N	O
24)	**N_2**	N		
25)	**Al^{3+}**	Al		
26)	**H_2O_2**	H	O	
27)	**H_2SO_4**	H	S	O
28)	**NH_4Cl**	N	H	Cl
29)	**FeO**	Fe	O	
30)	**SiO_2**	Si	O	

Rules for Assigning Oxidation Numbers

1. The oxidation number of any uncombined element is 0.
2. The oxidation number of a monatomic ion equals the charge on the ion.
3. The more-electronegative element in a binary compound is assigned the number equal to the charge it would have if it were an ion.
4. The oxidation number of fluorine in a compound is always -1
5. Oxygen has an oxidation number of -2 unless it is combined with F, when it is +2, or it is in a peroxide, such as H_2O_2, when it is -1
6. The oxidation state of H in most of its compounds is +1 unless it is combined with a metal, in which case it is -1
7. In compounds, the elements of groups 1 and 2 as well as aluminum have oxidation numbers +1, +2 and +3 respectively.
8. The sum of the oxidation numbers of all atoms in a neutral compound is 0.
9. The sum of the oxidation numbers of all atoms in a polyatomic ion equals charge of the ion.

Dougherty Valley HS Chemistry
Redox – Writing Half Reactions

Worksheet #2

Name: **Period:** **Seat#:**

Directions: In the left hand column, identify the oxidation states of the elements undergoing reduction/oxidation. In the right hand column balance the half reactions.

Rules:

1. Find oxidation #'s
2. Determine which elements are reduced/oxidized
3. Write each half reaction separately
4. Balance "unique" atoms (everything except oxygens and hyrdrogens)
5. Add H_2O's to balance any oxygens
6. Add H^+'s to balance any hydrogens
7. Add e^-'s to balance the charge

1) $Li + F_2 \rightarrow 2F^- + Li^+$	Balance Oxidation Half Reaction
	Balance Reduction Half Reaction
2) $Pb^{2+} + Mn^{2+} \rightarrow MnO_2 + Pb$	Balance Oxidation Half Reaction
	Balance Reduction Half Reaction
3) $Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$	Balance Oxidation Half Reaction
	Balance Reduction Half Reaction
4) $Mg + NO_3^- \rightarrow Mg^{2+} + NO$	Balance Oxidation Half Reaction
	Balance Reduction Half Reaction

5) $MnO_4^- + Pb \rightarrow Pb^{2+} + Mn^{2+}$	Balance Oxidation Half Reaction
	Balance Reduction Half Reaction
6) $Fe_2O_3(s) + 2Al(s) \rightarrow 2Fe(l) + Al_2O_3(s)$	Balance Oxidation Half Reaction
	Balance Reduction Half Reaction
7) $2Ag + Ce^{4+} \rightarrow Ag_2O_2 + Ce^{3+}$	Balance Oxidation Half Reaction
	Balance Reduction Half Reaction
8) $PbO_2 + Ag \rightarrow Ag^+ + Pb^{2+}$	Balance Oxidation Half Reaction
	Balance Reduction Half Reaction
9) $Hg_2^{2+} + Cu \rightarrow Cu^{2+} + 2Hg$	Balance Oxidation Half Reaction
	Balance Reduction Half Reaction

Dougherty Valley HS Chemistry
Redox – More Oxidation Numbers

Worksheet #3

Name: **Period:** **Seat#:**

Directions: In each of the following chemical compounds, determine the oxidation states of each element.

Q#	Name	Formula	Oxidation State for Each Element
1)	Sodium nitrate		
2)	Ammonia		
3)	Zinc oxide		
4)	Water		
5)	Calcium hydride		
6)	Carbon dioxide		
7)	Nitrogen		
8)	Sodium sulfate		
9)	Aluminum hydroxide		
10)	Magnesium phosphate		

Directions: In each of the following, determine what was oxidized and what was reduced.

Q#	Reaction	Element Oxidized	Element Reduced
11)	$Ca + H_2O \rightarrow CaO + H_2$		
12)	$2\ H_2 + O_2 \rightarrow 2\ H_2O$		

Worksheet #4

Name: **Period:** **Seat#:**

Directions: Answer the questions below. Remember that individual elements are oxidized/reduced, but the reactant molecule as a whole is the "oxidizing agent" or the "reducing agent."

1) What is at least one mnemonic (or other memory device) you can use to help you with Redox topics?

2) Consider the following redox reaction: $KMnO_4(aq) + NO(g) \rightarrow MnO_2(s) + KNO_3(aq)$

a. Give the ***oxidation number*** for each element in the compounds below:

$KMnO_4$: K =_______, Mn=_______, O =_______ **MnO_2:** Mn=_______, O =_______

NO : N=_______, O =_______ **KNO_3**: K=_______, N = _______, O = _______

b. The element oxidized is________________, and the oxidizing agent is______________.

The element reduced is________________, and the reducing agent is______________.

c. The total number of electrons transferred in this reaction is__________.

3) Consider the following redox reaction: $Fe_2O_3(s) + 3\ CO\ (g) \rightarrow 2\ Fe\ (s) + 3\ CO_2(g)$

a. Give the ***oxidation number*** for each element in the compounds below:

Fe_2O_3: Fe = _______, O =_______ **Fe**: Fe = _______

CO: C = _______, O =_______ **CO_2**: C = _______, O =_______

b. The element oxidized is________________, and the oxidizing agent is______________.

The element reduced is________________, and the reducing agent is______________.

c. The total number of electrons transferred in this reaction is__________.

4) Consider the following : $H_2SO_3(aq) + 2\ Mn(s) + 4HCl(aq) \rightarrow S(s) + 2\ MnCl_2(aq) + 3\ H_2O(l)$

a. Give the ***oxidation number*** for each element in the compounds below:

H_2SO_3: H = _______, S = _______, O =_______ **S**: S = _______

Mn: Mn = _______ **$MnCl_2$**: Mn = _______, Cl =_______

HCl: H = _______, Cl =_______ **H_2O**: H = _______, O =_______

b. The element oxidized is_______________, and the oxidizing agent is_______________.

The element reduced is_____________, and the reducing agent is_______________.

c. The total number of electrons transferred in this reaction is__________.

5) Consider the following reaction: $\mathbf{Pb}(s) + \mathbf{PbO_2}(s) + \mathbf{H_2SO_4}(aq) \rightarrow \mathbf{2\ PbSO_4}(s) + \mathbf{2\ H_2O}(l)$

a. Give the ***oxidation number*** for each element in the compounds below:

Pb: Pb = _______

PbSO$_4$: Pb = _______, S =_______, O =_______

PbO$_2$: Pb = _______ , O = _______

H$_2$O: H = _______, O =_______

H$_2$SO$_4$: H = _______, S =_______, O =_______

b. The element oxidized is________________, and the oxidizing agent is_______________.

The element reduced is_______________, and the reducing agent is_______________.

c. The total number of electrons transferred in this reaction is___________.

6) Consider the following reaction: $\mathbf{2\ H_2O_2}(aq) \rightarrow \mathbf{2\ H_2O}(l) + \mathbf{O_2}(aq)$

a. Give the ***oxidation number*** for each element in the compounds below:

H$_2$O$_2$: H = _______, O = _______

H$_2$O: H = _______, O =_______

O$_2$: O =_______

b. The element oxidized is________________, and the oxidizing agent is_______________.

The element reduced is________________, and the reducing agent is_______________.

c. The total number of electrons transferred in this reaction is___________.

7) Consider the following reaction: $\mathbf{3\ HNO_2}(aq) \rightarrow \mathbf{H_2O}(l) + \mathbf{HNO_3}(aq) + \mathbf{2NO}(g)$

a. Give the ***oxidation number*** for each element in the compounds below:

HNO$_2$: H = _______, N = _______, O = _______

H$_2$O: H = _______, O =_______

HNO$_3$: H = _______, N = _______, O = _______

NO: N = _______, O = _______

b. The element oxidized is________________, and the oxidizing agent is_______________.

The element reduced is________________, and the reducing agent is_______________.

c. The total number of electrons transferred in this reaction is___________.

8) Consider the following reaction: $\mathbf{Zn + 2MnO_2 + 2NH_4Cl \rightarrow ZnCl_2 + Mn_2O_3 + 2NH_3 + H_2O}$

a. The element oxidized is________________, and the oxidizing agent is_______________.

The element reduced is________________, and the reducing agent is_______________.

b. The total number of electrons transferred in this reaction is___________.

Dougherty Valley HS Chemistry
Redox – Oxidation and Reduction Practice

Worksheet #5

Name: **Period:** **Seat#:**

Directions: In each of the following equations, indicate the element that has been oxidized and the one that has been reduced. You should also label the oxidation state of each before and after the process. Also identify the oxidizing and reducing agent.

1)	$2\ Na + FeCl_2 \rightarrow 2\ NaCl + Fe$
2)	$2\ C_2H_2 + 5\ O_2 \rightarrow 4\ CO_2 + 2\ H_2O$
3)	$2\ PbS + 3\ O_2 \rightarrow 2\ SO_2 + 2\ PbO$
4)	$2\ H_2 + O_2 \rightarrow 2\ H_2O$
5)	$Cu + HNO_3 \rightarrow CuNO_3 + H_2$
6)	$AgNO_3 + Cu \rightarrow CuNO_3 + Ag$

Dougherty Valley HS Chemistry
Redox – Balancing Redox Rxns in Acidic and Basic Solutions

Worksheet #6

Name: **Period:** **Seat#:**

For Half-Reactions in Acidic Solution

Step One: Balance the atom being reduced/oxidized.
In our example, there is already one Mn on each side of the arrow, so this step is already done.

$$MnO_4^{1-} \rightarrow Mn^{2+}$$

Step Two: Balance the oxygen's.
Do this by adding water molecules (as many as are needed) to the side needing oxygen. In our case, the left side has 4 oxygen's, while the right side has none, so:

$$MnO_4^{1-} \rightarrow Mn^{2+} + 4H_2O$$

Notice that, when the water is added, hydrogen's also come along. There is nothing that can be done about this; we'll take care of it in the next step. A common question is: "Why can't I just add 4 oxygen atoms to the right side?" Quick answer: don't do it, it's wrong. There are not free oxygen atoms floating around in our reaction vessel. So you can't add them!

Step Three: Balance the hydrogen's.
Do this by adding hydrogen ions (as many as are needed) to the side needing hydrogen. In our example, we need 8 (notice the water molecule's formula, then consider 4 x 2 = 8).

$$8H^{1+} + MnO_4^{1+} \rightarrow Mn^{2+} + 4H_2O$$

Step Four: Balance the total charge.
This will be done using electrons. It is ALWAYS the last step. First, a comment. You do not need to look at the oxidation number for each atom. You only need to look at the charge on the ion or molecule, then sum those up.

Left side of the reaction, total charge is +7. There are 8 H+, giving 8 x +1 = +8 and a minus one from the permanganate. (A very typical wrong answer for the left side is zero. Someone only counted the +1 and the -1, they forget the 8.)
Right side of the reaction, total charge is +2. The water molecule is neutral (zero charge) and the single Mn is +2.

$$5e^- + 8H^{1+} + MnO_4^{1-} \rightarrow Mn^{2+} + 4H_2O$$

Five electrons reduces' the +7 to a +2 and the two sides are EQUAL in total charge.
The half-reaction is now correctly balanced!

For Half-Reactions in Basic Solution

Step One to Four: Balance the half-reaction AS IF it were in acid solution.
Just go about steps 1-4 business as usual! The half-reaction is actually in basic solution, but we are going to start out as if it were in acid solution and then fix it later to account for it being in a basic solution. Here are the 4 acid steps:

1) Balance the atom being reduced/oxidized.
2) Balance the oxygens.
3) Balance the hydrogens.
4) Balance the charge.

Let's use this half reaction for our example. Pretend we just finished steps 1-4: $2e^- + 2H^{1+} + PbO_2 \rightarrow PbO + H_2O$

Step Five: Convert all H^+ to H_2O.
If you are in a basic solution you will not have H^+ floating around. It is combined with the hydroxides that are present from the base! To convert the H+ into water add the same number of OH^- ions as you have H^+ ions, BUT you have to add them to <u>both</u> sides to preserve the balancing! The side with the H+ will determine how many hydroxide to add. In our case, the left side has 2 hydrogen ions, while the right side has none, so:

$$2e^- + 2H_2O + PbO_2 \rightarrow PbO + H_2O + 2OH^-$$

Notice that, when the two hydroxide ions on the left were added, they immediately reacted with the hydrogen ion present. The reaction is: $H^+ + OH^- \rightarrow H_2O$

Step Six: Remove any duplicate molecules or ions.
In our example, there are two water molecules on the left and one on the right. This means one water molecule may be removed from each side, giving:

$$2e^- + H_2O + PbO_2 \rightarrow PbO + 2OH^-$$

The half-reaction is now correctly balanced!

By the way, notice the $2OH^-$. Be careful to read that as two hydroxide ions ($2\ OH^-$) and NOT twenty hydride ions ($2O\ H^{1-}$). People have been known to do that.

Dougherty Valley HS Chemistry
Redox – Balancing Redox Rxns in Acidic and Basic Solutions

Directions: In each of the following equations do the following on binder paper:

- Balance the reaction in the type of solution indicated.
- If you need/want some extra practice:
  - Indicate the element that has been oxidized and the one that has been reduced.
  - Label the oxidation state of each before and after the process.
  - Some answers have been provided in italics to the side.

Reaction done in Acidic Solution

1) $Re \rightarrow ReO_2$ *($2H_2O + Re \rightarrow ReO_2 + 4H^+ + 4e^-$)*
2) $Cl_2 \rightarrow HClO$ *($2H_2O + Cl_2 \rightarrow 2HClO + 2H^+ + 2e^-$)*
3) $NO_3^- \rightarrow HNO_2$ *($2e^- + 3H^+ + NO_3^- \rightarrow HNO_2 + H_2O$)*
4) $H_2GeO_3 \rightarrow Ge$ *($4e^- + 4H^+ + H_2GeO_3 \rightarrow Ge + 3H_2O$)*
5) $H_2SeO_3 \rightarrow SeO_4^{2-}$
6) $Au \rightarrow Au(OH)_3$
7) $H_3AsO_4 \rightarrow AsH_3$
8) $H_2MoO_4 \rightarrow Mo$
9) $NO \rightarrow NO_3^-$

Reaction done in Basic Solution

10) $NiO_2 \rightarrow Ni(OH)_2$ *($2e^- + 2H_2O + NiO_2 \rightarrow Ni(OH)_2 + 2OH^-$)*
11) $BrO_4^- \rightarrow Br^-$ *($8e^- + 4H_2O + BrO_4^- \rightarrow Br^- + 8OH^-$)*
12) $SbO_3^- \rightarrow SbO_2^-$ *($2e^- + H_2O + SbO_3^- \rightarrow SbO_2^- + 2OH^-$)*
13) $Cu_2O \rightarrow Cu$ *($2e^- + H_2O + Cu_2O \rightarrow 2Cu + 2OH^-$)*
14) $S_2O_3^{2-} \rightarrow SO_3^{2-}$
15) $Tl^+ \rightarrow Tl_2O_3$
16) $Al \rightarrow AlO_2^-$
17) $Sn \rightarrow HSnO_2^-$
18) $CrO_4^{2-} \rightarrow Cr(OH)_3$

Dougherty Valley HS Chemistry
Redox – Extra Practice

Worksheet #7*

Name: **Period:** **Seat#:**

Directions: Any worksheet that is labeled with an * means it is suggested extra practice. We do not always have time to assign every possible worksheet that would be good practice for you to do. You can do this worksheet when you have extra time, when you finish something early, or to help you study for a quiz or a test. If and when you choose to do this Extra Practice worksheet, please do the work on binder paper. You will include this paper stapled into your Rainbow Packet when you turn it in, even if you didn't do any of this. We want to make sure we keep it where it belongs so you can do it later if you want to (or need to). If you did the work on binder paper you can include that in your Rainbow Packet after this worksheet. If we end up with extra class time then portions of this may turn into required work. If that happens you will be told which problems are turned into required. Remember there is tons of other extra practice on the class website…and the entire internet! See me if you need help finding practice on a topic you are struggling with.

Note *Some of these are really nasty...redox equations get awful really fast! Just go slow, use lots of binder paper, show each step, double check your counting, if you get really stuck then erase and start over.*

Balance these reactions. Some are in acidic solution, some are in basic solution. Some answers are provided in italics. I do NOT have a full worked out key for these, or answers to the ones without answers provided.

Acidic Solution

1) $ClO_3^- + SO_2 \rightarrow SO_4^{2-} + Cl^-$

$H_2O + ClO_3^- + 3SO_2 \rightarrow 3SO_4^{2-} + Cl^- + 6H^+$

2) $H_2S + NO_3^- \rightarrow S_8 + NO$

$16H^+ + 24H_2S + 16NO_3^- \rightarrow 3S_8 + 16NO + 32H_2O$

3) $MnO_4^- + H_2S \rightarrow Mn^{2+} + S_8$

$48H^+ + 16MnO_4^- + 40H_2S \rightarrow 16Mn^{2+} + 5S_8 + 64H_2O$

4) $Cu + SO_4^{2-} \rightarrow Cu^{2+} + SO_2$

$4H^+ + Cu + SO_4^{2-} \rightarrow Cu^{2+} + SO_2 + 2H_2O$

5) $MnO_4^- + CH_3OH \rightarrow CH_3COOH + Mn^{2+}$

6) $Cr_2O_7^{2-} + Fe^{2+} \rightarrow Cr^{3+} + Fe^{3+}$

7) $HNO_2 \rightarrow NO + NO_2$

8) $H_2C_2O_4 + MnO_4^- \rightarrow CO_2 + Mn^{2+}$

9) $O_2 + As \rightarrow HAsO_2 + H_2O$

10) $NO_2 \rightarrow NO_3^- + NO$

11) $ClO_4^- + Cl^- \rightarrow ClO^- + Cl_2$

12) $H_5IO_6 + Cr \rightarrow IO_3^- + Cr^{3+}$

13) $Fe + HCl \rightarrow HFeCl_4 + H_2$

14) $NO_3^- + H_2O_2 \rightarrow NO + O_2$

15) $BrO_3^- + Fe^{2+} \rightarrow Br^- + Fe^{3+}$

16) $Cr_2O_7^{2-} + C_2H_4O \rightarrow CH_3COOH + Cr^{3+}$

17) $MnO_4^- + C_2H_4O \rightarrow CH_3COOH + MnO_2$

18) $Zn + NO_3^- \rightarrow NH_4^+ + Zn^{2+}$

19) $HBr + SO_4^{2-} \rightarrow SO_2 + Br_2$

20) $NO_3^- + I_2 \rightarrow IO_3^- + NO_2$

21) $CuS + NO_3^- \rightarrow NO + Cu^{2+} + HSO_4^-$

22) $I^- + ClO^- \rightarrow I_3^- + Cl^-$

23) $As_2O_3 + NO_3^- \rightarrow H_3AsO_4 + NO$

24) $Br^- + MnO_4^- \rightarrow Br_2 + Mn^{2+}$

25) $CH_3OH + Cr_2O_7^{2-} \rightarrow CH_2O + Cr^{3+}$

26) $Mn^{2+} + BiO_3^- \rightarrow Bi^{3+} + MnO_4^-$

27) $S_8 + NO_3- \rightarrow SO_3^{2-} + NO$

28) $H_3AsO_4 + Zn \rightarrow AsH_3 + Zn^{2+}$

29) $P_4 + Cr_2O_7^{2-} \rightarrow H_3PO_4 + Cr^{3+}$

Basic Solution

30) $NH_3 + ClO^- \rightarrow N_2H_4 + Cl^-$

$2NH_3 + ClO^- \rightarrow N_2H_4 + Cl^- + H_2O$

31) $Au + O_2 + CN^- \rightarrow Au(CN)_2^- + H_2O_2$

$2H_2O + 2Au + O_2 + 4CN^- \rightarrow 2Au(CN)_2^- + H_2O_2 + 2OH^-$

32) $AlH_4^- + H_2CO \rightarrow Al^{3+} + CH_3OH$

$4H_2O + AlH_4^- + 4H_2CO \rightarrow Al^{3+} + 4CH_3OH + 4OH^-$

33) $Se + Cr(OH)_3 \rightarrow Cr + SeO_3^{2-}$

$6OH^- + 3Se + 4Cr(OH)_3 \rightarrow 4Cr + 3SeO_3^{2-} + 9H_2O$

34) $Br^- + MnO_4^- \rightarrow MnO_2 + BrO_3^-$

35) $H_2O_2 + Cl_2O_7 \rightarrow ClO_2^- + O_2$

36) $Fe + NiO_2 \rightarrow Fe(OH)_2 + Ni(OH)_2$

37) $MnO_4^- + H_2O_2 \rightarrow MnO_2 + O_2$

38) $Zn + BrO_4^- \rightarrow [Zn(OH)_4]^{2-} + Br^-$

39) $MnO_4^- + S^{2-} \rightarrow MnO_2 + S_8$

40) $Pb(OH)_4^{2-} + ClO^- \rightarrow PbO_2 + Cl^-$

41) $Tl_2O_3 + NH_2OH \rightarrow TlOH + N_2$

42) $Fe(OH)_2 + CrO_4^{2-} \rightarrow Fe_2O_3 + Cr(OH)_4^-$

43) $Br_2 \rightarrow Br^- + BrO_3^-$

44) $ClO_2^- + H_2O \rightarrow ClO_{2-} + OH^-$

45) $Al + MnO_4^- \rightarrow MnO_2 + Al(OH)_4^-$

46) $NO_2^- + Al \rightarrow NH_3 + AlO_2^-$

47) $Cr + CrO_4^{2-} \rightarrow Cr(OH)_3$

Note: $Cr(OH)_3$ is found in BOTH half reactions!

48) $MnO_4^- + S^{2-} \rightarrow MnO_2 + SO_3^{2-}$

49) $Cl_2 + Br_2 \rightarrow OBr^- + Cl^-$

50) $H_2O_2 + I^- \rightarrow IO_3^-$

Note: IO_3^- is found in both half reactions!

51) $NO_3^- + NH_3 \rightarrow NO_2^-$

52) $S_8 + MnO_4^- \rightarrow SO_4^{2-} + MnO_2$