Name ________________________________

Date __________________ Period _____

Competition for Electrons

Aim

- write equations for oxidation and reduction half reactions

Notes

Atoms compete for each other's electrons

★ When chemical bonds form, electrons are either lost, gained or shared

★ Oxidation-Reduction reactions (Redox reactions)

- ✰ Metals
  - ✯ lose electrons (OXIDATION)[*NOTE: as when metals combine with oxygen*]
  - ✯ are oxidized
  - ✯ are reducing agents
- ✰ Nonmetals
  - ✯ gain electrons reducing their oxidation states (REDUCTION)
  - ✯ are reduced
  - ✯ are oxidizing agents

Oxidation **I**s **L**oss

Reduction **I**s **G**ain

★ Example 1 - $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

Mg	O_2
★ loses electrons ★ gets oxidized to Mg^{2+} ★ is the reducing agent for O_2	★ gains electrons ★ gets reduced to O^{2-} ★ is the oxidizing agent for Mg

- ✰ Half reactions — reaction showing either a gain or loss of electrons
  - ✯ $2Mg^0 \rightarrow 2Mg^{2+} + 4e^-$
  - ✯ $O_2^0 + 4e^- \rightarrow 2O^{2-}$
- ✰ Net equation (REDOX REACTION)— combination of the half reactions such that the number of electrons lost equals the number of electrons gained

$$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$$

★ Example 2 - More active metals replace less active metals in compounds by transferring electrons to them

- ✰ Sample Reaction:

$$Zn(s) + Cu(NO_3)_2(aq) \rightarrow Zn(NO_3)_2(aq) + Cu(s)$$

- ✰ Half reactions — reaction showing either a gain or loss of electrons
  - ✯ $Zn^0 \rightarrow Zn^{2+} + 2e^-$
  - ✯ $Cu^{2+} + 2e^- \rightarrow Cu^0$
- ✰ Net equation — combination of the half reactions such that the number of electrons lost equals the number of electrons gained

$$Cu^{2+} + Zn^0 \rightarrow Zn^{2+} + Cu^0$$

- ✰ Spectator ions — ions that are present during a reaction but do not participate in the reaction:

$$2NO_3^-$$

Oxidation number (Oxidation state) - number assigned to keep track of electrons based on the arbitrary assumption that shared electrons belong to the more electronegative element

★ Rules for assigning oxidation numbers

- ✰ Oxidation numbers for atoms that are free elements are always zero
- ✰ The oxidation numbers of ions are the same as the charge on the ion
- ✰ Some elements have only one oxidation state
  - ✯ group 1 metals always form 1+ ions and always have a +1 oxidation state
  - ✯ group 2 metals always form 2+ ions and always have a +2 oxidation state
- ✰ Some elements usually have a particular oxidation state
  - ✯ oxygen has a -2 oxidation state except in peroxides where it is -1 and in compounds with fluorine (OF_2) where it is +2
  - ✯ hydrogen has a +1 oxidation state except in hydrides with group 1 and group 2 metals
- ✰ the sum of the oxidation numbers
  - ✯ in a compound it is always zero
  - ✯ in a polyatomic ion it is equal to the charge on the ion

★ Finding oxidation numbers

- ✰ apply the rules
- ✰ construct a table if necessary

Sample Problem

Find the oxidation state of the elements in $K_2Cr_2O_7$.

Element	K	Cr	O	TOTAL
Subscript	2	2	7	
Oxidation state	+1	?	-2	
Sum of oxidation states	+2	??	-14	0

[a] potassium is a group one metal; its oxidation state is always +1

[b] oxygen usually has an oxidation state of -2

[c] the sum of oxidation states of each element is the product of the subscript and the oxidation state

[d] find the –sum of the oxidation states of chromium (??) by setting the sum of all the oxidation states to zero

(+2) + ?? + (-14) = 0

?? = +12

[f] find the oxidation state of chromium (?) by dividing the sum (+12) by the subscript (2)

+12 ÷ 2 = +6

Answer the questions below by circling the number of the correct response

1. In this reaction, the oxidation number (oxidation state) of C changes from: $2CO_2 \rightarrow 2CO + O_2$
(1) 0 to +4 (2) +2 to +4 (3) +3 to 0 (4) +4 to +2

2. In the reaction:
$2KMnO_4 + 3H_2SO_4 + 5H_2S \rightarrow 5S + 2MnSO_4 + K_2SO_4 + 8H_2O$
the oxidation number of sulfur changes from
(1) +5 to -5 (2) -5 to +5 (3) 0 to -2 (4) -2 to 0

3. What is the oxidation number of Cr in Na_2CrO_4?
(1) +1 (2) +2 (3) +3 (4) +6

4. What is the oxidation state of the chromium in $K_2Cr_2O_7$?
(1) +5 (2) +6 (3) +3 (4) +12

5. In the reaction $Pb + 2Ag^+ \rightarrow Pb^{+2} + 2Ag$, the reducing agent is
(1) Ag (2) Ag^+ (3) Pb (4) Pb^{+2}

6. Which is not an oxidation-reduction reaction?
(1) $4Na + O_2 \rightarrow 2Na_2O$
(2) $Fe + 2HCl \rightarrow FeCl_2 + H_2$
(3) $CaCl_2(aq) + 2AgNO_3(aq) \rightarrow 2AgCl(s) + Ca(NO_3)_2(aq)$
(4) $2H_2O \rightarrow 2H_2 + O_2$

7. Given: $2Al + 3Zn^{+2} \rightarrow 2Al^{+3} + 3Zn$. In this reaction, the oxidizing agent is (1) Al (2) Al^{+3} (3) Zn (4) Zn^{+2}

8. Given: $2Al + 3Zn^{+2} \rightarrow 2Al^{+3} + 3Zn$ In this reaction, electrons are transferred from (1) Al to Al^{+3} (2) Zn^{+2} to Zn (3) Al to Zn^{+2} (4) Zn^{+2} to Al

9. What is the oxidation number of nitrogen in N_2O_3? (1) +1 (2) +2 (3) +3 (4) +6

10. In the reaction $3CO + Fe_2O_3 \rightarrow 3CO_2 + 2Fe$, the oxidation number of the iron changes from (1) +2 to 0 (2) +2 to +3 (3) +3 to +2 (4) +3 to 0

11. What is the oxidation number of Br in BrO_3^{-2}?
(1) +1 (2) +6 (3) +5 (4) +4

12. Which is the reducing agent in the following reaction?
$Cl_2(aq) + 2KBr(aq) \rightarrow 2KCl(aq) + Br_2(aq)$
(1) Cl_2 (2) H_2O (3) K^+ (4) Br^-

13. What is the oxidation number of carbon in $C_2O_4^{-2}$?
(1) +1 (2) +2 (3) +3 (4) +4

14. Which is an oxidation-reduction reaction?
(1) $CaCO_3 \rightarrow CaO + CO_2$
(2) $KOH + HBr \rightarrow KBr + H_2O$
(3) $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$
(4) $Mg + Cl_2 \rightarrow MgCl_2$

15. $MnSO_4$ is a product in a reaction that contained $KMnO_4$ as a reactant. The oxidation number of the manganese changed from
(1) -2 to +5 (2) +7 to +2 (3) +5 to -2 (4) -7 to +2

16. Given the balanced equation:
$2HNO_3 + 3H_2S \rightarrow 4H_2O + 2NO + 3S$
Which is reduced? (1) S (2) S-2 (3) N+2 (4) N+5

17. During the reaction $Ca + H_2 \rightarrow CaH_2$, the oxidation number of the hydrogen changes from
(1) 0 to +1 (2) +1 to 0 (3) 0 to -1 (4) -1 to 0

18. In the reaction $Sn^{+4} + H_2(g) \rightarrow Sn^{+2} + 2H^+$, the reducing agent is
(1) Sn^{+4} (2) H_2 (3) Sn^{+2} (4) H^+

19. Given: $3Ag + 4HNO_3 \rightarrow NO + 3AgNO_3 + 2H_2O$. The reducing agent in this reaction is
(1) Ag (2) Ag^{+1} (3) H^{+1} (4) N^{+2}

20. The reaction $NaCl(s) \rightarrow Na^+(aq) + Cl^-(aq)$ is an example of
(1) an oxidation reaction, only
(2) a reduction reaction, only
(3) both an oxidation and a reduction reaction
(4) neither an oxidation nor a reduction reaction

21. The oxidation number of manganese in $KMnO_4$ is
(1) +1 (2) +7 (3) +3 (4) +4

22. In the reaction $Sn^{+2} + 2Fe^{+3} \rightarrow Sn^{+4} + 2Fe^{+2}$, the reducing agent is
(1) Fe^{+2} (2) Fe^{+3} (3) Sn^{+2} (4) Sn

23. An oxidizing agent will always
(1) lose electrons
(2) increase in oxidation number
(3) be reduced
(4) increase in mass