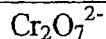


6. Each year the same "types" of reactions are used. The ability to recognize reaction types should assist you in determining products. Types include:

(A) REDOX Reactions

Type indicators: Strong Oxidizers and/or Strong Reducers

STRONG OXIDIZERS:



O_3 (ozone)

Halogens (F_2 , Cl_2 , Br_2 , I_2)

Reactants in reactions with large positive E° (reduction potentials)

STRONG REDUCERS:

Group I and II metals (Alkali and Alkaline Earth metals)

Products in reactions with large negative E° (reduction potentials)

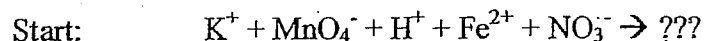
NOTE: Group I and II metals (except Beryllium and Magnesium) will reduce H in water to hydrogen gas producing hydroxide ion. (calcium in HOT water only!)

Once a REDOX reaction has been identified, remember: A species cannot be oxidized without another species being reduced--an oxidizer will become reduced, and a reducer will become oxidized. The common oxidation states of the metals can be determined from the Reduction Potential table provided with this part of the exam. When writing products be sure to use the common oxidized and reduced states. Watch for "common compounds" to be formed.

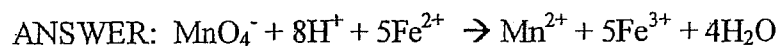
EXAMPLE:

2002 Exam Question 4(g)

"Acidified solutions of potassium permanganate and iron (II) nitrate are mixed together."



Mn (in MnO_4^-) has an oxidation state of 7+ it will become reduced to 2+. Fe^{2+} will become oxidized to Fe^{3+} . K^+ and NO_3^- are spectators. H_2O will be formed from the H^+ and the oxygen in MnO_4^-



4. Know the strong bases (i.e. any compound that completely ionizes in solution to produce OH⁻ REGARDLESS OF SOLUBILITY!)

- (a) group I (and heavier group II) metal hydroxides. [e.g. NaOH, KOH, Ca(OH)₂]
- (b) amide ion (NH₂⁻)
- (c) hydride ion (H⁻)
- (d) methide ion (CH₃⁻)
- (e) oxide ion (O²⁻)
- (f) nitride ion (N³⁻)

5. Metal oxides are BASIC and produce OH⁻ in aqueous solution.

EXAMPLE:

2002 Exam Question 4(c)

"Solid cesium oxide is added to water"

Cesium oxide is a metal oxide, producing OH⁻ in aqueous solution.

ANSWER: Cs₂O + H₂O → 2Cs⁺ + 2OH⁻

6. Don't forget!

- (a) An acid reacts with carbonates and bicarbonates to produce carbon dioxide and water.
- (b) An acid reacts with a sulfide to produce hydrogen sulfide (H₂S) gas.
- (c) Ammonium ion reacts with hydroxide ion to produce NH₃ and H₂O.

7. Don't forget! The reaction of a strong acid with a strong base will ALWAYS be:



EXAMPLE:

2003 Exam Question 4(d)

"A 0.02 M hydrochloric acid solution is mixed with an equal volume of 0.01 M calcium hydroxide solution."

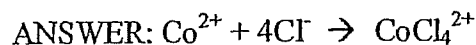
ANSWER: H⁺ + OH⁻ → H₂O

EXAMPLE:

2002 Exam Question 4(d)

"Excess concentrated hydrochloric acid is added to a 1.0 M solution of cobalt (II) chloride."

Cobalt is a transition metal with a 2+ oxidation state. Chloride ion is a common ligand.

**(E) Decomposition Reaction**

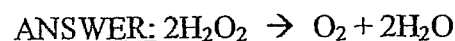
The most common decomposition reaction used is the decomposition of a metal carbonate with heat. Carbon dioxide and a metal oxide will be formed. In the case of a bicarbonate, carbon dioxide, water, and a metal carbonate will be formed.

Sometimes decomposition will be a REDOX reaction:

EXAMPLE:

2003 Exam Question 4(c)

"A solution of hydrogen peroxide is exposed to strong sunlight"

**(F) Combustion Reaction**

The most common application is the burning of a hydrocarbon or an organic compound in air. Unless otherwise stated, assume complete combustion with carbon dioxide and water as the only products.

NOTE: This type of problem is where your knowledge of organic chemistry is most likely to be tested. Remember—each equation has two product points. Even if you don't know the formula of the reactant, knowing that it is a combustion reaction and indicating carbon dioxide and water as products will score part credit on the equation!

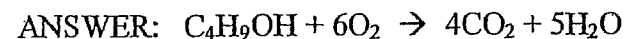
EXAMPLE:

2000 Exam Question 4(b)

"Butanol is burned in air"

Assume you do not know the formula for butanol. The answer:

???? $\rightarrow \text{CO}_2 + \text{H}_2\text{O}$ will score partial credit



Name: _____

AP Chemistry Chemical Equations Worksheet

Write the balanced chemical equation (excluding spectator ions) underneath each reaction description, and answer the question.

(a) A solution of ammonia is added to a dilute solution of acetic acid.	Identify the conjugate acid-base pairs in this reaction.
(b) Solutions of sodium hydroxide and acetic acid are mixed.	Acetic acid is a weak acid. If equal volumes of equal molar solutions are mixed, will the solution pH be >7 , 7 , or <7 ? Explain.
(c) Hydrogen sulfide gas is bubbled through excess potassium hydroxide solution.	Write the successive ionization equations for H_2S .
(d) Solid barium oxide is added to distilled water.	Is the resulting solution acidic, basic or neutral? Explain.
(e) Solid calcium oxide is exposed to a stream of carbon dioxide gas.	What type of reaction has occurred?
(f) Solid dinitrogen pentoxide is added to water.	Is the final solution acidic, basic or neutral? Explain.
(g) Carbon disulfide vapor is burned in excess oxygen.	What is the oxidizing agent in this reaction?

(s) Solutions of silver nitrate and sodium chromate are mixed.	What is the oxidation number of chromium in the chromate ion?
(t) Glacial acetic acid is mixed with liquid methanol (nonaqueous).	What type of organic reaction can this be characterized as?
(u) Chlorine gas is bubbled into a cold, dilute solution of potassium hydroxide.	What element is undergoing oxidation and what element is undergoing reduction?
(v) A strip of copper is immersed in a concentrated nitric acid solution.	List at least two observations that indicate a chemical reaction is occurring.
(w) Hydrogen gas is passed over hot iron(II) oxide powder.	What is the oxidation number of the hydrogen in hydrogen gas?
(x) Acidified potassium permanganate is added to a solution of sodium nitrite.	Write and balance the oxidation half-reaction for mass and charge.
(y) A solution of sodium bromide is added to an acidified solution of potassium bromate.	Write and balance the reduction half-reaction for mass and charge.
(z) Aluminum metal is added to a solution of copper(II) chloride.	List at least two observations that indicate a chemical reaction is occurring.
(aa) Excess chlorine gas is passed over hot iron filings.	What type of reaction is occurring?
(bb) Magnesium metal is added to nitrogen gas.	What is the oxidation number of magnesium before and after the reaction?

AP Chemistry Chemical Equations Worksheet

Answer Key

Changes to the AP Chemistry Exam format for 2007 include modification to Question 4 in Section II. Previously, students were asked to write chemical equations for any five of eight given sets of chemical reactions. The new format requires students to write balanced chemical equations showing only the reacting substances (excluding spectator ions) for three different sets of reactants and to answer a short question (requiring no calculator) about each reaction. The questions are intended to test the students' understanding of the meaning of the reactions.

The College Board has provided only a few examples of the types of questions that might be asked. (Visit the College Board Web site at www.apcentral.collegeboard.com/apc/public/courses/150180.html?type=print for examples.) AP Chemistry teachers have asked us if we have any products or worksheets to address this new format. The following list of practice chemical equations is provided as a helpful tool to assist teachers. We have compiled these questions based on our interpretation of the questions on the College Board Web site. Flinn Scientific has no additional information or guidance other than that provided by the College Board on its Web site.

In each of the 38 reactions listed below, a representative question about the reaction and the answer to the question are included, along with the balanced chemical equation. We hope that you will find this worksheet helpful in preparing students for the new AP Chemistry chemical equation section.

(a) A solution of ammonia is added to a dilute solution of acetic acid. $\text{NH}_3 + \text{CH}_3\text{COOH} \rightarrow \text{NH}_4^+ + \text{CH}_3\text{COO}^-$	Identify the conjugate acid–base pairs in this reaction. Answer: NH_3 (base) and NH_4^+ (acid) CH_3COOH (acid) and CH_3COO^- (base)
(b) Solutions of sodium hydroxide and acetic acid are mixed. $\text{OH}^- + \text{CH}_3\text{COOH} \rightarrow \text{H}_2\text{O} + \text{CH}_3\text{COO}^-$	Acetic acid is a weak acid. If equal volumes of equal molar solutions are mixed, will the solution pH be >7, 7, or <7? Explain. Answer: >7. The salt of a weak acid (CH_3COO^-) is basic in solution.
(c) Hydrogen sulfide gas is bubbled through excess potassium hydroxide solution. $\text{H}_2\text{S} + 2\text{OH}^- \rightarrow \text{S}^{2-} + 2\text{H}_2\text{O}$	Write the successive ionization equations for H_2S . Answer: $\text{H}_2\text{S} + \text{H}_2\text{O} \rightleftharpoons \text{HS}^- + \text{H}_3\text{O}^+$ $\text{HS}^- + \text{H}_2\text{O} \rightleftharpoons \text{S}^{2-} + \text{H}_3\text{O}^+$
(d) Solid barium oxide is added to distilled water. $\text{BaO} + \text{H}_2\text{O} \rightarrow \text{Ba}^{2+} + 2\text{OH}^-$	Is the resulting solution acidic, basic or neutral? Explain. Answer: Basic. Metal oxides form basic compounds in water.
(e) Solid calcium oxide is exposed to a stream of carbon dioxide gas. $\text{CaO} + \text{CO}_2 \rightarrow \text{CaCO}_3$	What type of reaction has occurred? Answer: A synthesis (or combination) reaction.
(f) Solid dinitrogen pentoxide is added to water. $\text{N}_2\text{O}_5 + \text{H}_2\text{O} \rightarrow 2\text{H}^+ + 2\text{NO}_3^-$	Is the final solution acidic, basic or neutral? Explain. Answer: Acidic. Nonmetal oxides form acidic compounds in water.
(g) Carbon disulfide vapor is burned in excess oxygen. $\text{CS}_2 + 3\text{O}_2 \rightarrow \text{CO}_2 + 2\text{SO}_2$	What is the oxidizing agent in this reaction? Answer: Oxygen.

(s) Solutions of silver nitrate and sodium chromate are mixed. $2\text{Ag}^+ + \text{CrO}_4^{2-} \rightarrow \text{Ag}_2\text{CrO}_4$	What is the oxidation number of chromium in the chromate ion? Answer: +6.
(t) Glacial acetic acid is mixed with liquid methanol (nonaqueous). $\text{CH}_3\text{COOH} + \text{CH}_3\text{OH} \rightarrow \text{CH}_3\text{COOCH}_3 + \text{H}_2\text{O}$	What type of organic reaction can this be characterized as? Answer: An esterification reaction.
(u) Chlorine gas is bubbled into a cold, dilute solution of potassium hydroxide. $\text{Cl}_2 + 2\text{OH}^- \rightarrow \text{ClO}^- + \text{Cl}^- + \text{H}_2\text{O}$	What element is undergoing oxidation and what element is undergoing reduction? Answer: Chlorine, Cl, is being reduced to -1 (Cl^-) and also being oxidized to +1 in ClO^- .
(v) A strip of copper is immersed in a concentrated nitric acid solution. $\text{Cu} + 4\text{H}^+ + 2\text{NO}_3^- \rightarrow \text{Cu}^{2+} + 2\text{NO}_2 + 2\text{H}_2\text{O}$	List at least two observations that indicate a chemical reaction is occurring. Answer: Solution color changes from colorless to blue. Bubbles of NO_2 gas are observed at the copper strip. The gas is brown.
(w) Hydrogen gas is passed over hot iron(II) oxide powder. $\text{H}_2 + \text{FeO} \rightarrow \text{Fe} + \text{H}_2\text{O}$	What is the oxidation number of the hydrogen in hydrogen gas? Answer: Zero—the oxidation number of an atom in its elemental form is zero.
(x) Acidified potassium permanganate is added to a solution of sodium nitrite. $2\text{MnO}_4^- + 6\text{H}^+ + 5\text{NO}_2^- \rightarrow 2\text{Mn}^{2+} + 3\text{H}_2\text{O} + 5\text{NO}_3^-$	Write and balance the oxidation half-reaction for mass and charge. Answer: $\text{H}_2\text{O} + \text{NO}_2^- \rightarrow \text{NO}_3^- + 2\text{H}^+ + 2\text{e}^-$
(y) A solution of sodium bromide is added to an acidified solution of potassium bromate. $5\text{Br}^- + 6\text{H}^+ + \text{BrO}_3^- \rightarrow 3\text{Br}_2 + 3\text{H}_2\text{O}$	Write and balance the reduction half-reaction for mass and charge. Answer: $12\text{H}^+ + 2\text{BrO}_3^- + 10\text{e}^- \rightarrow \text{Br}_2 + 6\text{H}_2\text{O}$
(z) Aluminum metal is added to a solution of copper(II) chloride. $2\text{Al} + 3\text{Cu}^{2+} \rightarrow 2\text{Al}^{3+} + 3\text{Cu}$	List at least two observations that indicate a chemical reaction is occurring. Answer: The aluminum dissolves, a red solid precipitates, the blue color of the solution fades, and the solution temperature increases.
(aa) Excess chlorine gas is passed over hot iron filings. $3\text{Cl}_2 + 2\text{Fe} \rightarrow 2\text{FeCl}_3$	What type of reaction is occurring? Answer: A synthesis reaction (or a redox reaction).
(bb) Magnesium metal is added to nitrogen gas. $3\text{Mg} + \text{N}_2 \rightarrow \text{Mg}_3\text{N}_2$	What is the oxidation number of magnesium before and after the reaction? Answer: Magnesium goes from zero in Mg to +2 in Mg_3N_2 .

