

AP Equations Review

Write the formulas to show the reactants and the products for any FIVE of the laboratory situations described below. Answers to more than five choices will not be graded. In all cases, a reaction occurs. Assume that solutions are aqueous unless otherwise indicated. Represent substances in solution as ions if the substances are extensively ionized. Omit formulas for any ions or molecules that are unchanged by the reaction. You need not balance the equations.

Work on these review questions independently. Remember, you get 1 point for correct reactant formulas and 2 points for correct products. This section is 15% of the Free Response score. Score yourself for each for each year's set of reactions. The mean score is 5 out of 15 points.

2003

- A solution of potassium phosphate is mixed with a solution of calcium acetate.
- Solid zinc carbonate is added to 1.0 M sulphuric acid.
- A solution of hydrogen peroxide is exposed to strong sunlight.
- A 0.02 M hydrochloric acid is mixed with an equal volume of 0.01 M calcium hydroxide solution.
- Excess concentrated ammonia is added to solid silver chloride.
- Magnesium ribbon is burned in oxygen.
- A bar of strontium metal is immersed in a 1.0 M copper(II) nitrate solution.
- Solid dinitrogen pentoxide is added to water.

2003B

- Hot hydrogen gas is passed over heated copper(II) oxide.
- Solid sodium hydroxide is added to water.
- Propanoane is burned in air.
- A solution of lead(II)nitrate is added to a solution of potassium sulfate.
- Ammonia gas is mixed with hydrogen chloride gas.
- Sulfur trioxide is bubbled through water.
- Excess concentrated potassium hydroxide is added to a solution of nickel(II) chloride.
- Solid sodium acetate is added to 1.0 M hydrochloric acid.

2002

- A solution of sodium iodide is added to a solution of lead(II)acetate.
- Pure phosphorus is burned in air.
- Solid cesium oxide is added to water.
- Excess concentrated hydrochloric acid is added to 1.0 M solution of cobalt(II)chloride.
- Solid sodium hydrogen carbonate (sodium bicarbonate) is strongly heated.
- An excess of hydrochloric acid is added to solid zinc sulphide.
- Acidified solutions of potassium permanganate and iron(II)nitrate are mixed together.
- A solution of potassium hydroxide is added to ammonium chloride.

2002B

- A sample of 1-propanol is burned in air.
- Solutions of sodium chromate and lead(II)nitrate are mixed.
- A bar of iron metal is added to a solution of copper(II)sulfate.
- Concentrated ammonia solution is added to a copper(II)sulfate solution.
- Sulfur dioxide gas is bubbled into a beaker of water.
- Equal volumes of 0.1 M sodium phosphate and 0.1 M hydrochloric acid are mixed.
- Hydrogen chloride gas is bubbled through a solution of potassium cyanide.
- Liquid bromine is carefully added to a solution of potassium iodide.

2001

- Sulfur dioxide gas is bubbled into distilled water.
- A drop of potassium thiocyanate solution is added to a solution of iron (III) nitrate.
- A piece of copper wire is placed in a solution of silver nitrate.

- d) Solutions of potassium hydroxide and propanoic acid are mixed.
- e) Solution of iron (II) chloride is added to an acidified solution of sodium dichromate.
- f) Chlorine gas is bubbled through a solution of potassium bromide.
- g) Solutions of strontium nitrate and sodium sulfate are mixed.
- h) Powdered magnesium carbonate is heated strongly.

2000

- a) A small piece of calcium metal is added to hot distilled water.
- b) Butanol is burned in air.
- c) Excess concentrated ammonia solution is added to a solution of nickel (II) sulfate.
- d) A solution of copper (II) chloride is added to a solution of sodium sulfide.
- e) A solution of tin (II) nitrate is added to a solution of silver nitrate.
- f) Excess hydrobromic acid solution is added to a solution of potassium hydrogen carbonate.
- g) Powdered strontium oxide is added to distilled water.
- h) Carbon monoxide gas is passed over hot iron (III) oxide.

1998

- a) Solutions of tin (II) chloride and iron (III) chloride are mixed.
- b) Solutions of cobalt (II) nitrate and sodium hydroxide are mixed.
- c) Ethene gas is burned in air.
- d) Equal volumes of equimolar solutions of phosphoric acid and potassium hydroxide are mixed.
- e) Solid calcium sulfite is heated in a vacuum.
- f) Excess hydrochloric acid is added to a solution of diamminesilver (I) nitrate
- g) Solid sodium oxide is added to distilled water.
- h) A strip of zinc is added to a solution of 6.0 molar hydrobromic acid.

1997

- a) Excess potassium hydroxide solution is added to a solution of aluminum nitrate.
- b) A solution of sodium bromide is added to an acidified solution of potassium bromate.
- c) Sulfur dioxide gas is bubbled into distilled water.
- d) Phosphine (phosphorus trihydride) gas is bubbled into liquid boron trichloride.
- e) Hydrogen gas is passed over hot iron (II) oxide powder.
- f) Solid potassium amide is added to distilled water.
- g) A strip of magnesium metal is heated strongly in pure nitrogen gas.
- h) A solution of nickel chloride is added to a solution of sodium sulfide.

1996

- a) Solid calcium carbonate is strongly heated.
- b) A piece of nickel metal is immersed in a solution of copper (II) sulfate.
- c) Equal moles of disodium hydrogen phosphate and hydrochloric acid are mixed in solution.
- d) Chlorine gas is bubbled into a solution of sodium bromide.
- e) Ammonia gas is bubbled into a solution of ethanoic (acetic) acid.
- f) Solid ammonium carbonate is added to a saturated solution of barium hydroxide.
- g) Drops of liquid dinitrogen trioxide are added to distilled water.
- h) Solutions of potassium permanganate and sodium oxalate are mixed.

1995

- a) Ethanol is burned in oxygen.
- b) Solid barium oxide is added to distilled water.
- c) Chlorine gas is bubbled into a cold, dilute solution of potassium hydroxide.
- d) A solution of iron (II) nitrate is exposed to air for an extended period of time.
- e) Excess concentrated sulfuric acid is added to calcium phosphate.
- f) Hydrogen sulfide gas is bubbled into a solution of mercury (II) chloride.

- g) Solid calcium hydride is added to distilled water.
- h) A bar of zinc metal is immersed in a solution of copper (II) sulfate.

1994

- a) Excess sodium cyanide is added to a solution of silver nitrate.
- b) Solutions of manganese (II) sulfate and ammonium sulfide are mixed.
- c) Phosphorus (V) oxide powder is sprinkled over distilled water.
- d) Solid ammonium carbonate is heated.
- e) Carbon dioxide gas is bubbled through a concentrated solution of potassium hydroxide.
- f) A concentrated solution of hydrochloric acid is added to solid potassium permanganate.
- g) A small piece of sodium metal is added to distilled water.
- h) A solution of potassium dichromate is added to an acidified solution of iron (II) chloride.

1993

- a) A strip of copper is immersed in dilute nitric acid.
- b) Potassium permanganate solution is added to an acidic solution of hydrogen peroxide.
- c) Concentrated hydrochloric acid is added to solid manganese (II) sulfide.
- d) Excess chlorine is passed over hot iron filings.
- e) Water is added to a sample of solid magnesium nitride.
- f) Excess sulfur dioxide is bubbled through a dilute solution of potassium hydroxide.
- g) Excess concentrated ammonia solution is added to a suspension of silver chloride.
- h) Solutions of tripotassium phosphate and zinc nitrate are mixed.

1992

- a) An excess of sodium hydroxide solution is added to a solution of magnesium nitrate.
- b) Solid lithium nitride is added to water.
- c) Solutions of ammonia and hydrofluoric acid are mixed.
- d) A piece of aluminum metal is added to a solution of silver nitrate.
- e) A solution of potassium iodide is electrolyzed.
- f) Solid potassium oxide is added to water.
- g) An excess of nitric acid solution is added to a solution of tetramminecopper (II) sulfate.
- h) Carbon dioxide gas is bubbled through water containing a suspension of calcium carbonate.

1991

- a) Solid aluminum oxide is added to a solution of sodium hydroxide.
- b) Solid calcium oxide is heated in the presence of sulfur trioxide gas.
- c) Equal volumes of 0.1 molar sulfuric acid and 0.1 molar potassium hydroxide are mixed.
- d) Calcium metal is heated strongly in nitrogen gas.
- e) Solid copper (II) sulfide is heated strongly in oxygen gas.
- f) A concentrated hydrochloric acid solution is heated with some powdered manganese dioxide.
- g) A concentrated solution of ammonia is added to a solution of zinc iodide.
- h) A solution of copper (II) sulfate is added to a solution of barium hydroxide.

1990

- a) Solutions of sodium iodide and lead nitrate are mixed.
- b) A solution of ammonia is added to a solution of ferric chloride.
- c) A solution of hydrogen peroxide is heated.
- d) Solutions of silver nitrate and sodium chromate are mixed.
- e) Hydrogen sulfide gas is bubbled through a solution of potassium hydroxide.
- f) Solid dinitrogen pentoxide is added to water.
- g) A piece of solid bismuth is heated strongly in oxygen.
- h) A strip of copper metal is added to a concentrated solution of sulfuric acid.

Reactions Review: Answers

2003

- a) $\text{PO}_4^{3-} + \text{Ca}^{+2} \rightarrow \text{Ca}_3(\text{PO}_4)_2$
b) $\text{ZnCO}_3 + \text{H}^+ + \text{HSO}_4^- \rightarrow \text{Zn}^{+2} + \text{CO}_2 + \text{H}_2\text{O} + \text{SO}_4^{2-}$ **or,**
 $\text{ZnCO}_3 + \text{H}^+ \rightarrow \text{Zn}^{+2} + \text{CO}_2 + \text{H}_2\text{O}$
c) $\text{H}_2\text{O}_2 \rightarrow \text{H}_2\text{O} + \text{O}_2$
d) $\text{OH}^- + \text{H}^+ \rightarrow \text{H}_2\text{O}$
e) $\text{AgCl} + \text{NH}_3 \rightarrow \text{Ag}(\text{NH}_3)_2^+ + \text{Cl}^-$
f) $\text{Mg} + \text{O}_2 \rightarrow \text{MgO}$
g) $\text{Sr} + \text{Cu}^{2+} \rightarrow \text{Sr}^{2+} + \text{Cu}$
h) $\text{N}_2\text{O}_5 + \text{H}_2\text{O} \rightarrow \text{H}^+ + \text{NO}_3^-$

2003B

- a) $\text{H}_2 + \text{CuO} \rightarrow \text{Cu} + \text{H}_2\text{O}$
b) $\text{NaH} + \text{H}_2\text{O} \rightarrow \text{Na}^+ + \text{OH}^- + \text{H}_2$
c) $\text{C}_3\text{H}_6\text{O} + \text{O}_2 \rightarrow \text{H}_2\text{O} + \text{CO}_2$
d) $\text{Pb}^{+2} + \text{SO}_4^{-2} \rightarrow \text{PbSO}_4$
e) $\text{HCl} + \text{NH}_3 \rightarrow \text{NH}_4\text{Cl}$
f) $\text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}^+ + \text{HSO}_4^-$
g) $\text{OH}^- + \text{Ni}^{2+} \rightarrow \text{Ni}(\text{OH})_4^{2-}$
h) $\text{NaC}_2\text{H}_3\text{O}_2 + \text{H}^+ \rightarrow \text{HC}_2\text{H}_3\text{O}_2 + \text{Na}^+$

2002

- a) $\text{I}^- + \text{Pb}^{+2} \rightarrow \text{PbI}_2$
b) $\text{P}_4 + \text{O}_2 \rightarrow \text{P}_4\text{O}_{10}$
c) $\text{Cs}_2\text{O} + \text{H}_2\text{O} \rightarrow \text{Cs}^{2+} + \text{OH}^-$
d) $\text{Co}^{+2} + \text{Cl}^- \rightarrow \text{CoCl}_4^{2-}$
e) $\text{NaHCO}_3 \rightarrow \text{Na}_2\text{CO}_3 + \text{H}_2\text{O} + \text{CO}_2$
f) $\text{H}^+ + \text{ZnS} \rightarrow \text{Zn}^{2+} + \text{H}_2\text{S}$
g) $\text{MnO}_4 + \text{H}^+ + \text{Fe}^{2+} \rightarrow \text{Mn}^{2+} + \text{Fe}^{3+} + \text{H}_2\text{O}$
h) $\text{NH}_4\text{Cl} + \text{OH}^- \rightarrow \text{NH}_3 + \text{Cl}^- + \text{H}_2\text{O}$

2002B

- a) $\text{C}_3\text{H}_7\text{OH} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$
b) $\text{CrO}_4^{2-} + \text{Pb}^{2+} \rightarrow \text{PbCrO}_4$
c) $\text{Fe} + \text{Fe}^{3+} \rightarrow \text{Fe}^{2+}$
d) $\text{NH}_3 + \text{Cu}^{+2} \rightarrow \text{Cu}(\text{NH}_3)_4^{2+}$ **OR** $\text{OH}^- + \text{Cu}^{2+} \rightarrow \text{Cu}(\text{OH})_2$
e) $\text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3$ **OR** $\text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{HSO}_3^- + \text{H}^+$
f) $\text{H}^+ + \text{PO}_4^{3-} \rightarrow \text{HPO}_4^{2-}$
g) $\text{HCl} + \text{CN}^- \rightarrow \text{Cl}^- + \text{HCN}$
h) $\text{Br}_2 + \text{Cl}^- \rightarrow \text{Br}^- + \text{Cl}_2$

2001

- a) $\text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3$
 b) $\text{Fe}^{+3} + \text{SCN} \rightarrow [\text{Fe}(\text{SCN})]^{+2}$
 c) $\text{Cu} + \text{Ag}^+ \rightarrow \text{Cu}^{+2} + \text{Ag}$
 d) $\text{C}_2\text{H}_5\text{COOH} + \text{OH}^- \rightarrow \text{C}_2\text{H}_5\text{COO}^- + \text{H}_2\text{O}$
 e) $\text{Fe}^{+2} + \text{Cr}_2\text{O}_7^{-2} + \text{H}^+ \rightarrow \text{Fe}^{+3} + \text{Cr}^{+3} + \text{H}_2\text{O}$
 f) $\text{Cl}_2 + \text{Br}^- \rightarrow \text{Cl}^- + \text{Br}_2$
- g) $\text{Sr}^{+2} + \text{SO}_4^{-2} \rightarrow \text{SrSO}_4$
 h) $\text{MgCO}_3 \rightarrow \text{CO}_2 + \text{MgO}$

2000

- a) $\text{Ca} + \text{H}_2\text{O} \rightarrow \text{Ca}(\text{OH})_2 + \text{H}_2$
 b) $\text{C}_4\text{H}_9\text{OH} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$
 c) $\text{NH}_3 + \text{Ni}^{+2} \rightarrow [\text{Ni}(\text{NH}_3)_4]^{+2}$
 d) $\text{Cu}^{+2} + \text{S}^{-2} \rightarrow \text{CuS}$
 e) $\text{Sn}^{+2} + \text{Ag}^+ \rightarrow \text{Sn}^{+4} + \text{Ag}$
 f) $\text{H}^+ + \text{HCO}_3^- \rightarrow \text{H}_2\text{O} + \text{CO}_2$
 g) $\text{SrO} + \text{H}_2\text{O} \rightarrow \text{Sr}^{+2} + \text{OH}^-$ or $\text{Sr}(\text{OH})_2$
 h) $\text{CO} + \text{Fe}_2\text{O}_3 \rightarrow \text{CO}_2 + \text{Fe}$

1998

- a) $\text{Sn}^{+2} + \text{Fe}^{+3} \rightarrow \text{Sn}^{+4} + \text{Fe}^{+3}$
 b) $\text{Co}^{+2} + \text{OH}^- \rightarrow \text{Co}(\text{OH})_2$
 c) $\text{C}_2\text{H}_4 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$
 d) $\text{H}_3\text{PO}_4 + \text{OH}^- \rightarrow \text{H}_2\text{PO}_4^{-1} + \text{H}_2\text{O}$
 e) $\text{CaSO}_3 \rightarrow \text{SO}_2 + \text{CaO}$
 f) $\text{Ag}(\text{NH}_3)_2^+ + \text{H}^+ \rightarrow \text{Ag}^+ + \text{NH}_4^+$
 g) $\text{Na}_2\text{O} + \text{H}_2\text{O} \rightarrow \text{NaOH}$
 h) $\text{Zn} + \text{H}^+ \rightarrow \text{Zn}^{+2} + \text{H}_2$

1997

- a) $\text{OH}^- + \text{Al}^{3+} \rightarrow \text{Al}(\text{OH})_3$ (or $\text{Al}(\text{OH})_4^-$; $\text{Al}(\text{OH})_4(\text{H}_2\text{O})_2^-$; Al_2O_3 ; $\text{Al}_2\text{O}_3 \cdot x \text{H}_2\text{O}$; AlO_2^-)
 b) $\text{Br}^- + \text{H}^+ + \text{BrO}_3^- \rightarrow \text{Br}_2 + \text{H}_2\text{O}$
 c) $\text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3$ (or $\rightarrow \text{H}^+ + \text{HSO}_3^-$; or $\rightarrow \text{H}^+ + \text{HSO}_3^- + \text{SO}_3^{2-}$)
 d) $\text{PH}_3 + \text{BCl}_3 \rightarrow \text{PH}_3\text{BCl}_3$
 e) $\text{H}_2 + \text{FeO} \rightarrow \text{Fe} + \text{H}_2\text{O}$
 f) $\text{KNH}_2 + \text{H}_2\text{O} \rightarrow \text{NH}_3 + \text{OH}^- + \text{K}^+$ (or $\rightarrow \text{NH}_4\text{OH} + \text{OH}^- + \text{K}^+$)
 g) $\text{Mg} + \text{N}_2 \rightarrow \text{Mg}_3\text{N}_2$
 h) $\text{Ni}^{2+} + \text{S}^{2-} \rightarrow \text{NiS}$ (or $\text{Ni}^{2+} + \text{H}_2\text{S} \rightarrow \text{NiS} + \text{H}^+$; or $\text{Ni}^{2+} + \text{HS}^- \rightarrow \text{NiS} + \text{H}^+$)

1996

- a) $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$

- b) $\text{Ni} + \text{Cu}^{2+} \rightarrow \text{Ni}^{2+} + \text{Cu}$
- c) $\text{HPO}_4^{2-} + \text{H}^+ \rightarrow \text{H}_2\text{PO}_4^-$
- d) $\text{Cl}_2 + \text{Br}^- \rightarrow \text{Cl}^- + \text{Br}_2$
- e) $\text{NH}_3 + \text{CH}_3\text{COOH} \rightarrow \text{NH}_4^+ + \text{CH}_3\text{COO}^-$
- f) $(\text{NH}_4)_2\text{CO}_3 + \text{Ba}^{2+} + \text{OH}^- \rightarrow \text{NH}_3 + \text{BaCO}_3 + \text{H}_2\text{O}$
- g) $\text{N}_2\text{O}_3 + \text{H}_2\text{O} \rightarrow \text{HNO}_2$
- h) $\text{MnO}_4^- + \text{C}_2\text{O}_4^{2-} \rightarrow \text{MnO}_2 + \text{CO}_2$

1995

- a) $\text{C}_2\text{H}_5\text{OH} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$
- b) $\text{BaO} + \text{H}_2\text{O} \rightarrow \text{Ba}^{2+} + \text{OH}^-$
- c) $\text{Cl}_2 + \text{OH}^- \rightarrow \text{Cl}^- + \text{ClO}^-$ (or $\text{ClO}^-/\text{ClO}_2^-/\text{ClO}_3^-$) + H_2O
- d) $\text{Fe}^{2+} + \text{O}_2 (+ \text{H}_2\text{O}) \rightarrow \text{Fe}_2\text{O}_3$ or $\text{FeO}(\text{OH})$ or $\text{Fe}(\text{OH})_3$
- e) $\text{H}^+ + \text{SO}_4^{2-} + \text{Ca}_3(\text{PO}_4)_2 \rightarrow \text{CaSO}_4$ (or ions) + H_3PO_4
- f) $\text{H}_2\text{S} + \text{Hg}^{2+} \rightarrow \text{HgS} + \text{H}^+$ or
 $\text{H}_2\text{S} + \text{HgCl}_2 \rightarrow \text{HgS} + \text{H}^+ + \text{Cl}^-$
- g) $\text{CaH}_2 + \text{H}_2\text{O} \rightarrow \text{Ca}(\text{OH})_2$ [or $\text{Ca}^{2+} + \text{OH}^-$] + H_2
- h) $\text{Zn} + \text{Cu}^{2+} \rightarrow \text{Zn}^{2+} + \text{Cu}$

1994

- a) $\text{CN}^- + \text{Ag}^+ \rightarrow \text{Ag}(\text{CN})_2^-$
- b) $\text{Mn}^{2+} + \text{S}^{2-} \rightarrow \text{MnS}_{(s)}$
- c) P_4O_{10} (or P_2O_5) + $\text{H}_2\text{O} \rightarrow \text{H}_3\text{PO}_4$
- d) $(\text{NH}_4)_2\text{CO}_3 \rightarrow \text{NH}_3 + \text{CO}_2 + \text{H}_2\text{O}$
- e) $\text{CO}_2 + \text{OH}^- \rightarrow \text{CO}_3^{2-} + \text{H}_2\text{O}$
- f) $\text{KMnO}_4 + \text{H}^+ + \text{Cl}^- \rightarrow \text{Cl}_2 + \text{Mn}^{2+} + \text{H}_2\text{O} + \text{K}^+$
- g) $\text{Na} + \text{H}_2\text{O} \rightarrow \text{Na}^+ + \text{OH}^- + \text{H}_2$
- h) $\text{Cr}_2\text{O}_7^{2-} + \text{H}^+ + \text{Fe}^{2+} \rightarrow \text{Cr}^{3+} + \text{H}_2\text{O} + \text{Fe}^{3+}$

1993

- a) $\text{Cu} + \text{H}^+ + \text{NO}_3^- \rightarrow \text{Cu}^{2+} + \text{NO}$ (or NO_2) + H_2O
- b) $\text{MnO}_4^- + \text{H}_2\text{O}_2 \rightarrow \text{Mn}^{2+} + \text{O}_2 + \text{H}_2\text{O}$
- c) $\text{H}^+ + \text{MnS} \rightarrow \text{H}_2\text{S} + \text{Mn}^{2+}$
- d) $\text{Fe} + \text{Cl}_2 \rightarrow \text{FeCl}_3$
- e) $\text{Mg}_3\text{N}_2 + \text{H}_2\text{O} \rightarrow \text{Mg}(\text{OH})_2$ (or $\text{Mg}^{2+} + \text{OH}^-$) + NH_3
- f) $\text{SO}_2 + \text{OH}^- \rightarrow \text{HSO}_3^-$
- g) $\text{AgCl} + \text{NH}_3 \rightarrow \text{Ag}(\text{NH}_3)_2^+ + \text{Cl}^-$
- h) $\text{Zn}^{2+} + \text{PO}_4^{3-} \rightarrow \text{Zn}_3(\text{PO}_4)_2$

1992

- a) $\text{OH}^- + \text{Mg}^{2+} \rightarrow \text{Mg}(\text{OH})_2$

- b) $\text{LiH} + \text{H}_2\text{O} \rightarrow \text{Li}^+ + \text{OH}^- + \text{H}_2$
- c) $\text{NH}_3 + \text{HF} \rightarrow \text{NH}_4^+ + \text{F}^-$
- d) $\text{Al} + \text{Ag}^+ \rightarrow \text{Al}^{3+} + \text{Ag}$
- e) $\text{I}^- + \text{H}_2\text{O} \rightarrow \text{I}_2 \text{ (or } \text{I}_3^-) + \text{H}_2 + \text{OH}^-$
- f) $\text{K}_2\text{O} + \text{H}_2\text{O} \rightarrow \text{K}^+ + \text{OH}^-$
- g) $\text{H}^+ + \text{Cu}(\text{NH}_3)_4^{2+} \rightarrow \text{Cu}^{2+} + \text{NH}_4^+$
- h) $\text{CO}_2 + \text{H}_2\text{O} \text{ (or } \text{H}_2\text{CO}_3) + \text{CaCO}_3 \rightarrow \text{Ca}^{2+} + \text{HCO}_3^-$

1991

- a) $\text{Al}_2\text{O}_3(s) + \text{OH}^-(aq) \rightarrow [\text{Al}(\text{OH})_4]^-(aq) \quad \text{or} \quad \text{Al}_2\text{O}_3(s) + \text{H}_2\text{O} \rightarrow \text{Al}(\text{OH})_3(s)$
- b) $\text{CaO}(s) + \text{SO}_3(g) \rightarrow \text{CaSO}_4(s)$
- c) $\text{H}^+(aq) + \text{OH}^-(aq) \rightarrow \text{H}_2\text{O}$
- d) $\text{Ca}(s) + \text{N}_2(g) \rightarrow \text{Ca}_3\text{N}_2(s)$
- e) $\text{CuS}(s) + \text{O}_2(g) \rightarrow \text{Cu}(s) + \text{SO}_2(g) \text{ \{or } \text{CuO}(s) \backslash \text{Cu}_2\text{O}(s)\}$
- f) $\text{MnO}_2(s) + \text{H}^+(aq) + \text{Cl}^-(aq) \rightarrow \text{Mn}^{2+}(aq) + \text{H}_2\text{O} + \text{Cl}_2(g)$
- g) $\text{Zn}^{2+}(aq) + \text{NH}_3(aq) \rightarrow [\text{Zn}(\text{NH}_3)_4]^{2+}(aq) \quad \text{or} \quad \text{Zn}^{2+}(aq) + \text{NH}_3(aq) + \text{H}_2\text{O} \nrightarrow \text{Zn}(\text{OH})_2(s) + \text{NH}_4^+(aq)$
- h) $\text{Cu}^{2+}(aq) + \text{SO}_4^{2-}(aq) + \text{Ba}^{2+}(aq) + \text{OH}^-(aq) \rightarrow \text{Cu}(\text{OH})_2(s) + \text{BaSO}_4(s)$

1990

- a) $\text{I}^-(aq) + \text{Pb}^{2+}(aq) \rightarrow \text{PbI}_2(s)$
- b) $\text{OH}^-(aq) + \text{Fe}^{3+}(aq) \rightarrow \text{Fe}(\text{OH})_3(s)$
- c) $\text{H}_2\text{O}_2(aq) \rightarrow \text{H}_2\text{O} + \text{O}_2(g)$
- d) $\text{Ag}^+(aq) + \text{CrO}_4^{2-}(aq) \rightarrow \text{Ag}_2\text{CrO}_4(s)$
- e) $\text{H}_2\text{S} + \text{OH}^-(aq) \rightarrow \text{S}^{2-}(aq) + \text{H}_2\text{O}$
- f) $\text{N}_2\text{O}_5(s) + \text{H}_2\text{O} \rightarrow \text{H}^+(aq) + \text{NO}_3^-(aq)$
- g) $\text{Bi}(s) + \text{O}_2(g) \rightarrow \text{Bi}_2\text{O}_3(s)$
- h) $\text{Cu}(s) + \text{H}^+(aq) + \text{SO}_4^{2-}(aq) \rightarrow \text{Cu}^{2+}(aq) \text{ \{or } \text{Cu}^+(aq)\} + \text{H}_2\text{O} + \text{SO}_2$