

AP Chemistry Exam Reactions: Questions and Answers

With the new format of the exam in 2007 and the availability of both questions and answers on the web at AP Central (<http://apcentral.collegeboard.com:80/apc/public/courses/4606.html>), I have determined not to update this page any longer. Please create an account as a teacher at AP Central and navigate to the full exams and scoring rubrics which are available back to 2003

Beginning in 2007, question 4 is no longer 5 out of 8 responses but rather three required responses. Also, in addition to writing the reactants and products, the equation must be balanced and there is a question about the chemical reaction.

2007

- (a) A solution of sodium hydroxide is added to a solution of lead(II) nitrate.

If 1.0 L volumes of 1.0 M solutions of sodium hydroxide and lead(II) nitrate are mixed together, how many moles of product(s) will be produced? Assume the reaction goes to completion.

- (b) Excess nitric acid is added to solid calcium carbonate.

Briefly explain why statues made of marble (calcium carbonate) displayed outdoors in urban areas are deteriorating.

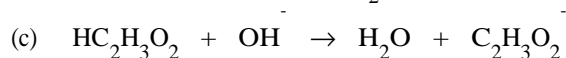
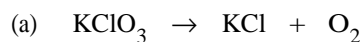
- (c) A solution containing silver(I) ion (an oxidizing agent) is mixed with a solution containing iron(II) ion (a reducing agent).

If the contents of the reaction mixture described above are filtered, what substance(s), if any, would remain on the filter paper?

- (a) (i) Balanced equation: $2\text{OH}^- + \text{Pb}^{2+} \rightarrow \text{Pb}(\text{OH})_2(\text{s})$
(ii) The moles of each reactant are obtained by multiplying the volume times the molarity. OH^- is 1 mole. Pb^{2+} is 1 mole. Since the balanced equation shows that 2 moles of OH^- are consumed for each 1 mole of Pb^{2+} , the moles of product would be 0.50 moles.
- (b) (i) Balanced equation: $2\text{H}^+ + \text{CaCO}_3 \rightarrow \text{Ca}^{2+} + \text{H}_2\text{CO}_3$ (or $\text{CO}_2 + \text{H}_2\text{O}$)
(ii) Combustion products from automobiles contain nitrogen oxide compounds. When the nitrogen oxides dissolve in water in the air it turns the rain acidic and the reaction above causes the calcium carbonate to slowly dissolve.
- (c) (i) Balanced equation: $\text{Ag}^+ + \text{Fe}^{2+} \rightarrow \text{Ag} + \text{Fe}^{3+}$
(ii) One of the products is solid silver metal. When filtered the solid silver metal would appear on the filter paper.

2006

- (a) Solid potassium chlorate is strongly heated.
(b) Solid silver chloride is added to a solution of concentrated hydrochloric acid.
(c) A solution of ethanoic (acetic) acid is added to a solution of barium hydroxide.
(d) Ammonia gas is bubbled into a solution of hydrofluoric acid.
(e) Zinc metal is placed in a solution of copper(II) sulfate.
(f) Hydrogen phosphide (phosphine) gas is added to boron trichloride gas.
(g) A solution of nickel(II) bromide is added to a solution of potassium hydroxide.
(h) Hexane is combusted in air.



- (d) $\text{NH}_3 + \text{HF} \rightarrow \text{NH}_4^+ + \text{F}^-$
 (e) $\text{Zn} + \text{Cu}^{2+} \rightarrow \text{Zn}^{2+} + \text{Cu}$
 (f) $\text{PH}_3 + \text{BCl}_3 \rightarrow \text{H}_3\text{PBCl}_3$
 (g) $\text{Ni}^{2+} + \text{OH}^- \rightarrow \text{Ni}(\text{OH})_2$
 (h) $\text{C}_6\text{H}_{14} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$

2005

- (a) A strip of zinc is placed in a solution of nickel (II) nitrate.
 (b) Solid aluminum hydroxide is added to a concentrated solution of potassium hydroxide.
 (c) Ethyne (acetylene) is burned in air.
 (d) Solid calcium carbonate is added to a solution of ethanoic (acetic) acid.
 (e) Lithium metal is strongly heated in nitrogen gas.
 (f) Boron trifluoride gas is added to ammonia gas.
 (g) Sulfur trioxide gas is bubbled into a solution of sodium hydroxide.
 (h) Equal volumes of 0.1 M solutions of lead(II) nitrate and magnesium iodide are combined.

- (a) $\text{Zn} + \text{Ni}^{2+} \rightarrow \text{Zn}^{2+} + \text{Ni}$
 (b) $\text{Al}(\text{OH})_3 + \text{OH}^- \rightarrow \text{Al}(\text{OH})_4^-$
 (c) $\text{C}_2\text{H}_2 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$
 (d) $\text{CaCO}_3 + \text{HC}_2\text{H}_3\text{O}_2 \rightarrow \text{Ca}^{2+} + \text{C}_2\text{H}_3\text{O}_2^- + \text{CO}_2 + \text{H}_2\text{O}$
 (e) $\text{Li} + \text{N}_2 \rightarrow \text{Li}_3\text{N}$
 (f) $\text{BF}_3 + \text{NH}_3 \rightarrow \text{BF}_3\text{NH}_3$
 (g) $\text{SO}_3 + \text{OH}^- \rightarrow \text{SO}_4^{2-} + \text{H}_2\text{O}$
 (h) $\text{Pb}^{2+} + \text{I}^- \rightarrow \text{PbI}_2$

2005 Form B

- (a) A solution of potassium carbonate is added to a solution of strontium nitrate.
 (b) Propene is burned in air.
 (c) Excess ammonia is added to a solution of zinc nitrate.
 (d) Ethanoic acid (acetic acid) is added to a solution of barium hydroxide.
 (e) A small piece of potassium is added to water.
 (f) Powdered iron metal is strongly heated with powdered sulfur.
 (g) A solution of sodium fluoride is added to a solution of hydrochloric acid.
 (h) A strip of lead metal is added to a solution of silver nitrate.

- (a) $\text{CO}_3^{2-} + \text{Sr}^{2+} \rightarrow \text{SrCO}_3$
 (b) $\text{C}_3\text{H}_6 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$
 (c) $\text{NH}_3 + \text{Zn}^{2+} \rightarrow \text{Zn}(\text{NH}_3)_6^{2+}$
 (d) $\text{OH}^- + \text{HC}_2\text{H}_3\text{O}_2 \rightarrow \text{C}_2\text{H}_3\text{O}_2^- + \text{H}_2\text{O}$
 (e) $\text{K} + \text{H}_2\text{O} \rightarrow \text{OH}^- + \text{H}_2 + \text{K}^+$
 (f) $\text{Fe} + \text{S} \rightarrow \text{FeS}$
 (g) $\text{H}^+ + \text{F}^- \rightarrow \text{HF}$
 (h) $\text{Pb} + \text{Ag}^+ \rightarrow \text{Pb}^{2+} + \text{Ag}$

2004

- (a) A solution of copper(II) sulfate is spilled onto a sheet of freshly polished aluminum metal.
 (b) Dimethyl ether is burned in air.
 (c) A 0.1 M nitrous acid solution is added to the same volume of a 0.1 M sodium hydroxide solution.
 (d) Hydrogen iodide gas is bubbled into a solution of lithium carbonate.

- (e) An acidic solution of potassium dichromate is added to a solution of iron(II) nitrate.
- (f) Excess concentrated aqueous ammonia is added to a solution of nickel(II) bromide.
- (g) A solution of sodium phosphate is added to a solution of aluminum nitrate.
- (h) Concentrated hydrochloric acid is added to a solution of sodium sulfide.

- (a) $\text{Cu}^{2+} + \text{Al} \rightarrow \text{Cu} + \text{Al}^{3+}$
- (b) $\text{C}_2\text{H}_6\text{O} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$
- (c) $\text{HNO}_2 + \text{OH}^- \rightarrow \text{H}_2\text{O} + \text{NO}_2^-$
- (d) $\text{HI} + \text{CO}_3^{2-} \rightarrow \text{I}^- + \text{CO}_2 + \text{H}_2\text{O}$ OR $\text{I}^- + \text{HCO}_3^-$
- (e) $\text{Cr}_2\text{O}_7^{2-} + \text{Fe}^{2+} + \text{H}^+ \rightarrow \text{Fe}^{3+} + \text{Cr}^{3+} + \text{H}_2\text{O}$
- (f) $\text{Ni}^{2+} + \text{NH}_3 \rightarrow [\text{Ni}(\text{NH}_3)_6]^{2+}$
- (g) $\text{PO}_4^{3-} + \text{Al}^{3+} \rightarrow \text{AlPO}_4$
- (h) $\text{H}^+ + \text{HS}^- \rightarrow \text{H}_2\text{S}$

2004 Form B

- (a) Cadmium metal is placed in a solution of tin(II) chloride.
- (b) Magnesium pellets are placed in 1.0 M hydrochloric acid.
- (c) Sulfur in its standard state is burned in air.
- (d) Solutions of silver nitrate and sodium chloride are combined.
- (e) Solid iron(II) sulfite is heated strongly.
- (f) Powdered barium oxide is mixed with water.
- (g) Excess saturated sodium fluoride solution is added to a solution of aluminum sulfate.
- (h) Solid potassium carbonate is added to 1.0 M sulfuric acid.

- (a) $\text{Cd} + \text{Sn}^{2+} \rightarrow \text{Sn} + \text{Cd}^{2+}$
- (b) $\text{Mg} + \text{H}^+ \rightarrow \text{Mg}^{2+} + \text{H}_2$
- (c) $\text{S}_8 + \text{O}_2 \rightarrow \text{SO}_2$ OR $\text{S} + \text{O}_2 \rightarrow \text{SO}_2$
- (d) $\text{Ag}^+ + \text{Cl}^- \rightarrow \text{AgCl}$
- (e) $\text{FeSO}_3 \rightarrow \text{FeO} + \text{SO}_2$
- (f) $\text{BaO} + \text{H}_2\text{O} \rightarrow \text{Ba}^{2+} + \text{OH}^-$
- (g) $\text{F}^- + \text{Al}^{3+} \rightarrow [\text{AlF}_6]^{3-}$
- (h) $\text{K}_2\text{CO}_3 + \text{H}^+ \rightarrow \text{CO}_2 + \text{H}_2\text{O} + \text{K}^+$

2003

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

- (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) $\text{H}_2\text{O}_2 \rightarrow \text{O}_2 + \text{H}_2\text{O}$
- (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) $\text{N}_2\text{O}_5 + \text{H}_2\text{O} \rightarrow \text{H}^+ + \text{NO}_3^-$

2003 Form B

- (a) Hot hydrogen gas is passed over heated copper(II) oxide solid.
 (b) Solid sodium hydride is added to water.
 (c) Propanone is burned in air.
 (d) A solution of lead(II) nitrate is added to a solution of potassium sulfate.
 (e) Ammonia gas is mixed with hydrogen chloride gas.
 (f) Sulfur trioxide gas is bubbled into water.
 (g) Excess concentrated potassium hydroxide solution is added to a solution of nickel(II) chloride.
 (h) Solid sodium acetate is added to 1.0 M hydrobromic acid.

- (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) $\text{C}_3\text{H}_6\text{O} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$
 (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) $\text{OH}^- + \text{Ni}^{2+} \rightarrow \text{Ni}(\text{OH})_2$
 (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) A solution of sodium iodide is added to a solution of lead (II) acetate.
 (b) Pure solid phosphorus (white form) is burned in air.
 (c) Solid cesium oxide is added to water.
 (d) Excess concentrated hydrochloric acid is added to a 1.0 M solution of cobalt (II) chloride.
 (e) Solid sodium hydrogen carbonate (sodium bicarbonate) is strongly heated.
 (f) An excess of hydrochloric acid is added to solid zinc sulfide.
 (g) Acidified solutions of potassium permanganate and iron(II) nitrate are mixed together.
 (h) A solution of potassium hydroxide is added to solid ammonium chloride.

- (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) $\text{Cs}_2\text{O} + \text{H}_2\text{O} \rightarrow \text{Cs}^+ + \text{OH}^-$
 (d) $\text{Cl}^- + \text{Co}(\text{H}_2\text{O})_6^{2+} \rightarrow \text{H}_2\text{O} + \text{CoCl}_4^{2-}$ OR $\text{Cl}^- + \text{Co}^{2+} \rightarrow \text{H}_2\text{O} + \text{CoCl}_4^{2-}$
 (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) $\text{MnO}_4^- + \text{H}^+ + \text{Fe}^{2+} \rightarrow \text{H}_2\text{O} + \text{Fe}^{3+} + \text{Mn}^{2+}$
 (h) $\text{NH}_4\text{Cl} + \text{OH}^- \rightarrow \text{NH}_3 + \text{Cl}^- + \text{H}_2\text{O}$

2002 Form B

- (a) A sample of 1-propanol is burned in air.
 (b) Solutions of sodium chromate and lead nitrate are mixed.
 (c) A bar of iron metal is added to a solution of iron(III) chloride.
 (d) Concentrated ammonia solution is added to copper(II) sulfate solution.
 (e) Sulfur dioxide gas is bubbled into a beaker of water.

- (f) Equal volumes of 0.1 M sodium phosphate and 0.1 M hydrochloric acid are mixed.
- (g) Hydrogen chloride gas is bubbled through a solution of potassium cyanide.
- (h) Liquid bromine is carefully added to a solution of potassium iodide.

- (a) $C_3H_7OH + O_2 \rightarrow CO_2 + H_2O$
- (b) $CrO_4^{2-} + Pb^{2+} \rightarrow PbCrO_4$
- (c) $Fe + Fe^{3+} \rightarrow Fe^{2+}$
- (d) $NH_3 + Cu^{2+} \rightarrow Cu(NH_3)_4^{2+}$ OR $OH^- + Cu^{2+} \rightarrow Cu(OH)_2$
- (e) $SO_2 + H_2O \rightarrow H_2SO_3$ OR $SO_2 + H_2O \rightarrow H^+ + HSO_3^-$
- (f) $PO_4^{3-} + H^+ \rightarrow HPO_4^{2-}$
- (g) $HCl + CN^- \rightarrow HCN + Cl^-$
- (h) $Br_2 + I^- \rightarrow Br^- + I_2$

2001

- (a) Sulfur dioxide gas is bubbled into distilled water.
 - (b) A drop of potassium thiocyanate solution is added to a solution of iron(III) nitrate.
 - (c) A piece of copper wire is placed in a solution of silver nitrate.
 - (d) Solutions of potassium hydroxide and propanoic acid are mixed.
 - (e) A 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.
- (a) $SO_2 + H_2O \rightarrow H^+ + HSO_3^-$ (or $H_3O^+ + HSO_3^-$ or H_2SO_3)
 - (b) $Fe^{3+} + SCN^- \rightarrow [Fe(SCN)]^{2+}$ (or $[Fe(SCN)(H_2O)_5]^{2+}$ or $[Fe(SCN)(H_2O)_3]^{2+}$)
 - (c) $Cu + Ag^+ \rightarrow Cu^{2+} + Ag$
 - (d) $C_2H_5COOH + OH^- \rightarrow C_2H_5COO^- + H_2O$
 - (e) $Fe^{2+} + Cr_2O_7^{2-} + H^+ \rightarrow Fe^{3+} + Cr^{3+} + H_2O$
 - (f) $Cl_2 + Br^- \rightarrow Cl^- + Br_2$
 - (g) $Sr^{2+} + SO_4^{2-} \rightarrow SrSO_4$
 - (h) $MgCO_3 \rightarrow MgO + CO_2$

2000

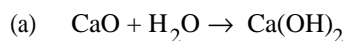
- (a) A small piece of calcium metal is added to hot distilled water.
 - (b) Butanol is burned in air.
 - (c) Excess concentrated ammonia solution is added to a solution of nickel (II) sulfate.
 - (d) A solution of copper (II) chloride is added to a solution of sodium sulfide.
 - (e) A solution of tin (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.
- (a) $Ca + H_2O \rightarrow Ca(OH)_2 + H_2$ (or $Ca^{2+} + OH^- + H_2$)
 - (b) $C_4H_9OH + O_2 \rightarrow CO_2 + H_2O$
 - (c) $NH_3 + Ni^{2+} \rightarrow Ni(NH_3)_x^{2+}$, where x = any integer from 1 through 6
 - (d) $Cu^{2+} + S^{2-} \rightarrow CuS$
 - (e) $Sn^{2+} + Ag^+ \rightarrow Sn^{4+} + Ag$
 - (f) $H^+ + HCO_3^- \rightarrow H_2O + CO_2$ (If H_2CO_3 , subtract 1 pt)

- (g) $\text{SrO} + \text{H}_2\text{O} \rightarrow \text{Sr}^{2+} + \text{OH}^-$ (or $\text{Sr}(\text{OH})_2$)
 (h) $\text{CO} + \text{Fe}_2\text{O}_3 \rightarrow \text{CO}_2 + \text{Fe}$

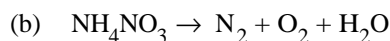
(Previous to 1996 the reactions were Part C. From 1996 to the present the reactions have been moved to Part A. No calculator can be used for the multiple choice or the new Part A.)

1999

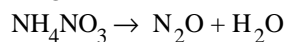
- (a) Calcium oxide powder is added to distilled water.
 (b) Solid ammonium nitrate is heated to temperatures above 300°C.
 (c) Liquid bromine is shaken with a .5 M sodium iodide solution.
 (d) Solid lead(II) carbonate is added to a .5 M sulfuric acid solution.
 (e) A mixture of powdered iron(III) oxide and powdered aluminum metal is heated strongly.
 (f) Methylamine gas is bubbled into distilled water.
 (g) Carbon dioxide gas is passed over hot solid, sodium oxide.
 (h) A .2 M barium nitrate solution is added to an alkaline .2 M potassium chromate solution.



No penalty for the set of products { Ca^{2+} , OH^- , and $\text{Ca}(\text{OH})_2$ }

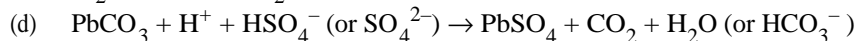
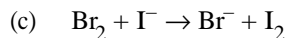


OR



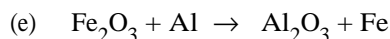
Two points earned for $\text{NH}_4\text{NO}_2 \rightarrow \text{N}_2 + \text{H}_2\text{O}$

No penalty for other oxides of nitrogen (e.g., NO, NO₂, N₂O₃, N₂O₄ - but not N₂O₅)

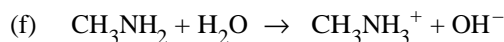


No reactant point earned for H₂SO₄

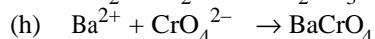
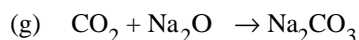
No product point earned for H₂CO₃



No penalty for the set of products { FeO, Fe, and Al₂O₃ }

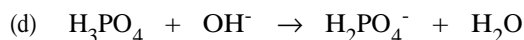
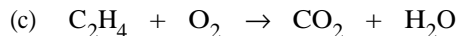
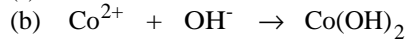
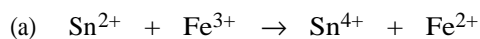


Two points earned for $\text{MeNH}_2 + \text{H}_2\text{O} \rightarrow \text{MeNH}_3^+ + \text{OH}^-$



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.



- (e) $\text{CaSO}_3 \rightarrow \text{CaO} + \text{SO}_2$
 (f) $\text{H}^+ + \text{Cl}^- + \text{Ag}(\text{NH}_3)_2^+ \rightarrow \text{AgCl} + \text{NH}_4^+$
 (g) $\text{Na}_2\text{O} + \text{H}_2\text{O} \rightarrow \text{Na}^+ + \text{OH}^-$
 (h) $\text{Zn} + \text{H}^+ \rightarrow \text{Zn}^{2+} + \text{H}_2$

1997

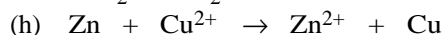
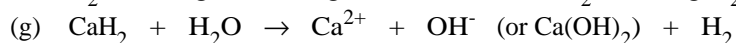
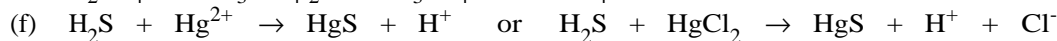
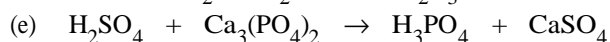
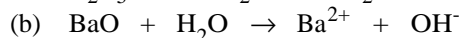
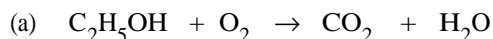
- (a) Excess potassium hydroxide solution is added to a solution of aluminum nitrate.
 (b) A solution of sodium bromide is added to an acidified solution of potassium bromate.
 (c) Sulfur Dioxide gas is bubbled into distilled water.
 (d) Phosphine (phosphorus trihydride) gas is bubbled into liquid boron 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.
- (a) $\text{Al}^{3+} + \text{OH}^- \rightarrow \text{Al}(\text{OH})_3$ Also acceptable: $\text{Al}(\text{OH})_4^-$, $\text{Al}(\text{OH})_4(\text{H}_2\text{O})_2^-$, Al_2O_3 , $\text{Al}_2\text{O}_3 \cdot x\text{H}_2\text{O}$, AlO_2^-
 (b) $\text{H}^+ + \text{Br}^- + \text{BrO}_3^- \rightarrow \text{Br}_2 + \text{H}_2\text{O}$
 (c) $\text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3$
 $\rightarrow \text{H}^+ + \text{HSO}_3^-$
 $\rightarrow \text{H}^+ + \text{HSO}_3^- + \text{SO}_3^{2-}$
 (d) $\text{PH}_3 + \text{BCl}_3 \rightarrow \text{H}_3\text{PBCl}_3$
 $\rightarrow \text{PH}_3\text{BCl}_3$
 (e) $\text{H}_2 + \text{FeO} \rightarrow \text{H}_2\text{O} + \text{Fe}$
 (f) $\text{KNH}_2 + \text{H}_2\text{O} \rightarrow \text{NH}_3 + \text{OH}^- + \text{K}^+$
 $\rightarrow \text{NH}_4\text{OH} + \text{OH}^- + \text{K}^+$
 (g) $\text{Mg} + \text{N}_2 \rightarrow \text{Mg}_3\text{N}_2$
 (h) $\text{Ni}^{2+} + \text{S}^{2-} \rightarrow \text{NiS}$
 $\text{Ni}^{2+} + \text{H}_2\text{S} \rightarrow \text{NiS} + \text{H}^+$
 $\text{Ni}^{2+} + \text{HS}^- \rightarrow \text{NiS} + \text{H}^+$

1996

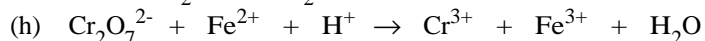
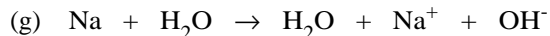
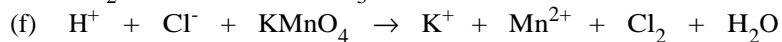
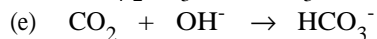
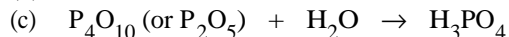
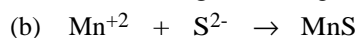
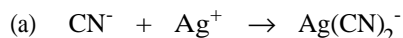
- (a) Solid calcium carbonate is strongly heated.
 (b) A piece of nickel metal is immersed in a solution of copper(II) sulfate.
 (c) Equal volumes of equimolar solutions of disodium hydrogen phosphate and hydrochloric acid are mixed.
 (d) Chlorine gas is bubbled into a solution of sodium bromide.
 (e) 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.
- (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) $\text{NH}_3 + \text{HC}_2\text{H}_3\text{O}_2 \rightarrow \text{C}_2\text{H}_3\text{O}_2^- + \text{NH}_4^+$
 (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) 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 solid 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 solution 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 gas is passed over hot iron filings.
- (e) Water is added to a sample of solid magnesium nitride.
- (f) Excess sulfur dioxide gas 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 tri-potassium phosphate and zinc nitrate are mixed.

- (a) $\text{Cu} + \text{H}^+ + \text{NO}_3^- \rightarrow \text{Cu}^{2+} + \text{NO} + \text{H}_2\text{O}$
 (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) $\text{Mg}_3\text{N}_2 + \text{H}_2\text{O} \rightarrow \text{Mg}(\text{OH})_2 + \text{NH}_3$
 (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) An excess of sodium hydroxide solution is added to a solution of magnesium nitrate.
 (b) Solid lithium hydride 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 tetraamminecopper(II) sulfate.
 (h) Carbon dioxide gas is bubbled through water containing a suspension of calcium carbonate.

- (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) $\text{I}^- + \text{H}_2\text{O} \rightarrow \text{I}_2 + \text{H}_2 + \text{OH}^-$
 (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) $\text{CaCO}_3 + \text{H}_2\text{O} \text{ (or } \text{H}_2\text{CO}_3) \rightarrow \text{Ca}^{+2} + \text{HCO}_3^-$

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 solution of hydrochloric acid is added to powdered manganese dioxide and gently heated.
 (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.

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

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.

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

1989

- (a) Solutions of zinc sulfate and sodium phosphate are mixed.
- (b) Solutions of silver nitrate and lithium bromide are mixed.
- (c) A stream of chlorine gas is passed through a solution of cold, dilute sodium hydroxide.
- (d) Excess hydrochloric acid solution is added to a solution of potassium sulfite.
- (e) A solution of tin(II) chloride is added to an acidified solution of potassium permanganate.
- (f) A solution of ammonium thiocyanate is added to a solution of iron(II) chloride.
- (g) Sample of boron trichloride gas and ammonia gas are mixed.
- (h) Carbon disulfide vapor is burned in excess oxygen.

- (a) $\text{Zn}^{+2} + \text{PO}_4^{-3} \rightarrow \text{Zn}_3(\text{PO}_4)_2$
- (b) $\text{Ag}^+ + \text{Br}^- \rightarrow \text{AgBr}$
- (c) $\text{Cl}_2 + \text{OH}^- \rightarrow \text{ClO}^- + \text{Cl}^- + \text{H}_2\text{O}$
- (d) $\text{H}^+ + \text{SO}_3^{-2} \rightarrow \text{H}_2\text{O} + \text{SO}_2$ or H_2SO_3
- (e) $\text{Sn}^{+2} + \text{H}^+ + \text{MnO}_4^- \rightarrow \text{Sn}^{+4} + \text{Mn}^{+2} + \text{H}_2\text{O}$
- (f) $\text{Fe}^{+3} + \text{SCN}^- \rightarrow \text{Fe}(\text{SCN})^{+2}$ or $\text{Fe}(\text{SCN})_6^{-3}$
- (g) $\text{BCl}_3 + \text{NH}_3 \rightarrow \text{Cl}_3\text{BNH}_3$
- (h) $\text{CS}_2 + \text{O}_2 \rightarrow \text{CO}_2 + \text{SO}_2$ (or SO_3)

1988

- (a) A solution of potassium iodide is added to an acidified solution of potassium dichromate.
- (b) A solution of sodium hydroxide is added to a solution of ammonium chloride.
- (c) A strip of magnesium is added to a solution of silver nitrate.
- (d) Solid potassium chlorate is heated in the presence of manganese dioxide as a catalyst.
- (e) Dilute hydrochloric acid is added to a solution of potassium carbonate.
- (f) Sulfur trioxide gas is added to excess water.
- (g) Dilute sulfuric acid is added to a solution of barium chloride.
- (h) A concentrated solution of ammonia is added to a solution of copper(II) chloride.

- (a) $\text{H}^+ + \text{I}^- + \text{Cr}_2\text{O}_7^{2-} \rightarrow \text{I}_2 + \text{Cr}^{+3} + \text{H}_2\text{O}$
 (b) $\text{OH}^- + \text{NH}_4^+ \rightarrow \text{H}_2\text{O} + \text{NH}_3$
 (c) $\text{Mg} + \text{Ag}^+ \rightarrow \text{Mg}^{+2} + \text{Ag}$
 (d) $\text{KClO}_3 \rightarrow \text{KCl} + \text{O}_2$ (with MnO_2 as a catalyst)
 (e) $\text{H}^+ + \text{CO}_3^{-2} \rightarrow \text{CO}_2 + \text{H}_2\text{O}$ (or H_2CO_3 or HCO_3^-)
 (f) $\text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}^+ + \text{HSO}_4^-$
 (g) $\text{SO}_4^{-2} + \text{Ba}^{+2} \rightarrow \text{BaSO}_4$ (or $\text{HSO}_4^- + \text{Ba}^{+2} \rightarrow \text{BaSO}_4 + \text{H}^+$)
 (h) $\text{Cu}^{+2} + \text{NH}_3 \rightarrow \text{Cu}(\text{NH}_3)_4^{+2}$

1987

- (a) Solid calcium is added to warm water.
 (b) Powdered magnesium oxide is added to a container of carbon dioxide gas.
 (c) Gaseous hydrogen sulfide is bubbled through a solution of nickel(II) nitrate.
 (d) Excess concentrated sodium hydroxide solution is added to solid aluminum hydroxide.
 (e) Solid silver is added to a dilute nitric acid (6M) solution.
 (f) Excess potassium hydroxide solution is added to a solution of potassium dihydrogen phosphate.
 (g) Hydrogen peroxide solution is added to a solution of iron(II) sulfate.
 (h) Propanol is burned completely in air.

- (a) $\text{Ca} + \text{H}_2\text{O} \rightarrow \text{Ca}(\text{OH})_2 + \text{H}_2$
 (b) $\text{MgO} + \text{CO}_2 \rightarrow \text{MgCO}_3$
 (c) $\text{H}_2\text{S} + \text{Ni}^{+2} \rightarrow \text{NiS} + \text{H}^+$
 (d) $\text{OH}^- + \text{Al}(\text{OH})_3 \rightarrow \text{Al}(\text{OH})_4^-$
 (e) $\text{Ag} + \text{H}^+ + \text{NO}_3^- \rightarrow \text{Ag}^+ + \text{H}_2\text{O} + \text{NO}$ (NO_2 also accepted)
 (f) $\text{OH}^- + \text{H}_2\text{PO}_4^- \rightarrow \text{PO}_4^{-3} + \text{H}_2\text{O}$
 (g) $\text{H}_2\text{O}_2 + \text{Fe}^{+2} \rightarrow \text{Fe}^{+3} + \text{H}_2\text{O}$
 (h) $\text{C}_3\text{H}_7\text{OH} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$

1986

- (a) A piece of lithium metal is dropped into a container of nitrogen gas.
 (b) Dilute hydrochloric acid is added to a solution of potassium sulfite.
 (c) Solid sodium oxide is added to water.
 (d) A solution of sodium sulfide is added to a solution of zinc nitrate.
 (e) A solution of ammonia is added to a dilute solution of acetic acid.
 (f) A piece of iron is added to a solution of iron(III) sulfate.
 (g) Ethene (ethylene) gas is bubbled through a solution of bromine.
 (h) Chlorine gas is bubbled into a solution of potassium iodide.
- (a) $\text{Li} + \text{N}_2 \rightarrow \text{Li}_3\text{N}$
 (b) $\text{H}^+ + \text{SO}_3^{-2} \rightarrow \text{HSO}_3^-$ (or H_2SO_3 or $\text{SO}_2 + \text{H}_2\text{O}$)
 (c) $\text{Na}_2\text{O} + \text{H}_2\text{O} \rightarrow \text{Na}^+ + \text{OH}^-$
 (d) $\text{Zn}^{+2} + \text{S}^{-2} \rightarrow \text{ZnS}$ (or $\text{Zn}^{+2} + \text{HS}^- \rightarrow \text{ZnS} + \text{H}^+$)
 (e) $\text{NH}_3 + \text{HC}_2\text{H}_3\text{O}_2 \rightarrow \text{NH}_4^+ + \text{C}_2\text{H}_3\text{O}_2^-$
 (f) $\text{Fe}^{+3} + \text{Fe} \rightarrow \text{Fe}^{+2}$
 (g) $\text{C}_2\text{H}_4 + \text{Br}_2 \rightarrow \text{C}_2\text{H}_4\text{Br}_2$
 (h) $\text{Cl}_2 + \text{I}^- \rightarrow \text{I}_2 + \text{Cl}^-$

1985

- (a) Sodium metal is added to water.
- (b) Dilute sulfuric acid is added to a solution of lithium hydrogencarbonate.
- (c) Ethanol and formic acid (methanoic acid) are mixed and warmed.
- (d) Excess concentrated potassium hydroxide solution is added to a precipitate of zinc hydroxide.
- (e) The gases boron trifluoride and ammonia are mixed.
- (f) A solution of tin(II) chloride is added to a solution of iron(III) sulfate.
- (g) Phosphorus(V) oxytrichloride is added to water.
- (h) An acidified solution of sodium permanganate is added to a solution of sodium sulfite.

- (a) $\text{Na} + \text{H}_2\text{O} \rightarrow \text{Na}^+ + \text{OH}^- + \text{H}_2$
- (b) $\text{H}^+ + \text{HCO}_3^- \rightarrow \text{H}_2\text{O} + \text{CO}_2$
- (c) $\text{C}_2\text{H}_5\text{OH} + \text{HCOOH} \rightarrow \text{HCOOC}_2\text{H}_5 + \text{H}_2\text{O}$
- (d) $\text{OH}^- + \text{Zn}(\text{OH})_2 \rightarrow \text{Zn}(\text{OH})_4^{2-}$
- (e) $\text{BF}_3 + \text{NH}_3 \rightarrow \text{F}_3\text{BNH}_3$
- (f) $\text{Sn}^{+2} + \text{Fe}^{+3} \rightarrow \text{Sn}^{+4} + \text{Fe}^{+2}$
- (g) $\text{POCl}_3 + \text{H}_2\text{O} \rightarrow \text{H}_3\text{PO}_4 + \text{H}^+ + \text{Cl}^-$
- (h) $\text{MnO}_4^- + \text{SO}_3^{2-} + \text{H}^+ \rightarrow \text{Mn}^{+2} + \text{SO}_4^{2-} + \text{H}_2\text{O}$

(During the years 1983 and 1984, the AP Chemistry Exam did not use the reactions prediction section in the essay questions but placed this in the multiple choice section.)

1982

- (a) Hydrogen gas is passed over hot iron(III) oxide.
- (b) Solutions of potassium iodide and potassium iodate are mixed in acid solution.
- (c) Dilute sulfuric acid is added to solid calcium fluoride.
- (d) Solid ammonium carbonate is heated.
- (e) Methane gas is mixed with an excess of chlorine gas.
- (f) A concentrated solution of ammonia is added to a suspension of zinc hydroxide.
- (g) Hydrogen peroxide is added to an acidified solution of sodium bromide.
- (h) Dilute hydrochloric acid is added to a dilute solution of mercury(I) nitrate.

- (a) $\text{H}_2 + \text{Fe}_2\text{O}_3 \rightarrow \text{Fe (or FeO)} + \text{H}_2\text{O}$
- (b) $\text{I}^- + \text{IO}_3^- \rightarrow \text{I}_2 + \text{H}_2\text{O}$
- (c) $\text{H}^+ + \text{SO}_4^{2-} + \text{CaF}_2 \rightarrow \text{HF} + \text{CaSO}_4$
- (d) $(\text{NH}_4)_2\text{CO}_3 \rightarrow \text{H}_2\text{O} + \text{CO}_2 + \text{NH}_3$
- (e) $\text{CH}_4 + \text{Cl}_2 \rightarrow \text{CCl}_4 + \text{HCl}$
- (f) $\text{Zn}(\text{OH})_2 + \text{NH}_3 \rightarrow \text{Zn}(\text{NH}_3)_4^{+2} + \text{OH}^-$
- (g) $\text{H}_2\text{O}_2 + \text{Br}^- + \text{H}^+ \rightarrow \text{Br}_2 + \text{H}_2\text{O}$
- (h) $\text{Hg}_2^{+2} + \text{Cl}^- \rightarrow \text{Hg}_2\text{Cl}_2$

1981

- (a) Magnesium metal is burned in nitrogen gas.
- (b) Sulfur dioxide gas is passed over solid calcium oxide.
- (c) Lead foil is immersed in silver nitrate solution.
- (d) A solution of ammonium sulfate is added to a saturated solution of barium hydroxide.
- (e) Acetic acid solution is added to a solution of sodium hydrogencarbonate.
- (f) Solid sodium dichromate is added to an acidified solution of sodium iodide.
- (g) A drop of potassium thiocyanate is added to a solution of iron(III) chloride.

(h) Ethanol is completely burned in air.

