# 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.

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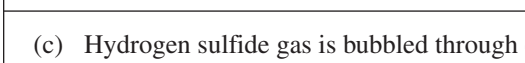
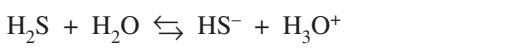
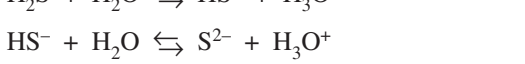
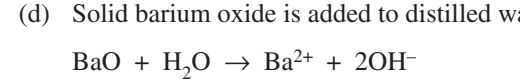
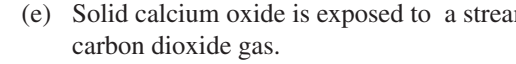
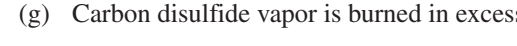
| (a) A solution of ammonia is added to a dilute solution of acetic acid.<br>  | Identify the conjugate acid–base pairs in this reaction.<br>**Answer:** $NH_3$ (base) and $NH_4^+$ (acid)<br>$CH_3COOH$ (acid) and $CH_3COO^-$ (base) |
| (b) Solutions of sodium hydroxide and acetic acid are mixed.<br>  | 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.<br>**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.<br>  | Write the successive ionization equations for $H_2S$.<br>**Answer:**  <br>  |
| (d) Solid barium oxide is added to distilled water.<br>  | Is the resulting solution acidic, basic or neutral? Explain.<br>**Answer:** Basic. Metal oxides form basic compounds in water. |
| (e) Solid calcium oxide is exposed to a stream of carbon dioxide gas.<br>  | What type of reaction has occurred?<br>**Answer:** A synthesis (or combination) reaction. |
| (f) Solid dinitrogen pentoxide is added to water.<br>  | Is the final solution acidic, basic or neutral? Explain.<br>**Answer:** Acidic. Nonmetal oxides form acidic compounds in water. |
| (g) Carbon disulfide vapor is burned in excess oxygen.<br>  | What is the oxidizing agent in this reaction?<br>**Answer:** Oxygen. |



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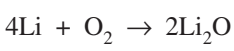
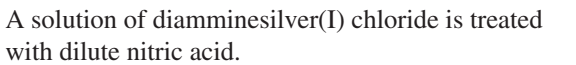
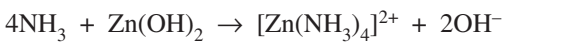
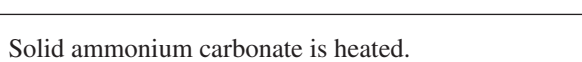
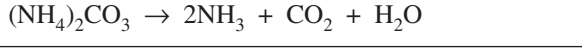
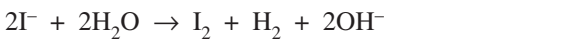
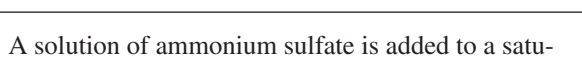
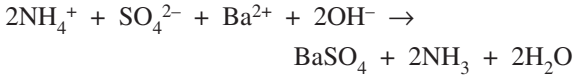
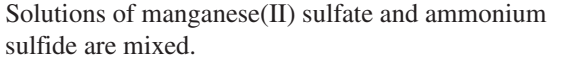
| (h) Lithium metal is burned in air.<br>  | Besides combustion, what type of reaction could this be classified as?<br>**Answer:** The reaction may be classified as both a synthesis and a redox reaction. |
| (i) A solution of diamminesilver(I) chloride is treated with dilute nitric acid.<br>  | What is the driving force for this reaction?<br>**Answer:** Precipitation of silver chloride. |
| (j) A concentrated solution of ammonia is added to a suspension of zinc hydroxide.<br>  | What are the possible molecular geometries for the complex ion product?<br>**Answer:** All $[ML_4]^{n+}$ complex ions have either a tetrahedral or square planar geometry. |
| (k) Excess concentrated sodium hydroxide solution is added to solid aluminum hydroxide.<br>  | Name any complex ion formed in the reaction.<br>**Answer:** Tetrahydroxoaluminate. |
| (l) Solid ammonium carbonate is heated.<br>  | Classify the type of reaction occurring.<br>**Answer:** This is a decomposition reaction. |
| (m) A solution of hydrogen peroxide is catalytically decomposed.<br>  | Name the element being reduced and the element being oxidized.<br>**Answer:** Oxygen is being both reduced and oxidized. |
| (n) A solution of potassium iodide is electrolyzed.<br>  | At which electrode would a gas be released?<br>**Answer:** Hydrogen gas is released at the cathode (the negative electrode). |
| (o) A solution of copper(II) sulfate is electrolyzed using inert electrodes.<br>  | Is the final solution acidic, basic, or neutral?<br>**Answer:** Acidic hydrogen ions ($H^+$) are produced in the reaction. |
| (p) A solution of ammonium sulfate is added to a saturated solution of barium hydroxide.<br>  | Identify any precipitate formed in the reaction.<br>**Answer:** Barium sulfate, $BaSO_4$. |
| (q) A solution of copper(II) chloride is added to a solution of sodium sulfide.<br>  | Name the spectator ions in this reaction.<br>**Answer:** The chloride ion, $Cl^-$, and the sodium ion, $Na^+$. |
| (r) Solutions of manganese(II) sulfate and ammonium sulfide are mixed.<br>  | List any precipitate that forms during the reaction.<br>**Answer:** Manganese(II) sulfide, MnS. |



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| (s) Solutions of silver nitrate and sodium chromate are mixed.<br>$2Ag^+ + CrO_4^{2-} \rightarrow Ag_2CrO_4$ | What is the oxidation number of chromium in the chromate ion?<br>**Answer:** +6. |
| (t) Glacial acetic acid is mixed with liquid methanol (nonaqueous).<br>$CH_3COOH + CH_3OH \rightarrow CH_3COOCH_3 + H_2O$ | What type of organic reaction can this be characterized as?<br>**Answer:** An esterification reaction. |
| (u) Chlorine gas is bubbled into a cold, dilute solution of potassium hydroxide.<br>$Cl_2 + 2OH^- \rightarrow ClO^- + Cl^- + H_2O$ | What element is undergoing oxidation and what element is undergoing reduction?<br>**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.<br>$Cu + 4H^+ + 2NO_3^- \rightarrow Cu^{2+} + 2NO_2 + 2H_2O$ | List at least two observations that indicate a chemical reaction is occurring.<br>**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.<br>$H_2 + FeO \rightarrow Fe + H_2O$ | What is the oxidation number of the hydrogen in hydrogen gas?<br>**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.<br>$2MnO_4^- + 6H^+ + 5NO_2^- \rightarrow 2Mn^{2+} + 3H_2O + 5NO_3^-$ | Write and balance the oxidation half-reaction for mass and charge.<br>**Answer:** $H_2O + NO_2^- \rightarrow NO_3^- + 2H^+ + 2e^-$ |
| (y) A solution of sodium bromide is added to an acidified solution of potassium bromate.<br>$5Br^- + 6H^+ + BrO_3^- \rightarrow 3Br_2 + 3H_2O$ | Write and balance the reduction half-reaction for mass and charge.<br>**Answer:** $12H^+ + 2BrO_3^- + 10e^- \rightarrow Br_2 + 6H_2O$ |
| (z) Aluminum metal is added to a solution of copper(II) chloride.<br>$2Al + 3Cu^{2+} \rightarrow 2Al^{3+} + 3Cu$ | List at least two observations that indicate a chemical reaction is occurring.<br>**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.<br>$3Cl_2 + 2Fe \rightarrow 2FeCl_3$ | What type of reaction is occurring?<br>**Answer:** A synthesis reaction (or a redox reaction). |
| (bb) Magnesium metal is added to nitrogen gas.<br>$3Mg + N_2 \rightarrow Mg_3N_2$ | What is the oxidation number of magnesium before and after the reaction?<br>**Answer:** Magnesium goes from zero in Mg to +2 in $Mg_3N_2$. |



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| (cc) Solid lithium hydride is added to distilled water.<br>$LiH + H_2O \rightarrow Li^+ + OH^- + H_2$ | Is the final solution acidic, basic or neutral? Explain.<br>**Answer:** Basic. Metallic hydrides react with water to form metallic hydroxides. |
| (dd) Benzene is treated with bromine in the presence of a catalyst.<br>$Br_2 + C_6H_6 \rightarrow C_6H_5Br + HBr$ | Classify the type of organic reaction that takes place.<br>**Answer:** This is a substitution reaction. |
| (ee) Solid lithium oxide is added to excess water.<br>$Li_2O + H_2O \rightarrow 2Li^+ + 2OH^-$ | Is the final solution acidic, basic or neutral? Explain.<br>**Answer:** Basic. Soluble metal oxides react in water to form bases (metallic hydroxides). |
| (ff) Solid potassium chlorate is heated in the presence of manganese dioxide as a catalyst.<br>$2KClO_3 \xrightarrow{MnO_2} 2KCl + 3O_2$ | How many moles of reaction products can be produced from one mole of potassium chlorate?<br>**Answer:** 2½ moles. |
| (gg) Dilute hydrochloric acid is added to a solution of potassium sulfite.<br>$2H^+ + SO_3^{2-} \rightarrow H_2O + SO_2$ | List all spectator ions.<br>**Answer:** Potassium, $K^+$, and chloride, $Cl^-$. |
| (hh) A solution of sulfuric acid is added to a solution of barium hydroxide until the same number of moles of each compound has been added.<br>$2H^+ + SO_4^{2-} + Ba^{2+} + 2OH^- \rightarrow BaSO_4 + 2H_2O$ | Is the final solution acidic, basic or neutral? Explain.<br>**Answer:** Neutral. The neutralization of a strong base [$Ba(OH)_2$] by a strong acid [$H_2SO_4$] yields a neutral solution. |
| (ii) A mixture of solid calcium oxide and solid tetraphosphorus decaoxide is heated.<br>$6CaO + P_4O_{10} \rightarrow 2Ca_3(PO_4)_2$ | Is the product compound(s) soluble in water?<br>**Answer:** No. Phosphates other than those of group 1 elements and $NH_4^+$ are insoluble. |
| (jj) Sulfur dioxide gas is passed over solid calcium oxide.<br>$SO_2 + CaO \rightarrow CaSO_3$ | Name the product compound(s).<br>**Answer:** Calcium sulfite. |
| (kk) Solid zinc sulfide is heated in an excess of oxygen.<br>$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$ | What change in oxidation state does sulfur undergo in this reaction?<br>**Answer:** Sulfur starts out as –2 in ZnS and ends up as +4 in $SO_2$. The charge is +6. |
| (ll) A solution of potassium iodide is added to an acidified solution of potassium dichromate.<br>$6I^- + 14H^+ + Cr_2O_7^{2-} \rightarrow 3I_2 + 2Cr^{3+} + 7H_2O$ | What is the reducing agent in this reaction?<br>**Answer:** The species that undergoes oxidation, in this case iodide ion, $I^-$, is the reducing agent. |



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