

AP[®] CHEMISTRY
2012 SCORING GUIDELINES

Question 4
(15 points)

(a) A piece of solid strontium carbonate is dropped into a 0.1 *M* solution of hydrochloric acid.

<p>(i) Balanced equation:</p> $2 \text{H}^+ + \text{SrCO}_3 \rightarrow \text{Sr}^{2+} + \text{CO}_2 + \text{H}_2\text{O}$ <p style="text-align: center;">OR,</p> $\text{H}^+ + \text{SrCO}_3 \rightarrow \text{Sr}^{2+} + \text{HCO}_3^-$	<p>1 point is earned for the correct reactants.</p> <p>2 points are earned for the correct products.</p> <p>1 point is earned for correctly balancing the equation for mass and charge.</p>
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(ii) Indicate one thing that would be observed as the reaction occurs.

The solid dissolves OR a gas is given off.	1 point is earned for either observation.
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(b) Magnesium metal is strongly heated in oxygen gas.

<p>(i) Balanced equation:</p> $2 \text{Mg} + \text{O}_2 \rightarrow 2 \text{MgO}$	<p>2 points are earned for the correct reactants.</p> <p>1 point is earned for the correct product.</p> <p>1 point is earned for correctly balancing the equation for mass and charge.</p>
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(ii) What is the oxidation number of magnesium before the reaction occurs, and what is the oxidation number of magnesium after the reaction is complete?

Oxidation number before = 0. Oxidation number after = +2.	1 point is earned for two correct responses.
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AP[®] CHEMISTRY
2012 SCORING GUIDELINES

Question 4 (continued)

(c) A solution of nickel(II) chloride is added to a solution of sodium hydroxide, forming a precipitate.

(i) Balanced equation: $\text{Ni}^{2+} + 2 \text{OH}^{-} \rightarrow \text{Ni}(\text{OH})_2$	2 points are earned for the correct reactants. 1 point is earned for the correct product. 1 point is earned for correctly balancing the equation for mass and charge.
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(ii) If equal volumes of 1.0 *M* nickel (II) chloride and 1.0 *M* sodium hydroxide are used, what ion is present in the solution in the highest concentration after the precipitate forms?

The chloride ion	1 point is earned for the correct ion.
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AP[®] CHEMISTRY
2010 SCORING GUIDELINES

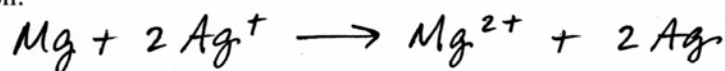
Question 4
(15 points)

For each of the following three reactions, write a balanced equation for the reaction in part (i) and answer the question about the reaction in part (ii). In part (i), coefficients should be in terms of lowest whole numbers. Assume that solutions are aqueous unless otherwise indicated. Represent substances in solutions as ions if the substances are extensively ionized. Omit formulas for any ions or molecules that are unchanged by the reaction. You may use the empty space at the bottom of the next page for scratch work, but only equations that are written in the answer boxes provided will be scored.

EXAMPLE:

A strip of magnesium metal is added to a solution of silver(I) nitrate.

(i) Balanced equation:



(ii) Which substance is oxidized in the reaction?

Mg is oxidized.

(a) A 0.2 M potassium hydroxide solution is titrated with a 0.1 M nitric acid solution.

(i) Balanced equation:



OR



One point is earned for each correct reactant.

One point is earned for the correct product.

One point is earned for correctly balancing (mass and charge) the equation.

(ii) What would be observed if the solution was titrated well past the equivalence point using bromthymol blue as the indicator? (Bromthymol blue is yellow in acidic solution and blue in basic solution.)

The solution would appear yellow.

One point is earned for the correct description of the solution.

AP[®] CHEMISTRY
2010 SCORING GUIDELINES

Question 4 (continued)

(b) Propane is burned completely in excess oxygen gas.

(i) Balanced equation: $\text{C}_3\text{H}_8 + 5 \text{O}_2 \rightarrow 3 \text{CO}_2 + 4 \text{H}_2\text{O}$	One point is earned for both correct reactants. Two points are earned for the correct products. One point is earned for correctly balancing the equation.
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(ii) When the products of the reaction are bubbled through distilled water, is the resulting solution neutral, acidic, or basic? Explain.

The resulting solution would be acidic because CO_2 reacts with water as a weak acid.	One point is earned for the correct choice with justification.
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(c) A solution of hydrogen peroxide is heated, and a gas is produced.

(i) Balanced equation: $2 \text{H}_2\text{O}_2 \rightarrow 2 \text{H}_2\text{O} + \text{O}_2$	One point is earned for the correct reactant. Two points are earned for the correct products. One point is earned for correctly balancing the equation.
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(ii) Identify the oxidation state of oxygen in hydrogen peroxide.

The oxidation state of O in H_2O_2 is -1 .	One point is earned for the correct oxidation state.
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AP[®] CHEMISTRY
2010 SCORING GUIDELINES (Form B)

Question 4
(15 points)

(a) Solid copper(II) sulfate pentahydrate is gently heated.

<p>(i) Balanced equation:</p> $\text{CuSO}_4 \cdot 5\text{H}_2\text{O} \rightarrow \text{CuSO}_4 + 5 \text{H}_2\text{O}$	<p>One point is earned for the reactant. Two points are earned for products. One point is earned for balancing the equation.</p>
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(ii) How many grams of water are present in 1.00 mol of copper(II) sulfate pentahydrate?

$1.00 \text{ mol CuSO}_4 \cdot 5\text{H}_2\text{O} \times \frac{5 \text{ mol H}_2\text{O}}{1.00 \text{ mol CuSO}_4 \cdot 5\text{H}_2\text{O}} \times \frac{18.0 \text{ g H}_2\text{O}}{1.00 \text{ mol H}_2\text{O}}$ $= 90.0 \text{ g H}_2\text{O}$	<p>One point is earned for the correct numerical answer.</p>
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(b) Excess concentrated aqueous ammonia is added to a solution of nickel(II) nitrate, leading to the formation of a complex ion.

<p>(i) Balanced equation:</p> $\text{Ni}^{2+} + 6 \text{NH}_3 \rightarrow [\text{Ni}(\text{NH}_3)_6]^{2+}$	<p>Two points are earned for reactants. One point is earned for the product. One point is earned for balancing (mass and charge) the equation.</p>
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(ii) Which of the reactants acts as a Lewis acid?

Ni^{2+}	<p>One point is earned for correct identification of the Lewis acid.</p>
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(c) Methylamine (CH_3NH_2) is added to a solution of hydrochloric acid.

<p>(i) Balanced equation:</p> $\text{CH}_3\text{NH}_2 + \text{H}^+ \rightarrow \text{CH}_3\text{NH}_3^+$ <p style="text-align: center;"><i>OR</i></p> $\text{CH}_3\text{NH}_2 + \text{H}_3\text{O}^+ \rightarrow \text{CH}_3\text{NH}_3^+ + \text{H}_2\text{O}$	<p>Two points are earned for reactants. One point is earned for the product. One point is earned for balancing (mass and charge) the equation.</p>
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(ii) Methylamine dissolves in water to form a solution. Indicate whether this solution is acidic, basic, or neutral.

<p>The solution would be basic (because it would react with water to form CH_3NH_3^+ ions and OH^- ions).</p>	<p>One point is earned for the correct choice.</p>
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AP[®] Chemistry
Free-Response Scoring Guidelines

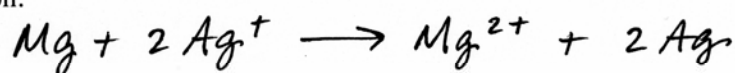
Question 4

For each of the following three reactions, in part (i) write a balanced equation and in part (ii) answer the question about the reaction. In part (i), coefficients should be in terms of lowest whole numbers. Assume that solutions are aqueous unless otherwise indicated. Represent substances in solutions as ions if the substances are extensively ionized. Omit formulas for any ions or molecules that are unchanged by the reaction. You may use the empty space at the bottom of the next page for scratch work, but only equations that are written in the answer boxes provided will be graded.

EXAMPLE:

A strip of magnesium metal is added to a solution of silver(I) nitrate.

(i) Balanced equation:

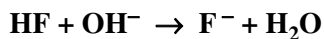


(ii) Which substance is oxidized in the reaction?

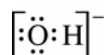
Mg is oxidized.

(a) Equal volumes of 0.1 M hydrofluoric acid and 0.1 M potassium hydroxide are combined.

(i) Balanced equation:

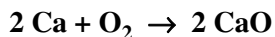


(ii) Draw the complete Lewis electron-dot diagram for the reactant that is the Brønsted-Lowry base in the forward reaction.



(b) Solid calcium metal burns in air.

(i) Balanced equation:



(ii) Predict the algebraic sign of ΔH° for the reaction. Explain your prediction.

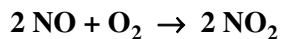
The sign of ΔH° will be negative because ΔG° is negative (the reaction occurs) and ΔS° is negative (a solid and a gas react to form a solid). According to the Gibbs-Helmholtz equation, $\Delta H^\circ = \Delta G^\circ + T\Delta S^\circ$. Therefore ΔH° is the sum of two negative quantities and as such must be negative.

AP[®] Chemistry
Free-Response Scoring Guidelines

Question 4 (continued)

(c) Samples of nitrogen monoxide gas and oxygen gas are combined.

(i) Balanced equation:



(ii) If the reaction is second order with respect to nitrogen monoxide and first order with respect to oxygen, what is the rate law for the reaction?

$$\text{rate} = k[\text{NO}]^2[\text{O}_2]$$

General Scoring Notes for Question 4

Five points are earned for each of parts (a), (b), and (c), distributed as follows.

Four points are earned for part (i): one point for the correct reactants, two points for the correct product(s), and one point for the correct coefficients in the balanced equation.

One point is earned for the correct answer in part (ii).