

**AP<sup>®</sup> CHEMISTRY**  
**2009 SCORING GUIDELINES**

**Question 4 (15 points)**

(a) A sample of solid iron(III) oxide is reduced completely with solid carbon.

<p>(i) Balanced equation:</p> $2 \text{Fe}_2\text{O}_3 + 3 \text{C} \rightarrow 4 \text{Fe} + 3 \text{CO}_2$ <p style="text-align: center;"><b>OR</b></p> $\text{Fe}_2\text{O}_3 + 3 \text{C} \rightarrow 2 \text{Fe} + 3 \text{CO}$	<p>One point is earned for both correct reactants.</p> <p>Two points are earned for the correct products (1 point each).</p> <p>One point is earned for correctly balancing (mass and charge) the equation.</p>
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(ii) What is the oxidation number of carbon before the reaction, and what is the oxidation number of carbon after the reaction is complete?

<p>The oxidation number of C before the reaction is 0, and the oxidation number of C after the reaction is +4.</p>	<p>One point is earned for both oxidation numbers consistent with part (i).</p>
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(b) Equal volumes of equimolar solutions of ammonia and hydrochloric acid are combined.

<p>(i) Balanced equation:</p> $\text{NH}_3 + \text{H}^+ \rightarrow \text{NH}_4^+$ <p style="text-align: center;"><b>OR</b></p> $\text{NH}_3 + \text{H}_3\text{O}^+ \rightarrow \text{NH}_4^+ + \text{H}_2\text{O}$	<p>Two points are earned for the correct reactants.</p> <p>One point is earned for the correct product(s).</p> <p>One point is earned for correctly balancing (mass and charge) the equation.</p>
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(ii) Indicate whether the resulting solution is acidic, basic, or neutral. Explain.

<p>The resulting solution is acidic because of the hydrolysis of the <math>\text{NH}_4^+</math> ion, which reacts with water to form <math>\text{NH}_3</math> and <math>\text{H}^+</math>.</p> <p><b>OR</b></p> <p>The mixing of a strong acid and a weak base results in an acidic solution.</p>	<p>One point is earned for a correct answer consistent with part (i).</p>
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**AP<sup>®</sup> CHEMISTRY**  
**2009 SCORING GUIDELINES**

**Question 4 (continued)**

(c) Solid mercury(II) oxide decomposes as it is heated in an open test tube in a fume hood.

<p>(i) Balanced equation:</p> $2 \text{HgO} \rightarrow 2 \text{Hg} + \text{O}_2$	<p>One point is earned for the correct reactant.</p> <p>Two points are earned for the correct products (1 point each).</p> <p>One point is earned for correctly balancing (mass and charge) the equation.</p>
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(ii) After the reaction is complete, is the mass of the material in the test tube greater than, less than, or equal to the mass of the original sample? Explain.

<p>The mass of the contents of the test tube will decrease owing to the loss of O<sub>2</sub> gas to the atmosphere.</p>	<p>One point is earned for a correct answer consistent with part (i).</p>
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CHEMISTRY

Part B

Time—40 minutes

NO CALCULATORS MAY BE USED FOR PART B.

Answer Question 4 below. The Section II score weighting for this question is 10 percent.

4. For each of the following three reactions, write a balanced equation in part (i) and answer the question 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 graded.

**EXAMPLE:**

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

(i) Balanced equation:

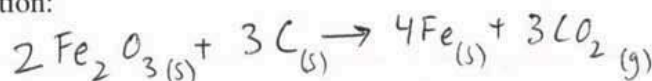


(ii) Which substance is oxidized in the reaction?

Mg is oxidized.

- (a) A sample of solid iron(III) oxide is reduced completely with solid carbon.

(i) Balanced equation:

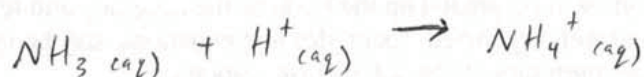


(ii) What is the oxidation number of carbon before the reaction, and what is the oxidation number of carbon after the reaction is complete?

Carbon: before reaction: 0  
after reaction: +4

(b) Equal volumes of equimolar solutions of ammonia and hydrochloric acid are combined.

(i) Balanced equation:

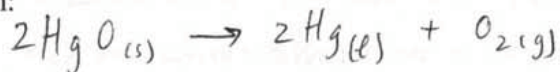


(ii) Indicate whether the resulting solution is acidic, basic, or neutral. Explain.

acidic, all ammonia will be converted to  $\text{NH}_4^+(\text{aq})$ . Then  $\text{NH}_4^+$ , a weak acid, will release a bit of  $\text{H}^+$  into the solution, causing it to be acidic

(c) Solid mercury(II) oxide decomposes as it is heated in an open test tube in a fume hood.

(i) Balanced equation:



(ii) After the reaction is complete, is the mass of the material in the test tube greater than, less than, or equal to the mass of the original sample? Explain.

less than the original mass, gaseous  $\text{O}_2$  escapes into the air

**YOU MAY USE THE SPACE BELOW FOR SCRATCH WORK, BUT ONLY EQUATIONS THAT ARE WRITTEN IN THE ANSWER BOXES PROVIDED WILL BE GRADED.**

CHEMISTRY

Part B

Time—40 minutes

NO CALCULATORS MAY BE USED FOR PART B.

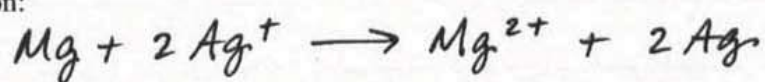
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**EXAMPLE:**

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

(i) Balanced equation:

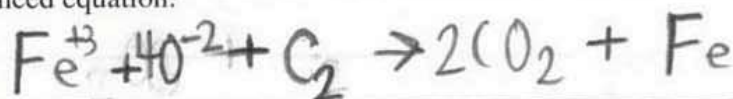


(ii) Which substance is oxidized in the reaction?

Mg is oxidized.

- (a) A sample of solid iron(III) oxide is reduced completely with solid carbon.

(i) Balanced equation:



(ii) What is the oxidation number of carbon before the reaction, and what is the oxidation number of carbon after the reaction is complete?

Before the oxidation the carbon has a neutral charge but after the oxidation it has a charge of -4.

(b) Equal volumes of equimolar solutions of ammonia and hydrochloric acid are combined.

(i) Balanced equation:

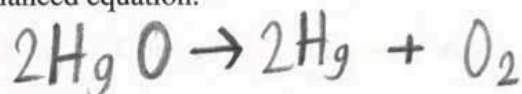


(ii) Indicate whether the resulting solution is acidic, basic, or neutral. Explain.

acidic

(c) Solid mercury(II) oxide decomposes as it is heated in an open test tube in a fume hood.

(i) Balanced equation:



(ii) After the reaction is complete, is the mass of the material in the test tube greater than, less than, or equal to the mass of the original sample? Explain.

The mass in the test tube would be lower, as the gaseous products would diffuse out of the test tube.

**YOU MAY USE THE SPACE BELOW FOR SCRATCH WORK, BUT ONLY EQUATIONS THAT ARE WRITTEN IN THE ANSWER BOXES PROVIDED WILL BE GRADED.**

## CHEMISTRY

## Part B

Time—40 minutes

NO CALCULATORS MAY BE USED FOR PART B.

4C  
1 of 2

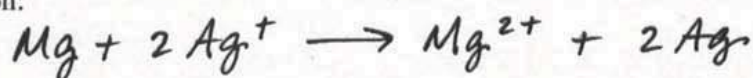
Answer Question 4 below. The Section II score weighting for this question is 10 percent.

4. For each of the following three reactions, write a balanced equation in part (i) and answer the question 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 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) A sample of solid iron(III) oxide is reduced completely with solid carbon.

(i) Balanced equation:



(ii) What is the oxidation number of carbon before the reaction, and what is the oxidation number of carbon after the reaction is complete?

Before: 0

After: +4

(b) Equal volumes of equimolar solutions of ammonia and hydrochloric acid are combined.

(i) Balanced equation:



(ii) Indicate whether the resulting solution is acidic, basic, or neutral. Explain.

Basic because  $\text{NH}_4$  is produced and  $\text{HCl}$  is broken apart.

(c) Solid mercury(II) oxide decomposes as it is heated in an open test tube in a fume hood.

(i) Balanced equation:



(ii) After the reaction is complete, is the mass of the material in the test tube greater than, less than, or equal to the mass of the original sample? Explain.

Greater than because heat causes the test tube and the contents to get heavier.

**YOU MAY USE THE SPACE BELOW FOR SCRATCH WORK, BUT ONLY EQUATIONS THAT ARE WRITTEN IN THE ANSWER BOXES PROVIDED WILL BE GRADED.**



**AP<sup>®</sup> CHEMISTRY**  
**2009 SCORING COMMENTARY**

**Question 4**

**Overview**

This question assessed students' ability to communicate their knowledge of chemical processes. Important skills tested included writing chemical formulas for substances and balancing equations. Additional aspects of the problem evaluated general understanding of chemical concepts presented to students in both the classroom and the laboratory.

**Sample: 4A**  
**Score: 15**

This response earned all 15 points: 4 for part (a)(i), 1 for part (a)(ii), 4 for part (b)(i), 1 for part (b)(ii), 4 for part (c)(i), and 1 for part (c)(ii).

**Sample: 4B**  
**Score: 10**

In part (a) the student earned 2 of the possible 5 points. The student did not earn the reactant point because the formulas for iron(III) oxide and carbon are incorrect. The student earned both product points for the correct product formulas. The balancing point was not earned because the charge is not balanced. In part (a)(ii) the point was not earned because the oxidation number given for carbon after the reaction is incorrect. In part (b) the student earned 3 of the possible 5 points. There are 2 reactant points and 1 product point available in part (b)(i). The formula for ammonia is correct, but hydrochloric acid is not shown as being extensively ionized, so only 1 of the 2 reactant points was earned. The product point was earned because " $\text{NH}_4^+$ " is correct and the inclusion of " $\text{Cl}^-$ " is consistent with the reactants given. Because the equation is both charge and mass balanced, the student earned the balancing point. In part (b)(ii) the point was not earned because there is no explanation for why the solution is acidic. The student earned all 5 points in part (c). The student earned the point in part (c)(ii) by indicating that there would be a loss of mass owing to the gas leaving the test tube.

**Sample: 4C**  
**Score: 5**

The student earned 3 of the possible 5 points in part (a). One of the 2 product points was not earned because " $\text{Fe}^{+3}$ " is not a correct product, and the balancing point was not earned because the charge is not balanced. In part (b) the student earned 1 of the 5 points. The formula for ammonia is correct, but the HCl is not shown as being extensively ionized, so only 1 of the 2 reactant points was earned. The product point was not earned because the ammonium ion is shown without a charge. The balancing point was not earned because the charges are not balanced. The point was not earned in part (b)(ii). In part (c) the student earned 1 of the 5 points. The reactant point was not earned because an extra reactant is included. Only 1 of the 2 product points was earned because mercury in the +2 state is incorrect. The balancing point was not earned because the equation is not mass or charge balanced. The point was not earned in part (c)(ii).