

**AP<sup>®</sup> CHEMISTRY**  
**2009 SCORING GUIDELINES (Form B)**

**Question 4 (15 points)**

- (a) A barium nitrate solution and a potassium fluoride solution are combined and a precipitate forms.

<p>(i) Balanced equation:</p> $\text{Ba}^{2+} + 2 \text{F}^{-} \rightarrow \text{BaF}_2$	<p>Two points are earned for the correct reactants (1 point each).</p> <p>One point is earned for the correct product.</p> <p>One point is earned for correctly balancing the equation for atoms and charge.</p>
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- (ii) If equimolar amounts of barium nitrate and potassium fluoride are combined, which reactant, if any, is the limiting reactant? Explain.

<p>According to the balanced chemical equation, twice as much potassium fluoride is required to completely react with the barium nitrate. Because there are equimolar amounts of barium nitrate and potassium fluoride, there is not enough potassium fluoride to react with all of the barium nitrate, so potassium fluoride is the limiting reactant.</p>	<p>One point is earned for a correct answer that is consistent with part (i).</p>
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- (b) A piece of cadmium metal is oxidized by adding it to a solution of copper(II) chloride.

<p>(i) Balanced equation:</p> $\text{Cd} + \text{Cu}^{2+} \rightarrow \text{Cd}^{2+} + \text{Cu}$	<p>One point is earned for <u>both</u> correct reactants.</p> <p>One point is earned for <u>both</u> correct products.</p> <p>One point is earned for correctly balancing the equation for atoms and charge.</p>
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- (ii) List two visible changes that would occur in the reaction container as the reaction is proceeding.

<p>In the solution, the blue color of the copper(II) cation would decrease, and eventually the solution would become colorless.</p> <p>Reddish-brown (or black) copper metal would plate out onto the piece of silvery cadmium metal.</p>	<p>Two points are earned for correctly describing the changes (1 point each).</p>
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**AP<sup>®</sup> CHEMISTRY**  
**2009 SCORING GUIDELINES (Form B)**

**Question 4 (continued)**

(c) A hydrolysis reaction occurs when solid sodium sulfide is added to distilled water.

<p>(i) Balanced equation:</p> $\text{Na}_2\text{S} + \text{H}_2\text{O} \rightarrow 2 \text{Na}^+ + \text{HS}^- + \text{OH}^-$ <p style="text-align: center;"><b>OR</b></p> $\text{Na}_2\text{S} + 2 \text{H}_2\text{O} \rightarrow 2 \text{Na}^+ + \text{H}_2\text{S} + 2 \text{OH}^-$	<p>One point is earned for <u>both</u> correct reactants.</p> <p>One point is earned for any <u>two</u> correct products; 2 points are earned for all <u>three</u> correct products.</p> <p>One point is earned for correctly balancing the equation for atoms and charge.</p>
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(ii) Indicate whether the pH of the resulting solution is less than 7, equal to 7, or greater than 7. Explain.

<p>The pH of the resulting solution is greater than 7. The hydrolysis reaction of <math>\text{S}^{2-}</math> produces the base <math>\text{OH}^-</math>, thus raising the pH above 7.</p>	<p>One point is earned for a correct answer that is 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:

$$\text{Mg} + 2\text{Ag}^+ \rightarrow \text{Mg}^{2+} + 2\text{Ag}$$

(ii) Which substance is oxidized in the reaction?

*Mg is oxidized.*

- (a) A barium nitrate solution and a potassium fluoride solution are combined and a precipitate forms.

(i) Balanced equation:

$$\text{Ba}^{2+} + 2\text{F}^- \rightarrow \text{BaF}_2$$

(ii) If equimolar amounts of barium nitrate and potassium fluoride are combined, which reactant, if any, is the limiting reactant? Explain.

*KF potassium fluoride is the limiting reactant*

4A2

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(b) A piece of cadmium metal is oxidized by adding it to a solution of copper(II) chloride.

(i) Balanced equation:

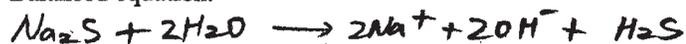


(ii) List two visible changes that would occur in the reaction container as the reaction is proceeding.

1. color of solution changes from blue ( $\text{Cu}^{2+}$ ) to colorless.
2. Cu precipitates

(c) A hydrolysis reaction occurs when solid sodium sulfide is added to distilled water.

(i) Balanced equation:



(ii) Indicate whether the pH of the resulting solution is less than 7, equal to 7, or greater than 7. Explain.

greater than 7.

$\text{OH}^-$  ions are produced.

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

**B B B B B B B B B B B B B**

**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:

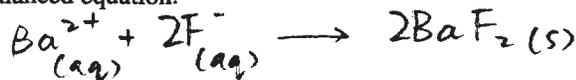


(ii) Which substance is oxidized in the reaction?

Mg is oxidized.

- (a) A barium nitrate solution and a potassium fluoride solution are combined and a precipitate forms.

(i) Balanced equation:



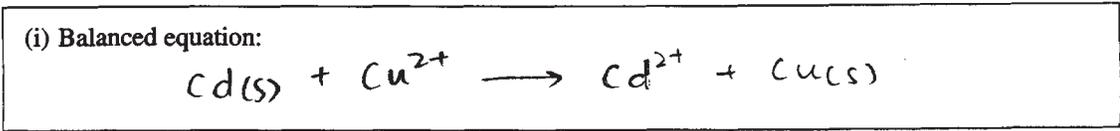
(ii) If equimolar amounts of barium nitrate and potassium fluoride are combined, which reactant, if any, is the limiting reactant? Explain.

Ba<sup>2+</sup> is the limiting reactant because one mole of Ba<sup>2+</sup> is needed to produce 2 mol BaF<sub>2</sub>. It will be used up more quickly than F<sup>-</sup> which has 2 mol

4B<sub>2</sub>

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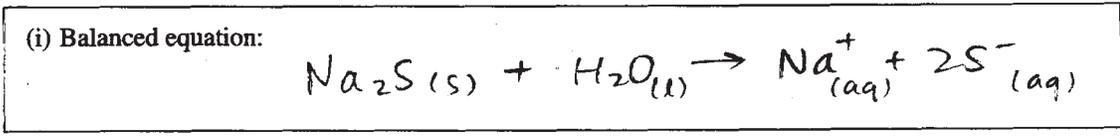
(b) A piece of cadmium metal is oxidized by adding it to a solution of copper(II) chloride.



(ii) List two visible changes that would occur in the reaction container as the reaction is proceeding.

Cd(s) is used up in the reaction as it  
turns in cadmium chloride. Color of the solution  
changes from blue to colorless

(c) A hydrolysis reaction occurs when solid sodium sulfide is added to distilled water.



(ii) Indicate whether the pH of the resulting solution is less than 7, equal to 7, or greater than 7. Explain.

The solution is less than 7 because S<sup>-</sup>  
will react with water to form an acid.

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

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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:  
$$\text{Mg} + 2\text{Ag}^+ \rightarrow \text{Mg}^{2+} + 2\text{Ag}$$

(ii) Which substance is oxidized in the reaction?  
Mg is oxidized.

- (a) A barium nitrate solution and a potassium fluoride solution are combined and a precipitate forms.

(i) Balanced equation:  
$$\text{Ba}(\text{NO}_3)_2 + 2\text{KF} \rightarrow \text{BaF}_2 + 2\text{KNO}_3$$

(ii) If equimolar amounts of barium nitrate and potassium fluoride are combined, which reactant, if any, is the limiting reactant? Explain.  
The limiting reactant is barium nitrate, because it has more molar mass < heavier >.

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**B B B B B B B B B B B B B**

(b) A piece of cadmium metal is oxidized by adding it to a solution of copper(II) chloride.

(i) Balanced equation:



(ii) List two visible changes that would occur in the reaction container as the reaction is proceeding.

The color will change, heavier.

(c) A hydrolysis reaction occurs when solid sodium sulfide is added to distilled water.

(i) Balanced equation:



(ii) Indicate whether the pH of the resulting solution is less than 7, equal to 7, or greater than 7. Explain.

pH would be less than 7, because of acid  $\text{HSO}_4^-$ .

**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 (Form B)**

**Question 4**

**Sample: 4A**

**Score: 14**

This response earned 14 of the possible 15 points: 4 for part (a)(i), 3 for part (b)(i), 2 for part (b)(ii), 4 for part (c)(i), and 1 for part (c)(ii). In part (a)(ii) although the answer is correct, the required explanation is not given, and the point was not earned.

**Sample: 4B**

**Score: 9**

This response earned 9 of the possible 15 points. In part (a)(i) both reactant points were earned for showing the correct reactants with correct charges. The product point was earned, but the balancing point was not earned. In part (a)(ii) the response incorrectly identifies the limiting reactant and so did not earn the point. In part (b)(i) 1 point was earned for the correct reactants with proper charges; 1 point was earned for the correct products with proper charges; and 1 point was earned for balancing. In part (b)(ii) both points were earned—one for the fading of the blue color and one for stating that cadmium solid is “used up.” In part (c) the only point earned was for the correct reactants.

**Sample: 4C**

**Score: 5**

This response earned 5 of the possible 15 points. In part (a)(i) neither reactant point was earned because both reactants are shown in molecular form, but 1 product point was earned because the products are consistent with the molecular reactants. The balancing point was not earned. In part (a)(ii) the response incorrectly identifies the limiting reactant and so did not earn the point. In part (b)(i) the reactant point was not earned because the reactants are shown in molecular form; 1 product point was earned because the products are consistent with the molecular reactants; and 1 point was earned for balancing. In part (b)(ii) neither point was earned because the color change is not specified and the term “heavier” is vague and incorrect. In part (c)(i) 1 point was earned for the correct reactants. Neither of the product points nor the balancing point was earned. In part (c)(ii) 1 point was earned for stating that the pH is less than 7, owing to the production of an acidic species, because this is consistent with the products given.