AP® CHEMISTRY
2010 SCORING GUIDELINES (Form B)

Question 4
(15 points)

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

(i) Balanced equation: $CuSO_4 \cdot 5H_2O \rightarrow CuSO_4 + 5\ H_2O$	One point is earned for the reactant. Two points are earned for products. One point is earned for balancing the equation.

(ii) How many grams of water are present in 1.00 mol of copper(II) sulfate pentahydrate?

$1.00\ \text{mol}\ CuSO_4\ 5H_2O \times \frac{5\ \text{mol}\ H_2O}{1.00\ \text{mol}\ CuSO_4\ 5H_2O} \times \frac{18.0\ \text{g}\ H_2O}{1.00\ \text{mol}\ H_2O}$ $= 90.0\ \text{g}\ H_2O$	One point is earned for the correct numerical answer.

(b) Excess concentrated aqueous ammonia is added to a solution of nickel(II) nitrate, leading to the formation of a complex ion.

(i) Balanced equation: $Ni^{2+} + 6\ NH_3 \rightarrow [Ni(NH_3)_6]^{2+}$	Two points are earned for reactants. One point is earned for the product. One point is earned for balancing (mass and charge) the equation.

(ii) Which of the reactants acts as a Lewis acid?

Ni^{2+}	One point is earned for correct identification of the Lewis acid.

(c) Methylamine (CH_3NH_2) is added to a solution of hydrochloric acid.

(i) Balanced equation: $CH_3NH_2 + H^+ \rightarrow CH_3NH_3^+$ *OR* $CH_3NH_2 + H_3O^+ \rightarrow CH_3NH_3^+ + H_2O$	Two points are earned for reactants. One point is earned for the product. One point is earned for balancing (mass and charge) the equation.

(ii) Methylamine dissolves in water to form a solution. Indicate whether this solution is acidic, basic, or neutral.

The solution would be basic (because it would react with water to form $CH_3NH_3^+$ ions and OH^- ions).	One point is earned for the correct choice.

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, 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 scored.

EXAMPLE:

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

(i) Balanced equation:

$$Mg + 2Ag^+ \longrightarrow Mg^{2+} + 2Ag$$

(ii) Which substance is oxidized in the reaction?

Mg is oxidized.

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

(i) Balanced equation:

$$CuSO_4 \cdot 5H_2O \xrightarrow{\Delta} CuSO_4 + 5H_2O$$

(ii) How many grams of water are present in 1.00 mol of copper(II) sulfate pentahydrate?

there are 90.20g of water in 1.00 mol of copper (II) sulfate pentahydrate.

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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.

(i) Balanced equation:

$Ni^{2+} + 4NH_3 \rightarrow Ni(NH_3)_4^{2+}$

(ii) Which of the reactants acts as a Lewis acid?

Ni^{2+} acts as a lewis acid.

(c) Methylamine (CH_3NH_2) is added to a solution of hydrochloric acid.

(i) Balanced equation:

$CH_3NH_2 + H^+ \rightarrow CH_3NH_3^+$

(ii) Methylamine dissolves in water to form a solution. Indicate whether this solution is acidic, basic, or neutral.

this solution is basic.

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

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CHEMISTRY
Part B
Time—40 minutes
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(i) Balanced equation:

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(ii) Which substance is oxidized in the reaction?

Mg is oxidized.

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

(i) Balanced equation:

$CuSO_4 \cdot 5H_2O \xrightarrow{\Delta} CuSO_4 + 5H_2O$

(ii) How many grams of water are present in 1.00 mol of copper(II) sulfate pentahydrate?

$CuSO_4 \cdot 5H_2O \longrightarrow H_2O$

1 : 5 × 18g

1 : ? = 90g of water

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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.

(i) Balanced equation:

$NH_3 + Ni^{2+} \longrightarrow [Ni(NH_3)]^{2+}$

(ii) Which of the reactants acts as a Lewis acid?

lewis acid => electron acceptor Ni^{2+}

(c) Methylamine (CH_3NH_2) is added to a solution of hydrochloric acid.

(i) Balanced equation:

$CH_3NH_2 + Cl^- \longrightarrow CH_3NHCl + H_2$

(ii) Methylamine dissolves in water to form a solution. Indicate whether this solution is acidic, basic, or neutral.

the solution will be basic

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CHEMISTRY
Part B
Time—40 minutes
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EXAMPLE:

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

(i) Balanced equation:

$Mg + 2Ag^+ \longrightarrow Mg^{2+} + 2Ag$

(ii) Which substance is oxidized in the reaction?

Mg is oxidized.

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

(i) Balanced equation:

$CuSO_4 \cdot 5H_2O(s) \rightarrow Cu^{2+} + SO_4^{2-} + 5H_2O$

(ii) How many grams of water are present in 1.00 mol of copper(II) sulfate pentahydrate?

$(64\ g/mol + 32\ g/mol + 64\ g/mol + 5 \times 18\ g/mol) \times 1.00\ mol$

$= 250\ g.$

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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.

(i) Balanced equation:

$NH_3 + Ni(NO_3)_2 \rightarrow [Ni_4(NHNO_3)_2]^{2-}$

(ii) Which of the reactants acts as a Lewis acid?

NH_3 is a Lewis acid

(c) Methylamine (CH_3NH_2) is added to a solution of hydrochloric acid.

(i) Balanced equation:

$CH_3NH_2 + H^+ \rightarrow CH_3^+ + NH_3$

(ii) Methylamine dissolves in water to form a solution. Indicate whether this solution is acidic, basic, or neutral.

the solution is acidic.

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

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AP® CHEMISTRY
2010 SCORING COMMENTARY (Form B)

Question 4

Sample: 4A
Score: 15

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

Sample: 4B
Score: 12

This response earned 12 of the possible 15 points. The response earned all the points possible in parts (a) and (b). In part (c)(i) 1 of the reactant points was earned for the methylamine; the product point and the balancing point were not earned. The point was earned in part (c)(ii).

Sample: 4C
Score: 7

This response earned 7 of the possible 15 points. In part (a)(i) 1 point was earned for the reactants and 1 point for balancing atoms and charge, but only 1 of the two product points was earned because the copper(II) sulfate is shown as being dissociated. In part (a)(ii) the point was not earned because the student incorrectly determines the mass of water present. In part (b)(i) 1 of the 2 reactant points was earned for the ammonia, the product point was not earned because there is not an acceptable complex ion shown, and the balancing point was not earned. In part (b)(ii) the point was not earned because the student incorrectly identifies ammonia as the Lewis acid. In part (c)(i) 2 points were earned for the correct reactants, the product point was not earned, and 1 point was earned for balancing mass and charge in the given equation. In part (c)(ii) the point was not earned because the student incorrectly indicates that the solution is acidic.