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:

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

(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: $H_3O^+ + OH^- \rightarrow 2\,H_2O$ ***OR*** $H^+ + OH^- \rightarrow H_2O$	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.

Question 4 (continued)

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

(i) Balanced equation: $C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$	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.

(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.

(c) A solution of hydrogen peroxide is heated, and a gas is produced.

(i) Balanced equation: $2\ H_2O_2 \rightarrow 2\ H_2O + O_2$	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.

(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.

4A,

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 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:

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

(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 net equation:

$OH^-_{(aq)} + H^+_{(aq)} \longrightarrow H_2O_{(l)}$

(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.)

Once the titration is past the equivalence point, the excess acid will turn the solution acidic and the indicator will be yellow.

GO ON TO THE NEXT PAGE.

4A2

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

(i) Balanced equation:

$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$

(ii) When the products of the reaction are bubbled through distilled water, is the resulting solution neutral, acidic, or basic? Explain.

The resulting solution will be acidic because CO_2 reacts with water to form the weak acid, H_2CO_3.

(c) A solution of hydrogen peroxide is heated, and a gas is produced.

(i) Balanced equation:

$2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$

(ii) Identify the oxidation state of oxygen in hydrogen peroxide.

The oxidation of the oxygen in hydrogen peroxide is -1.

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

4B,

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 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:

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

(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.

$K^{+} + OH^{-} + HNO_3 \rightarrow H_2O + K^{+} + NO_3^{-}$

(i) Balanced equation:

$$OH^{-} + H^{+} \longrightarrow H_2O$$

(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.)

IT WOULD BE YELLOW AS MORE HNO_3 IS ADDED (BEYOND EQUIV. PT) THEREFORE MAKING AN ACID SLN

4B 2

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

(i) Balanced equation:

$C_2H_4 + 3O_2 \rightarrow 2H_2O + 2CO_2$

(ii) When the products of the reaction are bubbled through distilled water, is the resulting solution neutral, acidic, or basic? Explain.

NEUTRAL - NO OH^- OR H^+ IONS WILL DISSOCIATE

(c) A solution of hydrogen peroxide is heated, and a gas is produced.

(i) Balanced equation:

$H_2O_2 \rightarrow H_2 + O_2$

(ii) Identify the oxidation state of oxygen in hydrogen peroxide.

OXYGEN = 1-

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

4C

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 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:

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

(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: $OH^- + H^+ \longrightarrow H_2O_{(l)}$

~~$OH^- + H^+ + NO_3$~~

(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 will be ~~green~~ blue.

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

4C2

(i) Balanced equation:

$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$

(ii) When the products of the reaction are bubbled through distilled water, is the resulting solution neutral, acidic, or basic? Explain.

The solution is neutral. Neither of the products are strong acids or bases, in this reaction.

(c) A solution of hydrogen peroxide is heated, and a gas is produced.

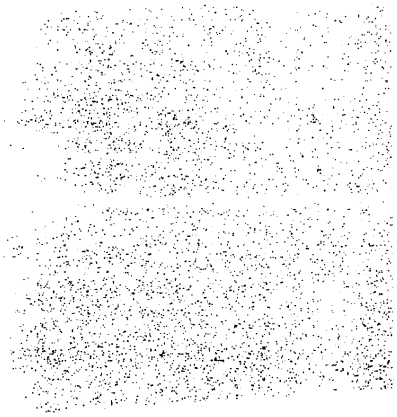
(i) Balanced equation:

$H_2O_2 + heat \rightarrow$

(ii) Identify the oxidation state of oxygen in hydrogen peroxide.

Oxygen is a -1 oxidation state.

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



AP® CHEMISTRY
2010 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 possible 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

In this response 5 points were earned for part (a). The response earned 3 of the possible 5 points in part (b). The reactant point was not earned because the formula for propane is incorrect. Both product points and the balancing point were earned. In part (b)(ii) the point was not earned because the solution is acidic, not neutral. In part (c) the response earned 4 of the possible 5 points. The response earned the reactant point but only 1 of the 2 product points for identifying O_2 but not H_2O. The response earned 1 point for the balanced equation. The response earned the point in part (c)(ii) for the correct oxidation number for oxygen in peroxide.

Sample: 4C
Score: 9

In part (a) this response earned 4 of the possible 5 points. The response did not earn the point in part (a)(ii) because the color of the solution is given as blue. The response earned 3 of the possible 5 points for part (b). In part (b)(i) the reactant point was not earned because the formula for propane is incorrect. Both product points and the balancing point were earned. In part (c) the response earned 2 of the possible 5 points. In part (c)(i) the reactant point was earned. No products were written so no points were earned for products or for balancing the equation. In part (c)(ii) the point was earned for giving the oxidation number of oxygen as –1.