AP® CHEMISTRY
2007 SCORING GUIDELINES (Form B)

Question 4

For each of the following three reactions, in part (i) write a balanced equation for the reaction 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.

(a) Solid ammonium carbonate decomposes as it is heated.

(i) Balanced equation: $(NH_4)_2CO_3 \rightarrow 2\,NH_3 + CO_2 + H_2O$	One point is earned for the correct reactant. Two points are earned for correct products. One point is earned for balancing mass and charge.

(ii) Predict the algebraic sign of $\Delta S°$ for the reaction. Explain your reasoning.

The algebraic sign of $\Delta S°$ for the reaction will be positive because one mole of solid (with relatively low entropy) is converted into four moles of gas (with much greater entropy).	One point is earned for the correct answer.

(b) Chlorine gas, an oxidizing agent, is bubbled into a solution of potassium bromide.

(i) Balanced equation: $Cl_2 + 2\,Br^- \rightarrow 2\,Cl^- + Br_2$	One point is earned for correct reactants. Two points are earned for correct products. One point is earned for balancing mass and charge.

(ii) What is the oxidation number of chlorine <u>before</u> the reaction occurs? What is the oxidation number of chlorine <u>after</u> the reaction occurs?

The oxidation number of chlorine is 0 before the reaction and −1 after the reaction.	One point is earned for the correct answer.

(c) A small piece of sodium is placed in a beaker of distilled water.

(i) Balanced equation: $2\,Na + 2\,H_2O \rightarrow H_2 + 2\,Na^+ + 2\,OH^-$	One point is earned for correct reactants. Two points are earned for correct products. One point is earned for balancing mass and charge.

(ii) The reaction is exothermic, and sometimes small flames are observed as the sodium reacts with the water. Identify the product of the reaction that burns to produce the flames.

It is the H_2 gas that burns.	One point is earned for the correct answer.

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 for the reaction 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:

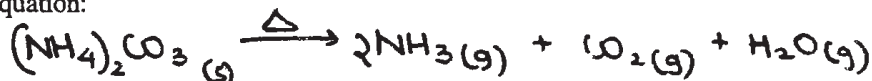$$Mg + 2Ag^+ \longrightarrow Mg^{2+} + 2Ag$$

(ii) Which substance is oxidized in the reaction?

Mg is oxidized.

(a) Solid ammonium carbonate decomposes as it is heated.

(i) Balanced equation:

$$(NH_4)_2CO_3(s) \xrightarrow{\Delta} 2NH_3(g) + CO_2(g) + H_2O(g)$$

(ii) Predict the algebraic sign of $\Delta S°$ for the reaction. Explain your reasoning.

$\Delta S°$ will be positive because the products are gases which are much more random and disordered than the solid reactants

(b) Chlorine gas, an oxidizing agent, is bubbled into a solution of potassium bromide.

(i) Balanced equation:

$$Cl_2(g) + 2Br^-(aq) \longrightarrow Br_2(g) + 2Cl^-(aq)$$

(ii) What is the oxidation number of chlorine before the reaction occurs? What is the oxidation number of chlorine after the reaction occurs?

before reaction: oxidation number is 0
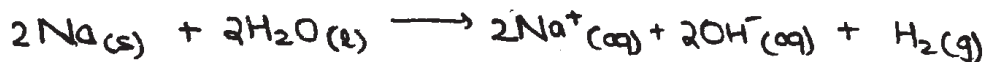*after the reaction: oxidation number is −1*

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B B B B B B B B B B B B B B B 4A₂

$2Na + 2H_2O \rightarrow 2NaOH + H_2$

(c) A small piece of sodium is placed in a beaker of distilled water.

(i) Balanced equation:

$$2 Na_{(s)} + 2H_2O_{(l)} \longrightarrow 2Na^+_{(aq)} + 2OH^-_{(aq)} + H_2(g)$$

(ii) The reaction is exothermic, and sometimes small flames are observed as the sodium reacts with the water. Identify the product of the reaction that burns to produce the flames.

The hydrogen gas burns to produce the flames ($H_2(g)$)

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.

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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 ammonium carbonate decomposes as it is heated.

(i) Balanced equation:

$$(NH_4)_2CO_3 + O_2 \rightarrow NH_3 + CO_2 + H_2O$$

(ii) Predict the algebraic sign of $\Delta S°$ for the reaction. Explain your reasoning.

It will be positive because solid goes to gas → more disorder & more entropy.

(b) Chlorine gas, an oxidizing agent, is bubbled into a solution of potassium bromide.

(i) Balanced equation:

$$Cl_2 + Br^- \rightarrow Cl^- + Br_2$$

(ii) What is the oxidation number of chlorine <u>before</u> the reaction occurs? What is the oxidation number of chlorine <u>after</u> the reaction occurs?

Before, the oxidation number is 0. After, the oxidation number is (-1)

-16-   **GO ON TO THE NEXT PAGE.**

(c) A small piece of sodium is placed in a beaker of distilled water.

(i) Balanced equation:

$$Na + H_2O \rightarrow Na^+ + OH^- + H_2 \uparrow$$

(ii) The reaction is exothermic, and sometimes small flames are observed as the sodium reacts with the water. Identify the product of the reaction that burns to produce the flames.

H_2 burns to produce flames

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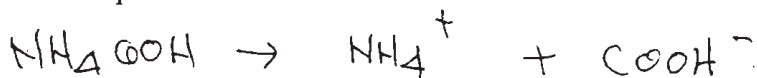
$$Mg + 2Ag^+ \longrightarrow Mg^{2+} + 2Ag$$

(ii) Which substance is oxidized in the reaction?

Mg is oxidized.

(a) Solid ammonium carbonate decomposes as it is heated.

(i) Balanced equation:

$$NH_4COOH \rightarrow NH_4^+ + COOH^-$$

(ii) Predict the algebraic sign of $\Delta S°$ for the reaction. Explain your reasoning.

$\Sigma NH_4COOH - (\Sigma NH_4 + \Sigma COOH)$

(b) Chlorine gas, an oxidizing agent, is bubbled into a solution of potassium bromide.

(i) Balanced equation:

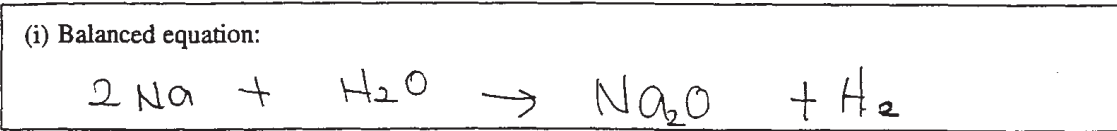$$2KBr + Cl_2 \rightarrow 2K_2Cl_2 + 2Br$$

(ii) What is the oxidation number of chlorine <u>before</u> the reaction occurs? What is the oxidation number of chlorine <u>after</u> the reaction occurs?

before → 0   after → -2

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4C₂

(c) A small piece of sodium is placed in a beaker of distilled water.

(i) Balanced equation:

$$2 Na + H_2O \rightarrow Na_2O + H_2$$

(ii) The reaction is exothermic, and sometimes small flames are observed as the sodium reacts with the water. Identify the product of the reaction that burns to produce the flames.

H_2 ⊗ make a flames

YOU MAY USE THE SPACE BELOW FOR SCRATCH WORK, BUT ONLY EQUATIONS THAT ARE WRITTEN IN THE ANSWER BOXES PROVIDED WILL BE GRADED.
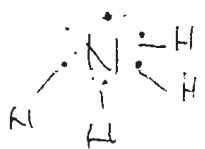
Question 4

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). The student includes the phase subscripts, though they were not necessary for full credit.

Sample: 4B
Score: 11

The reactant point was not earned in part (a)(i) because extraneous oxygen is included. Both product points were earned for a correct set of consistent products. The balancing point was not earned. The point was earned in part (a)(ii). In part (b)(i) 1 reactant point and 2 product points were earned, but the balancing point was not earned. The point was earned in part (b)(ii). In part (c)(i) 1 reactant point and 2 product points were earned, but the balancing point was not earned. The point was earned in part (c)(ii).

Sample: 4C
Score: 6

In part (a) the reactant point and product points were not earned. The balancing point was earned. The point was not earned in part (a)(ii). In part (b)(i) the reactant point was not earned because the reactants are not represented in ionic form. The product points were not earned because the products are not correctly represented. The balancing point was earned. The point was not earned in part (b)(ii) because only one of the oxidation numbers is correct. In part (c)(i) 1 point was earned for the correct reactants, 1 product point was earned, and the balancing point was earned. The point was earned in part (c)(ii).