AP® CHEMISTRY
2007 SCORING GUIDELINES

Question 4

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) A solution of sodium hydroxide is added to a solution of lead(II) nitrate.

(i) Balanced equation: $$2\,OH^- + Pb^{2+} \rightarrow Pb(OH)_2$$	One point is earned for the correct reactants. Two points are earned for the correct product. One point is earned for balancing the equation for mass and charge.

(ii) If 1.0 L volumes of 1.0 M solutions of sodium hydroxide and lead(II) nitrate are mixed together, how many moles of product(s) will be produced? Assume the reaction goes to completion.

A total of 0.5 mol of $Pb(OH)_2$ will be produced.	One point is earned for the correct number of moles.

(b) Excess nitric acid is added to solid calcium carbonate.

(i) Balanced equation: $$2\,H^+ + CaCO_3 \rightarrow Ca^{2+} + H_2O + CO_2$$	One point is earned for the correct reactants. Two points are earned for all three of the correct products; one point is earned for any one or two of the three. One point is earned for balancing the equation for mass and charge.

(ii) Briefly explain why statues made of marble (calcium carbonate) displayed outdoors in urban areas are deteriorating.

The H^+ ions in acid rain react with the marble statues and the soluble compounds of Ca that are formed wash away.	One point is earned for a correct answer involving acid precipitation.

(c) A solution containing silver(I) ion (an oxidizing agent) is mixed with a solution containing iron(II) ion (a reducing agent).

(i) Balanced equation: $$Ag^+ + Fe^{2+} \rightarrow Ag + Fe^{3+}$$	One point is earned for the correct reactants. One point is earned for each of the two correct products. One point is earned for balancing the equation for mass and charge.

(ii) If the contents of the reaction mixture described above are filtered, what substance(s), if any, would remain on the filter paper?

The precipitated solid silver will remain on the filter paper.	One point is earned for the correct substance.

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) A solution of sodium hydroxide is added to a solution of lead(II) nitrate.

(i) Balanced equation:

$$2OH^- + Pb^{2+} \longrightarrow Pb(OH)_2$$

(ii) If 1.0 L volumes of 1.0 M solutions of sodium hydroxide and lead(II) nitrate are mixed together, how many moles of product(s) will be produced? Assume the reaction goes to completion.

.5 moles of product will be produced.

(b) Excess nitric acid is added to solid calcium carbonate. *Cc*

(i) Balanced equation:

$$2H^+ + CaCO_3 \longrightarrow H_2O + CO_2 + Ca^{2+}$$

(ii) Briefly explain why statues made of marble (calcium carbonate) displayed outdoors in urban areas are deteriorating. *(produced when NO₂ dissolves in H₂O to form HNO₃)*
H⁺ ions in the acidic rain, reacts with CaCO₃ in statues according to the above equation; CaCO₃ dissolves, the statues are deteriorated.
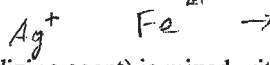
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Ag^+ Fe^{2+} $\rightarrow$

(c) A solution containing silver(I) ion (an oxidizing agent) is mixed with a solution containing iron(II) ion (a reducing agent).

(i) Balanced equation:

$$Ag^+ + Fe^{2+} \rightarrow Fe^{3+} + Ag$$

(ii) If the contents of the reaction mixture described above are filtered, what substance(s), if any, would remain on the filter paper?

Ag solid would remain on the filter paper.

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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4B₁

CHEMISTRY
Part B
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EXAMPLE:

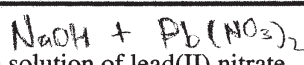A strip of magnesium metal is added to a solution of silver(I) nitrate.
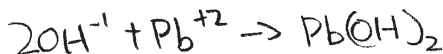
(i) Balanced equation:

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

(ii) Which substance is oxidized in the reaction?

$$Mg \text{ is oxidized.}$$

$NaOH + Pb(NO_3)_2$

(a) A solution of sodium hydroxide is added to a solution of lead(II) nitrate.

(i) Balanced equation:

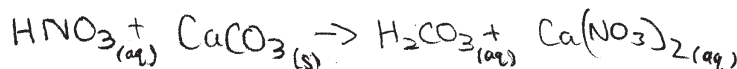$$2OH^{-1} + Pb^{+2} \rightarrow Pb(OH)_2$$

(ii) If 1.0 L volumes of 1.0 M solutions of sodium hydroxide and lead(II) nitrate are mixed together, how many moles of product(s) will be produced? Assume the reaction goes to completion.

0.5 mols.

$CaCO_3$

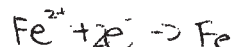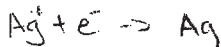(b) Excess nitric acid is added to solid calcium carbonate.

(i) Balanced equation:

$$HNO_{3(aq)} + CaCO_{3(s)} \rightarrow H_2CO_{3(aq)} + Ca(NO_3)_{2(aq)}$$

(ii) Briefly explain why statues made of marble (calcium carbonate) displayed outdoors in urban areas are deteriorating.

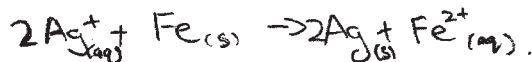This is because the acid in the rain is decomposing the marble. *

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$Ag^+ + e^- \rightarrow Ag \qquad Fe^{2+} + 2e^- \rightarrow Fe$

(c) A solution containing silver(I) ion (an oxidizing agent) is mixed with a solution containing iron(II) ion (a reducing agent).

(i) Balanced equation:

$$2Ag^+_{(aq)} + Fe_{(s)} \rightarrow 2Ag_{(s)} + Fe^{2+}_{(aq)}.$$

(ii) If the contents of the reaction mixture described above are filtered, what substance(s), if any, would remain on the filter paper?

Solid silver (Ag)

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

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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 solution of sodium hydroxide is added to a solution of lead(II) nitrate.

(i) Balanced equation:

$$2 NaOH + Pb(NO_3)_2 \longrightarrow 2 NaNO_3 + Pb(OH)_2$$

(ii) If 1.0 L volumes of 1.0 M solutions of sodium hydroxide and lead(II) nitrate are mixed together, how many moles of product(s) will be produced? Assume the reaction goes to completion.

Three moles of product are produced.

(b) Excess nitric acid is added to solid calcium carbonate.

(i) Balanced equation:

$$HNO_3 + CaCO_3 \longrightarrow Ca(NO_3)_2 + CO + H_2O$$

(ii) Briefly explain why statues made of marble (calcium carbonate) displayed outdoors in urban areas are deteriorating.

The acids are breaking down the CaCO₃ because of acid rain.

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4C₂

(c) A solution containing silver(I) ion (an oxidizing agent) is mixed with a solution containing iron(II) ion (a reducing agent).

(i) Balanced equation:

$$Ag^+ + Fe^{2+} \rightarrow Fe^+ + Ag$$
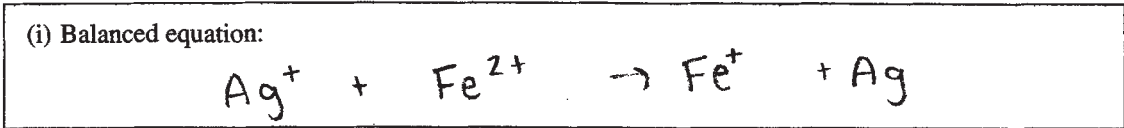
(ii) If the contents of the reaction mixture described above are filtered, what substance(s), if any, would remain on the filter paper?

The silver would remain on the filter paper

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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Question 4

Overview

This question tested students' understanding of precipitation reactions, gas-forming reactions, and oxidation-reduction reactions. Key points covered were:
- Application of solubility rules to reactants and products in a reaction
- Knowledge of spectator ions and how to handle them
- Writing correct net-ionic equations
- Application of solution stoichiometry for a limiting reagent
- Knowledge of mass and charge balance
- Knowledge of nomenclature

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

All points were earned in parts (a)(i) and (a)(ii). In part (b)(i) the reactant point was not earned because nitric acid is shown as not being ionized, as if it were a weak acid. The product points were not earned. Calcium nitrate is a soluble compound and should be written as ions; the nitrate ion is therefore a spectator ion and cancels out of both sides of the equation. In excess acid, carbonic acid forms water and carbon dioxide. Based on the reactants and products written, the reaction is not balanced, so the balance point was not earned. The explanation of deteriorating statues in part (b)(ii) is minimal but earned a point. In part (c)(i) Fe is not one of the reactants given in the question, so the reactant point was not earned. Using the reactants written, it is possible to have the silver species reduced (Ag^+ going to Ag) and the iron species oxidized (Fe going to Fe^{2+}), so the product points were earned. The written equation is both mass and charge balanced, so the balance point was earned. The point was earned in part (c)(ii).

Sample: 4C
Score: 7

In part (a)(i) the reactant point was not earned because the reactants are soluble and should not be shown as compounds. Only 1 out of 2 product points was earned (for the $Pb(OH)_2$); $NaNO_3$ should not be shown as a product. The balance point was earned because the equation is balanced for mass and charge. The point was not earned in part (a)(ii). In part (b)(i) the reactant point was not earned because nitric acid is shown as not being ionized, treating it as a weak acid. In the products, carbonic acid forms H_2O and CO_2. Any one of the three products of the reaction (Ca^{2+}, H_2O, and CO_2) could have earned 1 of the 2 product points, thus 1 product point was earned for the H_2O. The balance point was not earned because there is no mass balance. The point was earned in part (b)(ii). In part (c)(i) 1 point was earned for the reactants. Only 1 product point was earned because Fe^+ is a result of Fe^{2+} being reduced, not oxidized. The reaction is not charge balanced, so the balance point was not earned. The point was earned in part (c)(ii).