

AP[®] CHEMISTRY
2011 SCORING GUIDELINES (Form B)

Question 4
(15 points)

(a) Zinc metal is added to a hydrobromic acid solution.

Balanced equation: $\text{Zn} + 2 \text{H}^+ \rightarrow \text{Zn}^{2+} + \text{H}_2$	1 point is earned for the correct reactants. 2 points are earned for the correct products. 1 point is earned for the balanced equation.
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(ii) Write the oxidation half-reaction for the reaction.

$\text{Zn} \rightarrow \text{Zn}^{2+} + 2 e^-$	1 point is earned for the balanced half-reaction.
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(b) Solid lithium oxide is added to distilled water.

Balanced equation: $\text{Li}_2\text{O} + \text{H}_2\text{O} \rightarrow 2 \text{Li}^+ + 2 \text{OH}^-$	1 point is earned for the correct reactants. 2 points are earned for the correct products. 1 point is earned for the balanced equation.
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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.

The pH of the resulting solution would be greater than 7 because OH^- , a strong base, is formed in the reaction.	1 point is earned for the correct answer.
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(c) A 100 mL sample of 1 M strontium chloride solution is mixed with a 100 mL sample of 1 M sodium carbonate solution, resulting in the formation of a precipitate.

Balanced equation: $\text{Sr}^{2+} + \text{CO}_3^{2-} \rightarrow \text{SrCO}_3$	2 points are earned for the correct reactants. 1 point is earned for the correct product. 1 point is earned for the balanced equation.
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(ii) Describe what will occur if the precipitate is dried and a few drops of 1 M hydrochloric acid are added. Explain.

The precipitate disappears and bubbles of CO_2 form.	1 point is earned for a correct answer.
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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 scored.

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?

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

- (a) Zinc metal is added to a hydrobromic acid solution.

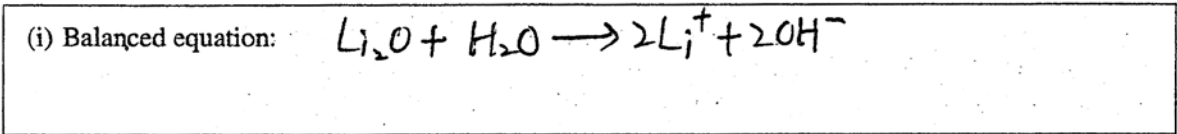
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(ii) Write the oxidation half-reaction for the reaction.

$$\text{Zn} \rightarrow \text{Zn}^{2+} + 2\text{e}^-$$

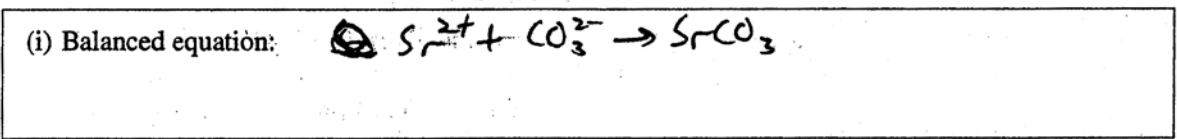
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(b) Solid lithium oxide is added to distilled water.



(ii) Indicate whether the pH of the resulting solution is less than 7, equal to 7, or greater than 7. Explain.
 The pH of the resulting solution is greater than 7, because LiOH is a base that dissociates to release OH⁻, making the solution basic.

(c) A 100 mL sample of 1 M strontium chloride solution is mixed with a 100 mL sample of 1 M sodium carbonate solution, resulting in the formation of a precipitate.



(ii) Describe what will occur if the precipitate is dried and a few drops of 1 M hydrochloric acid are added. Explain.
 The precipitate will ~~decompose~~ dissolve and there will be transparent, odorless gas formed, because

$$2\text{H}^+ + \text{CO}_3^{2-} \rightarrow \text{H}_2\text{O} + \text{CO}_2\uparrow$$

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

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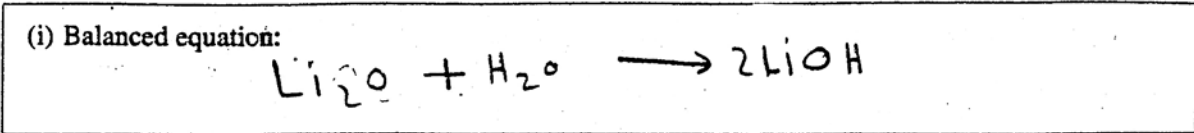
$$\text{Zn}_{(s)} + 2\text{HBr} \rightarrow \text{ZnBr}_2 + \text{H}_2$$

- (ii) Write the oxidation half-reaction for the reaction.

$$\text{Zn} \rightarrow \text{Zn}^{2+} + 2\text{e}^-$$

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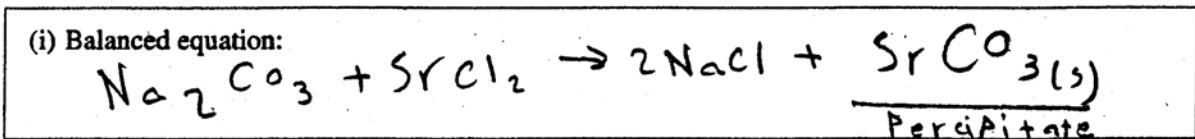
(b) Solid lithium oxide is added to distilled water.



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

greater than 7, LiOH is a basic solution and basic solutions have pH values greater than 7

(c) A 100 mL sample of 1 M strontium chloride solution is mixed with a 100 mL sample of 1 M sodium carbonate solution, resulting in the formation of a precipitate.



(ii) Describe what will occur if the precipitate is dried and a few drops of 1 M hydrochloric acid are added. Explain.

it will react producing salt, water vapor and CO₂ gas

$$\text{SrCO}_3 + 2\text{HCl} \rightarrow \text{SrCl}_2 + \text{H}_2\text{O} + \text{CO}_2$$

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CHEMISTRY

Part B

Time—40 minutes

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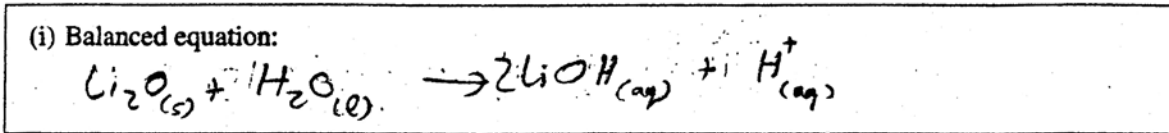
$$\text{Zn(s)} + \text{H}^+_{(\text{aq})} \rightarrow \text{Zn}^{2+}_{(\text{aq})} + \text{H}_2(\text{g})$$

(ii) Write the oxidation half-reaction for the reaction.

$$\text{Zn(s)} \rightarrow \text{Zn}^{2+}_{(\text{aq})} + 2\text{e}^-$$

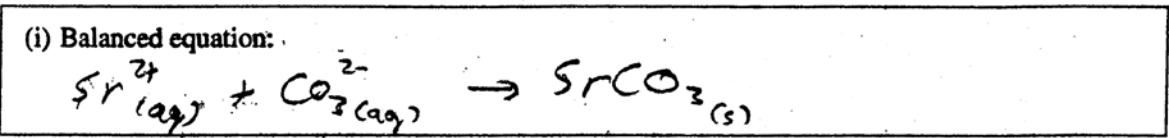
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(b) Solid lithium oxide is added to distilled water.



(ii) Indicate whether the pH of the resulting solution is less than 7, equal to 7, or greater than 7. Explain.
 The solution's pH will be less than 7, because the reaction produces H⁺ ions.

(c) A 100 mL sample of 1 M strontium chloride solution is mixed with a 100 mL sample of 1 M sodium carbonate solution, resulting in the formation of a precipitate.



(ii) Describe what will occur if the precipitate is dried and a few drops of 1 M hydrochloric acid are added. Explain.
H₂CO₃ will be formed and SrCl₂ will also be formed.

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AP[®] CHEMISTRY
2011 SCORING COMMENTARY (Form B)

Question 4

Sample: 4A

Score: 15

This response earned all 15 available points. Part (a) earned all 5 points: 1 point for the correct reactants, 2 points for the correct products, 1 point for balancing both the mass and charges, and 1 point for writing the correct oxidation half-reaction. Part (b) earned all 5 points: 1 point for the correct reactants, 2 points for the correct products, 1 point for balancing both the mass and charges, and 1 point for recognizing that a reaction that released OH^- ions would lead to a solution with a pH greater than 7. Part (c) also earned all 5 points: 2 points for the correct reactants, 1 point for the correct product, 1 point for balancing both the mass and charges, and 1 point for responding that the precipitate would dissolve and that CO_2 gas would be released.

Sample: 4B

Score: 11

Part (a)(i) did not earn the reactant point for representing hydrobromic acid, a strong acid, as undissociated "HBr." One product point was earned for H_2 , but showing the strong electrolyte ZnBr_2 as a molecular solid is incorrect, so the second product point was not earned. Part (b)(i) did not earn 1 of the 2 product points because the strong electrolyte LiOH is shown as undissociated. Part (c)(i) earned 1 of the 2 reactant points because both reactants — strong electrolytes each — are shown in undissociated form. The product point was earned because the correct product (SrCO_3) is shown and is consistent with the reactants.

Sample: 4C

Score: 9

Part (a)(i) did not earn the balancing point because of an unbalanced number of hydrogens and unbalanced charges. No product points were earned in part (b)(i) because of two separate mistakes in the products: the LiOH is represented as an undissociated molecule, and an unwarranted H^+ ion is shown. This part also did not earn the balancing point because the charges are unbalanced. The simultaneous generation of a base (LiOH) and an acid (H^+) does not make sense, so the point was not earned for part (b)(ii). Part (c)(ii) did not earn the point because of the inadequate description of the reaction between SrCO_3 and hydrochloric acid.