

AP[®] CHEMISTRY
2013 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:



(ii) Which substance is oxidized in the reaction?

Mg is oxidized.

(a) A 20.0 mL sample of 0.10 M potassium phosphate is added to a 30.0 mL sample of 0.10 M calcium chloride.



2 points are earned for the correct reactants.

1 point is earned for the correct product.

1 point is earned for the correct balance of both mass and charge.

(ii) How many moles of product are formed?

$$V \times M = (0.0200 \text{ L})(0.10 \text{ M}) = 0.0020 \text{ mol PO}_4^{3-}$$

$$V \times M = (0.0300 \text{ L})(0.10 \text{ M}) = 0.0030 \text{ mol Ca}^{2+}$$

Therefore, 0.0010 mole of $\text{Ca}_3(\text{PO}_4)_2$ is formed.

1 point is earned for the correct number of moles with mathematical justification.

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Question 4 (continued)

(b) Carbon dioxide gas is bubbled into freshly distilled water.

(i) $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}^+ + \text{HCO}_3^-$ OR $\text{CO}_2 + 2 \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{HCO}_3^-$ OR $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$	1 point is earned for the correct reactants. 2 points are earned for the correct product(s). 1 point is earned for the correct balance of both mass and charge.
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(ii) The pH of the solution decreases as the reaction proceeds. Explain.

The reaction produces an acidic species. The solution pH decreases as $[\text{H}^+]$ increases.	1 point is earned for a correct explanation.
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(c) A piece of zinc metal is placed in a 1.0 M solution of hydrochloric acid at 25°C.

(i) $\text{Zn} + 2 \text{H}^+ \rightarrow \text{Zn}^{2+} + \text{H}_2$	1 point is earned for the correct reactants. 2 points are earned for the correct products. 1 point is earned for the correct balance of both mass and charge.
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(ii) When a piece of zinc metal is placed in a 1.0 M solution of ethanoic (acetic) acid at 25°C, the rate of reaction is slower than when 1.0 M hydrochloric acid at 25°C is used. Explain.

Ethanoic acid is a weak acid while HCl is a strong acid, so $[\text{H}^+]$ will be less than it would be with HCl. The rate of reaction depends on $[\text{H}^+]$, so the rate will be slower in ethanoic acid than in hydrochloric acid.	1 point is earned for a correct explanation.
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