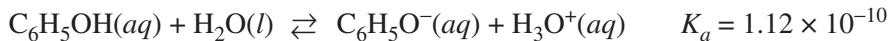


2016 AP[®] CHEMISTRY FREE-RESPONSE QUESTIONS



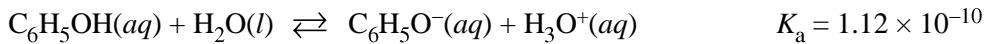
4. Phenol is a weak acid that partially dissociates in water according to the equation above.

- (a) What is the pH of a 0.75 M $\text{C}_6\text{H}_5\text{OH}(aq)$ solution?
- (b) For a certain reaction involving $\text{C}_6\text{H}_5\text{OH}(aq)$ to proceed at a significant rate, the phenol must be primarily in its deprotonated form, $\text{C}_6\text{H}_5\text{O}^-(aq)$. In order to ensure that the $\text{C}_6\text{H}_5\text{OH}(aq)$ is deprotonated, the reaction must be conducted in a buffered solution. On the number scale below, circle each pH for which more than 50 percent of the phenol molecules are in the deprotonated form ($\text{C}_6\text{H}_5\text{O}^-(aq)$). Justify your answer.

1 2 3 4 5 6 7 8 9 10 11 12 13 14

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2016 SCORING GUIDELINES**

Question 4



Phenol is a weak acid that partially dissociates in water, according to the equation above.

- (a) What is the pH of a 0.75 M $\text{C}_6\text{H}_5\text{OH}(aq)$ solution?

$K_a = \frac{[\text{C}_6\text{H}_5\text{O}^-][\text{H}_3\text{O}^+]}{[\text{C}_6\text{H}_5\text{OH}]}$ $1.12 \times 10^{-10} = \frac{x^2}{(0.75 - x)} \quad \text{Assume that } x \ll 0.75.$ $x^2 = 8.4 \times 10^{-11}$ $x = \sqrt{8.4 \times 10^{-11}}$ $x = 9.2 \times 10^{-6} \text{ M}$ $\text{pH} = -\log[\text{H}^+] = -\log(9.2 \times 10^{-6}) = 5.04$	<p>1 point is earned for a correct setup and calculation of $[\text{H}^+]$.</p> <p>1 point is earned for the correct setup and calculation of pH based on a correct setup for the $[\text{H}^+]$ calculation.</p>
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- (b) For a certain reaction involving $\text{C}_6\text{H}_5\text{OH}(aq)$ to proceed at a significant rate, the phenol must be primarily in its deprotonated form, $\text{C}_6\text{H}_5\text{O}^-(aq)$. In order to ensure that the $\text{C}_6\text{H}_5\text{OH}(aq)$ is deprotonated, the reaction must be conducted in a buffered solution. On the number scale below, circle each pH for which more than 50 percent of the phenol molecules are in the deprotonated form ($\text{C}_6\text{H}_5\text{O}^-(aq)$). Justify your answer.

<p>Numbers 10 through 14 should be circled.</p> <p>When $\text{pH} > \text{p}K_a$, the deprotonated form will predominate.</p> <p>$\text{p}K_a = -\log(1.12 \times 10^{-10}) = 9.95$, therefore at pH 10 and above, $[\text{C}_6\text{H}_5\text{O}^-] > [\text{C}_6\text{H}_5\text{OH}]$.</p>	<p>1 point is earned for circling 10–14.</p> <p>1 point is earned for the justification.</p>
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1 2 3 4 5 6 7 8 9 10 11 12 13 14