

Diprotic and Polyprotic Acids

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Phosphoric Acid



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- **Each ionization is characterized by a separate K_a value.**
- **Each successive K_a is smaller than the preceding one.**

Phosphoric Acid

$$7.5 \times 10^{-3}$$



$$6.2 \times 10^{-8}$$



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- **Each ionization is characterized by a separate K_a value.**
- **Each successive K_a is smaller than the preceding one.**
- **For a weak polyprotic acid, the first ionization produces much of the H^+ ions.**

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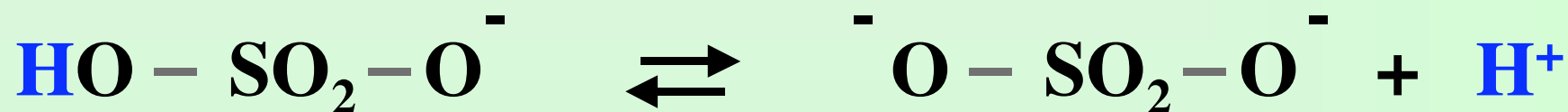
Sulfuric Acid

H_2SO_4 is a strong acid in its first ionization;
but a weak acid in its second.

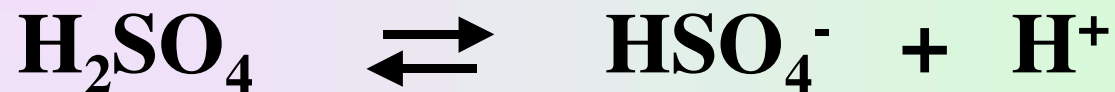
$K_a = \text{very large}$



$K_a = 0.013$



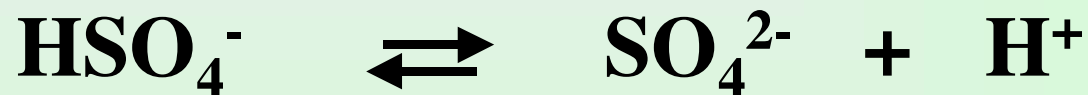
Calculate the pH of a 0.056 M solution of H_2SO_4 .



Init: 0.056 M 0 0

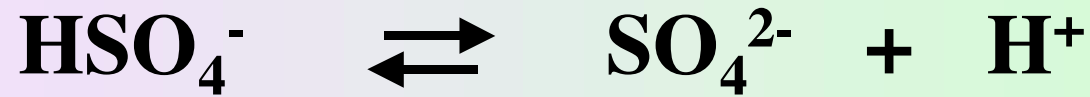
After first ionization:

0 0.056 M 0.056 M



0.056 M 0 0.056 M

0.056 M - x x 0.056 M + x



$$.056 - x$$

$$x$$

$$.056 + x$$

$$K_a = \frac{[\text{SO}_4^{2-}][\text{H}^+]}{[\text{HSO}_4^-]}$$

$$.013 = \frac{(x)(.056 + x)}{(.056 - x)}$$

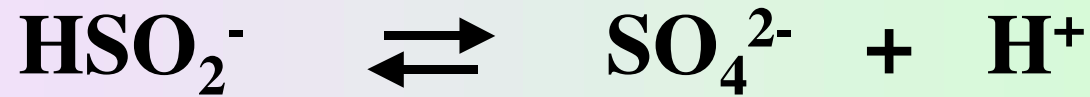
$$0.013 = \frac{(x)(.056)}{(.056)}$$

$$x = .013$$

$$100 \times \frac{.013}{(.056)}$$

$$= 23\%$$

assume x is small compared 0.056



$$.056 - x$$

$$x$$

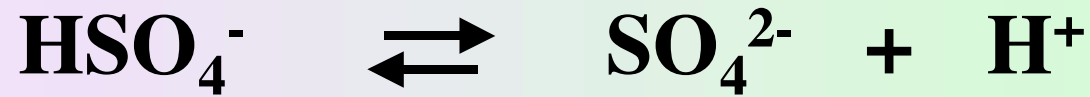
$$.056 + x$$

$$K_a = \frac{[\text{SO}_4^{2-}] [\text{H}^+]}{[\text{HSO}_4^-]}$$

$$x = .056 ;$$

$$.013 = \frac{(x)(.056 + x)}{(.056 - x)}$$

so the
assumption is
invalid



$$.056 - x$$

$$x$$

$$.056 + x$$

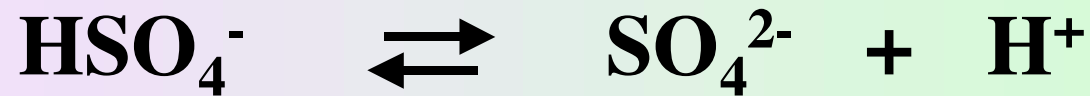
$$K_a = \frac{[\text{SO}_4^{2-}][\text{H}^+]}{[\text{HSO}_4^-]}$$

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$$x^2 + .069x - 7.28 \times 10^{-4} = 0$$

$$x = \frac{-.069 \pm \sqrt{.069^2 - 4(1)(-7.28 \times 10^{-4})}}{2(1)}$$

$$x = 0.0093$$



$$.056 - x$$

$$x$$

$$.056 + x$$

$$K_a = \frac{[\text{SO}_4^{2-}][\text{H}^+]}{[\text{HSO}_4^-]}$$

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$$x = 0.0093$$

$$[\text{H}^+] = (.056 + x)$$

$$= 0.063 \text{ M}$$

$$\text{pH} = 1.19$$

Quadratic equation

$$ax^2 + bx + c = 0$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$x^2 + .069 x - 7.28 \times 10^{-4} = 0$$

$$x = \frac{-.069 \pm \sqrt{.069^2 - 4(1)(-7.28 \times 10^{-4})}}{2(1)}$$

$$x = 0.0093$$