

# **Diprotic and Polyprotic Acids**

# Important Points

- **When an acid has more than one ionizable proton, the protons are lost in successive reactions.**

# Phosphoric Acid

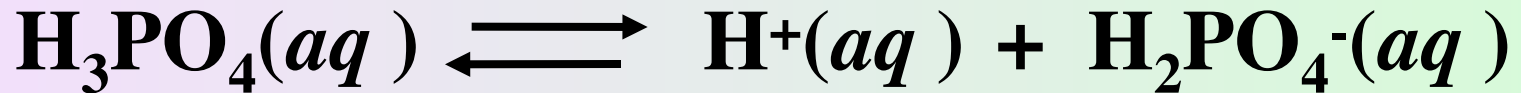


# Important Points

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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

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



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



$$4.8 \times 10^{-13}$$

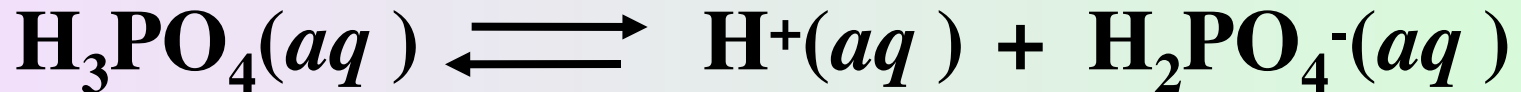


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- **Each ionization is characterized by a separate  $K_a$  value.**
- **Each successive  $K_a$  is smaller than the preceding one.**
- **For a weak polyprotic acid, the first ionization produces much of the  $H^+$  ions.**

# Phosphoric Acid

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



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



$$4.8 \times 10^{-13}$$



# Sulfuric Acid

**H<sub>2</sub>SO<sub>4</sub> is a strong acid in its first ionization;  
but a weak acid in its second.**

$K_a = \text{very large}$

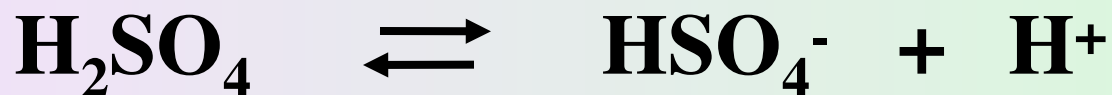


$K_a = 0.013$





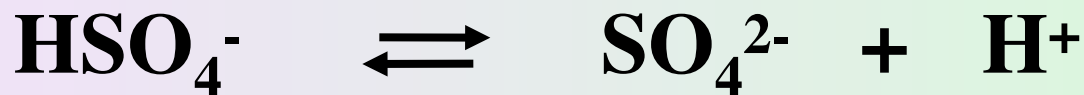
Calculate the pH of a 0.056 M solution of  $\text{H}_2\text{SO}_4$ .



Init:         $0.056 \text{ M}$                      $0$                      $0$

After first ionization:

$0$                      $0.056 \text{ M}$                      $0.056 \text{ M}$



$0.056 \text{ M}$                      $0$                      $0.056 \text{ M}$

$0.056 \text{ M} - x$                      $x$                      $0.056 \text{ M} + x$



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

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

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

$$x = .013$$

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

$$= 23\%$$

**assume x is small compared 0.056**



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

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

$$x = .056 ;$$

so the  
assumption is  
invalid



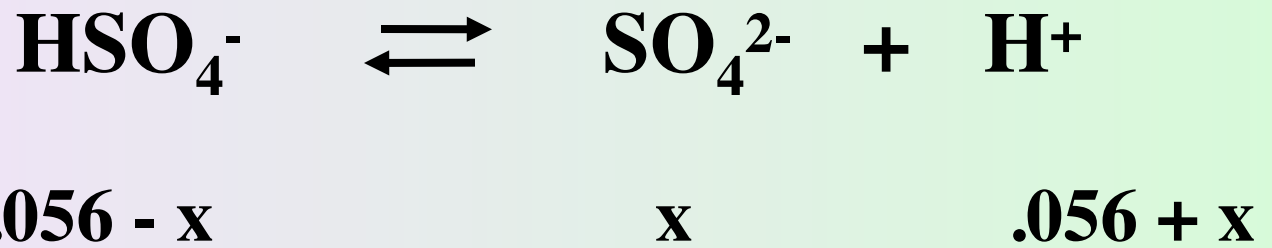
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$$x^2 + .069x - 7.28 \times 10^{-4} = 0$$

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

$$x = 0.0093$$



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$$x = 0.0093$$

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

$$= 0.063 \text{ M}$$

**pH = 1.19**



## Quadratic equation

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

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

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

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

$$x = 0.0093$$