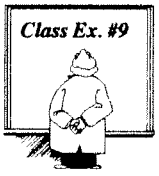
Comparing Acidity and Alkalinity of Solutions

To find how much more **acidic** or **alkaline** one solution is to another, use $10^{pH_1 - pH_2}$.



Pure water, swimming pool water, and sea water have pH levels of 7, 7.5, and 8.4 respectivel

a) How many times as alkaline is sea water than pure water?

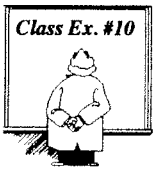
$10^{8.4-7} = 10^{1.4} = 25.11$ about 25 X

b) How many times as alkaline as swimming pool water is sea water?

$10^{8.4-7.5} = 10^{0.9} = 7.94 \sim$ about 8X.

Formula for pH

The pH of a solution is defined as $pH = -\log [H^+]$, where the H^+ is the hydrogen ion concentration (expressed as moles/litre).



A patient gave a urine sample which was found to have a pH of 5.7. What was the hydroge ion concentration? Answer in scientific notation using one decimal place.

$5.7 = -\log[H^+]$ $\quad [H^+] = 10^{-5.7}$

$-5.7 = \log[H^+]$ $\quad = 1.995 \times 10^{-6} = 2.0 \times 10^{-6}$ moles/L

Determine the pH of a solution, to the nearest tenth, if the hydrogen ion concentration is 3.4×10^{-4} mol/L. $pH = -\log(3.4 \times 10^{-4})$

$= 3.5$

Complete Assignment Questions #1 - #11

Assignment

1. How many times more intense was the 2011 earthquake in Japan (magnitude 9.0) than the 2012 earthquake in Peru (magnitude 6.3)? Answer to the nearest whole number

$10^{9.0-6.3} = 10^{2.7} = 501.18 \sim$ 501 times

2. At 2:45 pm on March 11, 2011, a major earthquake of magnitude 9.0 hit the east coast of Japan. Half an hour later, a second earthquake of magnitude 7.9 hit the same region. How many times more intense, to the nearest whole number, was the first earthquake than the second one?

$10^{9.0-7.9} = 10^{1.1} = 12.58...$ 13 times.

3. An earthquake in Peru had a magnitude of 7.7 on the Richter Scale. The following day a second earthquake with one third of the intensity of the first hit the same region. Determine the magnitude of the second earthquake to the nearest tenth.

$\frac{1}{3} = 10^{X-7.7}$ $\quad \log_{10}\frac{1}{3} = X - 7.7$

$X = 7.7 + \log(\frac{1}{3})$

$= 7.2228$

magnitude = 7.2

4. How many times more intense is the sound of a referee's whistle (125 dB) than a train whistle at 200 m (90 dB)? Answer to the nearest whole number.

125dB = 12.5 Bels
90dB = 9.0 Bels

$10^{12.5-9.0} = 10^{3.5} \approx$ 3162 times

5. How many times louder is a clarinet (95 dB) than a flute (89 dB)? Answer to the nearest whole number.

$10^{9.5-8.9} = 10^{0.6} = 3.98 \sim$ 4 times

6. Use the chart to answer the following to the nearest whole number.

Solution	pH
Black Coffee	5.1
Milk	6.6
Pure Water	7
Blood	7.5
Eggs	8

a) Eggs are how many times as alkaline as blood?

$10^{8-7.5} = 10^{0.5} = 3.162\ldots$ 3 times

b) Black coffee is how many times as acidic as milk?

$10^{6.6-5.1} = 10^{1.5} = 31.62$ — 32 times

7. A river has a pH value of 6.4 upstream from a chemical factory and a pH value of 5.8 downstream of the factory. Compare the acidity levels.

$10^{6.4-5.8} = 10^{0.6} = 3.98$ Downstream is about 4X more acidic than upstream.

8. The pH of a solution is defined as $pH = -\log(H^+)$, where H^+ is the hydrogen ion concentration (expressed as mol/L).

a) If a solution has a hydrogen ion concentration of 1.21×10^{-2} mol/L, determine the pl value, to the nearest tenth, of the solution.

$pH = -\log(1.21 \times 10^{-2}) = 1.917 =$ pH = 1.9

b) A vinegar solution has pH of 3.2. Determine its hydrogen ion concentration in scientific notation to one decimal place.

$3.2 = -\log[H^+]$
$-3.2 = \log[H^+]$
$[H^+] = 10^{-3.2}$
$[H^+] = 6.309 \times 10^{-4} \rightarrow 6.3 \times 10^{-4}$ mol/L

c) A weaker vinegar solution is 25% as acidic as the solution in b). Determine its pH value to the nearest tenth.

$\frac{1}{4} = 10^{3.2-x}$
$\log_{10}\frac{1}{4} = 3.2 - x$
$x = 3.2 - \log_{10}\frac{1}{4}$
$= 3.802$

pH = 3.8

9. a) The ionization of pure water is given by the equations:

$[H^+][OH^-] = 1.0 \times 10^{-14}$ and $[H^+] = [OH^-]$

If the pH of a solution is defined as pH = –log $[H^+]$, prove the pH of pure water is 7.0.

$[H^+][OH^-] = 1 \times 10^{-14}$

$[H^+][H^+] = 1 \times 10^{-14}$

$(H^+)^2 = 1 \times 10^{-14}$ ⇒ $[H^+] = \sqrt{1 \times 10^{-14}}$

$H^+ = 1 \times 10^{-7}$

$pH = -\log[H^+] = -\log(1 \times 10^{-7}) = 7.0$

b) Determine the pH, to the nearest tenth, of an acidic solution whose $[OH^-]$ concentration is 3.98×10^{-10} mol/L if $[H^+][OH^-] = 1.0 \times 10^{-14}$.

$[H^+](3.98 \times 10^{-10}) = 1.0 \times 10^{-14}$

$[H^+] = \frac{1.0 \times 10^{-14}}{3.98 \times 10^{-10}} = 2.512 \times 10^{-5}$

$pH = -\log(2.512 \times 10^{-5}) = 4.6$

Multiple Choice **10.** The loudness of sound can be modelled by the formula $dB = 10 \log\left(\frac{I}{I_0}\right)$, where I represents sound intensity, and I_0 represents a reference sound intensity.

If two different jets are flying together at an air show, each with a sound level of 120 decibels, then the approximate total decibel level is

A. 12.3 decibels

B. 24.0 decibels

C 123 decibels

D. 240 decibels

* see work on next page

let total dB level = 10x (x is total Bel level)

let I_1 = sound intensity for Jet 1, I_2 = sound intensity Jet 2.

and let I_3 = total sound intensity

$I_3 = I_1 + I_2$

$I_3 = 10^x I_0$

$I_1 = I_2 = 10^{12} I_0$

$10^x I_0 = 2 \times 10^{12} I_0$

$10^x = 2 \times 10^{12}$

$\log 10^x = \log(2 \times 10^{12})$

$x \log 10 = \log 2 + \log 10^{12}$

$x = \frac{\log 2 + 12 \log 10}{\log 10}$

$= 12.3$ Bels

$= 123$ dB.

$dB = 10 \log \frac{I}{I_0}$

$\frac{dB}{10} = \log \frac{I}{I_0}$ ⇒ $10^{\frac{dB}{10}} = \frac{I}{I_0}$ ⇒ $I = 10^{dB/10} I_0$

Numerical Response **11.** A major earthquake of magnitude 8.2 is 110 times as intense as a minor earthquake. The magnitude, to the nearest tenth, of the minor earthquake is _____.

(Record your answer in the numerical response box from left to right.)

6	.	2	

$110 = 10^{8.2 - x}$

$\log_{10} 110 = 8.2 - x$

$x = 8.2 - \log 110$

$x = 6.158$

Answer Key

1. 501 **2.** 13 **3.** 7.2 **4.** 3162 **5.** 4 **6. a)** 3 **b)** 32

7. Downstream is 4 times as acidic as upstream. **8. a)** 1.9 **b)** 6.3×10^{-4} **c)** 3.8

9. b) 4.6 **10.** C **11.**

6	.	2	

question #10

let total decibel level = $10x$ (x is total Bel level)

I_1 = sound intensity for Jet 1

I_2 = sound intensity for Jet 2

I_3 = sound intensity for both (total)

$I_1 + I_2 = I_3$

because $I_1 = I_2$ then $2(I_2) = I_3$

given formula: $dB = 10 \log\left(\frac{I}{I_0}\right)$ ⇒ rearrange to solve for I

$\frac{dB}{10} = \log\left(\frac{I}{I_0}\right)$ → write as an exponent

$\frac{I}{I_0} = 10^{\frac{dB}{10}}$

$I = 10^{\frac{dB}{10}} \cdot I_0$

$I = 10^{\frac{dB}{10}} \cdot I_0$

$I_3 = 10^{\frac{10x}{10}} \cdot I_0$

$I_3 = 10^{x} \cdot I_0$

120 dB ÷ 10 = 12 Bels.

$I_1 = I_2 = 10^{12} I_0$

$I_3 = 2 \cdot 10^{12} I_0$

$10^x I_0 = 2 \cdot 10^{12} I_0$

$10^x = 2 \cdot 10^{12}$

$\log 10^x = \log 2 + \log 10^{12}$

$x \log 10 = \log 2 + 12 \log 10$

$x = \frac{\log 2 + 12 \log 10}{\log 10}$

$x = 12.3$ Bels

$= 123$ dB.