Example 4.16
What is the pH of 0.0020 M HCl*(aq)*?

A. 2.00
B. 2.70
C. 3.00
D. 7.00

Solution
Determining an exact numerical value involves calculations. The pH for any solution is defined as pH = - log $[H_3O^+]$. For a strong acid, the pH is - log [HX]. It is best to use scientific notation for the concentration.

$$pH = - \log (2 \times 10^{-3})$$
$$pH = - (\log 2 + \log 10^{-3}) = - \log 2 - \log 10^{-3}$$
$$pH = - \log 2 - (-3) = 3 - \log 2$$
$$pH = 3 - 0.3 = 2.7$$

The correct answer is choice **B**. Choice D should have been eliminated, because the solution is acidic, so pH is less than 7.00. Choices A and C could also have been eliminated, if you noted that the log values ended in ".00". For a log to be a whole number, the concentration must be a power of ten. The fact that the concentration was .002 tells us that the log could not be a whole number. From this example, you should derive a shortcut for use in the future. You might take notice that the - log of 2×10^{-3} is equal to 3 - log 2, so why not remember this and skip a few steps in the future. Use the relationship: - log $(z \times 10^{-y})$ = y - log z.

This shortcut applies to all negative log calculations, including the conversion from K_a to pK_a. For instance, the pK_a for a weak acid with K_a equal to 4.1×10^{-6} is 6 - log 4.1. This value can be estimated to be greater than 5.0 (which is equal to 6 - log 10), but less than 5.5 (which is equal to 6 - log 3). A range of 5.0 to 5.5 should be good enough to choose the correct answer from four choices. With exact numerical questions on the MCAT, your goal should be to narrow the answer choice range enough so that three wrong answers may be eliminated.

Example 4.17
What is the pH of 100 mL of 0.030 M HBr*(aq)*?

A. 1.30
B. 1.52
C. 2.30
D. 7.00

Solution
The volume of the solution does not affect the pH, unless another solution is added. Using the shortcut, the pH is found as follows:

$$pH = - \log (3 \times 10^{-2}) = 2 - \log 3$$
$$pH = 2 - 0.48 = 1.52$$

The correct answer is choice **B**. Choice D should have been eliminated, because the solution is acidic, so pH is less than 7.00. Choices A and C could also have been eliminated, if you noted that the log values ended in ".30". This would come from logarithmic insights.

Example 4.18
What is the pOH of 0.050 M KOH*(aq)*?

A. 1.30
B. 1.70
C. 12.30
D. 12.70

Solution
The pOH of a basic solution is found in a manner similar to getting the pH of an acidic solution. Using the shortcut, the pOH is found as follows:

$$pOH = - \log (5 \times 10^{-2}) = 2 - \log 5$$
$$pOH = 2 - 0.7 = 1.30$$

The correct answer is choice **A**. Choices C and D should have been eliminated, because the solution is basic, so pH is greater than 7.00, and therefore pOH is less than 7.00. The pH of the solution can be found using pH = 14 - pOH, where pH = 14 - 1.30 = 12.70.

Example 4.19
What is the pH of 200 mL of 0.00391 M KOH*(aq)*?

A. 2.41
B. 2.61
C. 11.39
D. 11.59

Solution
This question would seem to be quite difficult at first glance; but if you follow the rules, it is easy. Because KOH is a strong base, it will fully dissociate when added to water. Plugging values into our shortcut method yields the following:

$$pOH = - \log (3.91 \times 10^{-3}) = 3 - \log 3.91$$
$$3 - \log 10 < 3 - \log 3.91 < 3 - \log 3 \ \therefore \ 2 < pOH < 2.5$$
$$\text{If } 2 < pOH < 2.5, \text{ then } 12 > pH > 11.5$$

The correct answer is choice **D**. Choices A and B should have been eliminated, because the solution is basic, so pH is greater than 7.00. Choice C is eliminated, because it does not fit into the range for the correct number. Some of you may have chosen to approximate 3.91 as 4, and solved accordingly. This method is fine, too.

You should be able to determine pH or pOH for strong compounds in less than fifteen seconds. Perhaps your MCAT will not have many calculation questions, but if you are fortunate enough to get a pH calculation question, you should finish it quickly, and carry the time you save over to more difficult questions.