

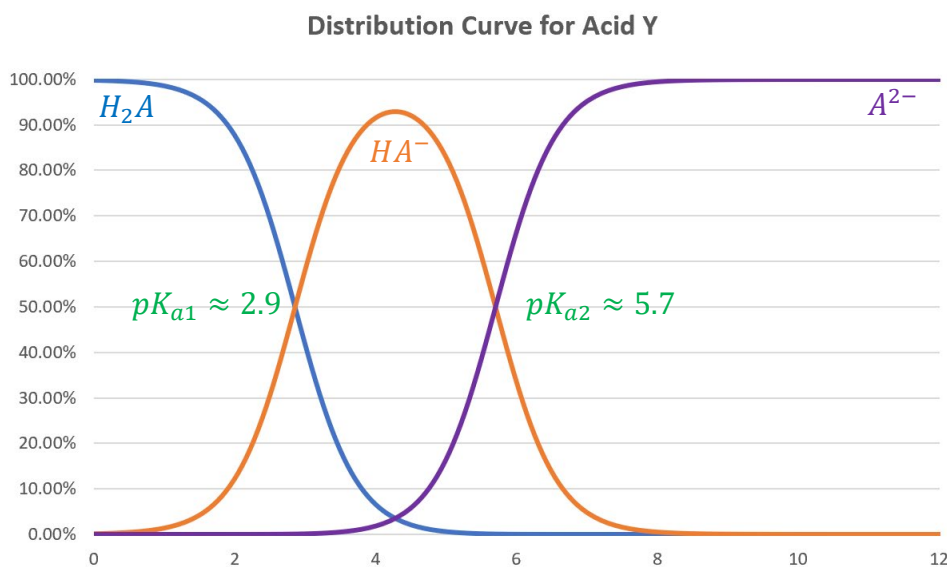
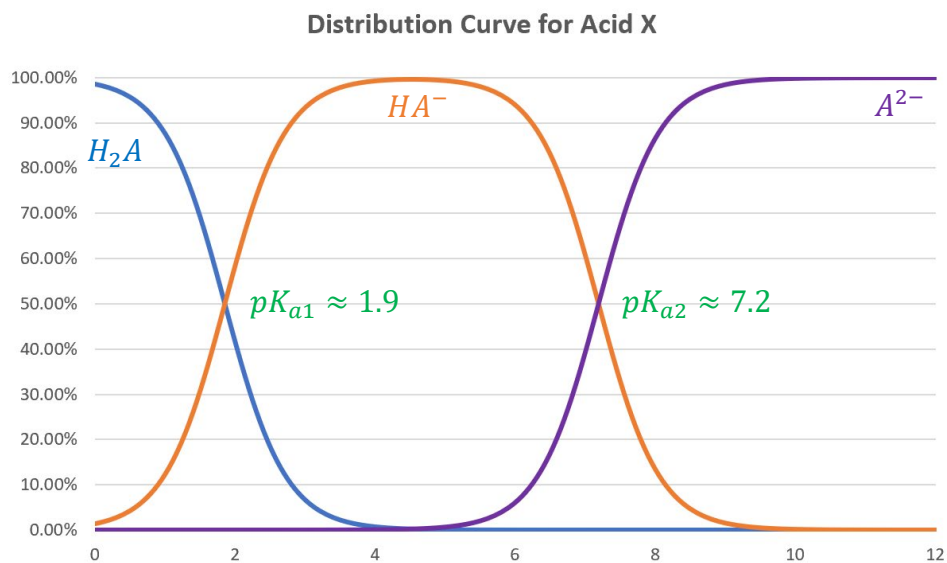
## Answers to Exercise 12.5

### Distribution Curves

1.

(a) Acids X and Y are both diprotic. Both graphs show three curves, each of which corresponds to one form of the acid. The blue curve is for fully protonated acid, the orange curve is for singly deprotonated acid, and the purple curve is for doubly deprotonated acid.

(b) + (d)



- (c) Acid X appears to contain significant amounts (close to 50% each) of both  $HA^-$  and  $A^{2-}$  at pH 7.  
Acid Y exists primarily as  $A^{2-}$  at pH 7. *The graph also suggests that about 5% of the acid is still in the  $HA^-$  form at this pH.*
- (d) Each point where two curves cross corresponds to a  $pK_a$  value for the acid. Since both Acid X and Acid Y are diprotic acids, they each have two  $pK_a$  values (one corresponding to each of the two “crossing points” on each graph).  
*See graphs for labels. If your estimated  $pK_a$  values are within about 0.2 of the ones shown, you've read the graph accurately enough for the purposes of this question.*
- (e) The key difference between Acid X and Acid Y is how close the two  $pK_a$  values are to each other. In Acid X, there is a large difference between the two  $pK_a$  values, so almost 100% of Acid X is deprotonated once before any it is deprotonated a second time. In Acid Y, the two  $pK_a$  values are much closer together. As such, some of the singly deprotonated acid can be deprotonated a second time before every acid molecule is deprotonated once.