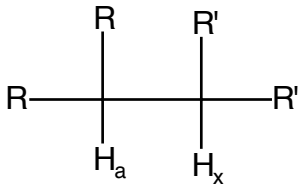
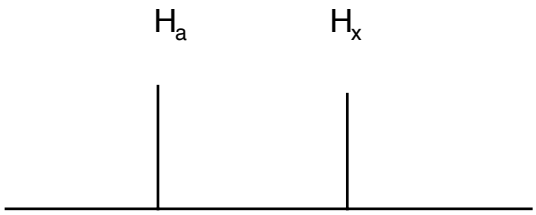
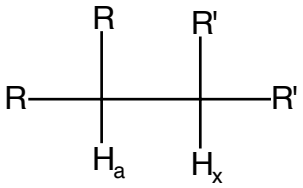
Answers to Problem 71, Chemistry 301X - 2006

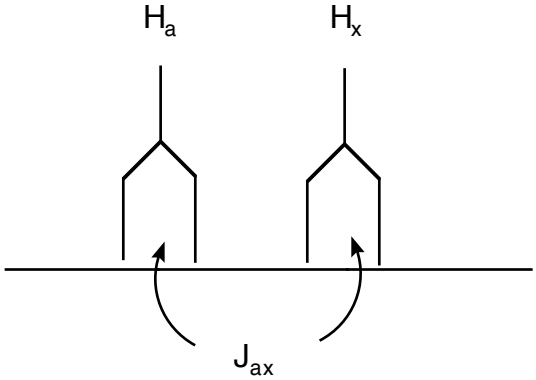
(a)



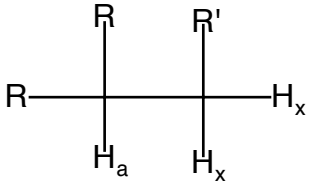


Each hydrogen H_a and H_x will appear as a doublet. Each is flanked (1,2 relationship) by a single other H, which can have a + 1/2 or – 1/2 spin. Hence, two lines. The spectrum will be a "pair of doublets."

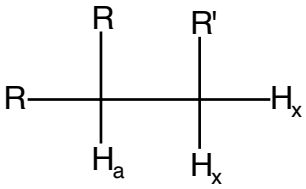


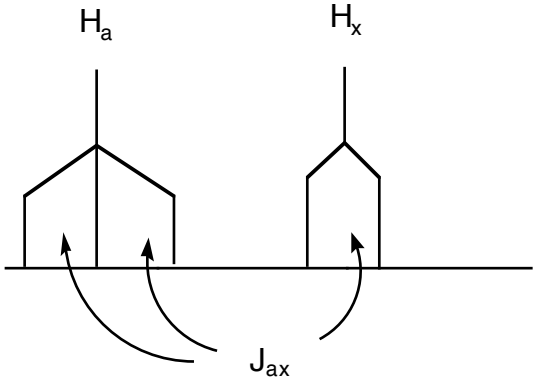


(b) Now predict the spectrum for the following "AX_2" system:

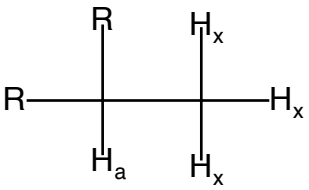


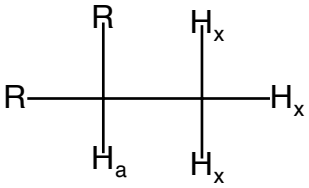
In this case, H_a is flanked by two equivalent H_x's. Thus it will appear as a 1:2:1 triplet. The two equivalent H_x's are adjacent to a singlet H_a and thus will appear, as in (a) as a doublet. The areas (integrals) of these signal will be in the ratio of 2:1.

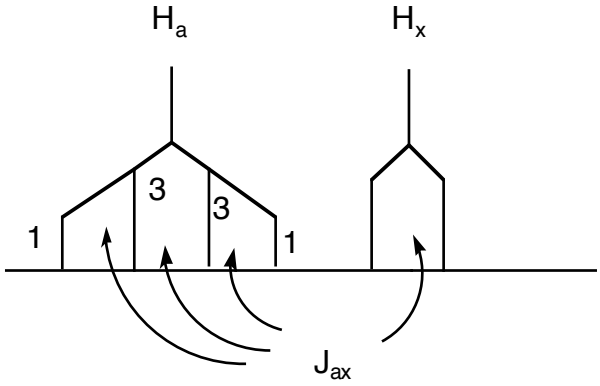




(c) Now do the same thing for "AX_3"



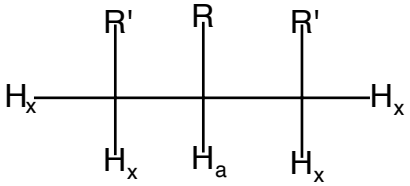




Finally, generalize: how many lines will appear when a hydrogen, H_a, is flanked by n adjacent equivalent hydrogens?

This is the "n + 1" rule. The number of lines is equal to the number of equivalent (critical word) hydrogens + 1.

Draw a molecule in which an H_a is flanked by four equivalent H_x's. Here is a popular answer:



Last year, one group claimed that this answer is wrong! They were right and got a bonus HT point! What's wrong with this answer? Here is a better one: