1 Cognitive reasoning in the chemical sciences 4.5

1. In this question, we use our knowledge of nodes and contour maps to mix two orbitals located on the same atom. Doing so paves the way for the understanding of hybridized atomic orbitals.

   (a) p_{x+y}

      i. The following statement is true: $p_x + p_y = p_{x+y}$. Assume the two p orbitals are both $2p$ orbitals. Find the points where $x + y = 0$. Please indicate where these points lie on the $z = 0$ plane.

      ii. Please draw a contour map for the p_{x+y} orbital.

      iii. Please draw the p_{x+y} orbital using the balloon convention for drawing orbitals.

   (b) p_{x-y}

      i. The following statement is true: $p_x - p_y = p_{x-y}$. Assume the two p orbitals are both $2p$ orbitals. Find the points where $x - y = 0$. Please indicate where these points lie on the $z = 0$ plane.

      ii. Please draw a contour map for the p_{x-y} orbital.

      iii. Please draw the p_{x-y} orbital using the balloon convention for drawing orbitals.

   (c) $p_{\frac{\sqrt{3}}{2}x+\frac{1}{2}y}$

      i. Find the points where $\frac{\sqrt{3}}{2}x + \frac{1}{2}y = 0$. Please indicate where these points lie on the $z = 0$ plane.

      ii. Please draw a contour map for the $p_{\frac{\sqrt{3}}{2}x+\frac{1}{2}y}$ orbital.

      iii. Please draw the $p_{\frac{\sqrt{3}}{2}x+\frac{1}{2}y}$ orbital using the balloon convention for drawing orbitals.

   (d) $s + p_x$

      i. The following statement is only approximately true: $s+p_x \approx (sp)_{\frac{1}{2}+x}$ Assume the p orbital is a $2p$ orbital. Find the points where $\frac{1}{2} + x = 0$. Please indicate where these points lie on the $z = 0$ plane.

      ii. Please draw a contour map for the $sp_{\frac{1}{2}+x}$ orbital.

      iii. Please draw the $(sp)_{\frac{1}{2}+x}$ orbital using the balloon convention for drawing orbitals. This orbital is a hybridized orbital.

   (e) $s - p_x$

      i. The following statement is only approximately true: $s-p_x \approx (sp)_{\frac{1}{2}-x}$ Assume the p orbital is a $2p$ orbital. Find the points where $\frac{1}{2} - x = 0$. Please indicate where these points lie on the $z = 0$ plane.

      ii. Please draw a contour map for the $sp_{\frac{1}{2}-x}$ orbital.

iii. Please draw the $(sp)_{\frac{1}{2}-x}$ orbital using the balloon convention for drawing orbitals. This orbital is a hybridized orbital.

2. It is possible to directly deduce the hybridized balloon orbital drawings from knowledge of the orbital function alone. I will show you how to do this in class. Using the method I teach you, please draw:

   (a) the p_{x+y} orbital using the balloon convention for drawing orbitals.

   (b) the p_{x-y} orbital using the balloon convention for drawing orbitals.

   (c) the $p_{\frac{\sqrt{3}}{2}x+\frac{1}{2}y}$ orbital using the balloon convention for drawing orbitals.

   (d) the $(sp)_{\frac{1}{2}+x}$ orbital using the balloon convention for drawing orbitals.

   (e) the $(sp)_{\frac{1}{2}-x}$ orbital using the balloon convention for drawing orbitals.