

8 QSAR (Spartan)

Exercise 1 Predicting the Rate Constant of HFC's with Atmospheric •OH.

This exercise will demonstrate the use of the Spartan Molecular Database (SMD), which contains calculated structures, energies and other properties. Use of the SMD can greatly reduce the computational time required for certain experiments. Also, the use of Spartan's linear regression analysis tool will be explored.

Chemical Sample	Log K	CH ₂ FCH ₂ F	2.04
CHF ₃	-0.620	CH ₃ CF ₃	0.113
CF ₃ CF ₂ CH ₂ F	0.800	CH ₃ CH ₂ F	2.36
CF ₃ CH ₂ CF ₃	-0.357	CH ₃ CHF ₂	1.56
CF ₃ CH ₂ OCH ₃	2.79	CH ₃ F	1.23
CF ₃ CH ₂ OCHF ₂	1.11	CHF ₃ CF ₃	0.279
CF ₃ CHF ₂ CF ₃	0.204	CHF ₂ CHF ₂	0.756
CF ₃ CHO	2.74	CHF ₂ OCF ₃	0.531
CH ₂ F ₂	1.04	CHF ₂ OCHF ₂	1.40
CH ₂ FCF ₃	0.690		

Build the first molecule (CHF₃) in the table above. Do NOT click the "View" icon. Once the first molecule is complete, choose File / New Molecule. Build the second molecule. Repeat the above process until all the molecules in the table have been constructed. Click on the "View" icon (5th across top) when you are finished. Click on the small up arrow (▲) next to the name (fluoroform) at the bottom right of the screen. Make sure the yellow square next to the "3-21G" is checked. Click on the "Replace All" button. The structures you've built have all been replaced with structures obtained at the Hartree-Fock 3-21G level of theory and stored in the SMD. Choose Setup / Calculations and select Single Point Energy at Ground state using Hartree-Fock 3-21G(*). Make sure the "Global Calculation" box at the bottom of the Calculations dialog is checked. Also check the "Orbital and Energies" box. Click on "OK" to close the Calculations dialog box. Choose Display / Surfaces. Make sure that the "Global Surfaces" box is checked. Click on "Add" and select "Surface: density; Property: potential; Resolution: medium". Click "OK". Choose "Setup / Submit". Save the file as "HFC_321G.spartan" in an appropriate location. Click "OK" to started message and "OK" to completed message. Choose Display / Spreadsheet and expand the window so that all 18 molecule labels, along with five empty columns, can be seen. Click in the top cell of the second column to highlight it. Click "Add" and select "Name". Click on the top cell of the third column and type in "Log K" and hit "enter". Continue down this column and type in the Log K values from the table, hitting "Enter" each time. Click in the top cell of the fourth column, click "Add", select "E HOMO" from the list, and click "OK". Click in the top box of the fifth column, click "Add", select "Dipole" from the list, and click "OK".

Finally, in the top cell of the sixth column, type in “# H Atoms” and hit “Enter”. Continue down this column and type in the number of H atoms for each molecule, followed by “Enter”.

Plot the log K value vs. E HOMO by choosing Display / Plots. For the X-Axis select “Log K” and select “E HOMO” for the Y-Axis. Click on “OK”. The points are connected by a cubic spline, which is obviously not useful in this case.

To perform a least-squares fit, choose Display / Properties and click on the curve on the plot. Select “Linear LSQ” from the “fit” menu in the Curve Properties box.

In the Spreadsheet, click on the empty cell at the bottom of the “Log K” column, and then click the “Add” button. Now click the “Linear Regression” tab in the “Add” window. In the “Fit” box, select “Log K” and in the “Using” box click “E (HOMO)”. Click “OK”. Two new rows appear at the bottom of the Spreadsheet

Choose Display / Properties, then click on the row labeled “Fit 1” in the Spreadsheet. The R^2 value for the linear regression appears in the “Regression Properties” window. Record the R^2 value in the Table on the next page.

To plot the other parameters against Log K, Save and Close the file. Re-open the “HFC_321G” file, click on one of the plot axes to select the plot, shrink the plot (Shift / Right Click, Drag), and move the plot (Right Click, Drag) to one side.

Choose Display / Plots. Place Log K on the X-Axis and Dipole on the Y-Axis, and click “OK”. Choose Display / Properties, click on the curve, and select “Linear LSQ” from the Curve Properties box. Shrink and move this new plot and place it next to the original plot.

Repeat the above process and plot Log K vs. # of H Atoms. Shrink and move this plot next to the other two.

In the Spreadsheet, click on the empty cell at the bottom of the “Dipole (debye)” column, and then click the “Add” button. Now click the “Linear Regression” tab in the “Add” window. In the “Fit” box, select “Log K” and in the “Using” box click “Dipole (debye)”. Click “OK”. Two additional rows appear at the bottom of the Spreadsheet

Choose Display / Properties, then click on the row labeled “Fit 2” in the Spreadsheet. The R^2 value for the linear regression appears in the “Regression Properties” window. Record the R^2 value in the Table on the next page.

Repeat the above process, and record the R^2 value for fitting Log K using “# H Atoms”.

The best fit will have the largest value of R^2 .

Which single calculated parameter best correlates with Log K? _____ How does this parameter relate to the reaction between an HFC and the hydroxyl radical?

Combinations of calculated parameters can also be used to fit experimental data. Click in an empty cell at the bottom of the spreadsheet. Click the “Add” button, then click the “Linear Regression” tab in the “Add” window. In the “Fit” box, select “Log K” and in the “Using” box click “E (HOMO)” and “Dipole (debye)”. Click “OK”. Two additional rows appear at the bottom of the Spreadsheet.

Choose Display / Properties, then click on the row labeled “Fit 4” in the Spreadsheet. The R^2 value for the linear regression appears in the “Regression Properties” window. Record the R^2 value in the Table.

Repeat these steps to fit the other combinations of two properties, as shown in the Table. Record the R^2 values for these fits as well.

Which combination of properties gives the best fit? _____

To view a plot of the fit using combined parameters, choose Display / Plots. Select "Log K" for The X-Axis, and select the corresponding "Fit #" from the Y-Axis list, and click "OK". If needed, adjust the size and position of the plot as described above.

What combination of properties gives the best correlation with Log K? _____

Fit	Using	R^2
Log K	E (HOMO)	
Log K	Dipole (debye)	
Log K	# H Atoms	
Log K	E (HOMO) and Dipole (debye)	
Log K	E (HOMO) and # H Atoms	
Log K	Dipole (debye) and # H Atoms	