In-Class Assignment: Signal-to-Noise Issues

Signal-to-noise issues are extremely important to practicing analytical chemists. When data is collected it represents a convolution of both real signal and background noise. The data needed for this exercise can be found in the Excel file (on-line: Excel-ICA).

The data provided is the response from the chromatographic detector prior to any elution of a benzene analyte coming out of the chromatograph instrument.

Instructions. Plot each of the data sets as a function of time (seconds) for a visual queue. Use the table of data to answer these questions.

1) The background noise in data sets 1-4 is equivalent and can be quoted as the standard deviation of baseline with no analyte present. Hint: use Excel and the first 20 data points to approximate the standard deviation.

Noise (N) for Data 1-4 ____________; ____________; ____________; ____________

Noise (N) for Data 5 and 6 ______________

2) What is the average background response for these data sets?

Average Background for Data 1-4 ____________

Average Background for Data 5 ____________  Average Background for Data 6 ____________

3) What is the approximate time at which the benzene elutes (passes through the detector)?

Time: ________________ seconds

The limit of detection (LOD) is defined when the signal-to-noise ratio is at ________?

The limit of quantification (LOQ) is defined when the signal-to-noise ratio is at ________?

4) How does one determine the Signal (S) response from the graphs provided? Be sure to consider effects from the average background response.
5) Using your generated plots, fill in the information in the table below.

<table>
<thead>
<tr>
<th>Data Set</th>
<th>Noise</th>
<th>Signal</th>
<th>S/N Ratio</th>
<th>Above/below LOD</th>
<th>Above/Below LOQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>4</td>
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</tbody>
</table>

6) Compare Data 5 and Data 6.

Noise in Data 5 ___________  Signal in Data 5 ____________  S/N Data 5 ____________
Noise in Data 6 ___________  Signal in Data 6 ____________  S/N Data 6 ____________

7) Let’s assume for the moment that these data sets are not chromatographic data sets, but rather scans from an instrument (like an IR spectrum). We also know that averaging multiple data sets of the same scan will increase the overall or cumulative S/N ratio. Noise is random and will sum to zero, while signal is cumulative and will not cancel out as the scans progress. Comparing the S/N ratio of Data 1 with Data 4, how much more S/N is present in Data 4? Knowing that the S/N ratio ~ \sqrt{(# \text{ scans})}, how many scans were done to get data 4, if Data 1 is from just a single scan?

8) Even though Data 6 has the strongest signal of all the data sets, why is it still below the limit of quantification?