1. An infinitely sharp zone of solute is place at the center of an uniform LC column at time t = 0. Under a constant flow, the standard deviation of the Gaussian band is 1.0 s after elution for time t_1. After 21 min more, at time t_2, the standard deviation is 2.00 s. What will be width after another 21 min, at time t_3?

2. An infinitely sharp zone of solute is place at the center of an uniform LC column at time t = 0. Under a flow with a rate of 0, the standard deviation of the Gaussian band is 1.0 mm after diffusion for time t_1. After 21 min more, at time t_2, the standard deviation is 2.00 mm. What will be width after another 21 min, at time t_3?

3. A chromatogram with ideal Gaussian bands, t_R = 9.0 and W_h = 2.0 min.

(a) How many theoretical plates are present?

(b) Find the plate height if the column is 10 cm long.

4. An open tubular column has a diameter of 207 µm and the thickness of the stationary phase on the inner wall is 0.5 µm. Unretained solute pass through in 63 s and a particular solute emerges in 433 s. Find the partition coefficient for this solute and find the fraction of time spent in the stationary phase.

5. A mixture of benzene, toluene, and air was injected in to an open tubular GC column that has an inner diameter of 250 μm and is coated on the inside with a layer of stationary phase 1.0 μm thick. Air gave a sharp peak spike in 42 s, whereas benzene required 251 s and toluene was eluted in 333 s. (1) Find the adjusted retention time and capacity factor for each solute. (2) Estimate the distribution coefficient (K = Cs/Cm) for benzene and toluene between stationary and mobile phases. (3) State what fraction of time benzene and toluene spend in the mobile phase.

6. In a typical liquid, molecules jump randomly to one side or another about 10^{10} times per second in steps of 0.3 nm length. Calculate the diffusion coefficient for such molecules.

7. A thin pulse of ethanol carried along at 0.040 cm/s by a uniformly flowing stream at 25 ^{o}C spreads by diffusion, D=1.24X10^{-5} cm^2/s. What is the plate height corresponding to this spreading?

8. Two component, each with plate height H = 0.0025 cm, are observed to migrate to positions X = 10.1 cm and X =9.9 cm, respectively, along a uniform column. How long must the column to be achieve baseline resolution?

9. The plate height H is found to be 0.010 cm for a particular amino acid in an ion exchange chromatography column. What is the zone width (4σ) after the amino acid has migrated 25 cm? What is the the zone width after a migration of 100 cm?

10. During a period of 3 min a liquid mobile phase traveling through a uniform silica gel column at a velocity of 0.04 cm/s carries a component 3 cm. What is the equilibrium fraction of solute in the mobile phase? What fraction of time does an average molecule spend attached to the stationary phase?

11. Calculate the plat height contributed by longitudinal diffusion in the mobile phase of a column for which $\gamma = 0.60$ and in which the mean flow velocity is 2.0 cm/s. First assume that the column is a GC column with a typical solute diffusivity of $D_m = 0.10\ cm^2/s$; second, assume a LC column with $D_m = 1.0 \times 10^{-5}\ cm^2/s$.

12. Determine what type of flow is present in each of the following systems. The density and viscosity of water at 20 ^oC are 1.00 g/cm^3 and 0.01 poise, respectively, and the density and viscosity of nitrogen at 100 ^oC and 1 atm are 0.08 g/cm^3 and 0.0002 poise, respectively.

(a) A LC system with a 2 m X 50 micron ID open tube using water as the mobile phase, flowing at 0.01 mL/min and at 20 °C.

(b) A GC system with a 25 m X 250 micron ID open tube using nitrogen as the mobile phase at a flow-rate of 2 mL/min at 2mL/min at 1 atm and 100 °C.

(c) An LC system with a 10 cm x 4.5 mm ID packed column containing 10 micron particles using water as the mobile phase, flowing at 1 mL/min at 20 °C. The void volume of the column is given as 1.25 mL.

(d) A GC system with a 2 m x 2 mm ID packed column containing 50 micron particles and using nitrogen as the mobile phase, flowing at 10 mL/min at 100 °C. The void volume of the column is given as 0.05 mL.

13. A mixture of two solute in injected into a 25 m X 0.2 mm ID capillary GC column using nitrogen as the carrier gas and a column temperature of 150 °C; the average flow rate of nitrogen through the column is 10 mL/min. The first solute in the injected mixture eluted with a retention time of 10.23 min and a baseline width of 0.15 min; the second solute in the mixture elutes at 10.41 min with a baseline width of 0.18 min. Injection of air (a non-retained solute) produces a peak at 0.08 min. The diffusion coefficient for both solute 1 and 2 under these conditions is roughly 1 X 10^{-1} cm^2/sec. Please determine each of the following values for this system.
(a) Separation factor α between solute 1 and 2. (b) the plate number for solute 1 and 2. (c) Is baseline resolution is achieved in this separation. (d) The average time it takes solute 1 to travel across the diameter of the GC capillary (i.e., 0.2 mm).

14. A 10 cm x 4.0 mm ID LC column packed with 10 micron particles produces a total total change in pressure of 300 psi between its inlet and outlet when water is used as the mobile phase at 1 mL/min. A chromatographer wants to use the same packing materials for different columns under same pressure between their inlet and outlet. (1) If a column with 10 cm x 16 mm ID, what is the flow rate in this column. (2) if a column with 1 m X 4.0 mm ID, what is the flow rate in the column?

15. A GC system is equipped with a 30 m X 250 micron ID open-tubular column. The column is coated with 1 µm thin-layer stationary phase. Please explain the reason why using H_2 at the carrier gas has a larger linear velocity for achieving optimized separation than using N_2 at the carrier gas.