1. Compute the CSTR performance for a second order irreversible reaction
\[ R_A = kC_A^2 \] as a function of \( D_A \) = \( kC_A \rho \) for \( \beta t = 0; 0.01; 0.1; 1.0; 5.0; 10; 100 \) using
2. Exchange in the mean model.
3. Recycle model.

Use established relations between \( \beta, h \) and \( R \).

Plot your results of \( x_A \) vs \( D_A \) with \( \beta t \) as parameter for each of the models. Also plot the conversion as a function of Damkoehler number at fixed \( \beta t \) for all models.

2. A porous sphere of radius \( R_0 \), whose pores are filled with fluid, initially at \( t = 0 \) has a uniform solute concentration throughout of \( C = C_i \). At time \( t = 0 \) the solute concentration at the outer surface of the sphere is increased to \( C = C_o \) and is maintained steady at that value. The resulting diffusion problem in the sphere has the following solution:

\[
\frac{C - C_i}{C_o - C_i} = 1 + 2R_0 \sum_{n=1}^{\infty} \frac{(-1)^n}{n} \sin\frac{n\pi r}{R_o} e^{-Dn^2\pi^2t/R_o^2}
\]

where \( R_o = \) sphere radius, \( r = \) radial position in the sphere, \( t = \) time.

Now consider solute A and solute B which undergo an instantaneous chemical reaction
\[ aA + bB \rightarrow P. \] The sphere initially contains A at \( C_{Ai} \) and then at \( t = 0 \) is exposed to \( C_{Bo} \) at the surface:

a) develop an expression for the position of the reaction interface as a function of time
b) find the time necessary for reacting i) 50%, ii) 90% and iii) 99% of A in the sphere.
c) illustrate the above using \( R_o = 0.5 \) cm; \( C_{Ai} = 10^{-3} \) (mol/cm\(^3\))
\[ D_A = D_B = 10^{-5} \left( \frac{cm^2}{s} \right); a = 1, b = 2, C_{Bo} = 10^{-3} \left( \frac{mol}{cm^3} \right). \]