Relaxing the assumption of $C_R = C_{feed}$

1. Usually we specify the desired cut, $\theta = \dfrac{Q_P}{Q_0}$
2. $Q_0 C_0 = Q_R C_R + Q_P C_P$
3. $Q_0 = Q_R + Q_P$
4. $1 = \dfrac{Q_R}{Q_0} + \theta$
5. $C_0 = (1-\theta) C_R + \theta C_P$ from equation (2) and (4)
6. $J_{solv,V} \cdot C_P = A_{solv}(\Delta P - \Delta\pi) C_P =$ salt flux leaving in permeate. [you might have to divide by the solvent density to get $J_{solv,V}$]
7. $J_{salt} = A_{salt}(C_R - C_P) =$ salt flux into membrane

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- Specify C_0 and θ
- Guess C_P value [how?]
- Calculate C_R from equation 5
- Calculate $J_{solv} C_P$ from equation 6, noting however that $J_{solv} = f(\pi_R, \pi_P)$. So recalculate π_R and π_P
- Note then that equation 6 and 7 must be equal
- Solve eqn 7 for C_P and use that as a revised value to iterate.

Alternative to the above

1. Specify C_0 and θ
2. Guess a reasonable rejection coefficient around 90 to 99%
3. From which you get a reasonable C_P guess
4. Calculate C_R from equation 5
5. Your guesses for C_P and C_R cannot be negative, and C_R must exceed C_0.
6. Calculate $J_{\mathrm{solv,\ V}} C_\mathrm{P}$ from equation 6, noting however that $J_{\mathrm{solv,\ V}} = f(\pi_\mathrm{R}, \pi_\mathrm{P})$. So recalculate π_R and π_P
7. Note then that equation 6 and 7 must be equal. So solve eqn 7 for C_P and use that as a revised value to iterate.
8. You should try this on a computer, rather than by hand.

Problem for home

Reverse osmosis with an NaCl-water feed, 2.5 g/L NaCl is being separated into a permeate and retentate stream using a TMP of 27.2 atm at 25 °C.

Through lab experiments the permeance of the membrane with respect to salt is 4.2×10^{-7} m.s^{-1} and solvent is 5.0×10^{-4} kg.s^{-1}.m^{-2}.atm^{-1}. The membrane is operated so the cut is at 40%, producing a permeate stream of 0.38 m^3 per hour.

Calculate the permeate concentration, retentate concentration, rejection coefficient, and separation factor. It is not reasonable to assume that the feed and retentate concentration are the same in this problem: we require accurate estimates.