

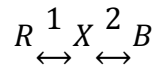
Conceptual Questions

- 1) We talk about time asymmetries in microscopic dynamics with regards to dissipation and a distance from equilibrium. What is the role for time symmetric properties? What role do they play in non-equilibrium systems?
- 2) Can you maintain Onsager reciprocity *arbitrarily* far from thermodynamic equilibrium?
- 3) Is there a limited energy budget for the cell?
- 4) Do cells care about energetic efficiency?
- 5) Are biological functions optimized by energetic principles? Extrema? Partitioning?

Analytical Questions

Adapted from Demirel.

- 6) Isomerization is the transformation of a molecule into a different isomer. Thus, there are two different conformations, cis and trans. Consider the following isomerization reaction:



In this open reaction system, the chemical potentials of reactant (R) and product (B) are maintained at fixed value by an inflow of R and outflow of B. The concentration of intermediate X is maintained at a non-equilibrium value, while the temperature is kept constant by the reaction exchanging heat with the environment. The affinities (forces) for reactions 1 and 2 are A_1 and A_2 . The reaction rates (flows) are J_{r1} which is the forward reaction rate, and J_{r2} which is the backward reaction rate. Determine the condition for minimum entropy production.