Bioengineering 499A: Systems and Synthetic Biology

January 09, 2009
Homework Assignment #1
Due: 16th January 2009

Points awarded for each question are indicated in square brackets. Return assignment with your name clearly indicated at the top of your answer sheet. [Total points: 100]

[12] **Question 1**.

5'……CTGACTAACAGCGCAGGCGAGCCGACCGGTGTTTACACGTTTCCCCCGCTGACTATATGTTCGTTTCCCCCGCTGACTAACAGC GCAGGCGAGCCGACCGGTGCGATCTATAGGAGGTGCACGATG CGTCCCCCGCTGA……3'

The above DNA sequence was taken from a fragment of the E. coli genome. Identify the following sites in the sequence:

1) The start codon
2) The ribosome binding site
3) The -35 and -10 promoter boxes.

[12] **Question 2.** Define the following terms:

a) Degree
b) Degree Distribution
c) Clustering Coefficient
d) Scale-free Network
e) Small-World Network
f) Path Length

[6] **Question 3.** Give one biological insight that has come from the study of non-stoichiometric networks

[8] **Question 3.** Assuming simple mass-action kinetics, write down rate laws for the following **irreversible** reactions:

A -> B

A + B -> C

2 A -> B

Write down the rate law for the following reversible reaction:

2A <-> 2B + C

[6] **Question 4.** Complete the right-hand sides for the following reaction:

2A + 3B -> 3A

$v =$

$\frac{dA}{dt} =$

$$\frac{dB}{dt} =$$

[5] **Question 5.** The rate of formation of NH_3 in the reaction:

N_2 (g) + 3 H_2 (g) -> 2 NH_3 (g) is 1.2 mmol L^{-1} s^{-1}. What is the rate of consumption of N_2 and H_2 ?

[8] **Question 6.** For the reaction A -> B, the concentration of A changes in time according to the equation:

$$A = A_o e^{-kt}$$

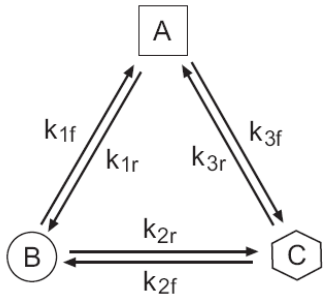
Where A_o is the initial concentration of A at time zero, t is the time and k the rate constant. Experiments indicate that the concentration of A halves within 3 seconds of the reaction starting. Estimate the value for the rate constant for the reaction.

[10] **Question 7.** Triose Phosphate isomerase catalyzes the interconversion of G3P and DHAP in glycolysis. The equilibrium constant for the reaction G3P <-> DHAP is 367 at 25°C.

If the total concentration of DHAP + G3P is 24 mM, compute the equilibrium concentration of G3P **and** DHAP.

[5] **Question 9.** For the reversible reaction A <-> B, derive the relationship between the equilibrium constant and the forward and reverse rate constants.

[4] **Question 10.** The figure below shows a cyclic reaction system governed by reversible mass-action rate laws.

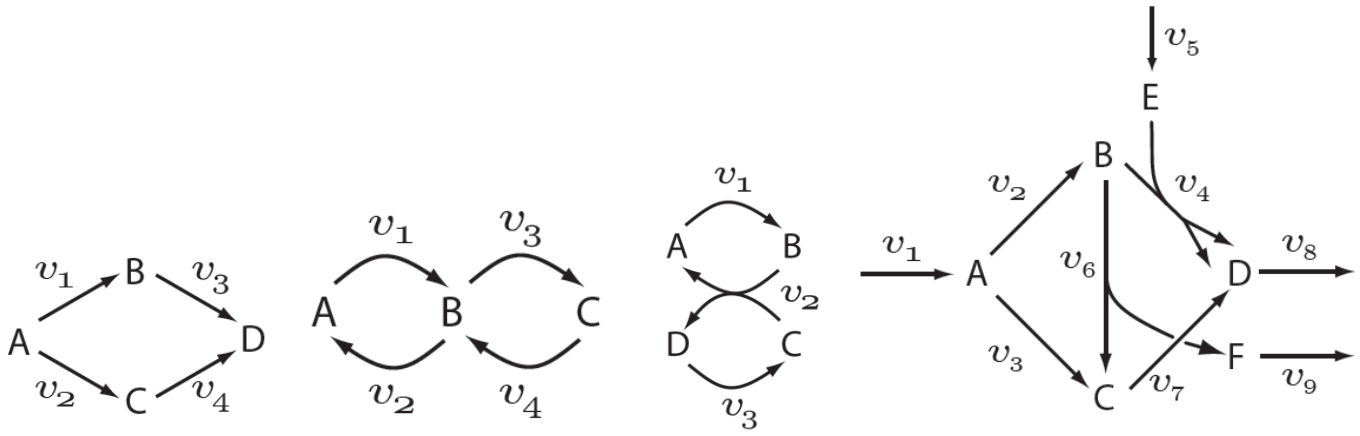


Show that the following relationship exists between the equilibrium constants:

$$K_{eq1}\, K_{eq2}\, K_{eq3} = 1$$

[8] **Question 11.** Write out the differential equations in each of the following networks.

Note: Reaction v_2 in (c) is C + B -> A + D; and v_4 in (d) is E + B -> 2D



(a) (b) (c) (d)

[16] **Question 11.** The following genetic network uses a notation developed by the BioTapestry group at ISB. If the v_i next to each gene represents the rate of expression of that gene and taking into account that each gene product has a first-order degradation rate, write out the differential equation model that describes this system. Choose appropriate rates laws for each rate, v_i.