⌘ S

CHEME 5440/7770: Prelim 1 Q2

Yujia Huang, yh945
Smith School of Chemical and Biomolecular Engineering,
Cornell University, Ithaca NY 14850

2. a) Formulate a three micro-state model for PEK activity

- **State s = 0**: no effector+no substrate (base state, no activity)
- **State s = 1**: no effector+substrate (the data shows low activity)
- **State s = 2**: effector+substrate (activity)

take the form

$$\hat{r}_j = r_j v(\dots)_j$$

The probability of each microstate is given by

$$p_i = \frac{1}{Z} \times f_i \exp\left(-\beta \epsilon_i\right) \qquad i = 0, 1, 2, \dots, \mathcal{S}$$

where

$$W_i = \exp\left(-\beta \epsilon_i\right)$$

$$Z = \sum_{s=0}^{\mathcal{S}} f_i \exp\left(-\beta \epsilon_i\right)$$

which gives:

$$p_i = \frac{f_i \exp\left(-\beta \epsilon_i\right)}{\sum_{s=0}^{\mathcal{S}} f_i \exp\left(-\beta \epsilon_i\right)} \qquad i = 0, 1, 2, \dots, \mathcal{S}$$

Given these microstates, we know that enzyme E can catalyze its reaction in microstate $s = 1$ and $s = 2$, thus:

$$v(\dots)_j = \frac{f_1 \exp\left(-\beta \epsilon_1\right) + f_2 \exp\left(-\beta \epsilon_2\right)}{\sum_{s=0}^{2} f_s \exp\left(-\beta \epsilon_s\right)}$$

let $j = 1$

$$r_1 = k_{cat} E_1 (\frac{F6P}{K_{K6P} + F6P})(\frac{ATP}{K_{ATP} + ATP})$$

$$\hat{r}_1 = r_1 v(\dots)_1$$

2. b) Estimate the parameters by using the dataset in Table 1

From definition we know $\epsilon_0 = 0$, then $W_0 = 1$ and we also know f_0 and f_1 are both set to 1. So I estimate ϵ_1, ϵ_2, the binding constant Kd and an order parameter n to get W_1, W_2 and f_2 to match the dataset in table 1.

Kd (mM) W1 W2

```
(1.54, 0.046, 260.0)
```

- `DSM_parameters`

```
v = [0.04397705544933078, 0.05389273057560039, 0.0824382077(
```

```
begin
    # get Effector - A
    A = [0:0.01:1;]
    v = A
    for i in eachindex(A)
        Kd = DSM_parameters[1]
        W0 = 1
        W1 = DSM_parameters[2]# state 1 (E bound to S,
        but no A)
        W2 = DSM_parameters[3] # state 2 (E bound to A)

        # setup system -
        R = 8.314           # units: J/mol-K
        T = 273.15 + 25.0   # units: K
        β = 1/R*T

        # setup binding parameters for state 2 -
        n = 2.0

        # compute the state-specific factor-
        f0 = 1.0 # state 0
        f1 = 1.0 # state 1
        f2 = ((A[i]/Kd)^(n))/(1+(A[i]/Kd)^(n)) # state 2

        # compute the v variable -
        microstate_0 = f0.*W0
        microstate_1 = f1.*W1
        microstate_2 = f2.*W2

        Z = microstate_0 + microstate_1 + microstate_2
        p1 = (1/Z)*microstate_1
        p2 = (1/Z)*microstate_2
        v[i] = p1 + p2
    end
    # show -
    with_terminal() do
        println("v = $(v)")
    end
end
```

Show the r_bar calculated when the concentration of the effector is the same as the ones that are shown in table 1. See if they are matched to each other.

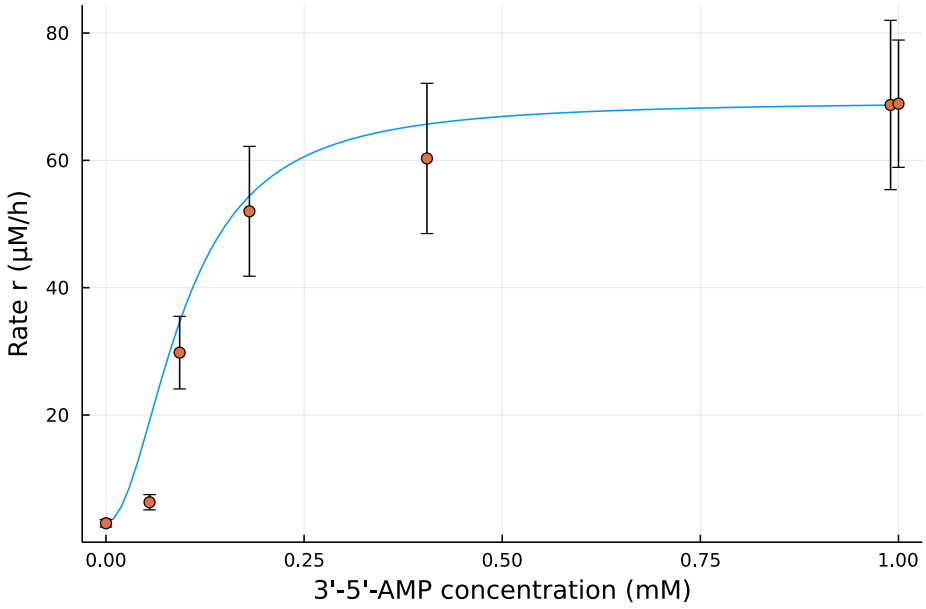
```
r_bar[1,5,9,18,40,99,100] = 3.05991612706268,12.60745895571
```

```
begin
# Set up some parameters
    S1 = 0.1 # units: mM -- concentration for F6P
    S2 = 2.3 # units: mM -- concentration for ATP
    E = 0.12 # units: μM
    K_F6P = 0.11 # units: mM
    K_ATP = 0.42 # units: mM
    kcat = 0.4 # units: s^-1

# calculate the rate
    r_bar = (kcat*E)*(S1/(S1+K_F6P))*
    (S2/(S2+K_ATP))*v*3600

# show -
    with_terminal() do
    println("r_bar[1,5,9,18,40,99,100] =
    $(r_bar[1]),$(r_bar[5]),$(r_bar[9]),$(r_bar[18]),$(r_b
    ar[40]),$(r_bar[99]),$(r_bar[100])")
    end
end
```

so the final results I choose are kd = 1.54, W1 = 0.046, W2 = 260.0

2. c) Plot the converted data with errorbars

from the image we can see the proposed model describes the data well except for the second one




```
begin

    # 3'-5'-AMP concentration -
    x = 0:0.01:1
    conc = [0, 0.055, 0.093, 0.181, 0.405, 0.990, 1.0]
    rate = [3, 6.3, 29.8, 52.0, 60.3, 68.7, 68.9]
    std = [0.59, 1.2, 5.7, 10.2, 11.8, 13.3, 10.0]

    # overall rate -
    y = r_bar

    # plot -
    plot(x,y,label="r")
    plot!(conc,rate,yerror=std,seriestype = :scatter,
    legend =false)
    xlabel!("3'-5'-AMP concentration (mM)",fontsize=18)
    ylabel!("Rate r (μM/h)",fontsize=18)

end
```

3. a) convert the <n> values in Table 2

```
[0.26125, 0.28875, 0.56375, 0.92125, 1.1825, 1.27875, 1.27875]
```

```
begin
    n_array = [19;21;41;67;86;93;93;]; #units: nM from
    the assume(ii)
    mc = 2 * 10^(-13) # units:g
    Vc = 2.75 # units: μm^3

    n_array_new = n_array * Vc / mc * 10^(-15)

end
```

```
md"""
##### 3. b)
"""
```

```
begin
    # import some packages -
    using PlutoUI
    using PrettyTables
    using LinearAlgebra
    using Plots
end
```