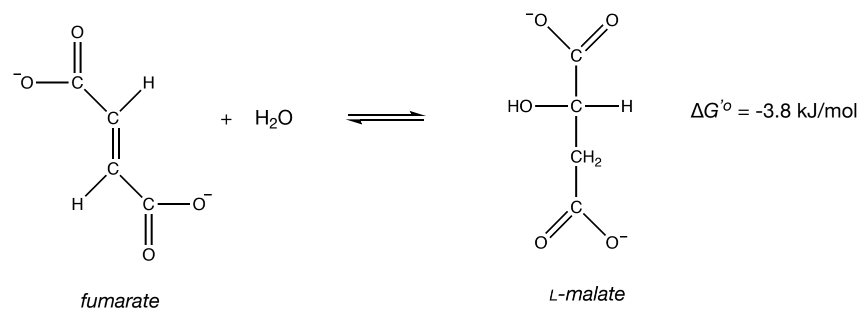
Name Key

Chem 352 - Fall 2018
Quiz 1

R = 8.314 *J/(mol•K)* = 0.08206 *(L•atm)/(mol•K)* [Ideal Gas Law Constant]
$K_w = 1.00 \times 10^{-14}$ M^2 [Ionization Product for water]

12/12

1. One of the citric acid cycle's reactions (the citric acid cycle is a pathway used in the complete oxidation of glucose to CO_2 and H_2O) involves the hydration of *fumarate* to form L-*malate*.



a. Is the reaction favorable under standard state conditions at 37°C? (Y/N) Y (4 pts)
Explain: The change in the free energy for a reaction, ΔG can be used to determine if a reaction is favorable or not as written. When ΔG is < 0, the reaction is favorable, when ΔG is > 0, the reaction is unfavorable, but is favorable in the reverse direction. When ΔG = 0, the reaction is at equilibrium, and is not favorable in either direction. For this reaction, you are asked if the reaction is favorable at *standard state conditions*, At standard state conditions, ΔG = ΔG°, the standard state free energy change. It is given that ΔG'° = -3.8 kJ/mol. therefore ΔG = -3.8 kJ/mol and the reaction is favorable as written.

b. What is the value of the equilibrium constant, K_{eq}, for this reaction at 37°C?

(4 pts)

at equlibrium, $\Delta G'^{o} = -RT\ln(K_{eq})$

$$\ln(K_{eq}) = \frac{-\Delta G'^{o}}{RT}$$

$$K_{eq} = e^{\left(\frac{-\Delta G'^{o}}{RT}\right)}$$

$$K_{eq} = \exp\left(\frac{-\left(-3.8\,\frac{kj}{mol}\right)}{\left(8.314 \times 10^{-3}\,\frac{kj}{mol•K}\right)(37 + 273\ K)}\right)$$

$$\boxed{K_{eq} = 4.37}$$

c. If the cellular concentration of *fumarate* is 1.33 mM, and the concentration of L-*malate* is 8.55 mM, is this reaction favorable under conditions found in a cell at 37°C? (Y/N) ______
Explain: Under the conditions given, ΔG > 0, therefore the reaction is not favorable.

when not at standard state condition,

(4 pts)

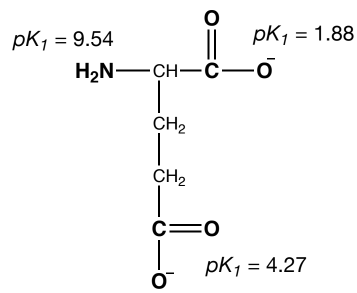
$$\Delta G = \Delta G'^{o} + RT\ln\left(\frac{[products]}{[reactants]}\right)$$

$$= -3.8\,\frac{kJ}{mol} + \left(8.314 \times 10^{-3}\,\frac{kJ}{mol•K}\right)(37 + 272\ K)\ln\left(\frac{8.55 \times 10^{-3}\ M}{1.33 \times 10^{-3}\ M}\right)$$

(H_2O is also the solvent, and so is not included as one of the reactants.)

$$\boxed{\Delta G = 1.00\,\frac{kJ}{mol}}$$

2. The structural formula for the amino acid glutamic acid is shown to right. Glutamic acid contains three ionizable groups; the structure shown has all three of these groups in their *deprotonated*, *conjugate base* forms. The pK_a values for these three groups are indicated in the figure.



glutamic acid

13/13

a. What is the expected *pH* for a 150 mM solution of glutamic acid in its *fully protonated* form? (show calculations)

It is the ionizable group which is the strongest acid and has the lowest pK_a that will have the greatest influence on the pH of the fully protonated form of glutamic acid in an aqueous solution. The $[H^+]$ of a weak acid solution is approximately equal to $\sqrt{K_a C_a}$, where K_a is the acid dissociation for the weak acid, and C_a is its concentration.

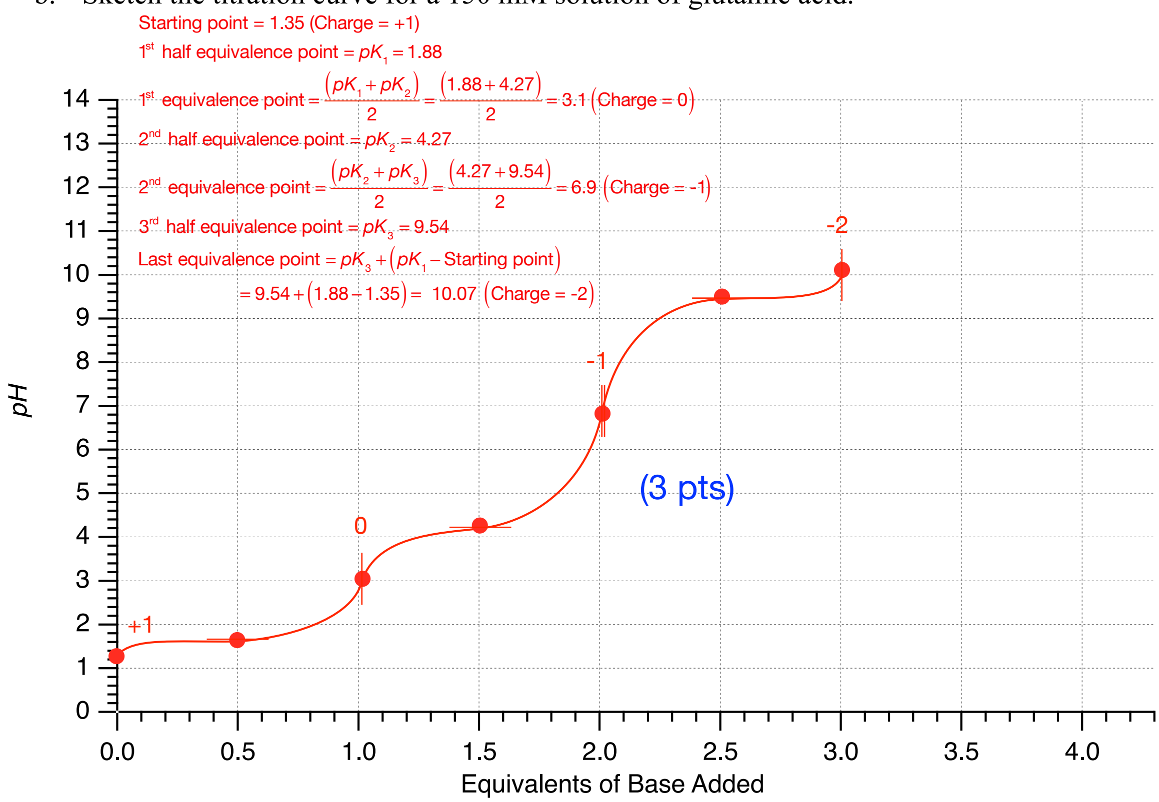
$$[H^+] \approx \sqrt{K_a C_a} \approx \sqrt{10^{-pK_1} C_a} \approx \sqrt{10^{-1.88}(150\times10^{-3}\,M)} \approx 4.44 \times 10^{-2}\ M$$

$$pH = -\log([H^+]) = -\log(4.44\times10^{-2}M)$$

$pH = 1.35$

(4 pts)

b. Sketch the titration curve for a 150 mM solution of glutamic acid.



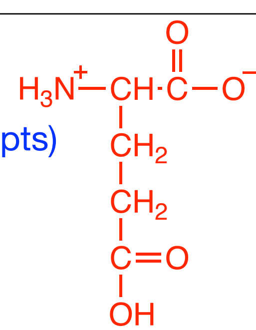
(3 pts)

c. In solution, at what *pH* does the predominant (major) species of glutamic acid have a *net charge* of 0? *pH* = 3.1
(The first equivalence or end point)

(This *pH* is also called the *isoelectric point*, *pI*, because at this *pH* glutamic acid does not move in an electrostatic field.)

d. Draw the structure for the predominant species of glutamic acid that is present at its isoelectric *pH*.

(3 pts)



25/25