Action Center #5

1. What is the effect of the following changes on the oxygen affinity of hemoglobin (decrease or increase)?
   a. pH changes from 7.4 to 7.2 decrease
   b. pCO2 in the lungs decreases from 6 kPa to 2 kPa increase
   c. When BPG changes from 5 mM (normal altitudes) to 8 mM (high altitudes) decrease
   d. When CO increases from 1.0 ppm to 30 ppm in a home that has a faulty furnace no change for CO-free Hb; decrease for CO-bound Hb

2. Use the equation shown below to make the following calculations. Calculate Y in the lungs when p50 = 24 torr, n = 3.1, and pO_2 = 100 torr. Then, calculate Y in the capillaries, where pO2 = 25 torr, n = 3.1, and p50 = 24 torr. What is the overall efficiency, which is the difference in percent of the fractional saturation in the lungs minus the fractional saturation in the tissues?

$$Y = \frac{pO_2^n}{pO_2^n + p_{50}^n}$$

$Y(l) = 100^{3.1}/(24^{3.1}+100^{3.1}) = 0.9882$
$Y(c) = 25^{3.1}/(24^{3.1}+25^{3.1}) = 0.5316$
(Y(l)-Y(c))*100% = 46%

3. Use the same values as above, but this time let n=1 instead of 3.1. Calculate Y in the lungs, Y in the capillaries. What is the overall efficiency?

$Y(l) = 100^1/(24^1+100^1) = 0.8064$
$Y(c) = 25^1/(24^1+25^1) = 0.5102$
(Y(l)-Y(c))*100% = 29.6%

4. Protein A has a binding site for ligand X with a Kd of 10^{-6} M. Protein B has a binding site for ligand X with a Kd of 10^{-9} M. Which protein has a higher affinity for ligand X? Why? Convert Kd to K(assoc.) for both proteins.

Protein B has a lower Kd, thus it has a higher affinity.
K(assoc.) = 1/Kd
Ka(B) = 10^9 M^{-1}
Ka(A) = 10^6 M^{-1}

5. An antibody binds to an antigen with a Kd of 5×10^{-8} M. At what concentration of antigen will Y be 0.2? 0.5? 0.6? 0.8?

Y = [L] / (Kd+[L])
[L] = Kd*Y/(1-Y)
For Y = 0.2, [L] = 1.25×10^{-8} M
For Y = 0.5, [L] = 5×10^{-8} M

For Y = 0.6, [L] = $7.5*10^{-8}$ M
For Y = 0.8, [L] = $2.0*10^{-7}$ M

6. A compound has two carboxyls and one amino group. The pKas of the groups are 1.8, 4.2, and 9.1, respectively. A biochemist has 80 ml of a 0.14 M solution of this compound at a pH of 4.9. She adds 25 ml of 0.12 M NaOH. What will be the final pH of the solution after the addition of the NaOH?

We have the total of 0.14mol/L * 0.08L = 0.0112 mol of compound. This amount also described the buffering capacity of each ionization stage.

At pH 4.9 all the carboxyls with pKa 1.8 are negatively charged (deprotonated).
Also, at pH 4.9 all of the amino groups with pKa 9.1 are positively charged (protonated).

For the carboxyl group with pKa of 4.2 (partially protonated):
[COOH]/[COO-] = 10^(pKa-pH) = 0.1995
Fraction of [COOH] = 0.1995/1.1995 = 0.1663
0.1663 of all carboxyls with pKa 4.2 still have a proton.
Converting this to mol gives 0.1663*0.0112mol = 0.001863mol

The added NaOH (0.12mol/L*0.025L = 0.003mol) will completely deprotonate that carboxyl group. This leaves (0.003mol-0.001863mol) 0.001137 mol OH-, which will deprotonate some of the NH_3^+ on the compound:

[NH2]/[NH3+] = 0.001137/(0.0112-0.001137) = 0.113

We can plug this into Henderson Hasselbalch to get the pH:
pH = pKa + log[NH2]/[NH3+] = 9.1 + log 0.113 = 8.2