Respiratory Gas Exchange Problem[1]

Bio390

Use the concepts of gas exchange found in our steady-state model that includes two convective and two diffusive steps in solving this problem.

Given:

P_{H2O} = 10 torr
average lung volume: 3.5L,
P_{AO2} = 110, P_{ACO2} = 40,
P_{vO2} = 50, P_{vCO2} = 46
resting expired minute volume = 6 L/m, breathing rate = 12
blood volume: 6L, cardiac output = 6 L/m
Hb saturates at 75 torr
initial: venous O2 content (bound + dissolved) = 15 vol% and
venous CO2 (bound + dissolved + bicarbonate) content: 53vol%
initial: arterial O2 content = 20 vol% and
CO2 content 49 vol%

The subject then hyperventilates until new steady-state values are achieved:
P_{AO2} = 120 and P_{ACO2} = 32 (both for steady-state hyperventilation)

1. What is the highest theoretically possible P_{AO2} if the subject is breathing room air? Lowest theoretically possible P_{ACO2} ?

Assume the eventual steady-state values of P_{AO2} = 120 and P_{ACO2} = 32:

2. Approximately how much will the amount of oxygen in the blood (O_2 and CO_2 contents) change (give approximate new equilibrial values in vol%)?
3. Does hyperventilation make any difference in bound oxygen?
4. Does hyperventilation make a large difference in dissolved oxygen?
5. When hyperventilation starts, which blood gas will reach steady-state sooner? Why? Which lung gas will reach a new steady-state value sooner? Why?
6. On a common axis, make a qualitative plot of the difference between blood and lung P_{O2} and P_{CO2} vs. time -- time should consist of before hyperventilation (steady-state), early hyperventilation and then continued hyperventilation (hint: where a steady-state is reached).
7. Make a qualitative plot of blood O_2 and CO_2 content with respect to time (using time as in #6).
8. Make a plot of alveolar P_{O2} and P_{CO2} with respect to time. There is no reason to make a separate plot for lung content for these two gases. Explain why not.
9. Make a plot of P_{ACO2} vs. P_{AO2} as is shown at then end of the packet 18 notes. On it label P_I for inspired air, P_A before hyperventilation (see data above), P_A at steady-state hyperventilation, and the path (change in O2 and CO2) taken in getting from the normal to hyperventilation point. Use your answers above to figure out how to draw this graph. Hint: remember that time is not directly a variable in this plot.
