Bio390 **Oxygen Transport by the Blood -- SOLUTION**

Animal Physiology

revised 12/4/17

Given the following:

For an HCT = 40 **bound** O_2 at saturation = 20 ml/dl

P_{aO2} =100 torr

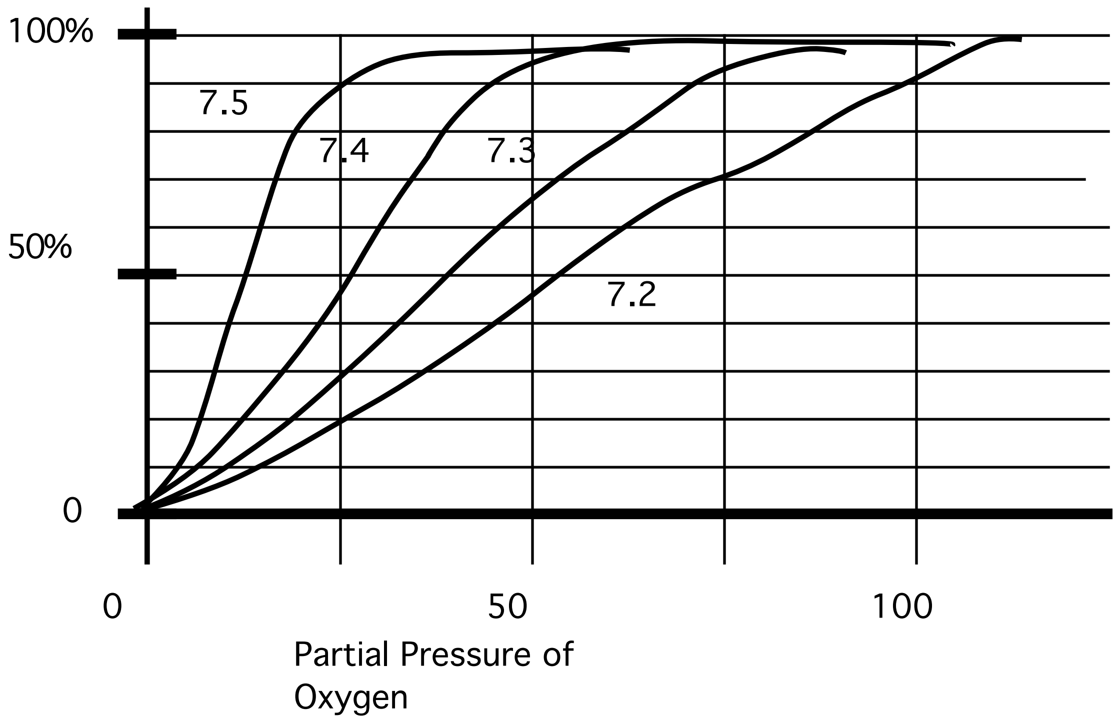
P_{vO2} =25 torr

Solubility of O_2 = 0.01 ml O_2 /torr * dl blood

HCT = 50

arterial pH = 7.4

RA pH = 7.2



(a) Find the oxygen content of arterial blood.

From the graph, simply go from the P_{aO2} which in this case is 100 up to the arterial blood curve, here the pH = 7.4 curve. The blood is saturated. Now we need the O_2 carrying capacity of this person's blood. Since their hct = 50%, then their blood can carry 50/40*20ml O_2 / dl blood = 25 ml O_2 / dl blood bound to Hb when the blood is saturated (which it is).

But there is also dissolved O_2 – the amount is simply the P_{O2} times the solubility, so 100 torr * 0.01 mL O_2 / (dL * torr) = 1 mL O_2

Thus: 25 + 1 = 26 mL O_2- / dL

(b) Find the total oxygen content of mixed venous (RA) blood. Why is RA blood termed "mixed venous"?

Same method as before except P_{aO2} = 25 torr and the pH = 7.2. Using the graph, this gives a % sat of 20% . Thus, the amount of O_2 carried is:

20/100 * 25 ml O_2 / dl blood = 5 ml O_2 / dl blood

Likewise, the amount in solution is
25 torr * 0.01 mL O_2 / (dL * torr) = 0.25 mL O_2 / dL

and the total in the RA is bound plus dissolved
= 5.25 mL O_2 / dL

(c) Find the total AV (arterial to venous) difference in oxygen content in ml O_2 per 100 ml blood.

This is the difference between the results in (a) and (b) which is the difference in bound O_2 plus the difference in the dissolved O_2 (see (e) below).

Δ Dissolved O_2 = α (P_{aO2} - P_{vO2}) = 0.01 ml O_2 /torr * dl blood * (100 - 25 torr) = 0.75 ml O_2 / dl blood

Δ bound O_2 = 25 - 5 ml O_2 / dl = 20 ml O_2 / dl

Thus, A-V O_2 is 20 + 0.75 ml O_2 / dl = **20.75 ml O_2 / dl**

OR using the numbers in (a) and (b) it is the A-V (i.e., RA) difference in O_2 content
= 26.00-5.25 =20.75 mL O_2 / dL

(d) Compare the value you found for (c) with what would have happened in the absence of a Bohr effect -- *i.e.*, if there had been no change in affinity due to a decrease in *p*H.

The Δ Dissolved O_2 will be the same as the example, as will be the arterial bound O_2. However, if there is no Bohr effect we will continue to use the *p*H = 7.4 graph to get the % sat of venous blood at 25 torr. This value is about 45%. Thus,

Δ Bound O_2 = 25 ml O_2 / dl blood * (100 - 45)/100 = 13.75 ml O_2 / dl blood

which is 13.75 / 20.75 = 0.66 as much O_2 as was delivered from bound as with the Bohr effect.
Total O_2 delivered in this case is:

Δ Bound + Δ Dissolved = 13.75 + 0.75 = **14.5 ml O_2 / dl blood** which is 14.5 / 20.75*100 =**70%** o f what was delivered with the Bohr effect.

(e) Write a general mathematical expression that would allow you to solve for AV difference in oxygen content using the variables you used in parts (a) to (d) above.

O_2 delivered = Δ Bound O_2 + Δ Dissolved $_{O2}$

= O_2 capacity *(%SAT arterial - % SAT venous)/100 + α (P_{aO2} - P_{vO2})

(f) Assume that the person lost 50% of her/his ability to carry oxygen bound to hemoglobin. If the person still needs the same amount of O_2 to live, what would happen to the following (make qualitative predictions (up, down, no change) only).

(i) A-V saturation: increase this difference, probably by decreasing decreasing venous % saturation (removal of more O_2 from blood in tissues) while maintaining P_{aO2}. Lactic acid production would hopefully not be a major "aid" in unloading bound O_2.

(ii) A-V Dissolved O_2: As above, decrease PvO2 – note again that this will also result in a decrease in venous % saturation – the change in P_{VO2} would preceed any change in % venous saturation.

(iii) Cardiac Output: Increase cardiac output -- delivery of more volume of blood per time could easily compensate for the reduced amount of O_2 available in each volume of blood that is delivered.

(iv) Anything else?: intervention -- breathe gas with a high P_{O2}.