

1. Extraction ratio (the quantity of oxygen that is being extracted from the circulation by the organ) =

$$\frac{\text{arterial-venous}}{\text{arterial}} * 100 \%$$

- For example: If we have an arterial conc. of 20 and a venous conc. of 15, we can determine that the extraction ratio is 25%.

2. O2 content (concentration) = (O2 bound to Hb) + (O2 dissolved in plasma)

$$[O_2] = (1.34 \times Hb \times SaO_2) + (PO_2 \times 0.003)$$

- Example: A person has a hemoglobin concentration of 10 gm/dl. The arterial oxygen content is 6.5 ml O2 /dl. What is saturation?

- A. 25%
- B. 50%
- C. 75%
- D. 100%

Answer: $6.5 = 1.34 \times 10 \times SaO_2$

$SaO_2 = 6.5 / 13.4 \sim 50\%$

3.

$$P_{\text{alveolar CO}_2} = \frac{V_{\text{CO}_2} (\text{CO}_2 \text{ production})}{V_R (\text{alveolar ventilation})} \times 0.863$$

• The volume of air moved into and out of the lungs per unit time.

• **Minute ventilation** = $V_T \times \text{Breaths/min}$

• **Alveolar ventilation** is minute ventilation corrected for the physiologic dead space.

$$\dot{V}_A = (V_T - V_D) \times \text{Breaths/min}$$

where

\dot{V}_A = Alveolar ventilation (mL/min)

V_T = Tidal volume (mL)

V_D = Physiologic dead space (mL)

Let's tidy up the idea:

$$\text{Flow } (Q) = DF \times K$$

$$dO_2 = \Delta P O_2 \times K$$

$$DL = K$$

$$K = \frac{dO_2}{\Delta P O_2}$$

$$\frac{dO_2}{\Delta P O_2} = K = DL = \frac{1}{R}$$

After playing with the equation

Where:

dO₂ = Diffusion of O₂, it represents Flow

K = Permeability

DL = Diffusion capacity of Lung

R = Resistance.

dO₂ / ΔP O₂ = how much O₂ / min * 1 mmHg (ΔP).

- ❖ RECALL: $DL = \frac{A}{dx} \times \frac{S O_2}{\sqrt{MW}}$
 - **DL**: diffusion capacity of the lung,
 - **A**; area (between 50-100 m², we can't calculate it, I cannot tell exactly what is left after the damage).
 - **dx**; thickness (also not easy to calculate since it ranges between 0.2-0.6),
 - **S O₂**; solubility of O₂ (from physics),
 - **MW**; molecular weight (also from physics)
 - **diffusion coefficient** = $\frac{S O_2}{\sqrt{MW}}$

$$K = \frac{\dot{V} O_2}{\Delta P O_2}$$

V_{o2}: rate of O₂ consumption (O₂ consumption/min), **ΔP O₂** = P_AO₂ - P_aO₂

5.

$$P O_2 A = P O_2 i - \frac{P a C O_2}{R}$$

PAO₂: alveolar PO₂, PO_{2i}: inhaled PO₂

PaCO₂: arterial PCO₂, R: respiratory exchange ratio

$$P i O_2 = F i O_2 \times (P B - P H_2 O)$$

FiO₂ = Percent of O₂ (if the doctor mentions it in question use it, but if the doctor doesn't mention it use it as 21%).

PB = atmospheric pressure (at sea level it = 760).

PH₂O = 47

- Example: A person is breathing from a gas tank containing 45% oxygen. What is the alveolar PO₂?

A. 149 mmHg B. 250 mmHg C. 270 mmHg

D. 320 mmHg E. 340 mmHg

Answer: PAO₂ = (760 - 47) x 45% - (40 / 0.8) = 270

- **Important:** The doctor may ask you to calculate **the alveolar arterial (A-a) gradient** for oxygen using the alveolar gas equation.

- To calculate **the A-a gradient**, we use the previous alveolar gas equation to find the alveolar PO₂.

6.

*(Henderson-Hasselbalch Equation) $\text{pH} = 6.1 + \log \left(\frac{[\text{HCO}_3^-]}{[\text{CO}_2]} \right)$

!! لا تنسوا إحضار الآلة الحاسبة

اللهم
صَلِّ وَسَلِّمْ وَبَارِكْ عَلَى سَيِّدِنَا مُحَمَّدٍ ﷺ

Physiology

الارقام المطلوب حفظها: 😊

Difference between pulmonary & systemic capillaries

	Pulmonary capillary	Systemic capillary
Pc	10 mm Hg	30 mm Hg
Πc	28 mmHg	28 mmHg
Pi	- 5 mmHg	Zero
Πi	14 mmHg*	7 mmHg

2. The lowest A-V difference is seen in the carotid bodies = 0.5, Then the kidneys follow with the second-lowest A-V difference (1.4).
3. Normally the extraction ratio = 25%. In exercise 75% - 85%. In some local tissues with extremely high metabolic rate → 100%.
4. Normal V/Q= 0.84 (4.2 L/min ÷ 5 L/min).
5. V/Q ratio of infinite (V/ 0 = infinite) --> wasted ventilation, the PO₂ is 150 and PCO₂ is zero.
6. V/Q ratio of 0 (0/Q=0) --> wasted perfusion, so alveolar PO₂ =40, PCO₂=45 (as the venous).
7. The pressure at the apex is (-8) and (-2) at the base in the standing position. (-8) means that the alveoli are inflated (highly negative surrounding pressure). While in the base, the alveoli are partially inflated. So, the apical alveoli have a low compliance while the basal alveoli have a high compliance.
8. PVR is 1/7 of TPR.

9. [O₂] in blood is found in two forms:

A- **Dissolved in plasma** (1.5%) = $PO_2 * \text{solubility of } O_2$

- Normally = $100 * 0.003 = 0.3 \text{ ml}$ of O₂/ dl of blood

B- **HbO₂ (98.5%): each 1g of Hb contains 1.34ml O₂.**

- The normal Hb concentration being: 14-16 in males (**consider it 15**, $15 * 1.34 = 20 \text{ ml}$ of O₂).

- So, the total [O₂] in blood is $20 + 0.3 = 20.3 \text{ ml/dl}$.

10. Only $1/3$ of the respiratory membrane is used at rest.

11. K_{co} or DL_{co} = $17 \text{ mL/min} * 1 \text{ mmHg}$ (يمكن حفظ مش متأكدة)

12. The diffusion coefficient diffusion coefficient = SO_2 / \sqrt{MW} , for:

o O₂=1, CO=0.8, CO₂=20.

13. DLO₂ = 1.25 DLCO = $21 \text{ mL/min} * 1 \text{ mmHg}$

14. DL_{co2} = 20 DLO₂ = $20 * 21 \approx 400$

During muscular exercise, increases 2-3 times due to:
- recruitment and distention of capillaries to utilize more than 1/3.
- Improvement in ventilation/ Perfusion ratio

15.

- ❖ If we say that blood makes 7% of human weight (assuming it is 70kg) then blood amount = $7\% * 70 = 5 \text{ L} = 5000 \text{ mL} = 5 * 10^6 \mu\text{L}$
- ❖ In each $1 \mu\text{L}$ of blood (which is a cube of $1 \text{ mm} * 1 \text{ mm} * 1 \text{ mm} = 1 \text{ mm}^3$), there are $5 * 10^6$ RBCs
 - **Be careful!!** You can say we have $5 * 10^6 \text{ RBCs/mm}^3$ OR $5 * 10^6 \text{ RBCs/}\mu\text{L}$, BUT you should **never** say $5 * 10^6/\text{L}$.
- ❖ In each RBC we have 280 million Hb molecules.
 - **Be careful!!** You should never say that each RBC can carry four O₂ molecules
× ×
 - **But you can say that one RBC can carry $280 * 10^6 * 4$ (because one Hb can carry four O₂ molecules, so we multiply 4 by the number of Hb molecules in one RBC) ✓**

16. **PO₂ at the end of the capillary is normally always equal to alveolar PO₂** (unless there is some pathology affecting diffusion).

17. At sea level, **Patm is equal to 760 mmHg.**

- 18. Percent of O₂ in the outside air is 21%.
- 19. In Alveolar Air, PAO₂=100 mmHg and PCO₂=40mmHg.
- 20. In the artery PaO₂=100 and PaCO₂=40.
- 21. In the vein PO₂=40 and PaCO₂=45.
- 22. CO binds to hemoglobin 250 times more strongly than O₂.
- 23.

Values to remember

PO ₂	O ₂ Sat (%)	
10	25	
20	35	
26	50	P50
30	60	
40	75	Venous
50	85	
60	90	Respiratory center stimulation
80	96	
100	98	Almost Fully saturated

important !!

24. Respiratory Exchange Ratio (RER):

- The cardiac output Q = 50 dL/min = 5L/min
- At rest, we extract 5mlO₂/1dl → 50 * 5 = 250ml/min VO₂ (O₂ consumption). In exercise, it increases 20-fold (5,000 ml/min).
- Similarly, the tissues release 4ml CO₂/1 dl → 50x4 = 200 ml/min VCO₂ (CO₂ production).

Respiratory exchange ratio (RER) =

$$\frac{VCO_2 \text{ (CO}_2 \text{ production)}}{VO_2 \text{ (O}_2 \text{ consumption)}} = \frac{4}{5} = \frac{200}{250} \text{ per minute} = 0.8$$

RER: ⇒ in fats = 0.7, ⇒ in protein = 0.8, ⇒ in mixed food = 0.8 ⇒ in carbohydrates = 1.

25. CO2:

1. 70% are transported as bicarbonate (HCO₃⁻)
2. 20% are transported as carbaminohemoglobin
3. 10% or 7% are transported dissolved in plasma

26. Decrease in PO₂ (**below 60 mmHg**): Stimulates the respiratory center.

27. Normal ABGs levels: **PO₂ = 100 mmHg, PCO₂ = 40 mmHg and PH = 7.4.**

28. مش متأكدة اذا حفظ

Pulmonary Pressures

– Pulmonary artery pressure and systemic pressures are not the same. Here pulmonary artery pressures are:

- systolic 25 mmHg
- diastolic 8 mmHg
- mean 14/15 mmHg
- capillary 7-10 mmHg
- Left Atrial and Pulmonary Venous Pressures = 2 (1-5) mmHg (estimated)
- Pulmonary wedge pressure = 5 mmHg (usually its 2 to 3 mmHg greater than the left atrial pressure)

﴿يَا أَيُّهَا الَّذِينَ ءَامَنُوا اذْكُرُوا اللَّهَ ذِكْرًا كَثِيرًا﴾

- سُبْحَانَ اللَّهِ
- اَلْحَمْدُ لِلَّهِ
- لَا إِلَهَ إِلَّا اللَّهُ
- اللَّهُ أَكْبَرُ
- لَا حَوْلَ وَلَا قُوَّةَ إِلَّا بِاللَّهِ
- سُبْحَانَ اللَّهِ وَبِحَمْدِهِ
- سُبْحَانَ اللَّهِ الْعَظِيمِ
- اَسْتَغْفِرُ اللَّهَ وَأَتُوبُ إِلَيْهِ
- اَللَّهُمَّ صَلِّ وَسَلِّمْ عَلٰى نَبِيِّنَا مُحَمَّدٍ ﷺ
- لَا إِلَهَ إِلَّا اللَّهُ، وَحْدَهُ لَا شَرِيكَ لَهُ، لَهُ الْمُلْكُ
- وَلَهُ الْحَمْدُ، وَهُوَ عَلَى كُلِّ شَيْءٍ قَدِيرٌ
- لَا إِلَهَ إِلَّا أَنْتَ سُبْحَانَكَ إِنِّي كُنْتُ مِنَ الظَّالِمِينَ