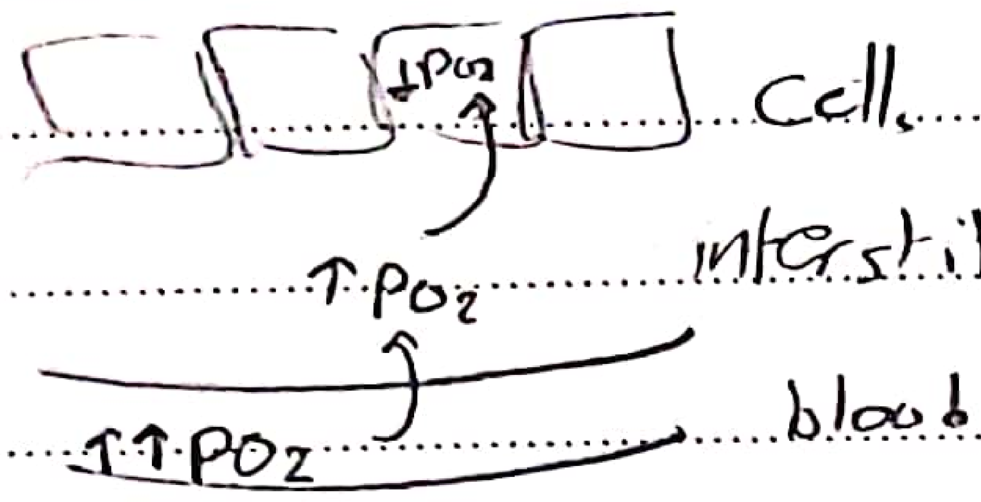
*Respiratory systeme :-

physiology / /

1.



O_2 ✓ → 36 ATP

O_2 ✗ → 2 ATP

* sealevel : atmospheric pressure = 760 mmHg

PO_2 160 ← (O_2) 21%

PN_2 600 ← (N_2) 79%

PCO_2 0.3 ← (CO_2) Zaa

	atm.	PO_2	PN_2
sea level	760	160	600
5.5 km	380	80	300
11 km	190	40	150

يقل الضغط كلما ارتفعنا

①

* COPD : chronic obstructive pulmonary disease

- emphysema (page 10 / sheet 3) + (page 4 / sheet 4)
- chronic bronchitis → irreversible
- Asthma → 90% reversible

- 70% of lung disease
- narrower the lumen → r ↓ → Resistance ↑ → difficulty in Expiration → شرح إضافي صفحة 12

/ /

(2)

* Restricted pulmonary diseases
- → Fibrosis
- → RDS: respiratory distress syndrom

- 20 - 25% of lung disease
- compliance ↓ , unstretched, rigid , collapsed

(3)

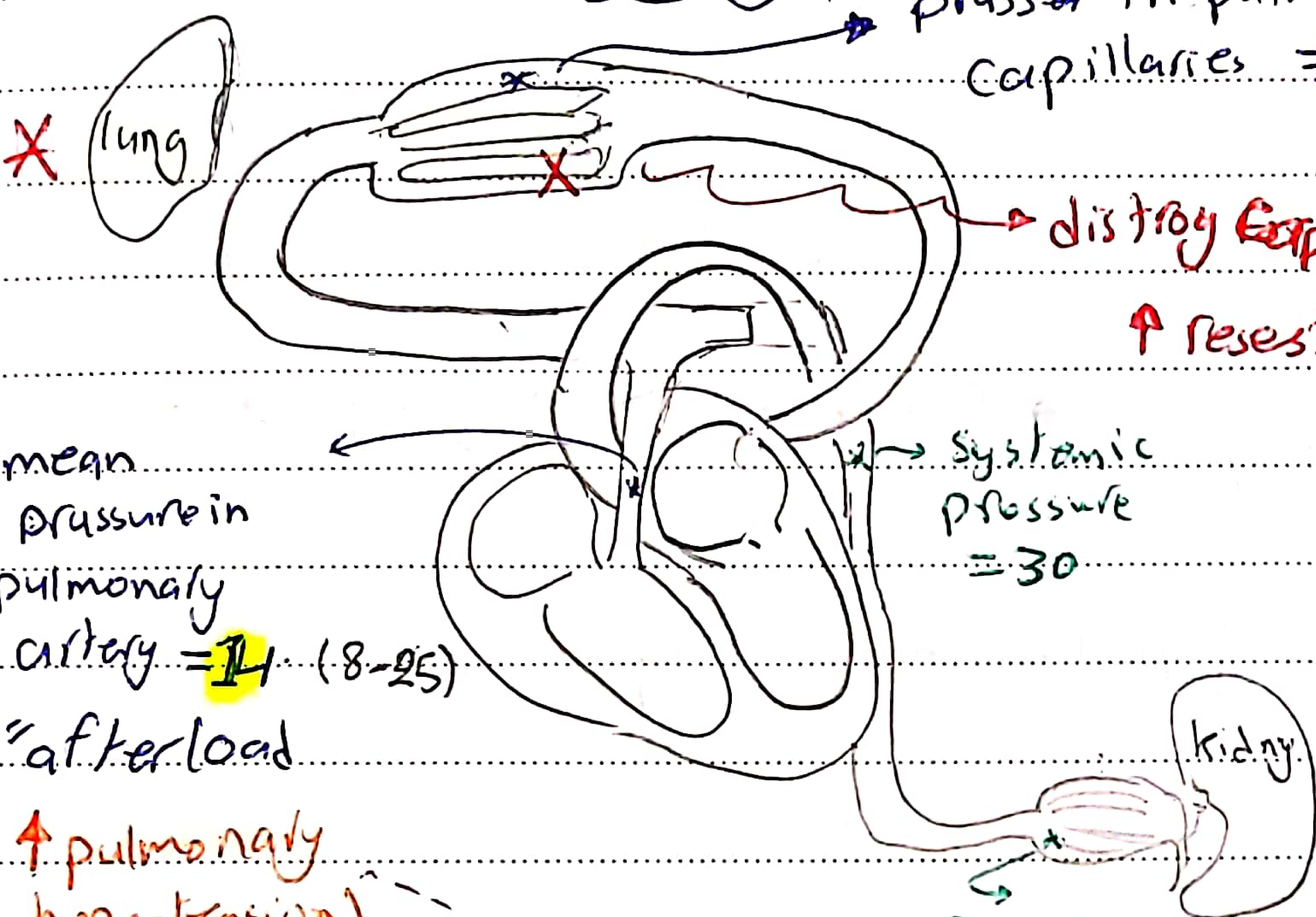
* problem in Respiratory membrain (Vascular pulmonary disease)
- ↳ membrane thickening
  - → pulmonary edema
  - → pneumonia
  - → TB
  - → fibrosis
  - → infiltration of interstitum (asbestosis / silicosis)
- ↑ thick , ↓ diffusion , ↓ gas exchange

* Respiratory failure : → Type 1 : PO_2 in blood = below (60)
PCO_2 = 40 (normal)

Type 2 : PO_2 < 50
PCO_2 > 50

Solubelity of CO_2 is 20 time of solubility of O_2

$CO_2 \cdot X20$



pressure in pulmonary capillaries = 7 mmHg] ↑ P in capillares → pulmonary edema ⇓ left heart failure

→ distroy capillareies → ↑ resestance

mean pressure in pulmonary artery = 14 (8-25) "afterload"

↑ pulmonary hepertension → right ventricle failure

Cor pulmonale "RV dilation"

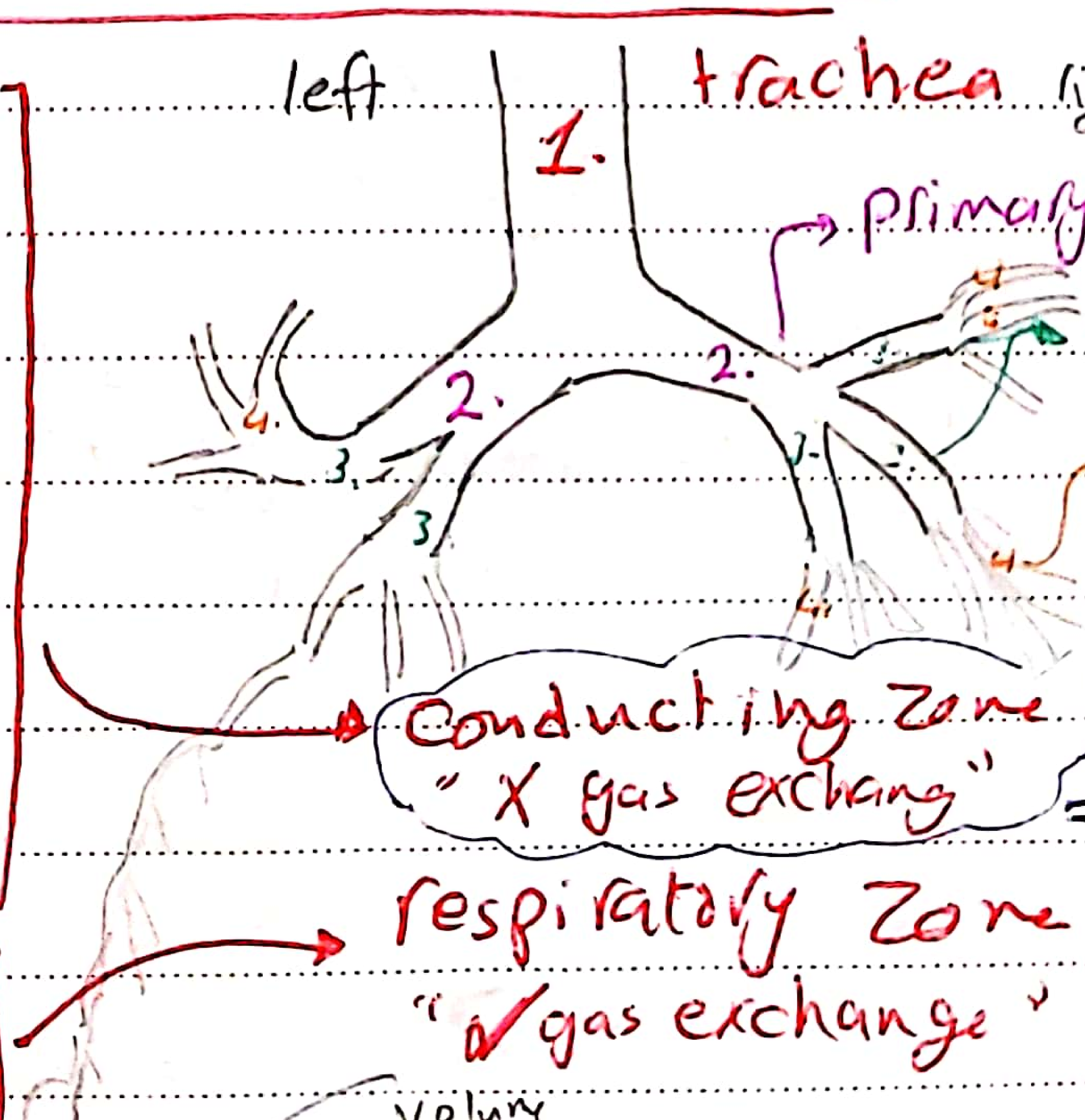
Pressure pulmonary A. = X5 = 70

→ systemic pressure = 30

glomerular capillaries = 60 "filtiration"

---

trachea ← 0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
terminal bronchiole ← 16
respiratory bronchiole ← 17
⋮
alveoli ← 23



primary bronchi

secondary bronch

tertiary bronch "segmental"

0–16 → Conducting Zone "X gas exchange" "Dead space" = volume = 2 ml/kg

for 75 kg man DS = 2X75 = 150

17–23 → respiratory Zone "✓ gas exchange"

volume ↳ = inspiration air volume − DSV (TV − DS)

500 ml − 15 ml = 350 ml

بشه مبدأ ؟

CO = HR X SV

/ /

* Respiratory minute Ventilation = Respiratory rate X alveolar air

(alveolar) A.V.R alveolar ventilation rate

12 X 350 mL = 4200 mL = 4.2 L

* Arterial Blood Gases test (ABGs test)

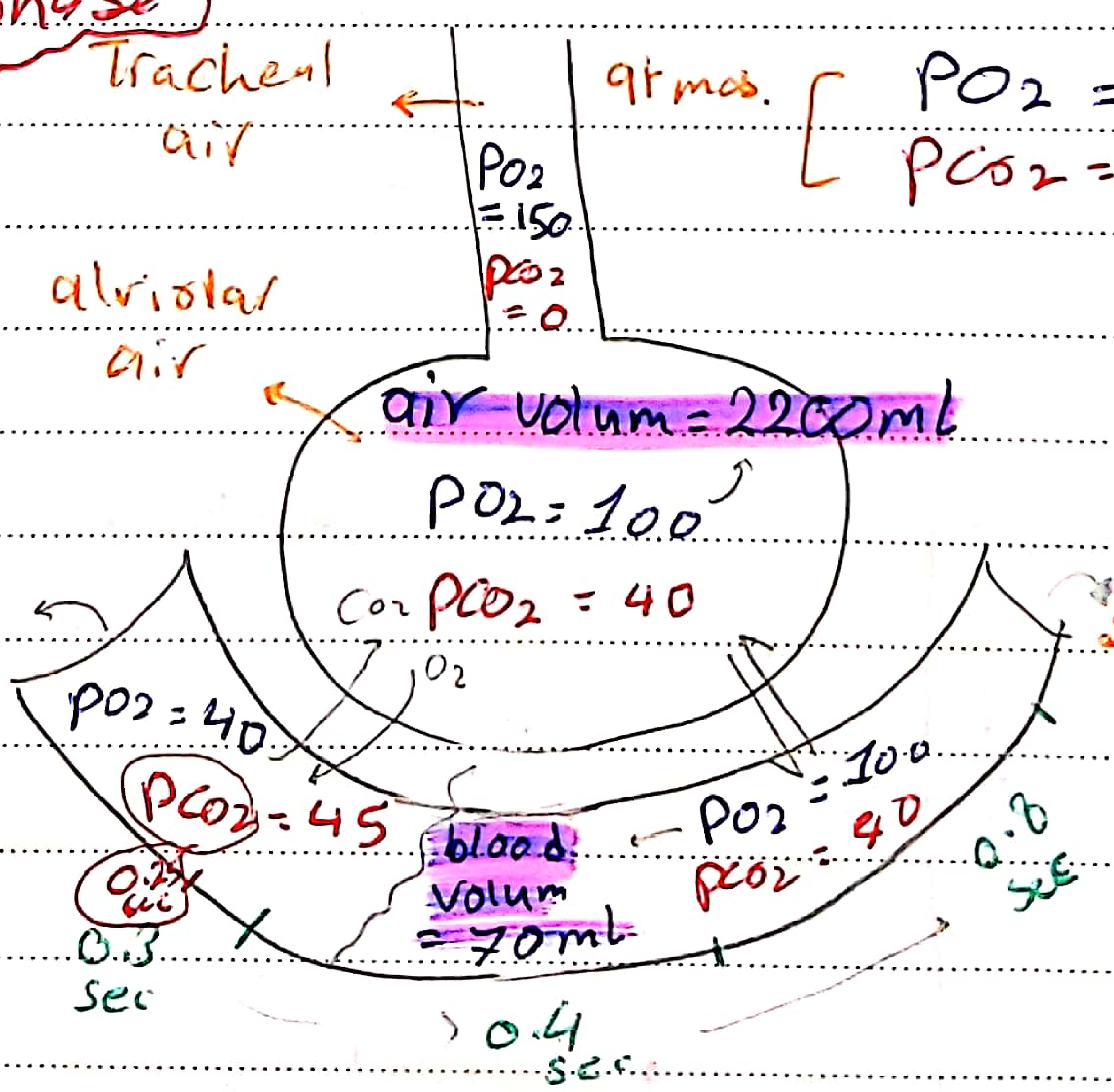
(بتاخذ من radial A.)

& PO_2 = ~~100~~ 95 mmHg → (ارتفاع 200) PCo = 40 mmHg] → Extrapulmonary hypoxia

or PO_2 < 100, PCo > 40] pulmonary hypoxia "not 100's, maby becous high altitude"

Resting phase

Tracheal air ← atmos. [PO_2 = 160, PCO_2 = 0]



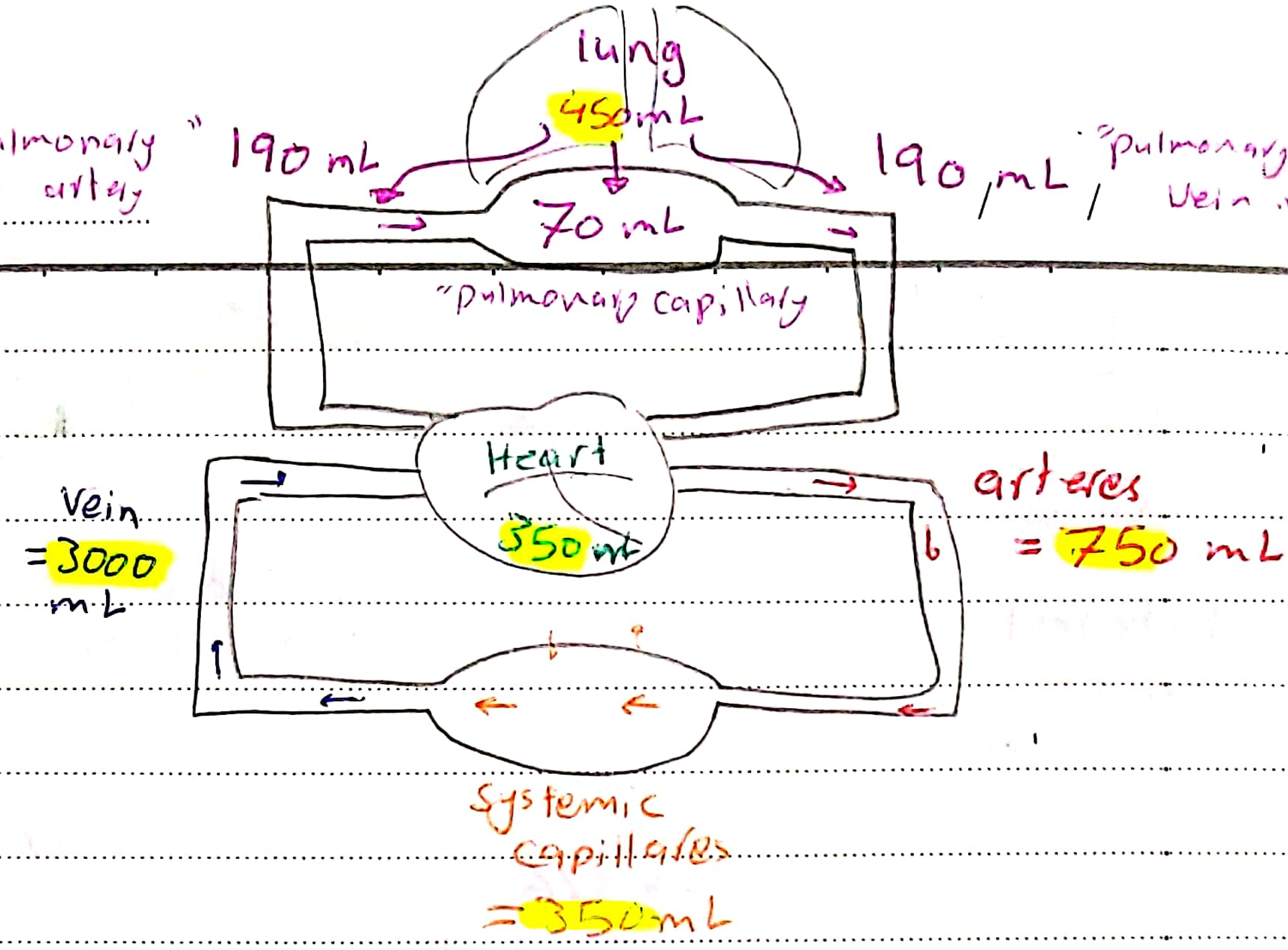
- ABGs test: normal during exercise

during exersise Cardia cycle time > complet gas exchang

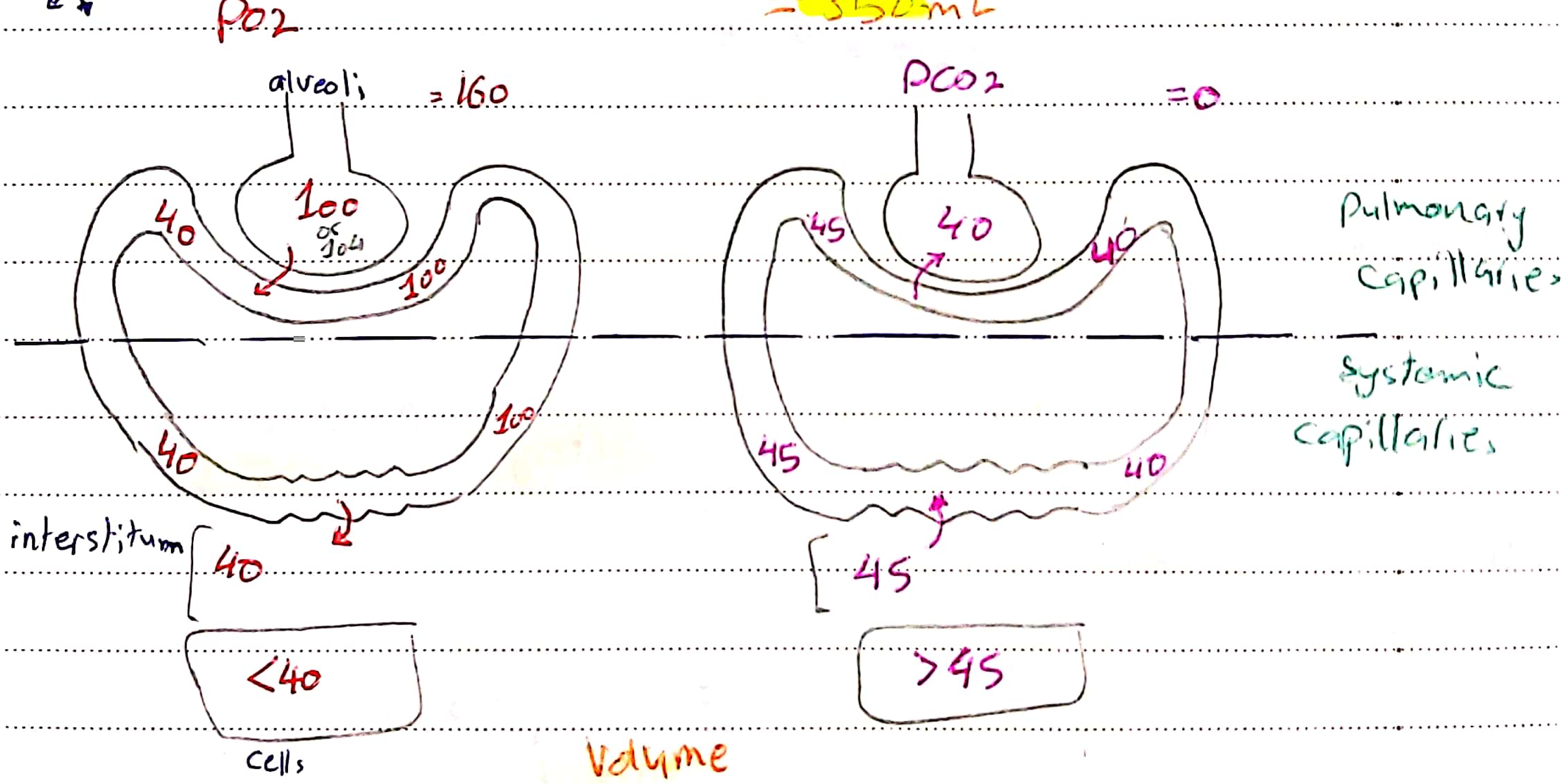
تصبح 0.4 > 0.3 = full oxygenation

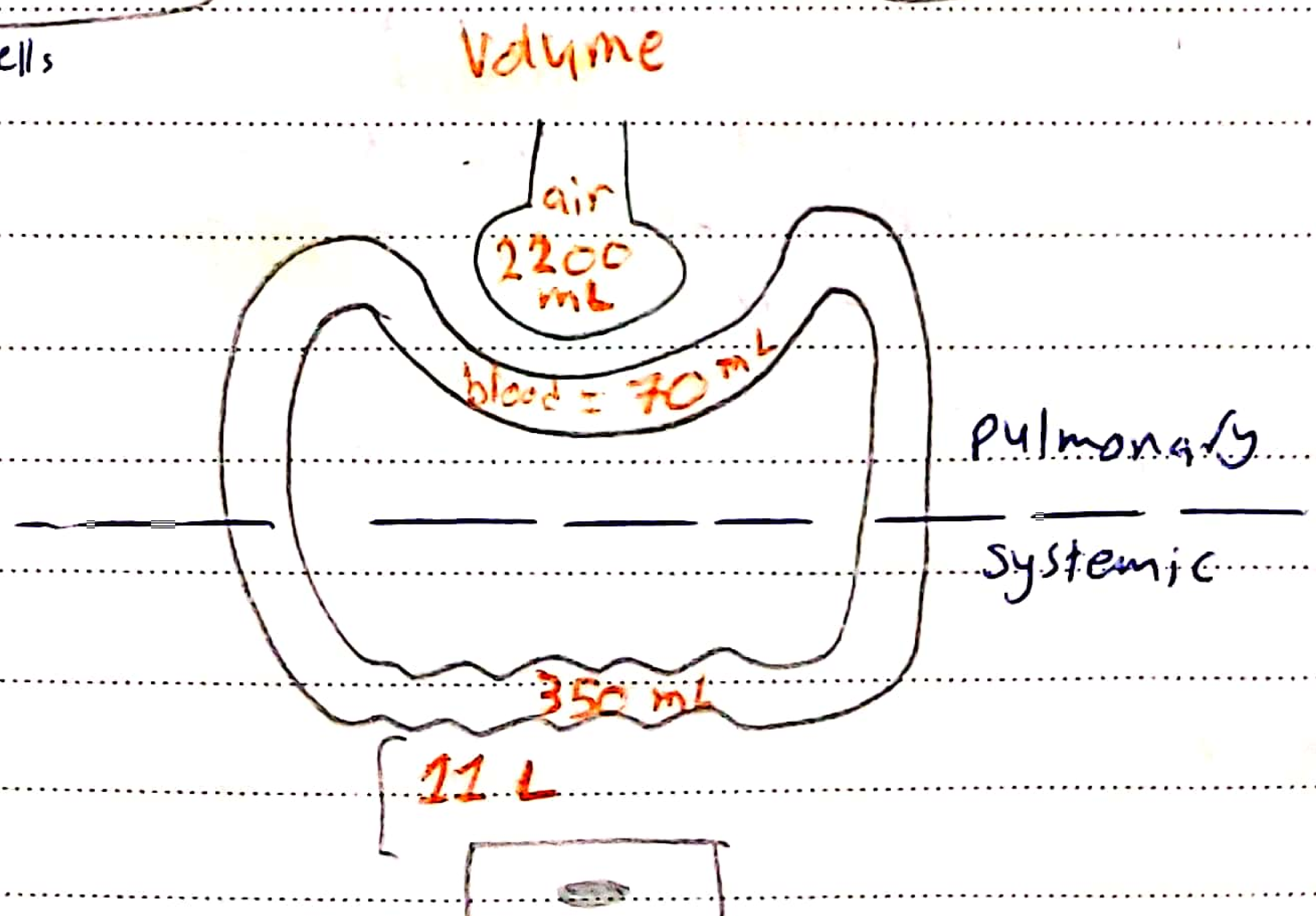
HR = 150, time = 60/HR = 60/150 = 0.4 // HR = 300, time = 60/300 = 0.2 → not full oxygenation

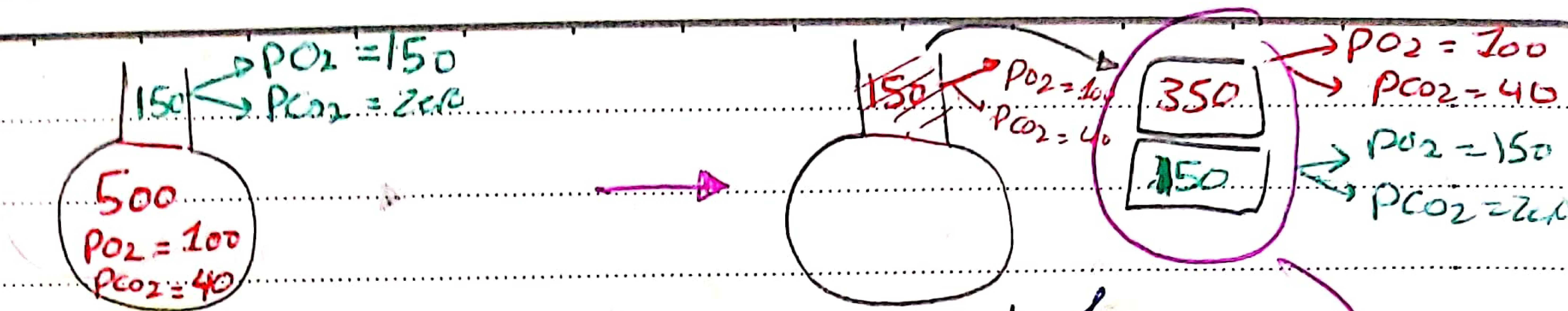
Blood Volum
= 5L
= 5000mL



*during rest







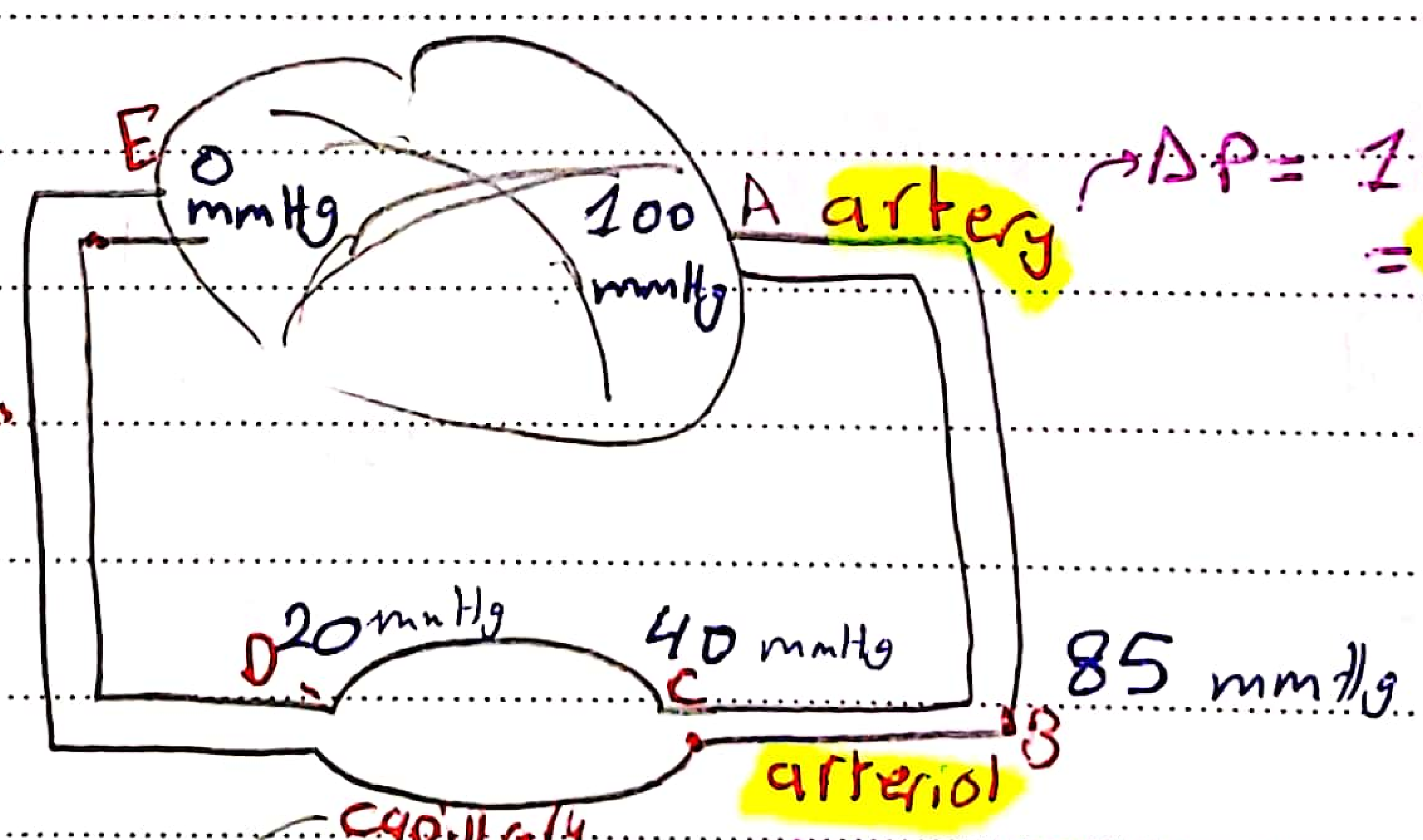
at the rest
"End of inspiration"

at end of expiration

expiratory mixed air (mouth-to-mouth ventilation)

$PO_2 = 116$
$PCO_2 = 28$

* presser



ΔP = 100 - 85 = 15 ↓

ΔP = 20 - 0 = 20

ΔP = 85 - 40 = 45 ↑

ΔP = 40 - 20 = 20

$\downarrow R = \frac{1}{a^2 \uparrow}$
cross area

"Series"
Total Peripheral resestance = 15 + 45 + 20 + 20 = 100 mmHg

"TR = $R_1 + R_2 + R_3 + R_4$"

قوانين

1. $F = \frac{\Delta P}{R}$ "ohm's low" , $R = \frac{8\eta L}{\pi r^4}$

2. ventilation = R.R X alviolar air
A

alviolar air → (TV − (DS)), DS → 2 mL/kg

RMV = RR * TV

RMV → respiratory minut ventilation: 6 L/min =
RR → respiratory rate: 12
TV → tidal volum: 500 mL per breath

3. Cardiac cycle time = $\frac{60}{HR}$

4. Diffusion (J) = Driving forced (ΔP) X $\left(\frac{A}{dx}\right)$ X $\left(\frac{S}{\sqrt{Mw}}\right)$

A: surface area of membrain
dx: Thickning of wall
S: solubility
Mw: moleaular weight

* $J = \Delta P \times \left(\frac{A}{dx}\right) \times \left(\frac{S}{\sqrt{Mw}}\right)$

5. $R = \frac{1}{\text{Permeability (k)}}$

6. F = Drivingforce ΔP X K "permeability"

$F = \Delta P \times K$

7. $K = \left(\frac{A}{dx}\right) \times \frac{S}{\sqrt{Mw}}$ = d ↑ diffusion CO_2 ← ↑ S CO_2

8. TBW (L) = 60 X weight kg
→ total body water (75 kg → 42 L [28] "[3]

قوانين

RMV = RR × TV (VT)

6 L/min = 12 × 500

$\frac{beat}{mint} \times \frac{mL}{beat}$

→ AMV = RR × (TV − DS)
alveolar
4.2 L = 12 × 350

→ DSMV = R.R × Ds
Deadspace
1.8 L = 12 × 150

9. $P_AO_2 \propto \frac{\dot{V}}{\dot{Q}} = \frac{\text{Ventilation}}{\text{cardiac output}}$

10. Boyle's law : $V_1P_1 = V_2P_2$ // ↑V → ↓P

11. $R = \frac{1}{G}$ / $G = \frac{1}{R}$ → Resestance
conductance

12. Work = ΔP × ΔV

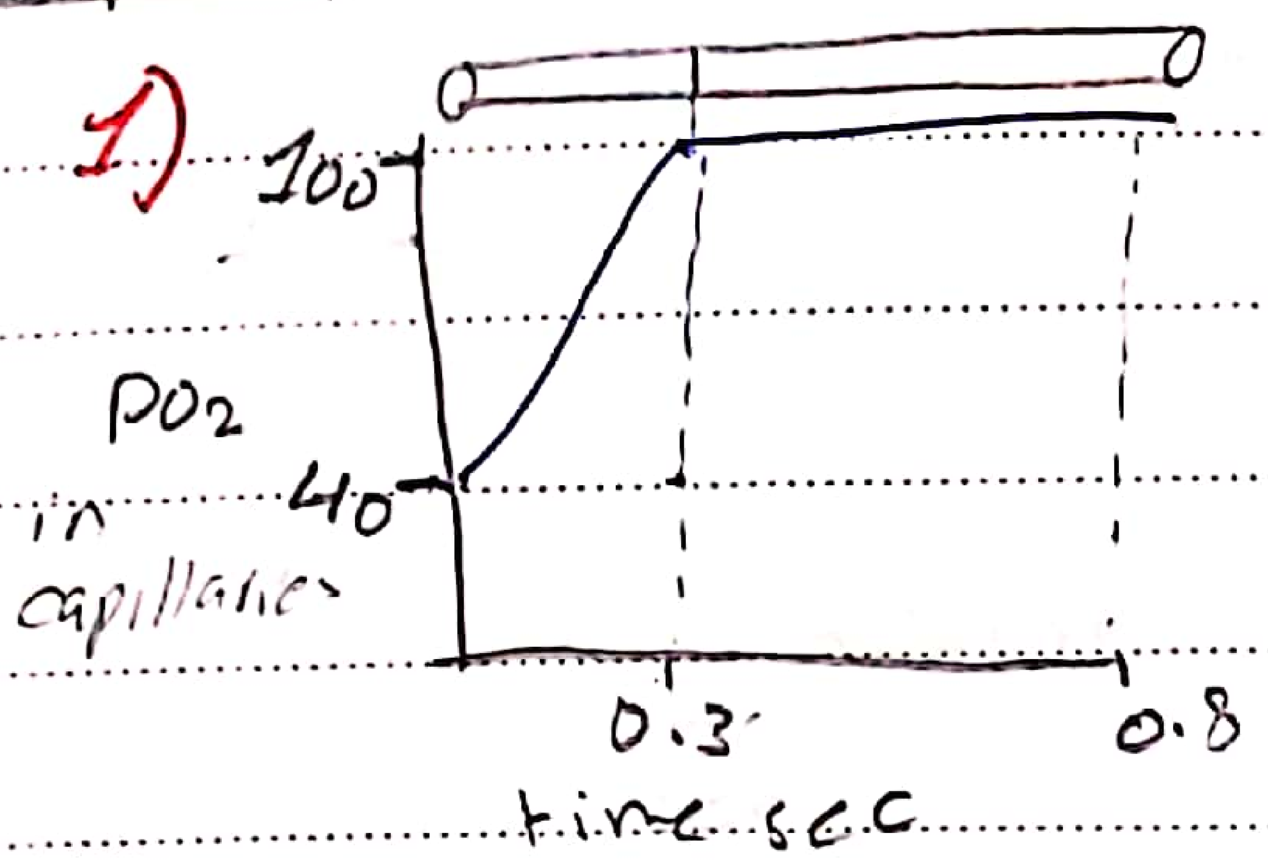
13. low of laplace ⇒ $\Delta P = \frac{2T}{r} = \frac{2 \times \text{surface tension}}{\text{radius}}$

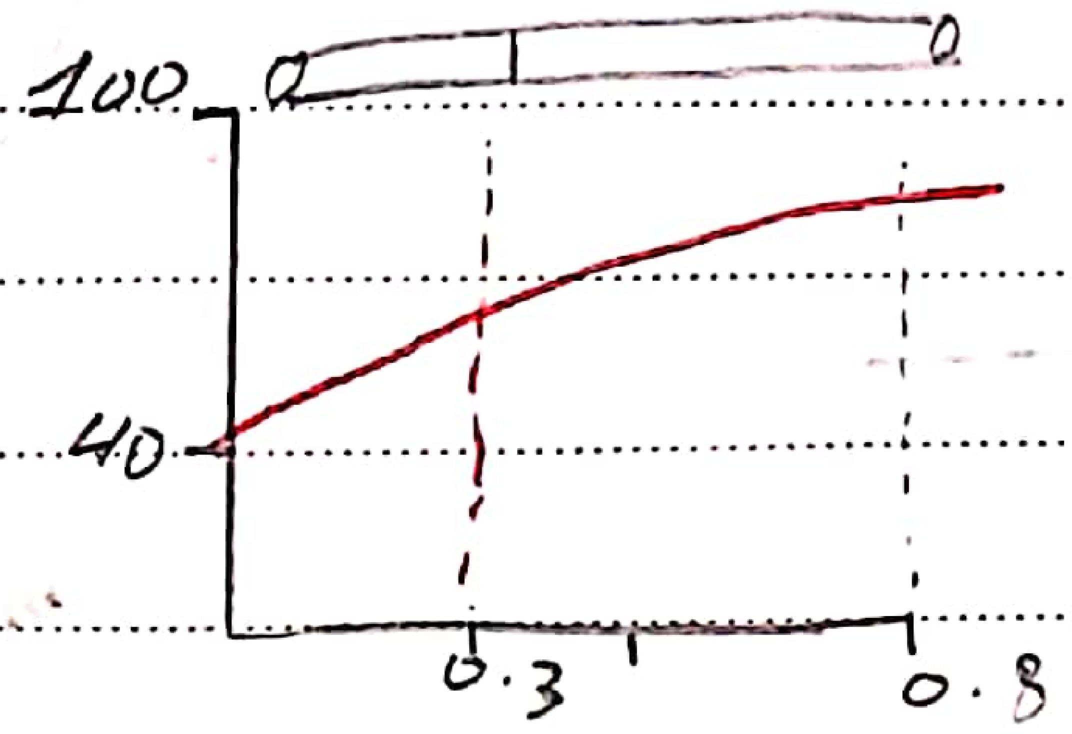
14. Concentration = $\frac{\text{amount}}{\text{area}}$

15. complianc = $\frac{\Delta V}{\Delta P}$

16. $DLO_2 = \frac{J \; ml/O_2}{\Delta PO_2}$, $DLO_2 = \frac{\dot{V}O_2}{\Delta PO_2}$
→ difusion capacity of lung
O2 consumption

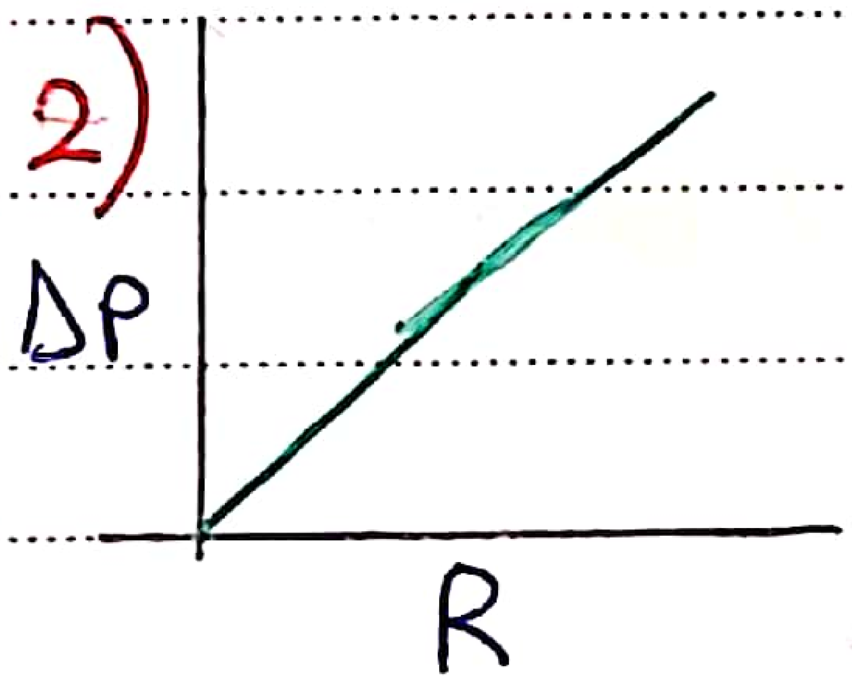
منحنيات / /

1) 



Normal — abnormal membrane

PO2 during Gas Exchange

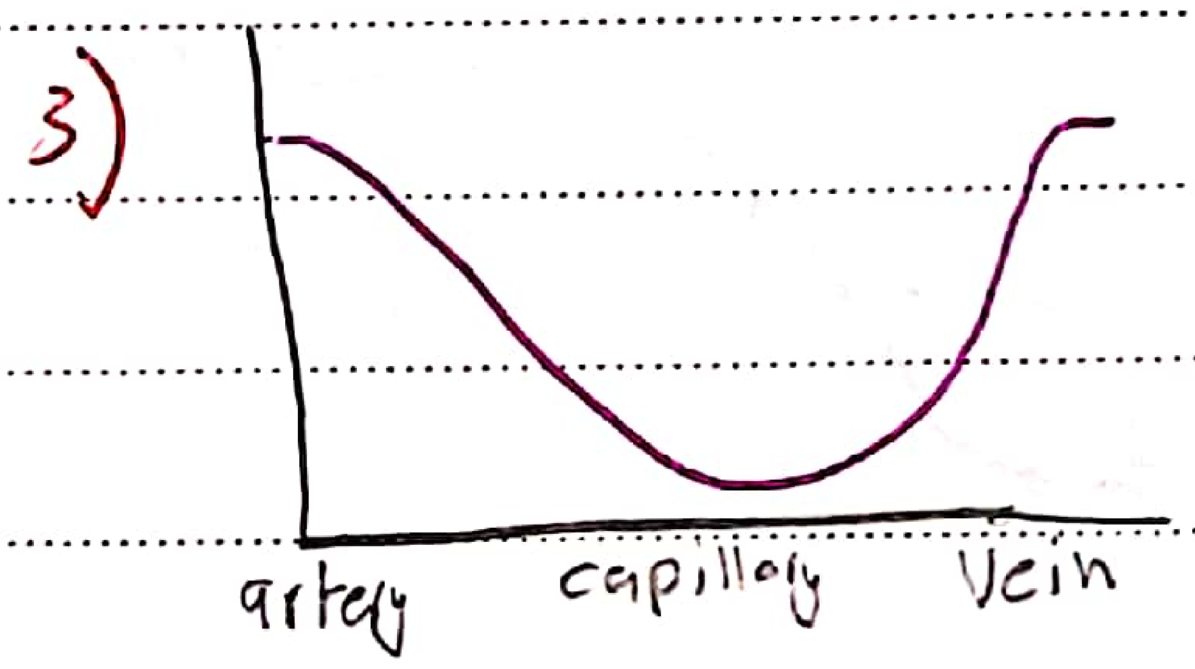
2) 

air resestance very low (1 unit) or almost zero "can negligible"

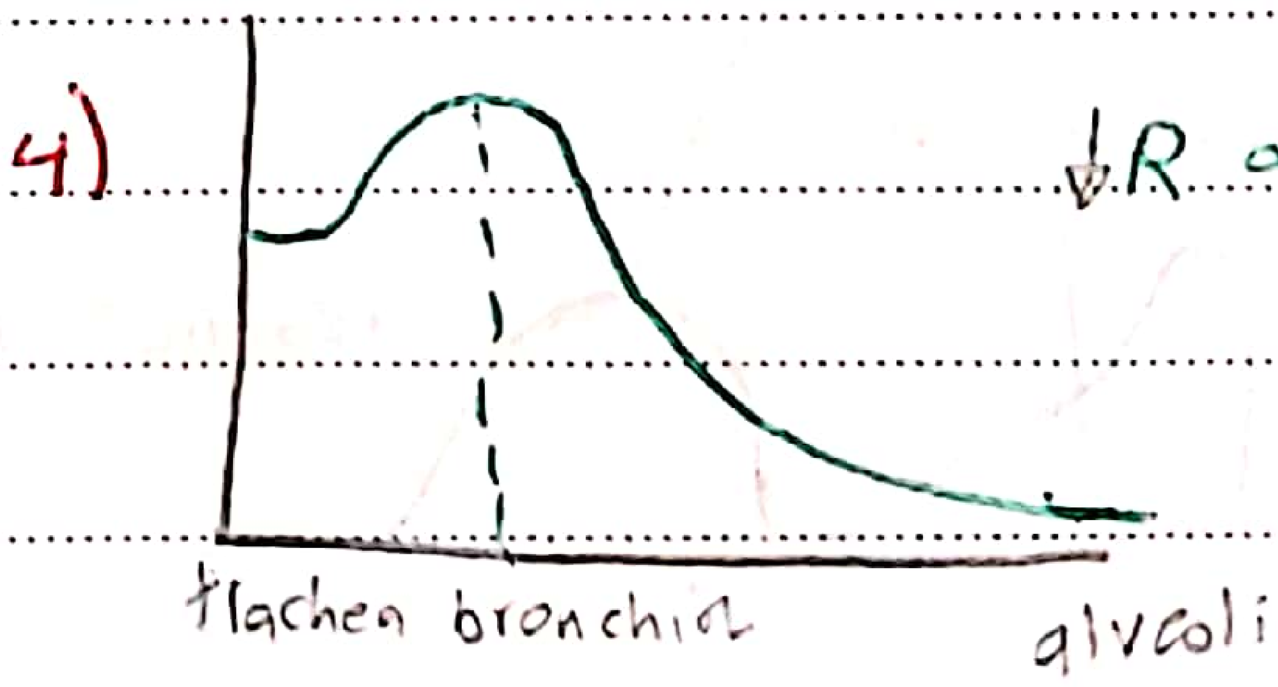
$\Delta P = (+1)$ or -1

if we mesure $\Delta P = 10$ ⟹ We can now R increas 10 time

→ $Q = \frac{\Delta P}{R} = \frac{1}{1} = 1$ unit ≈ 6L

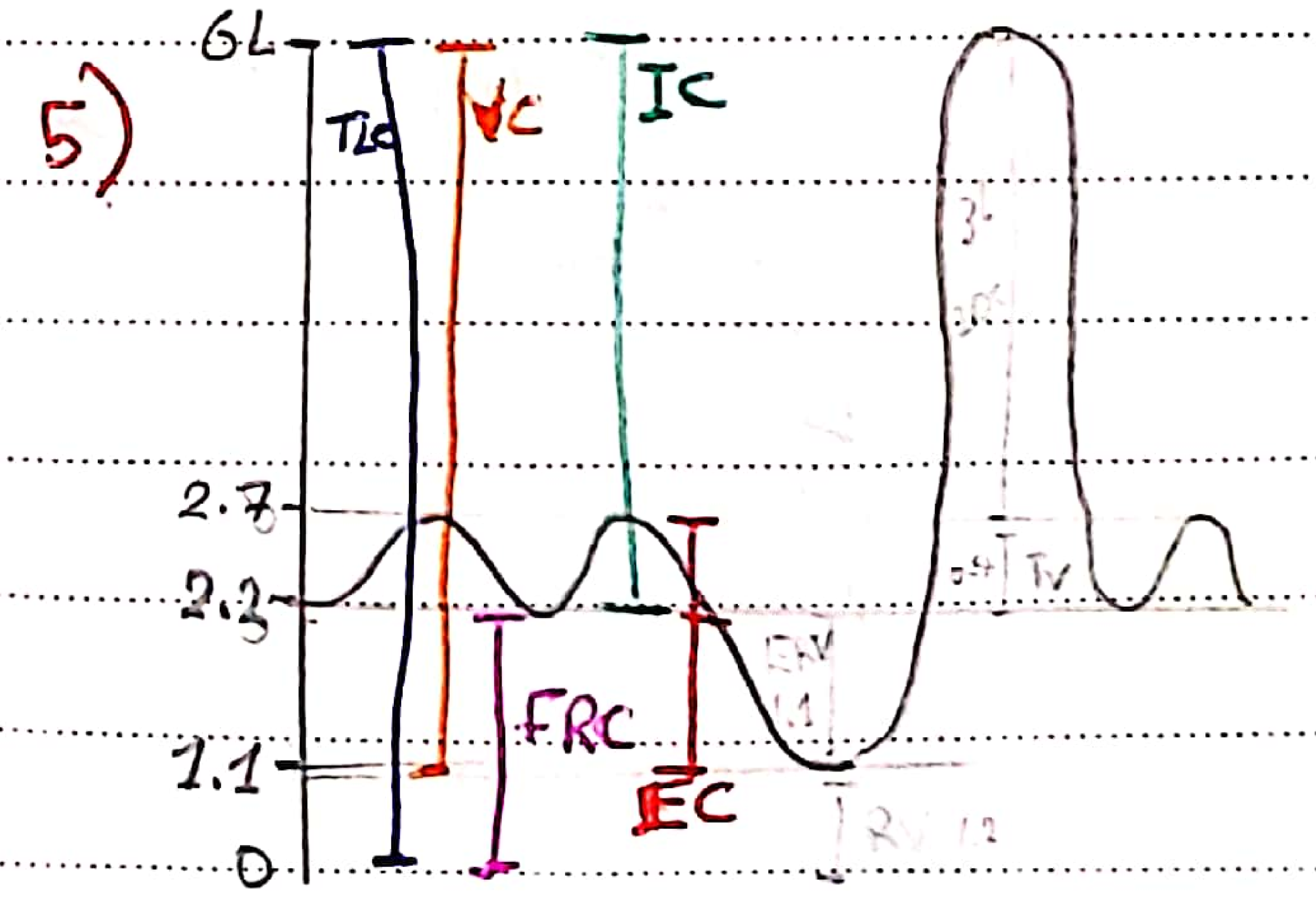
3) 

$\frac{Q}{\downarrow A}$ = ↑velosity

4) 

$\downarrow R \propto \frac{1}{\uparrow a^2}$

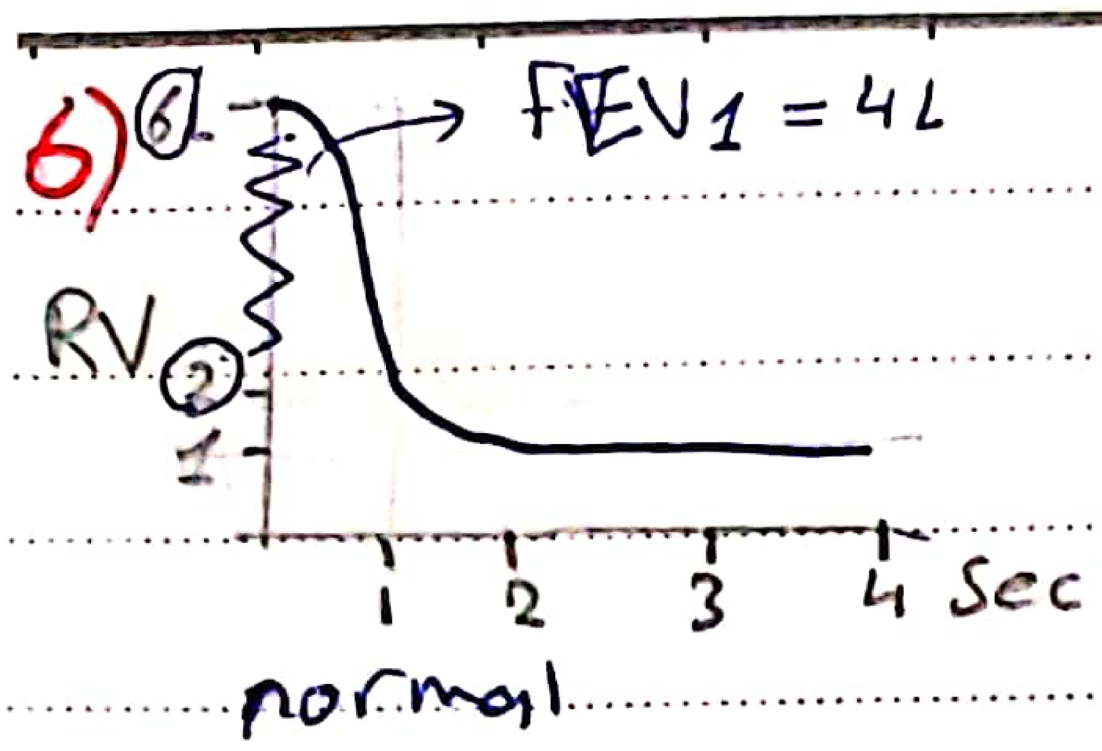
large airway → more resistance

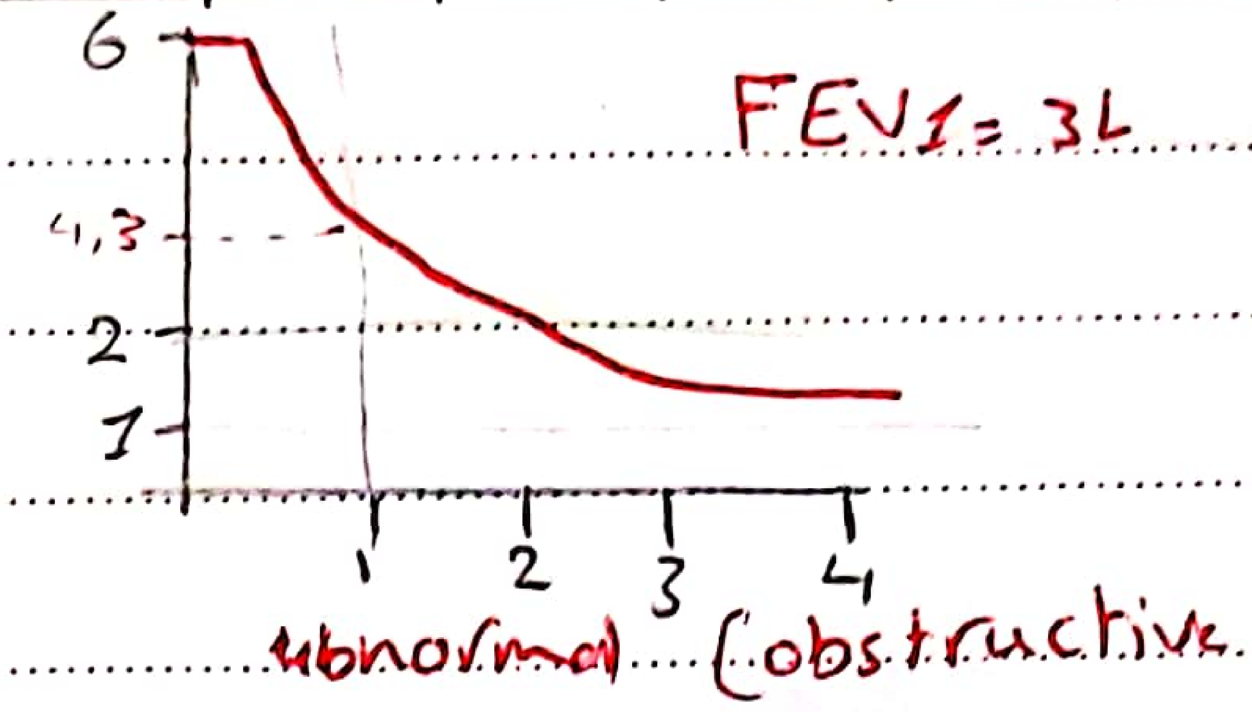
5) 

*RV ↑ with aging

ERV ↓ with aging

6)





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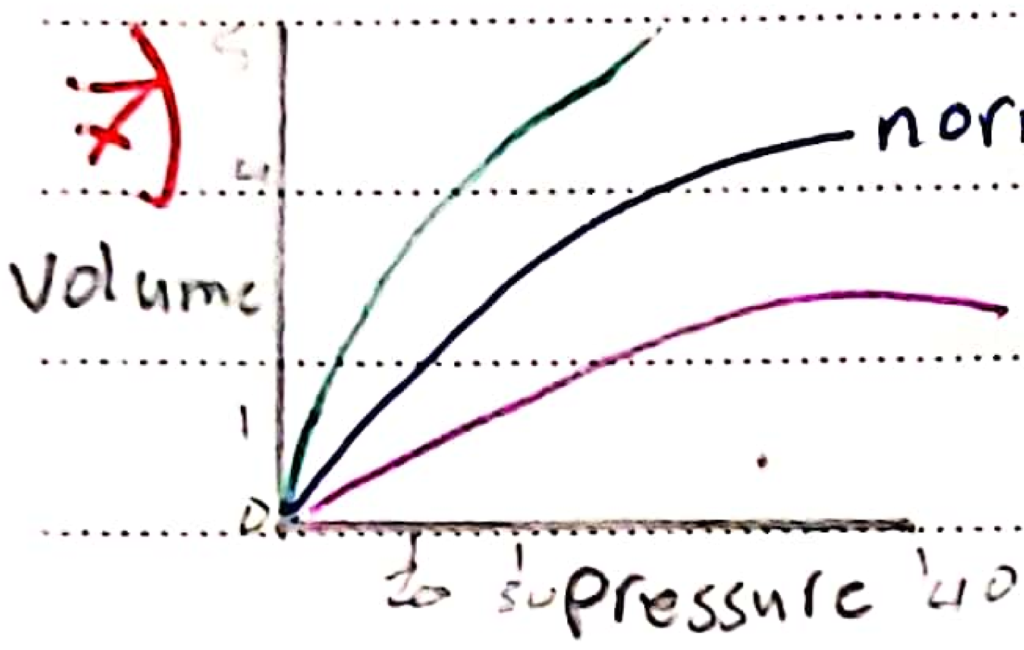
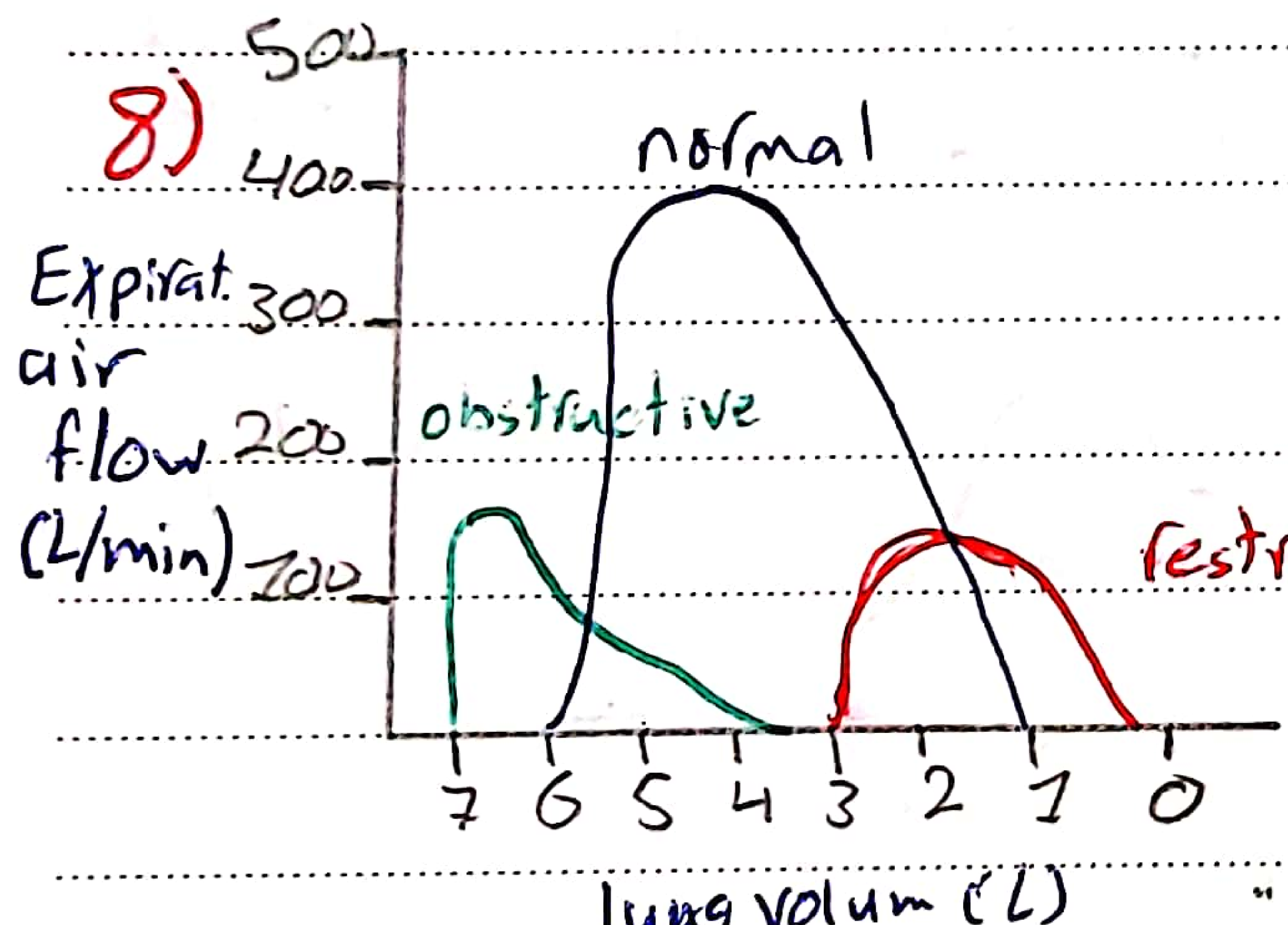


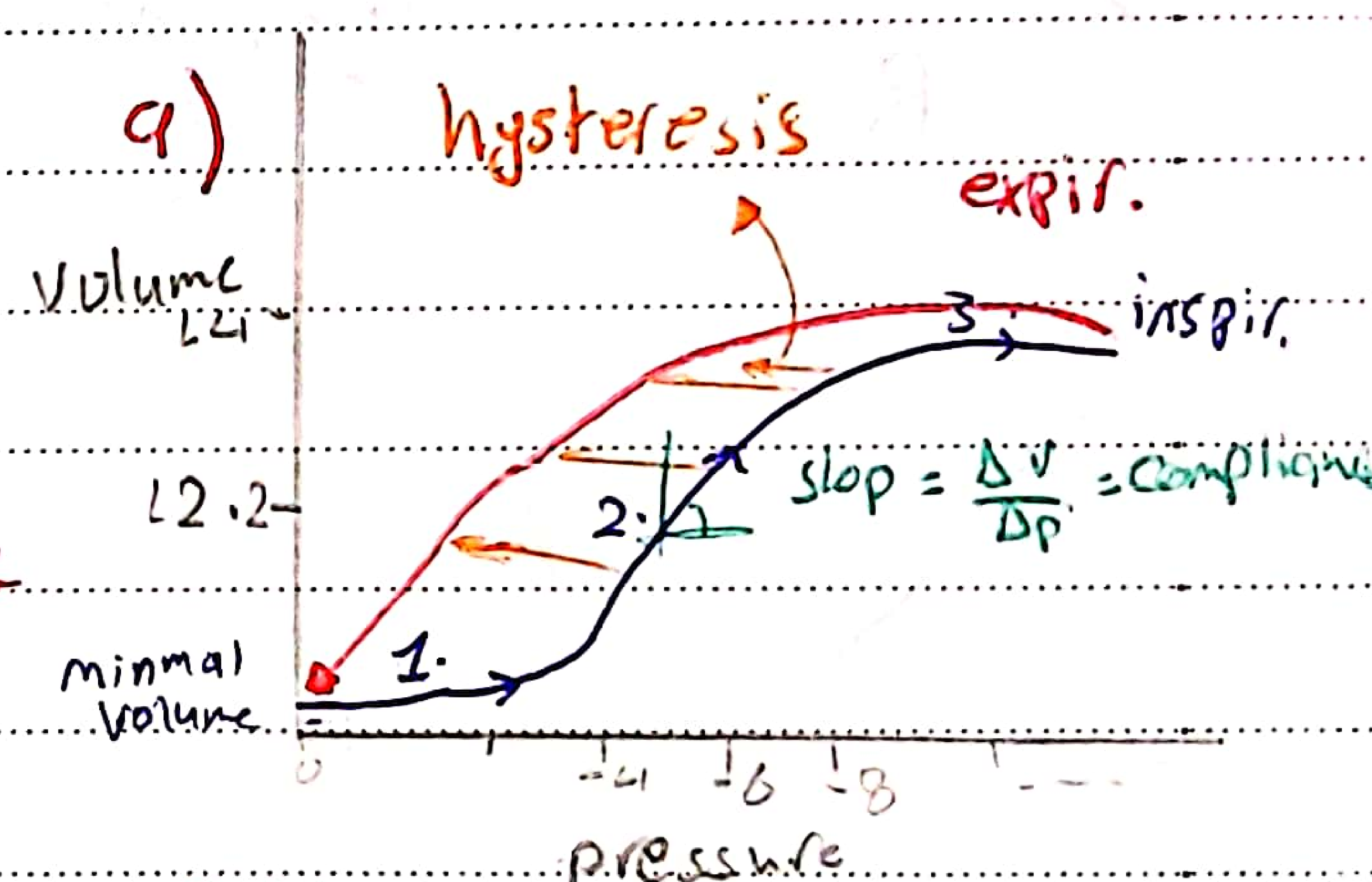
* Emphysema : ↑↑ compliance : little chang in pressure cause huge volum chang
– shift to left // lung cant deflated
* fibrosis : ↓↓ compliance : huge pressure chang cause little volum chang
– shif to right // lung cant inflate

8)



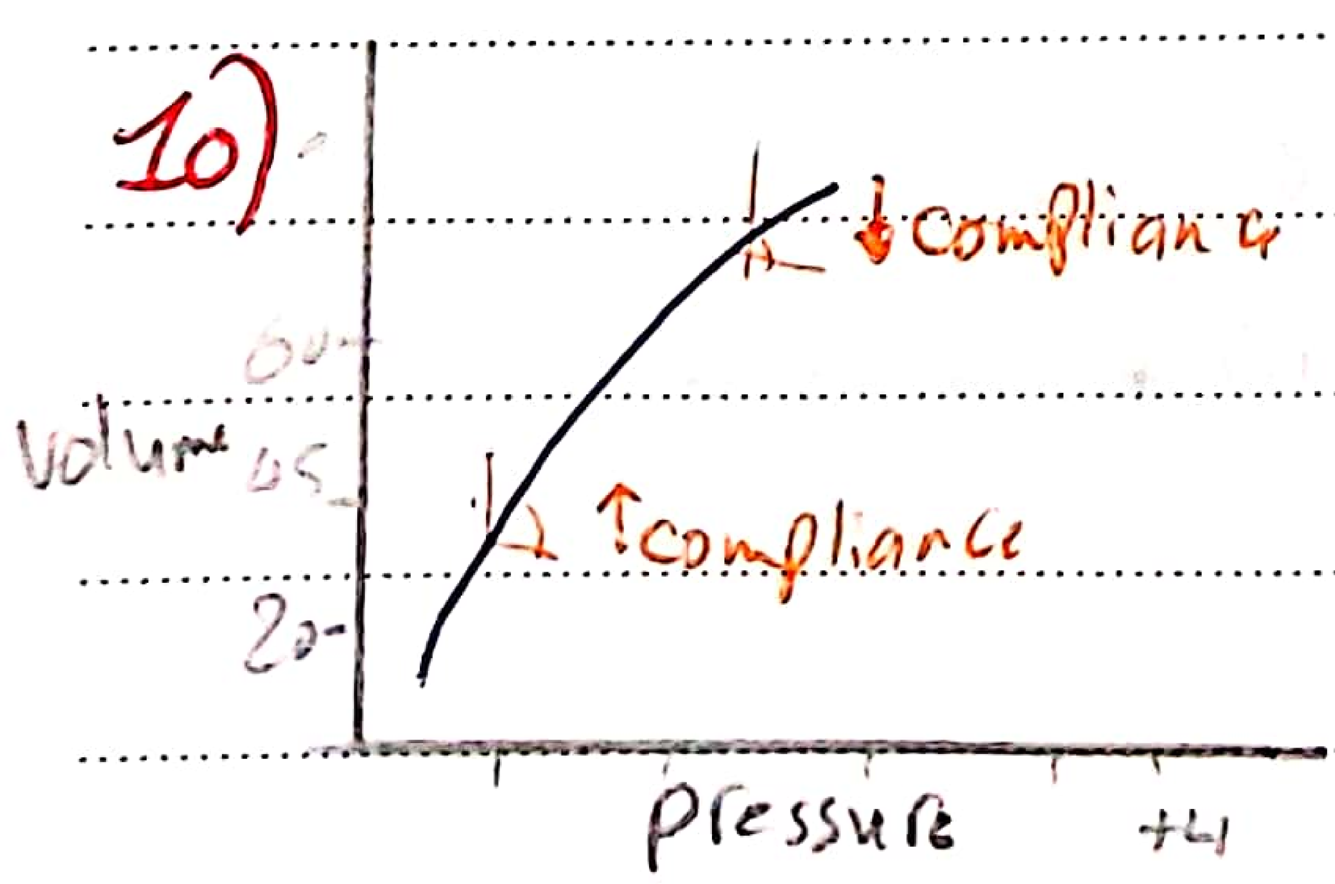
(Maximum expiratory flow rate)

9)

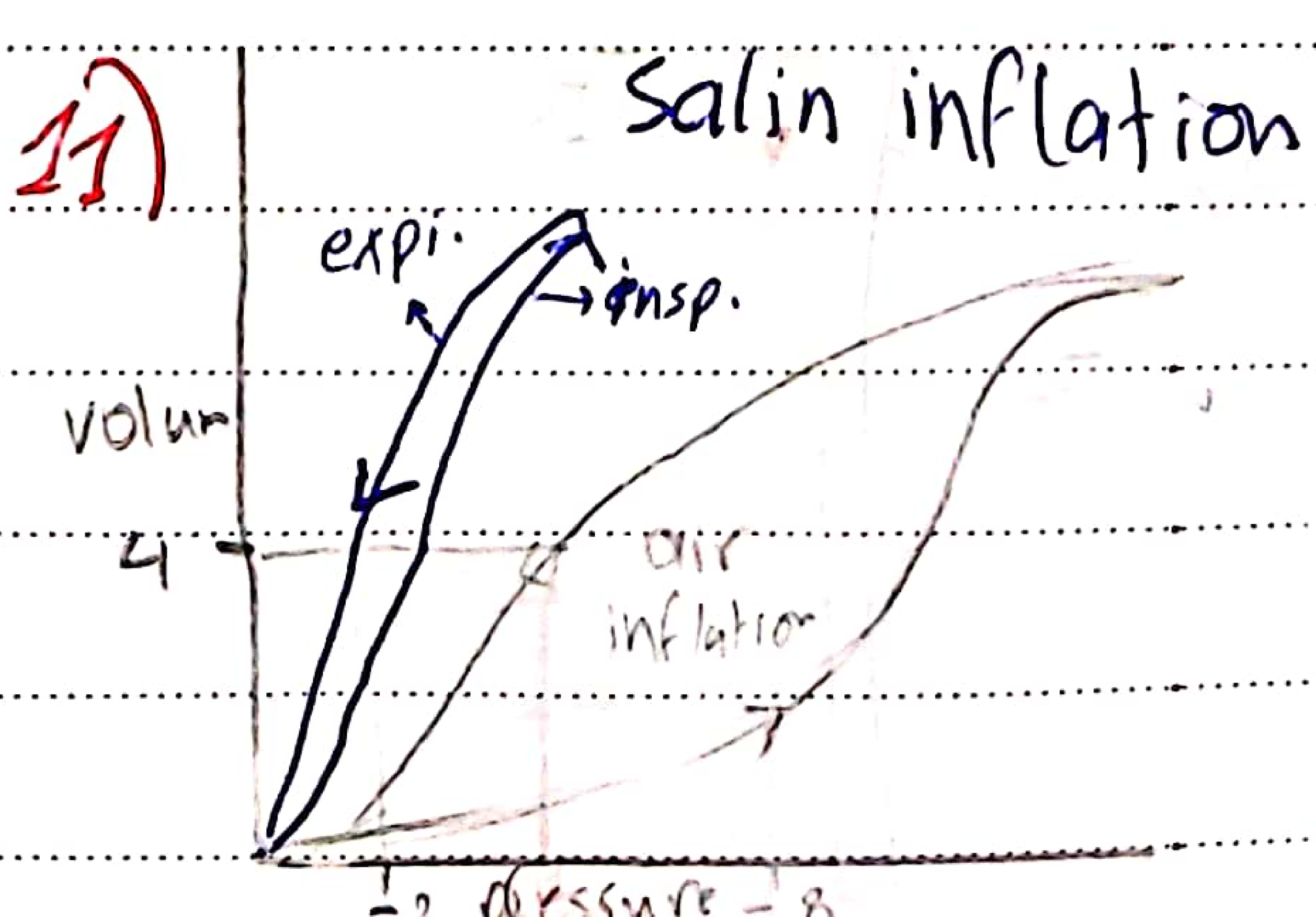


(inflated-complianc curve)

10)



11)

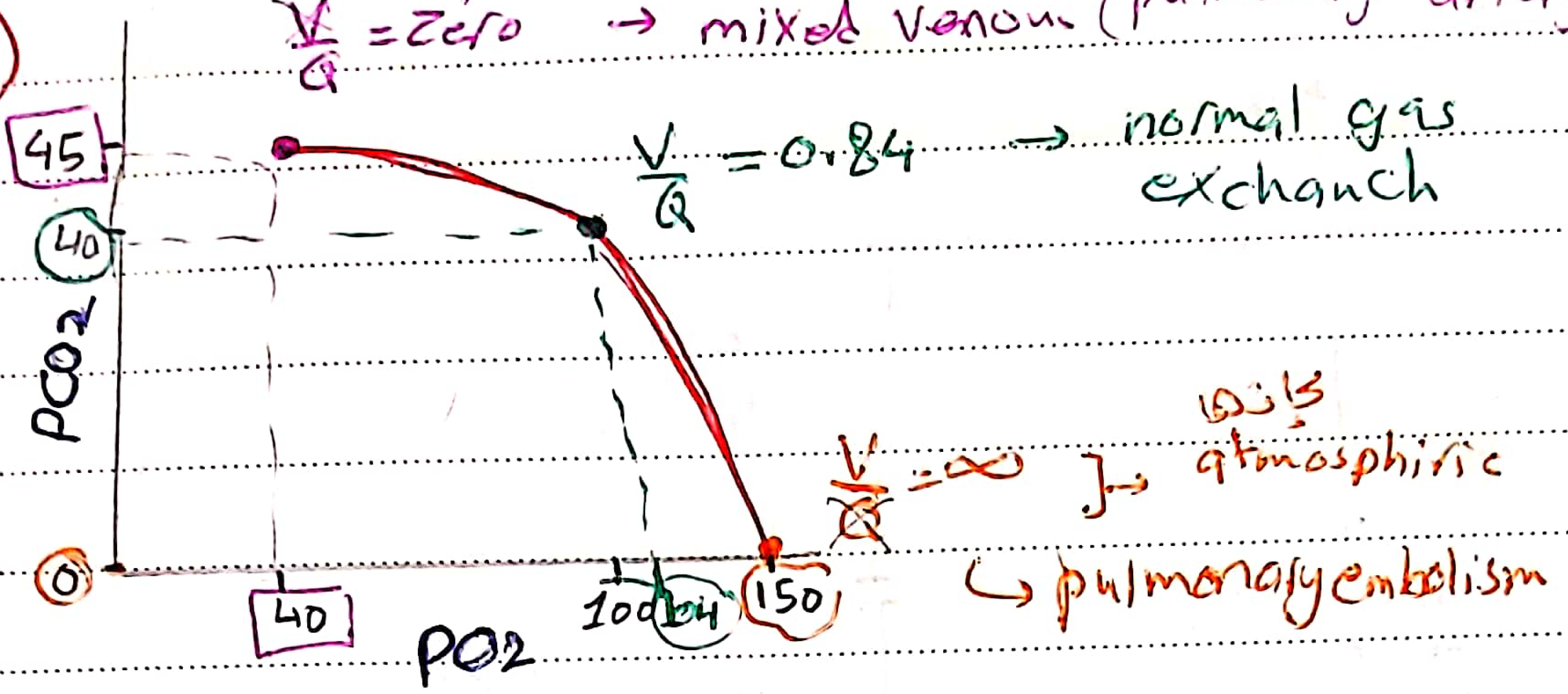


lung compliance curve = deflation curve

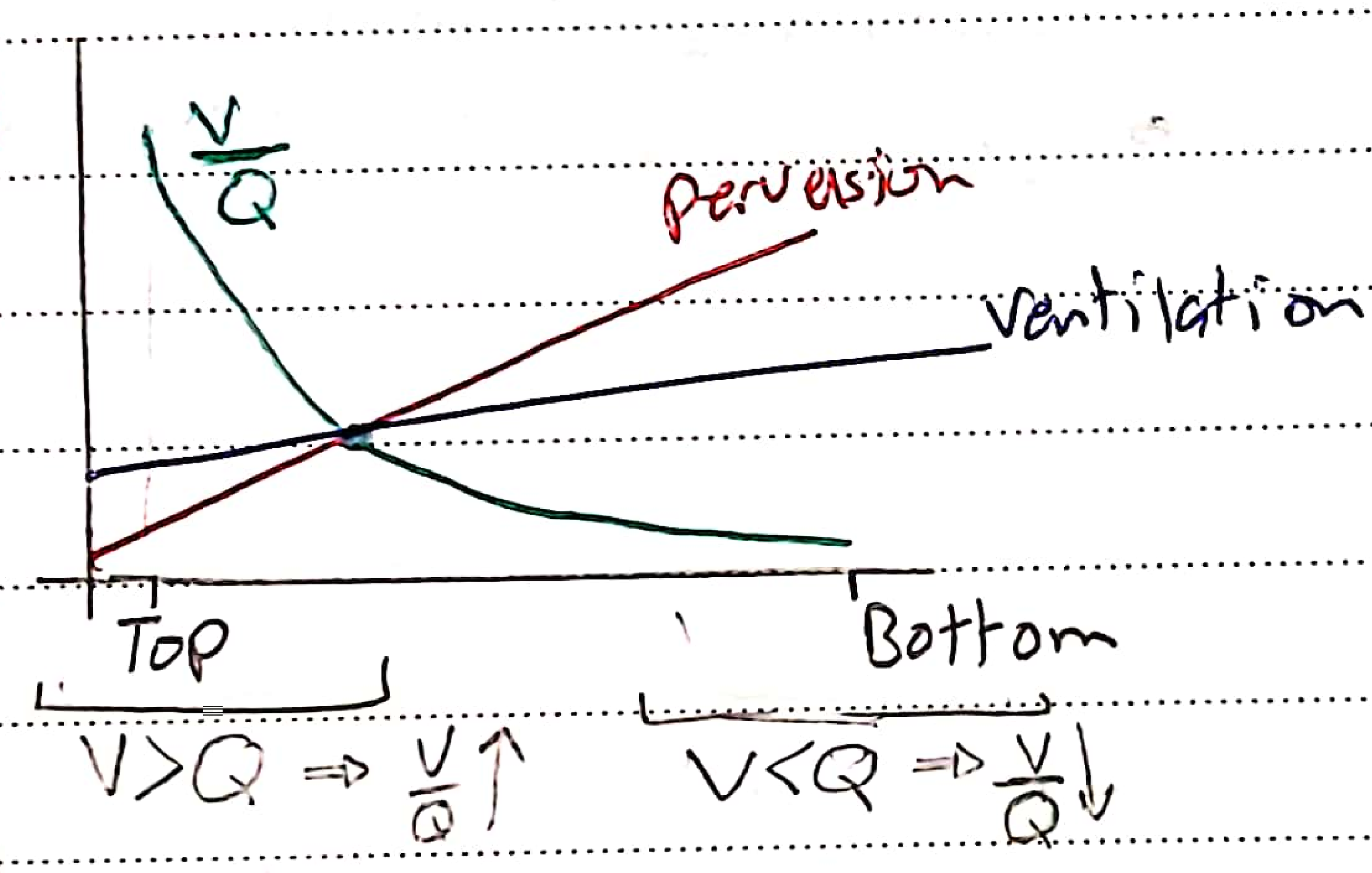
bronchial obstruction

/ /

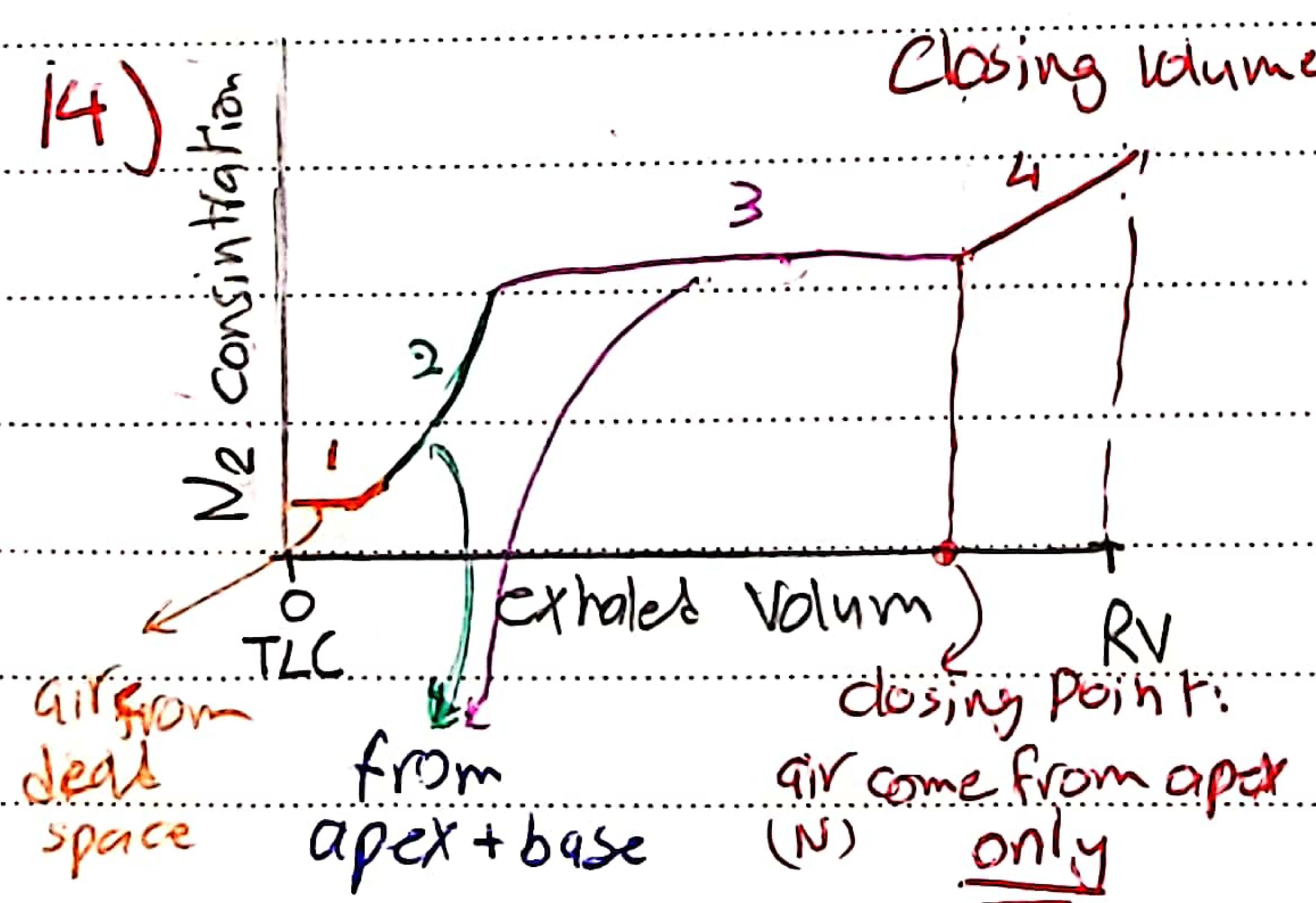
12)

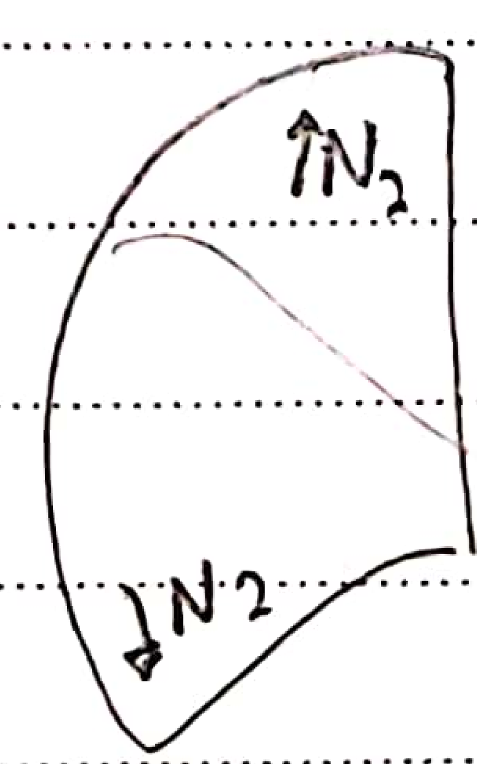


13)

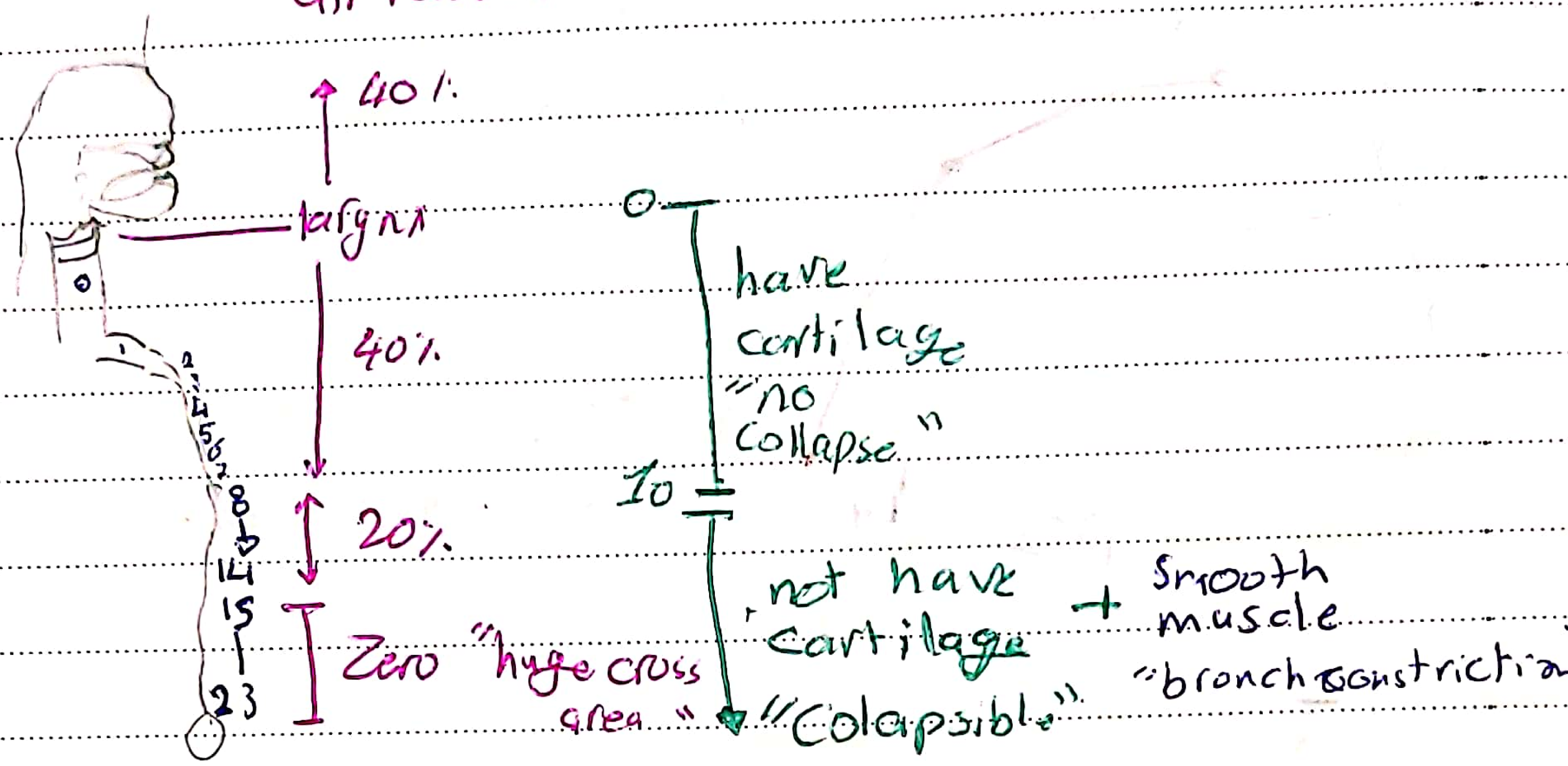


14)

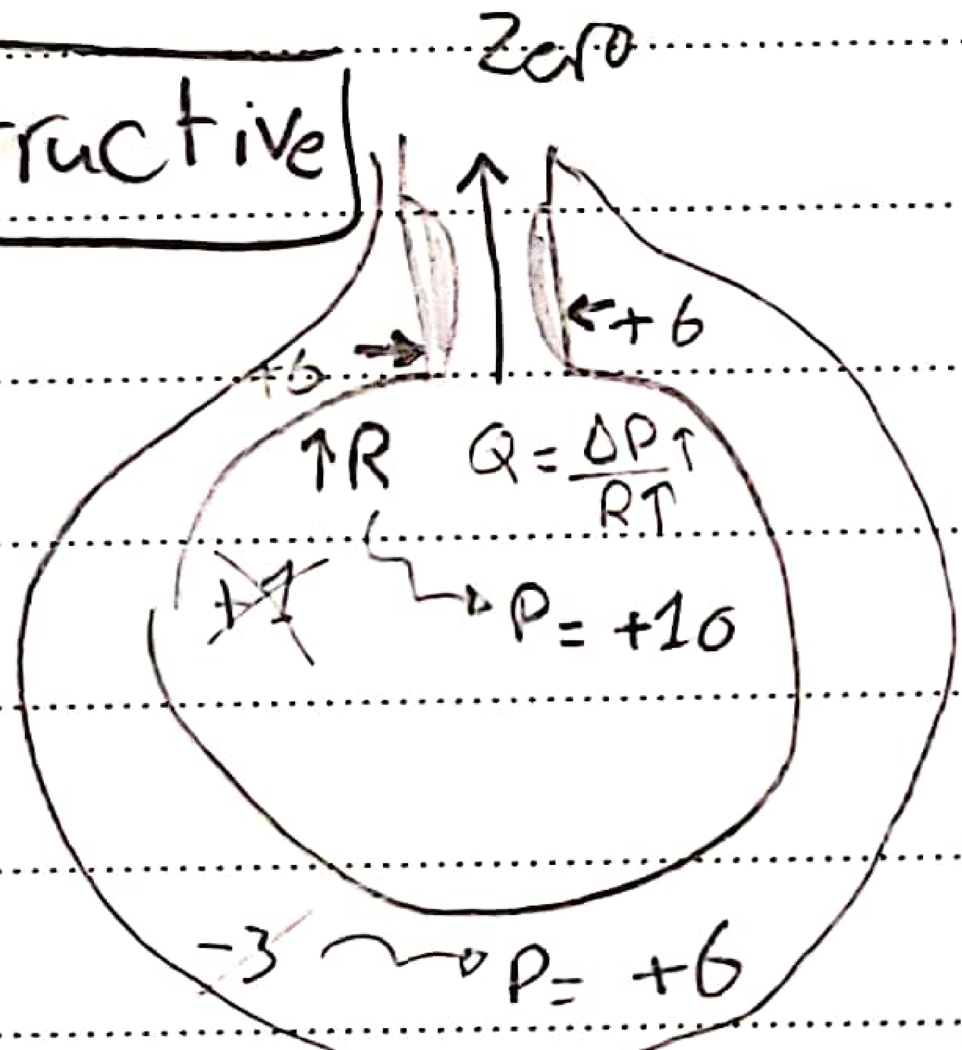




air reseserance



Obstructive



expiration

expiration V↓ P↑

* obstruction → small air R ↑

I should increase intraalveolar pressure

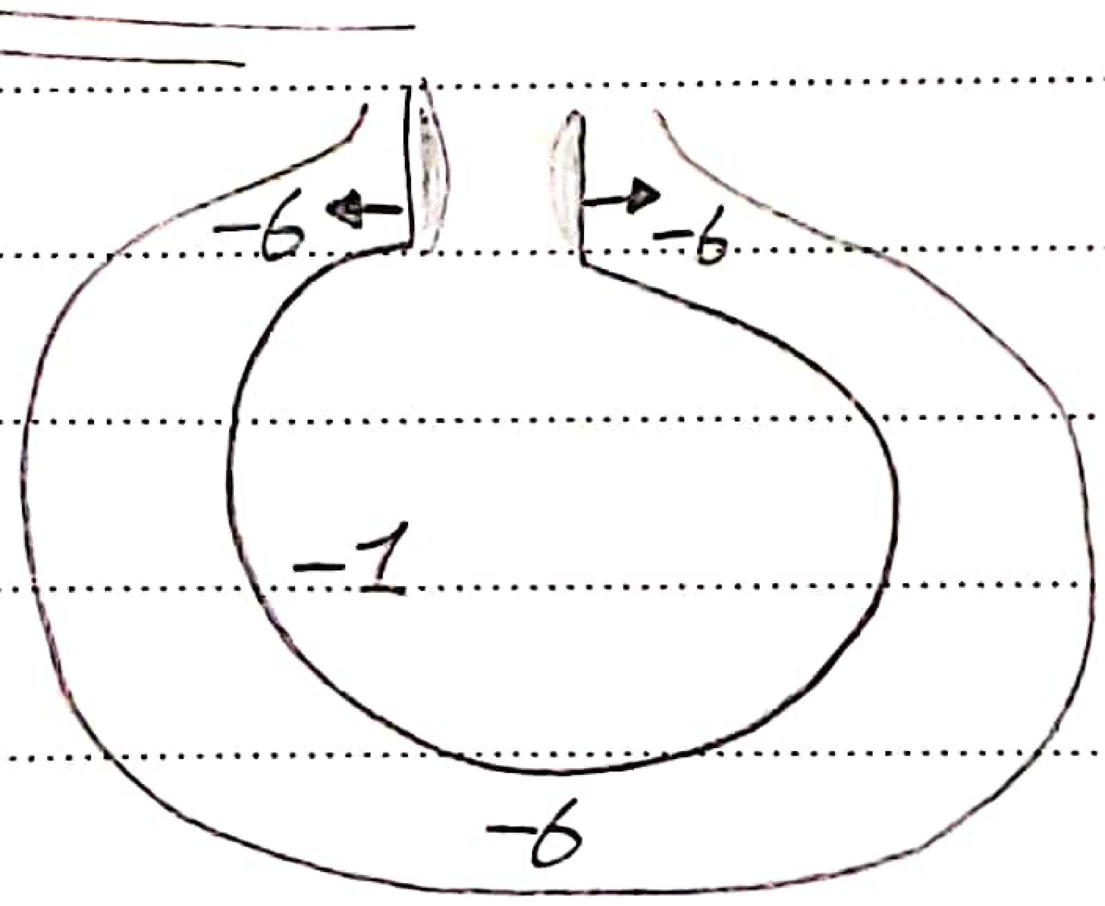
* active expiration → ↓chest volume

↑intrapleura preussar → ↑intraalveolar P

* coprisse airway → more close of bronchel

turbulant flow

"wheezing sound"



inspiration

* if R increase 10 time ΔP should increase also 10 time to maintain constant flow

* obstruction in upper airway → stridor

" " lower airway → wheezes

/ /

* lung volums —mesured by→ Spirometer (TV, IRV, ERV)
except → Helium dilution method – RV (FRC + TC)

$$V_1C_1 = V_2C_2$$

$$\text{bage} \leftarrow V_1C_1 = (V_1 + FRC)C_2$$

$$FRC = \frac{V_1(C_1 - C_2)}{C_2}$$

$$\Rightarrow RV = FRC - ERV$$

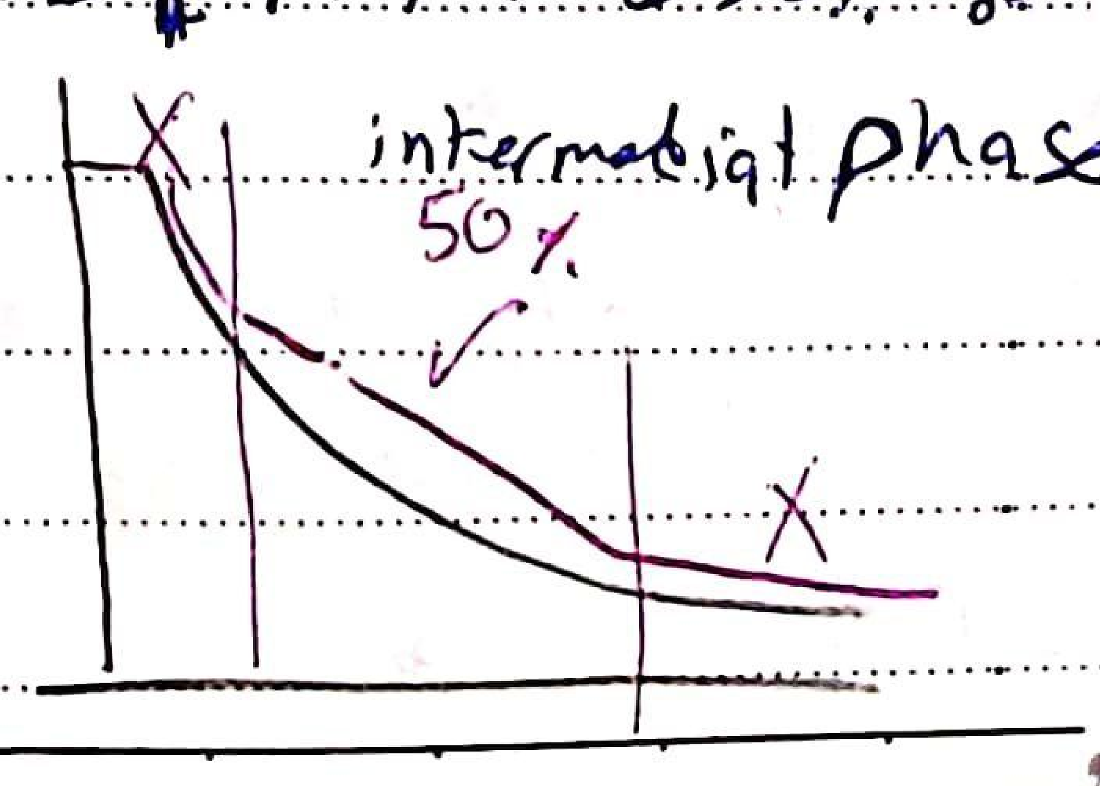
Pulmonary function test :

* forced lung capacity :
- amount of air exhalation forcefully
- normal FLC = VC vital capacity
abnormal (obstractiv) FLC < VC] → $\frac{FEV_1}{FVC} \geq 70$ normal
- Observed FEV1 / predicted FEV1 :

≥ 80	normal
60-79 %	mild COPD
40-59 %	moderat COPD
<40 %	sever COPD

↓ $\frac{FEV_1}{FVC} < 70$ obstuctive

* Mid mean Epiratory flow Rate "MEFR / mid 50%" :
- more sensitive
- cancel first 25% (easy in both N, abn.)
& last 25% (difficult in both)
- normal value = 3.5L



/ /

pulmonary function test (obstructive)

FEV1

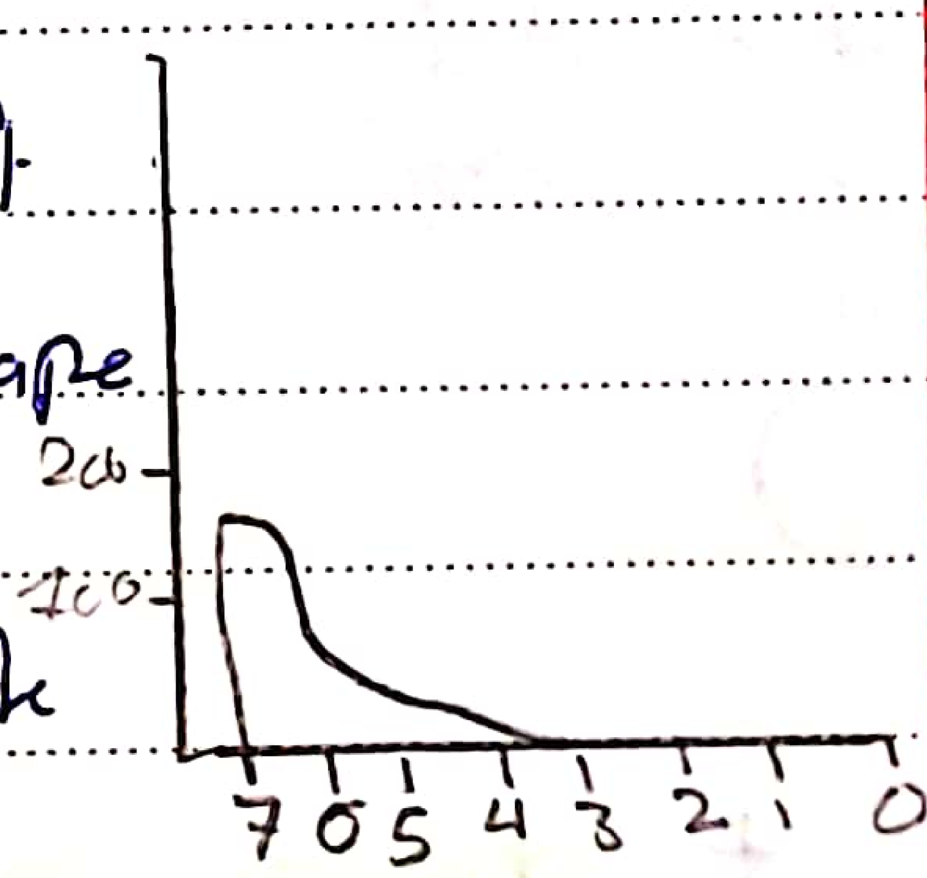
- ≥80 → normal
  - but patient suffe from dyspnea
  - ↓ **treadmill test**
    - NO
    - yes → **exercise induced esthma**
- "low FEV1" 60% → B2 agonist "salbutamol, albuterol"
  - increase FEV1 12%
    - yes → reversible (asthma) "غالبا"
    - No → cortisone "glococorticoid"
      - increase FEV1
        - yes → reversible
        - No → Irreversible "Emphysema or chronic bronclitis"

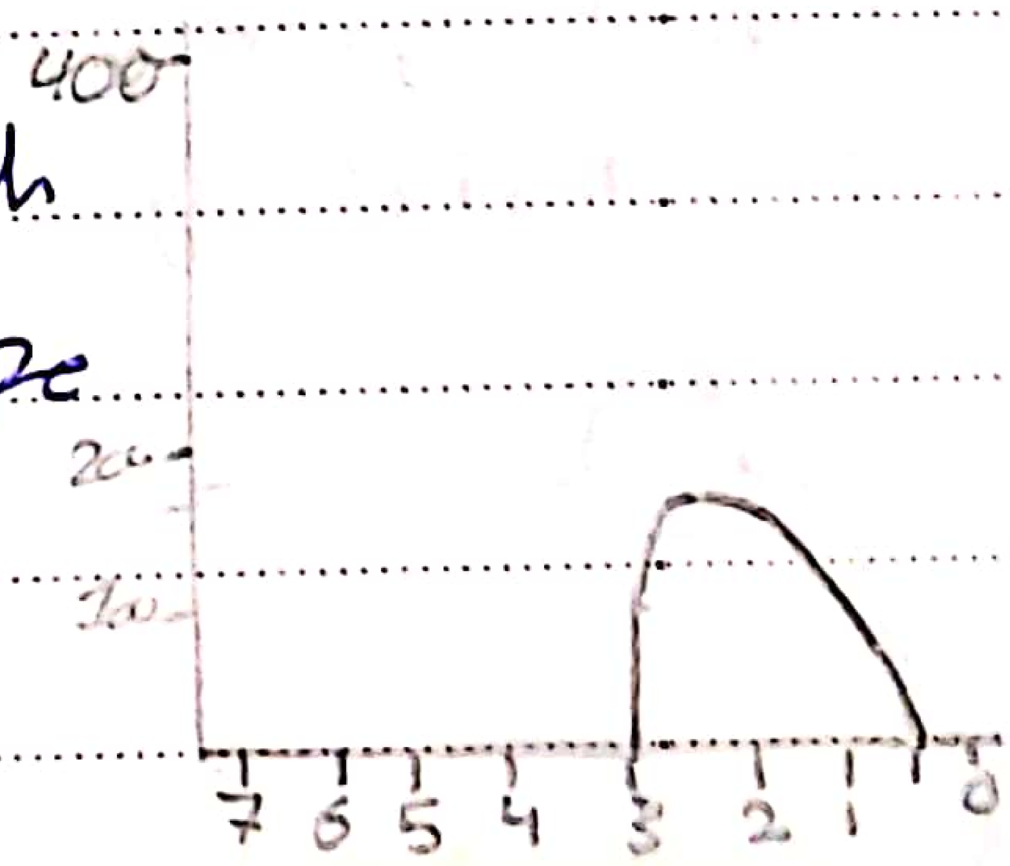
	Obstrictive pulmonary D.	Restrictive pulmonary D.
FEV1	↓ (3L)	↓ (3L)
FVC	normal or ↓ (4.5L)	↓ (3.5L)
FEV1 / FVC	↓ <70%	↑ or normal ≥80%
TLC	↑ 6 / 1	↓ 4 / 0.5
RV , FRC	↑	↓
Cause	diffecult of expiration	↓ compliance → diffecult of inspi.
example	emphysema	fibrosis
MEFR	↓	↓

* Maximum expiratory flow rate :

- velocity of inhalation air
- depends on : volum of air in lung at start of exhalation (TLC)
- 400L/min or 6-7L/s

obstructive	restrictive
↑ TLC	↕ TLC
↑ R V	↓ RV
shift to left	sheft to righ
Concave shape of carve	normal shape
lower peak	lower peak





[Compliance : how much the volume change per a unit chang in pressure (in vivo = 100 ml/cm water < vitro (200))

* Surface tension :-

- 2/3 elastic force is S.T , collapsing force
- ↑T during inflation // ↓T during deflation
- : intermolecular attraction between water molecule , they try to bring to the center

"↓P : easier to keep the lung inflated during deflated"

lung (air) —2 force→ T , Elastic fiber

lung (saline) NaCl —one force→ Elastic fiber → almost no hystere sis

/ /

* Hysteresis: deflation followed different pathway from inflation

Inflation:

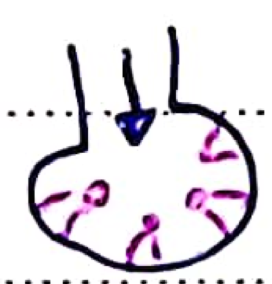
↑P (ΔP)

↑

↑T

↑

surfactant, not oriented in proper way ✗



deflation:

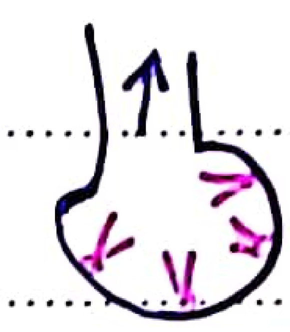
↓ΔP

↑

↓T

↑

surfactant oriented in proper way ✓



$\uparrow \Delta P = \frac{2T\uparrow}{r}$

* concentration of surfactant + orientation of it

Secretion 8 week of infant — completes 34-36 weeks

prolactin, estrogen, T4, glucocorticoids → (secretion)

* Infant Respiratory Distress Syndrome

IRDS: - premature babies → ↓ surfactant → ↑T → difficult breathe → hypoxia → pulmonary hypertension → open ductus arteriosus → mix venous arterial blood (pollution) → ↑ hypoxia → anarobic respiration → ↑ lactic acid → acidosis → RR = 60 → can die

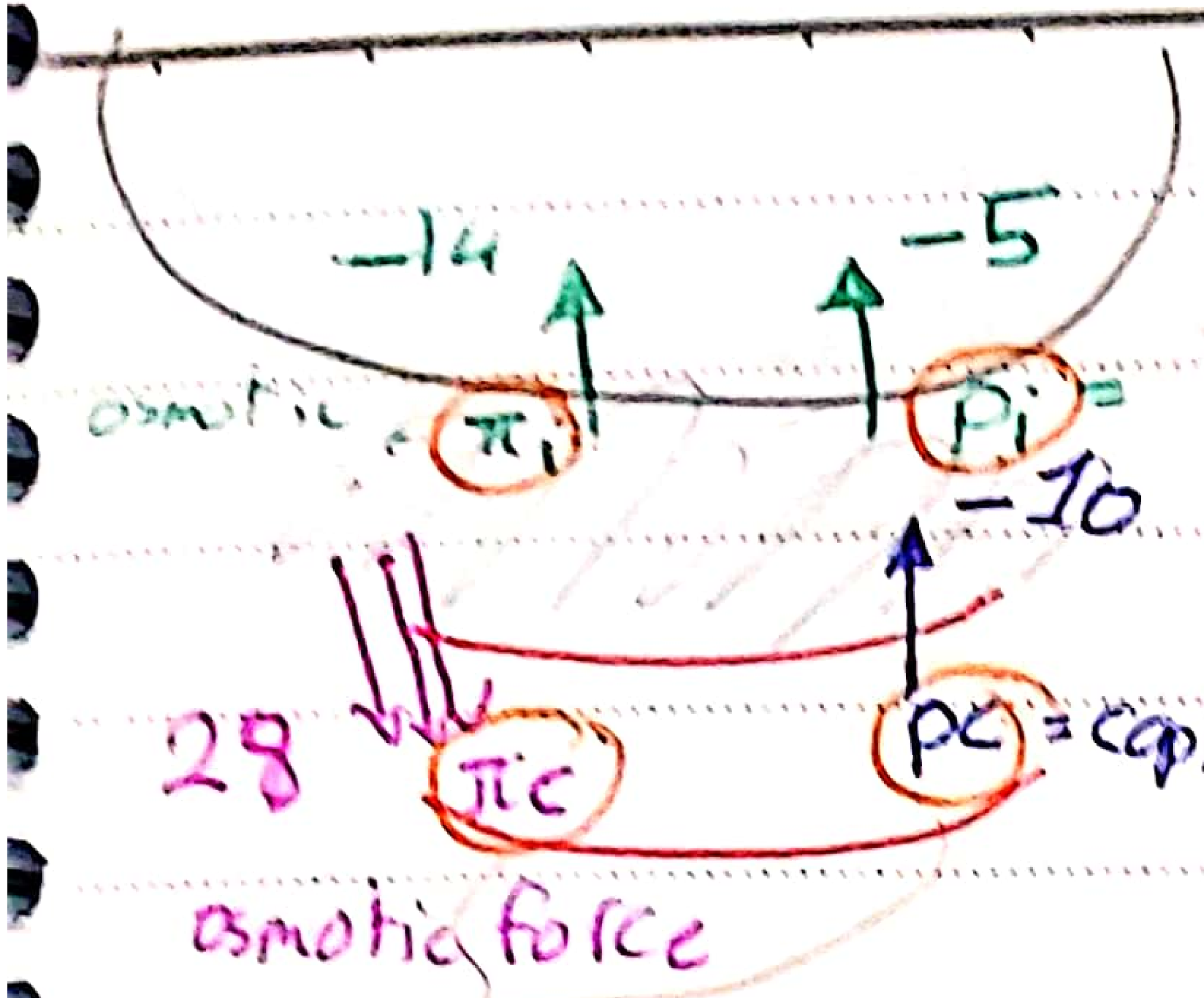
CPAP, PEEP → ⊖ (can die)

- lung markers (aminotic fluid):

1. lecithin / sphingomyelin >2 mature ✓
2. phosphatidylglycerol present ✓
3. surfactant / albumin
   - > 55 mature ✓
   - 35-55 intermediate ✗
   - < 35 immature ✗

2 Shots of "dexamethasone"

/ /



-14 - 5 - 10 = -29
+28
→ 1 unit by lymphatic system

MI
CLHF → > 1 unit → edema

take care of ecess ← lung full of lymphatics ↔ edema
filtrated fluid → edema don't occure

→ Starling forces "4 forces"

* Acut respiratory distress syndrome (ARDS) or Shocked lung / toxic lung / wet lung

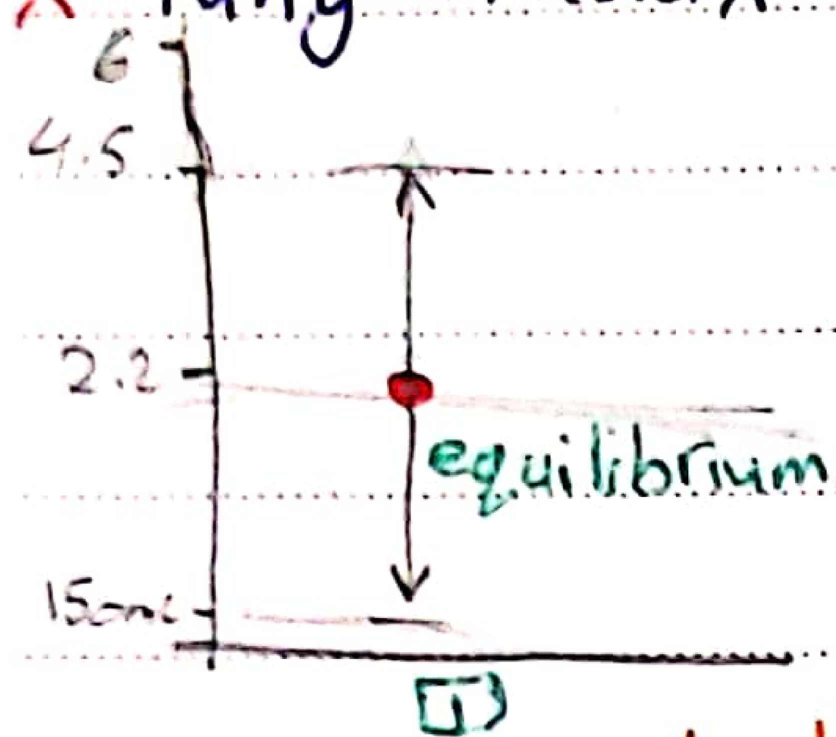
- x-ray : infiltration
- pulmonary capillary wedge pressure
  - < 18 (normal or locally by lung) ??
  - > 18 → left ventricular failure → edema
- PO_2 → :
  - < 200 ARDS
  - 200 - 300 acut lung injure → precursor of ARDS
  - > 300 No ARDS

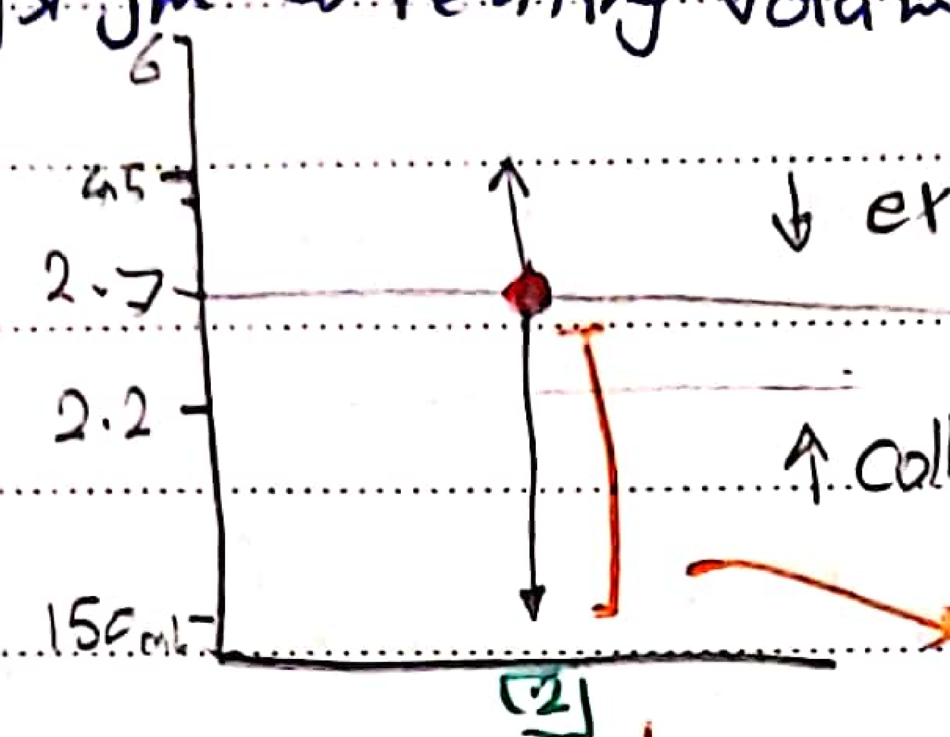
* Normal PO_2 = 100 / 0.21 = 476.2

* Thorax tend to expand → resting volum = 4.5 L

* lung tend to collapse → resting volume = 150 mL "minimal volume"

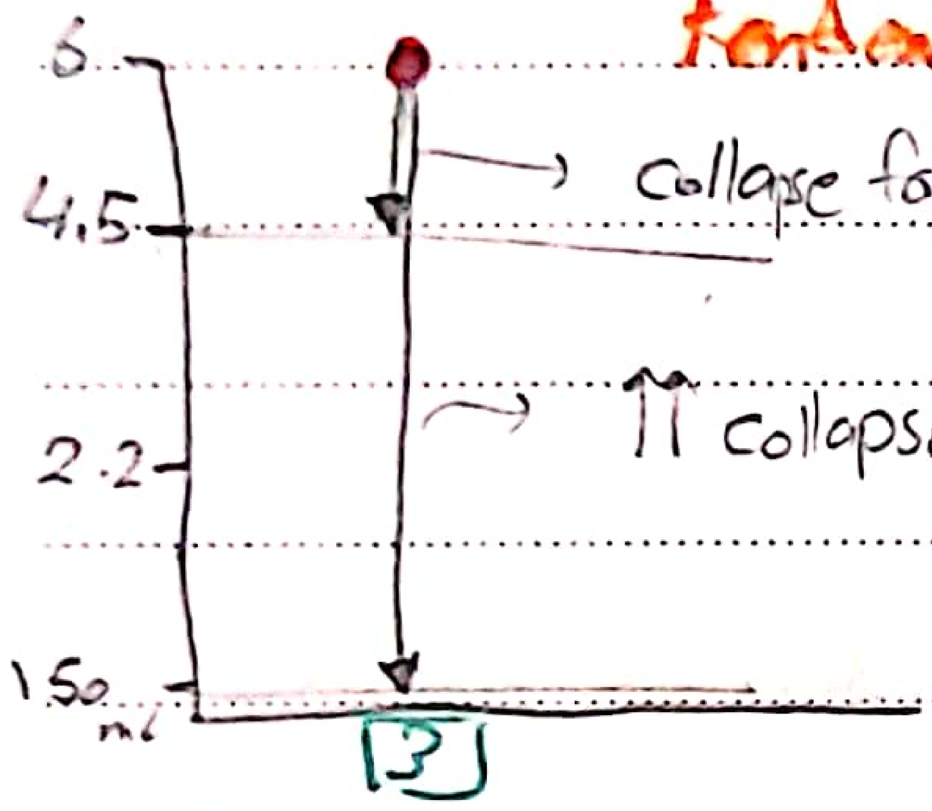
* lung–thorax system ⇒ resting volume = FRC = 2.2 L



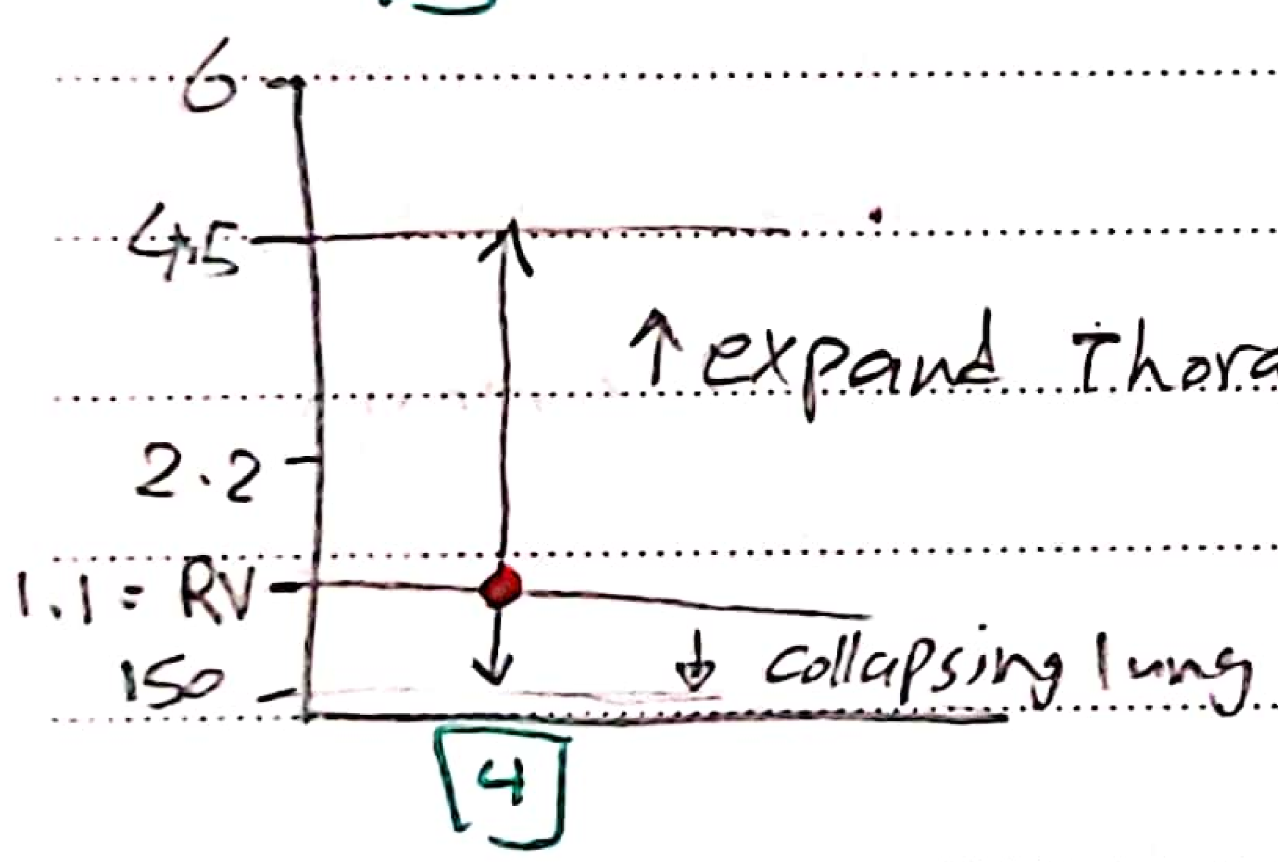


⇒ System tend to collaps → expiration passive

كلما كنت أبعد عن resting سوف تزيد tendancy



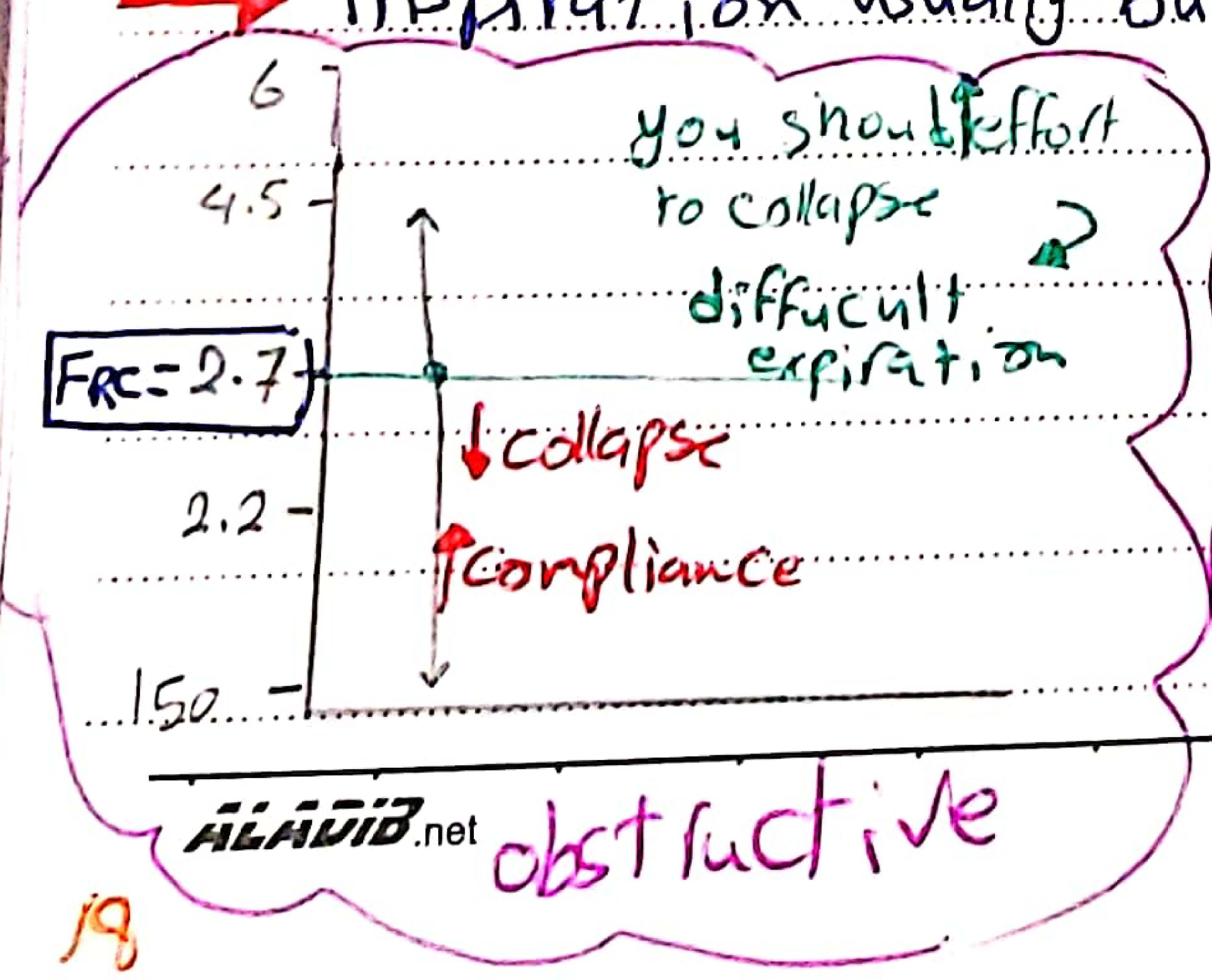
⇒ huge collapsing force

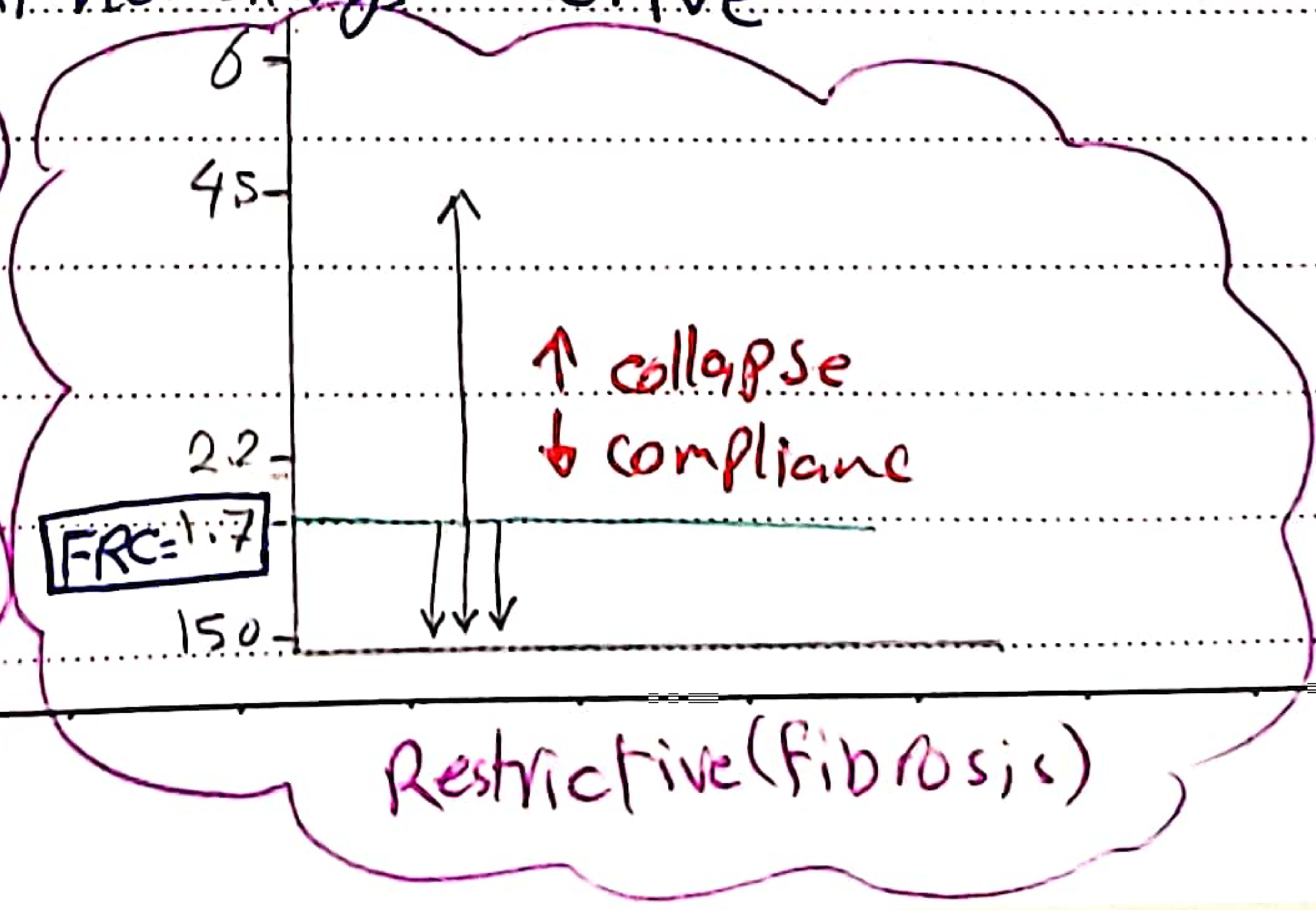


⇒ system tend to expand → inspiration passive

→ expiration usually but not always passive

→ inspiration usually but not always active





V/Q

* normal perfusion(Q) = 5L
normal ventilation(V) = 4.2L] $\frac{V}{Q} = 0.84$

curve 11 ص

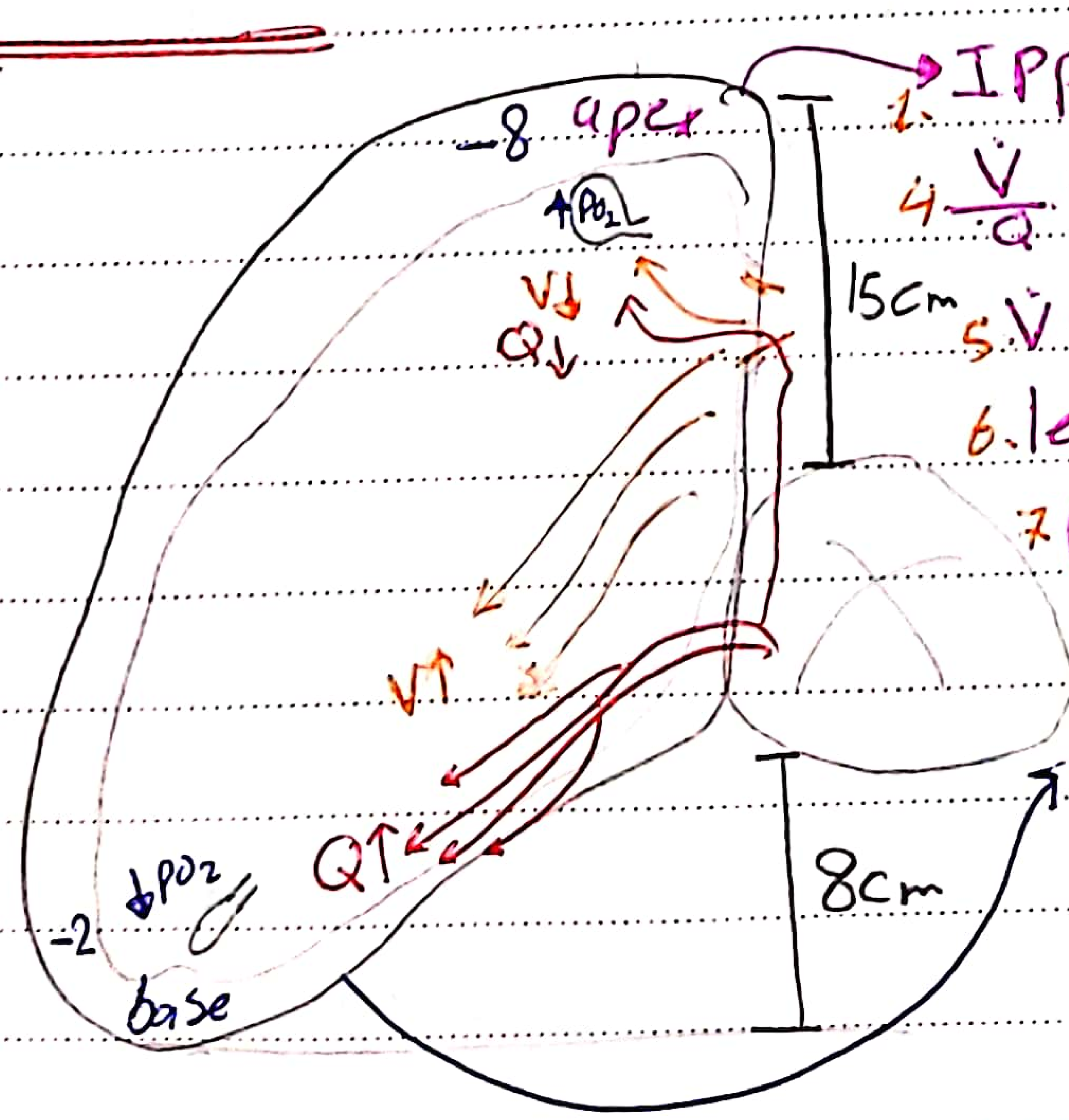
- ventilated + no perfusion = wasted ventilation
- perfusion + no ventilated = wasted perfusion
* Physiological Dead space(PDS) = ADS (=150mL) + alveolar wasted ventilation
* alveolar PO_2 = PO_2 inspired − (PCO_2/R)

$\frac{CO_2 \text{ per min}}{O_2 \text{ per min}} = 0.8 \left(\frac{200ml}{250}\right)$ = respiratory exchange ratio

- normal arterial PO_2 = PO_2 inspired − (PCO_2/R)
150 − (40 / 0.8) = 100 mmHg

713 * 21%
prusser in larynx

if we increase (21% O_2) → to 42% → 713 × 0.42 = 300
300 − (40/0.8) = 250 mmHg



1. IPP : −8
2. already inflated alveoli
3. ↓ compliance
4. $\frac{V}{Q} = 3.4 (>1)$
5. V = 0.24 > Q = 0.07
6. less ventilation / less perfusion
7. PO_2 > 100 → TB bacillus
PCO_2↓

1. IPP = −2
2. partially inflated
3. ↑ compliance
4. $\frac{V}{Q} = 0.62 (<1)$
5. Q = 1.29 > V = 0.81
6. more ventilation / more perfusion
7. PO_2 < 100 → cancer

curve 11 ص

* In ABG: we measure arterial $PO_2 = 95$ mmHg not 100 mmHg why:

venous admixture → 1. arterio venous anastomosis

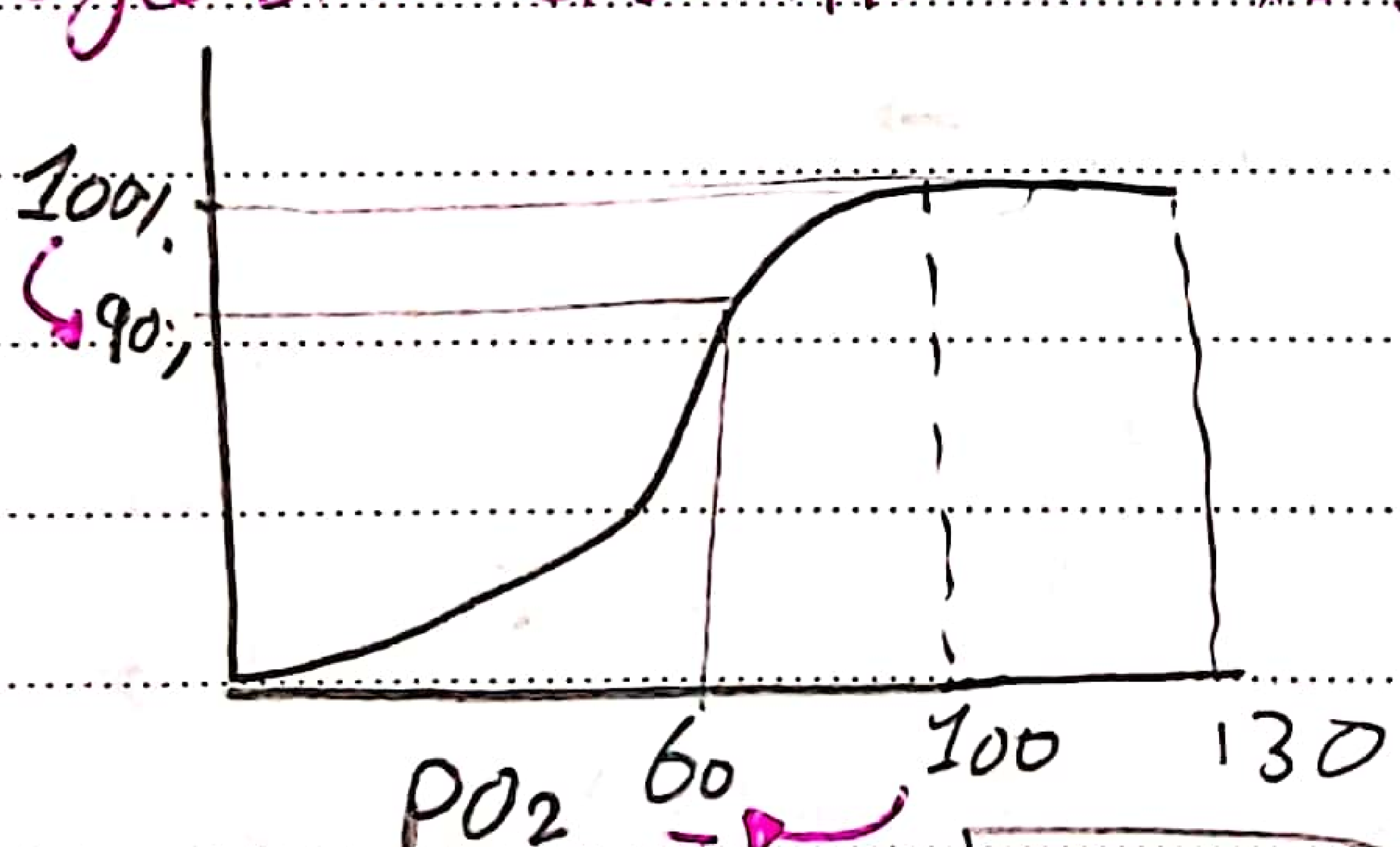
2. Cardiac circulation: some cardial vein go directly to left atrium

apex: $PO_2 = 130$
base: $PO_2 = 90$ ← 3. V/Q inequality in lung (V/Q)↑ in apex, (V/Q)↓ in base

4. 2% of blood supplies deep lung tissue "shunt flow" not exposed to air have $PO_2 = 40$ mmHg

* hyperventilated lung is unable to correct hypoventilated blood because hemoglobin dissociation curve is not leanear

hemoglobin curve (O_2)



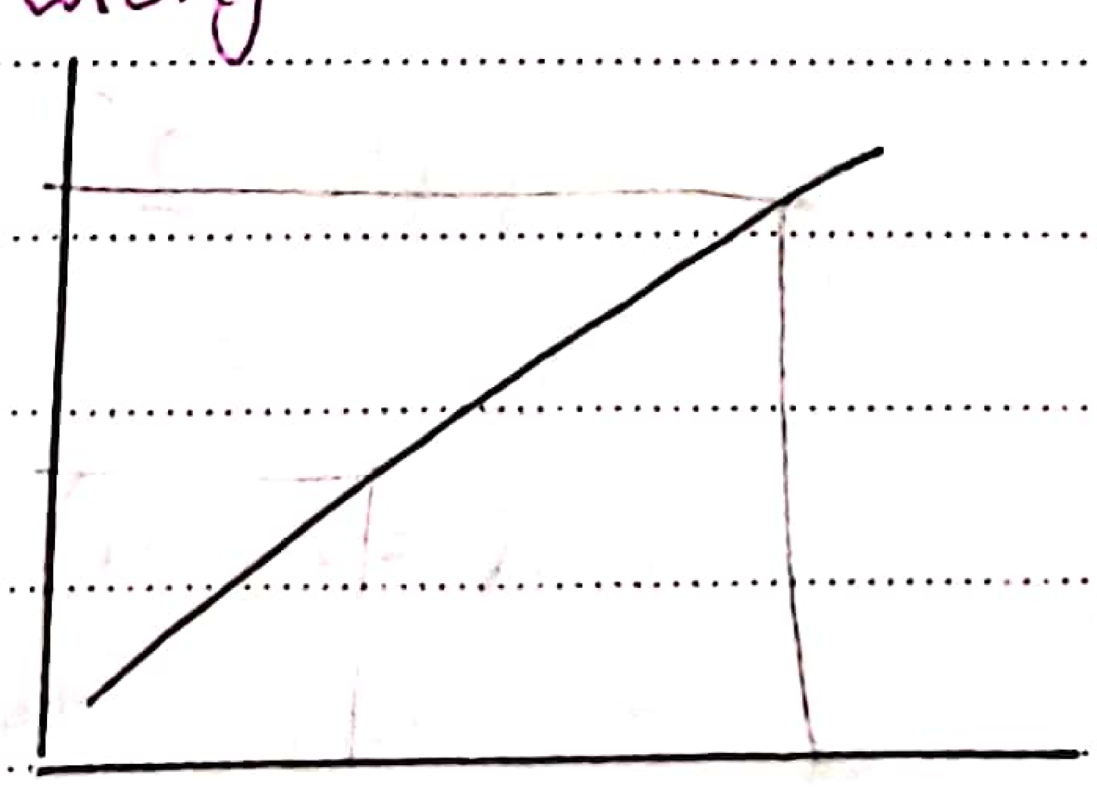
98.5% HbO_2
1.5% dissolved

not feeling any thing wrong

100 = 130

$\frac{100+90+90+90}{4} = 92.5$

hemoglobin curve (CO_2)



CO_2: self compansatory gas

$PCO_2 = 40\%$

/ /

* Measuremat of Diffusing capacity

? carbon mono oxide Method

- نحتاج هذا الفحص للاعبين (الماراثون)
- measure respiratory membrane (خصوصا) diffusing capacity

* diffusion coefficient = $\frac{S}{\sqrt{MW}}$ → for O_2 = 1 unit
  - for CO = 0.8
  - for CO_2 = 20
  (مقارنة)

- inhaled low amount of co → complitly bind with hemoglobin → PCo in capillary = 0 (Zero)

$\Delta P = PCO_{alveoli}$ ← $\Delta P = PCo_{alveoli} - PCO_{capill.}$ (Zero)

+ measuring the volume of Co absorbed in short time

$DLCO = \frac{\text{Volum Co}}{\Delta P} = \frac{\text{Volum Co}}{P_A Co} = 17\ ml/min/mmHg$

$DLCO = 17$ ——— diffusion coefficient Co = 0.8
$??? DLO_2$ ——— " " $O_2 = 1$
(ضرب تبادلي)

$0.8 \times DLO_2 = 17 \times 1$ → $DLO_2 = \frac{17}{0.8} = 21\ ml/mi/mmHg$

for CO_2 → $DLCO_2 = \frac{17 \times 20}{0.8} \approx 425 \approx 400\ ml$

---

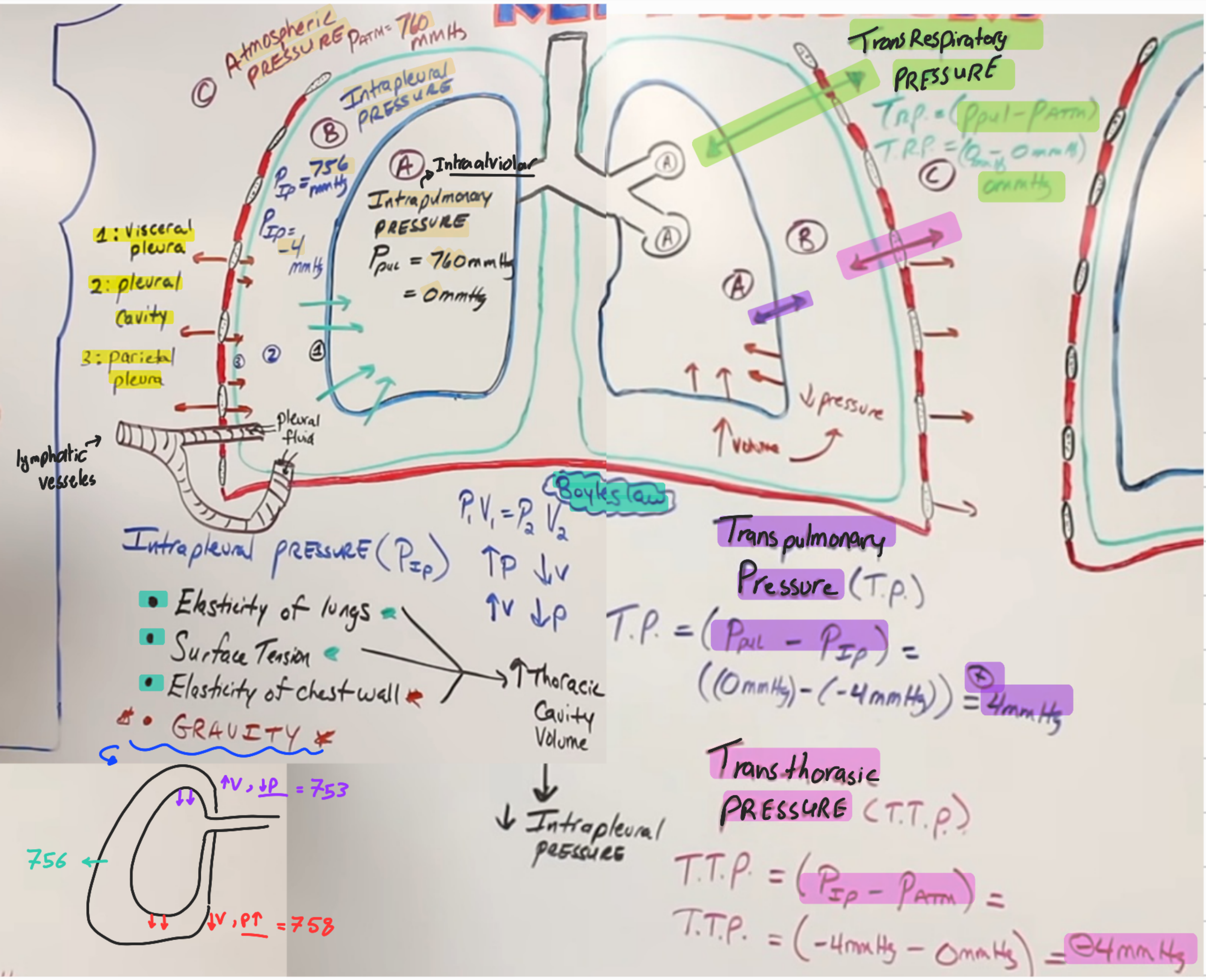
factor affected permeability of respiratory membrane:

1. thickness of membrane
2. surface area of membrane
3. diffusion coefficient of gas
4. partial pressure difference of gas between 2 sides

$K = \left(\frac{A}{dx}\right)\left(\frac{S}{\sqrt{MW}}\right)$

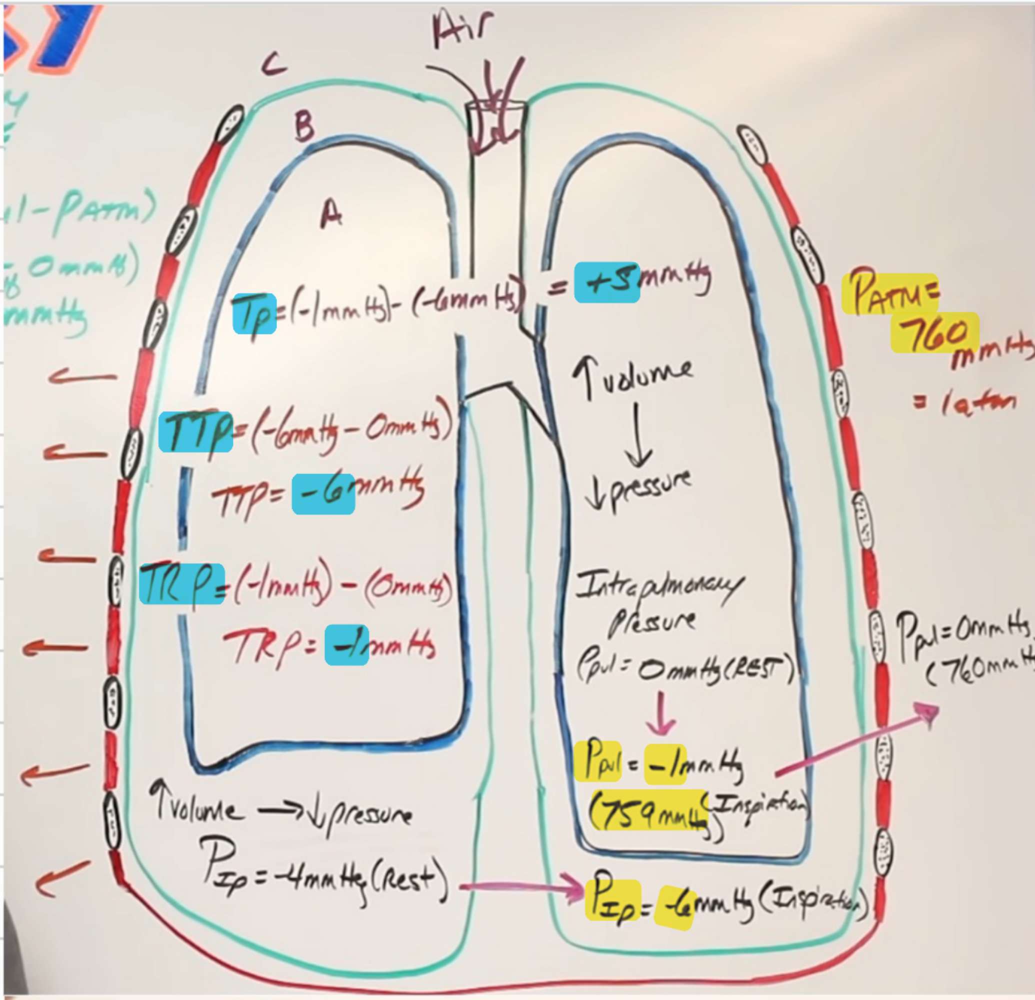
$K = \frac{Flow}{\Delta p}$

1. Mechanics of breathing : change of pressure /part 1 sh.3



	Interpulmorary P.		Interpuleural P.		Atmosphiric P.		
At rest	760	0	756	−4	760	0	= 1atm.
inspiration	759	−1	754	−6	760	0	
forced ins.		−2		−7			
Expiration	761	+1	756	−4	760	0	
forced exp.		+2		−3			

Mechanics of breathing : Inspiration /part 2



① External Intercostals & Diaphragm Contract

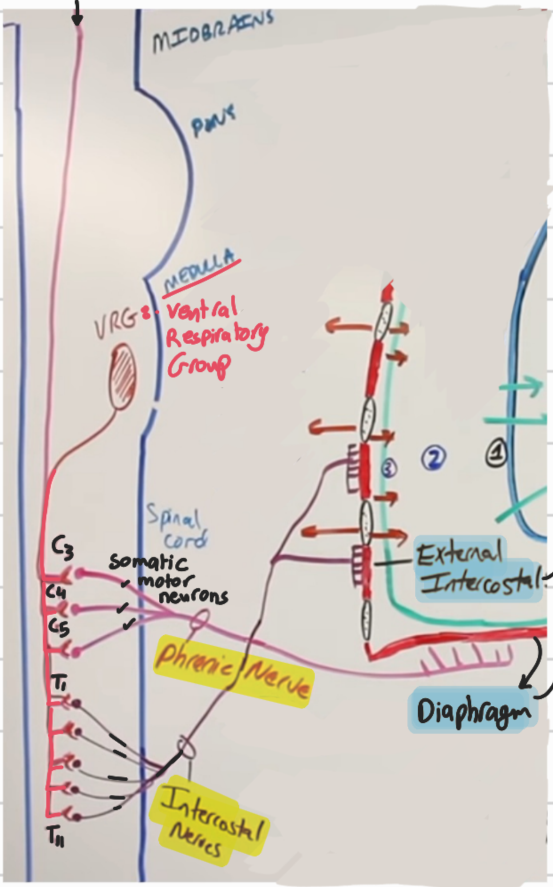
② ↑ Thoracic Cavity Volume

③ Ppul ↓ (-1mmHg) PIp ↓ (-6mmHg)

④ Tp : +5 mmHg TTP : -6 mmHg TRP : -1mmHg

↳ air go to lung until Ppul eaqule atmosphere p.
"until alviolar plessue become zero

cerebral cortex
"cortical" control



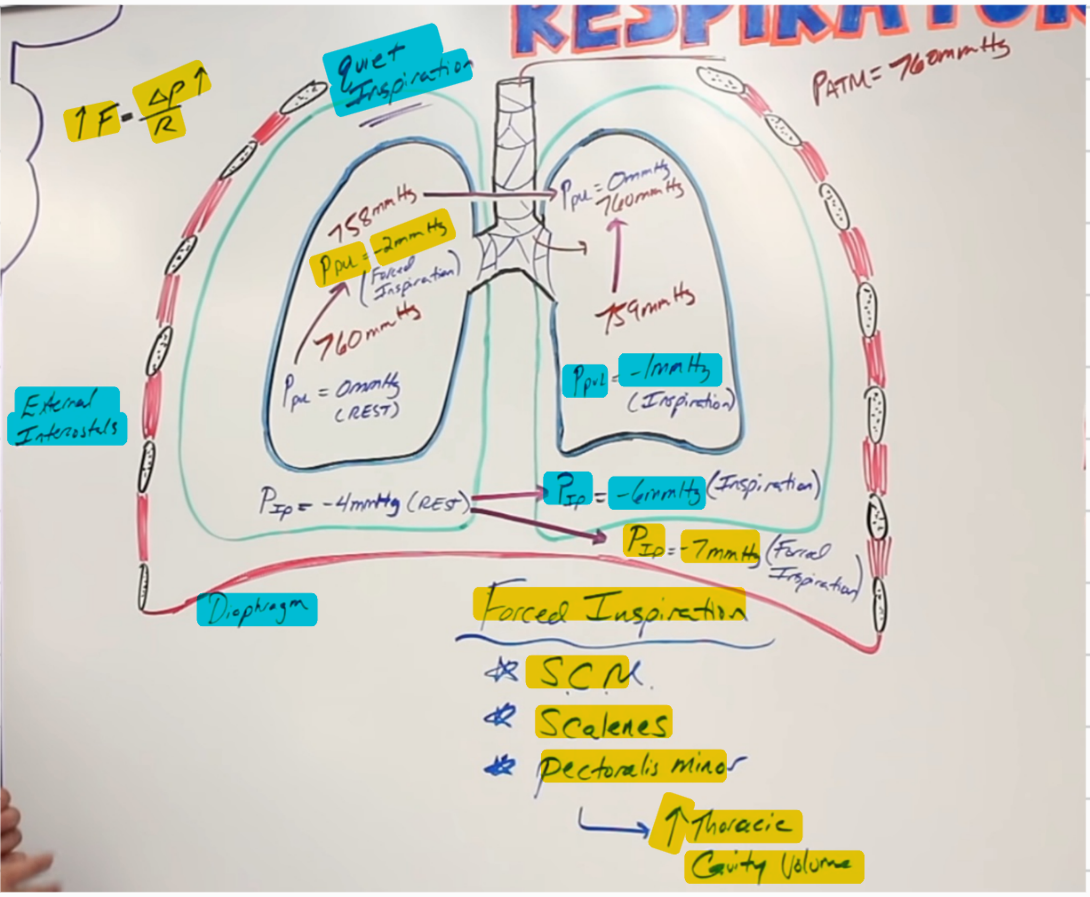
→ skeletal muscles → "Voluntary controle"

* When they contract : 1.

2.

3.  diaphragm downward

3. Mechanics of breathing : Expiration /part 3 8h.3



*Inspiration 2 types-

1) quit inspiration → diaphragm
   → External intercostal m.

2) Forced inspiration
   → sternochlidomastoid SCM
   → scalenes
   → pectoralis minor

← Expiration →