Study Guide for Exam 4

The Respiratory System

1) *Mechanics of breathing*

- Breathing consists of two phases
  - **Inspiration:** air flows into the lungs because the pressure outside of the lungs is greater than the pressure inside of the lungs
    - For this to occur, the lungs must expand, increasing lung volume, which decreases its pressure, allowing air to flow in
    - The **diaphragm** contracts, causing it to flatten. This allows the lungs/thoracic cavity to expand. The **external intercostals** also contract, elevating the ribs and widening thoracic cavity
  - **Expiration:** air flows out of the lungs because the pressure inside the lungs is greater than the atmospheric pressure
    - During quiet breathing, exhalation is passive, resulting from elastic recoil of the chest wall/lungs
    - During forceful breathing, the **rectus abdominus and internal intercostals** contract, increasing abdominal pressure and forcing the diaphragm upwards, decrasing volume

2) *Pressure Relationships in the thoracic cavity*

- Pressure in the thoracic cavity can be controlled by the diaphragm
- Respiratory pressure is always described relative to atmospheric pressure
  - **Atmospheric pressure (P_{ATM}):** pressure exerted by air surrounding the body (760 mm hg at sea level)
    - Negative respiratory pressure is less than P_{ATM} and positive pressure is greater than P_{ATM}
  - **Intrapleural (intrathoracic) pressure:** the pressure between the two pleural layers in the pleural cavity, always lower than atmospheric pressure
  - **Alveolar (intrapulmonic) pressure:** the pressure inside the lungs; must be lower than atmospheric pressure for inhalation to occur

3) *Pulmonary Ventilation*

- Aka breathing: the inflow and outflow of air, involving the exchange of gases between the atmosphere and alveoli of the lungs
  - Airflow is due to changing pressures inside lungs caused by contraction and relaxation of respiratory muscles

4) *Physical Factors affecting pulmonary ventilation*

- Airway resistance: friction is the major source of resistance to airflow
  - the relationship between flow (F), pressure (P), and resistance (R) is:

$$F = \frac{\Delta P}{R}$$

- gas flow is inversely proportional to resistance , which is greatest in medium-sized bronchi
- the pressure gradient between the atmosphere and alveoli (ΔP) is directly proportional to gas flow between the alveoli and atmosphere

- as airway resistance rises, breathing becomes more strenuous

5) *Dead space and alveolar ventilation*

- **Anatomical dead space:** volume of the conducting respiratory passages (150 mL)
  - Conducting zone is composed of the **bronchioles**

- **Alveolar Ventilation Rate (AVR):** how much air is reaching alveoli in one breath
  - Slow, deep breathing increases AVR, while rapid, shallow breathing decreases AVR

AVR	=	frequency	X	(Thoracic Vol – dead space)
(ml/min) 5250 ml/min		(breaths/min) 15/min		(ml/breath) 350 ml

6) *Gas exchange between blood, lungs and tissues*

- **Partial Pressure**: the total pressure exerted by a mixture of gases is the sum of the pressures exerted independently by each gas in the mixture
  - The partial pressure of each gas is *directly proportional* to its percentage in the mixture

- **Solubility** is also directly proportional to pressure. An increase in thoracic pressure causes an increase of solubility of gases

Atmospheric pressure= 760 mmHg:

O_2= 20.93%= 160 mm Hg

CO_2= 0.003%= 0.3 mm Hg

N_2= 79.04%= 600 mm Hg

7) *External respiration: Partial pressure gradients*

- Although carbon dioxide has a lower partial pressure gradient than oxygen, it is 20 times more soluble than O_2
  - It diffuses in equal amounts with oxygen

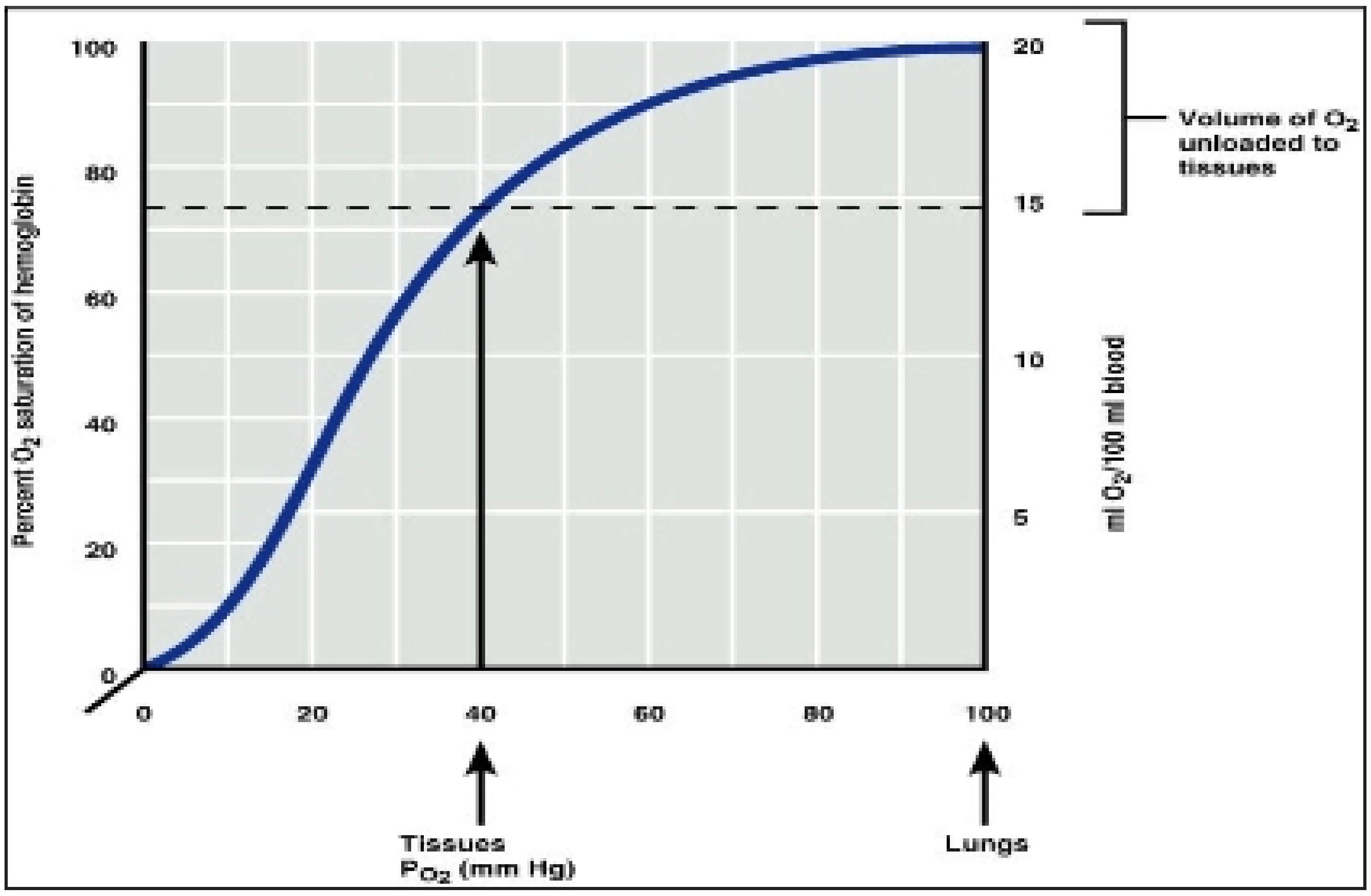
Partial Pressure Gradients

	Venous Blood	Alveolus	Arterial Blood
PCO_2	45 mm Hg	40 mm Hg	40 mm Hg
PO_2	40 mm Hg	104 mm Hg	104 mm Hg

8) *Transport of Respiratory gases by blood*

- **Hemoglobin (hb):** oxygen carrying protein in blood containing iron
  - Saturated Hb = when all four hemes of molecule are bound to O_2
    - 98% saturated arterial blood contains 20 mL of O_2 per 100 mL blood

- As it flows through capillaries, 5% is released into tissues



- To the right is the Oxygen vs. Hb curve
  - Plots the saturation of Hb vs. Pressure of O_2
- 98% sat: 20 mL
- 75% sat: 15 mL

- CO_2 diffuses quickly into red blood cells and joins with H_2O to form Carbonic acid, which quickly dissociates into ions

$$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^-$$

- In red blood cells, **carbonic anhydrase** catalyzes the reaction
  - As more carbon dioxide enters the blood, more oxygen dissociates from **hb**
    - **Haldone effect:** the lower the P_{O_2} and saturation of hb with O2, the more CO_2 can be carried in the blood

- The H_2CO_3-HCO_3^- buffer system
  - If concentration of H^+ begins to rise, excess H^+ is removed by combining it with HCO_3^-
  - if concentration of H^+ starts to decline, carbonic acid dissociates releasing H^+

9) *Control of Respiration*
  - Respiratory center = the brain stem
    - Control of respiration: medulla oblongata and Pons
      - both inspiratory and expiratory muscles
        - **inspiratory:** diaphragm and external intercostals
          - during forceful breathing: sternocleidomastoid and scalene
        - **expiratory:** internal intercostals and rectus abdominus

  - higher brain centers in cerebral cortex also have control over voluntary breathing
    - **central chemoreceptors:** located in medulla (70% response)
    - **peripheral chemoreceptors:** located in aortic and carotid bodies (30% response)
      - both of these affect the rate of inspiration and expiration