

**NROSCI/BIOSC 1070 and MSNBIO 2070**  
**Exam # 3**  
**November 15, 2019**

1) For each of the following, indicate whether the acidosis is of respiratory or metabolic origin, as well as whether the disturbance is compensated or uncompensated. **(2 point each; 12 points total).**

a) pH: 7.28  
 pO<sub>2</sub>: 100 mm Hg  
 pCO<sub>2</sub>: 22 mm Hg  
 HCO<sub>3</sub><sup>-</sup>: 10 Eq/L

Respiratory or Metabolic	Has Compensation Occurred?

b) pH: 7.3  
 pCO<sub>2</sub>: 50 mm Hg  
 HCO<sub>3</sub><sup>-</sup>: 27 Eq/L

Respiratory or Metabolic	Has Compensation Occurred?

c) pH: 7.32  
 pCO<sub>2</sub>: 29 mm Hg  
 HCO<sub>3</sub><sup>-</sup>: 14 Eq/L

Respiratory or Metabolic	Has Compensation Occurred?

- 2) In the chart below, provide “normal” values of an individual at rest for the following physiologic parameters. **(1 point each; 9 points total).**
- a) Arterial pO<sub>2</sub> (in mm Hg)
  - b) Arterial pCO<sub>2</sub> (in mm Hg)
  - c) Venous pO<sub>2</sub> (in mm Hg)
  - d) Venous pCO<sub>2</sub> (in mm Hg)
  - e) Arterial hemoglobin oxygen saturation (%)
  - f) Venous hemoglobin oxygen saturation (%)
  - g) Arterial bicarbonate concentration (in Eq/L or mEq/ml)
  - h) Atmospheric pO<sub>2</sub> at sea level (in mm Hg)
  - i) Atmospheric pCO<sub>2</sub> at sea level (in mm Hg)
- 3) An individual is breathing through a snorkel with a volume of 100 ml. Assuming that the individual’s anatomy is normal, calculate their alveolar ventilation (in ml/min) if they are breathing 12 breaths per minute with a tidal volume of 600 ml. **(5 points).**

- 4) The cardiac catheterization lab determines the following parameters for a patient:

Oxygen consumption = 250 ml O<sub>2</sub>/minute

Oxygen content in arterial blood = 0.20 ml O<sub>2</sub>/ml blood

Oxygen content in venous blood = 0.15 ml O<sub>2</sub>/ml blood

Heart rate = 50 beats/min

Calculate the patient's stroke volume. You must show your calculations. **(5 points)**.

- 5) A pulmonary disease results in an **increase** in lung compliance, without any change in total lung capacity or airway resistance. Spirometry shows a marked increase in some lung volumes in this patient. Which lung volumes are most increased in this patient? **(5 points)**.

6) During exercise, a number of physiological parameters change. Indicate whether a substantial change (if any) has occurred in each of the following physiological parameters after 25 minutes of maximal exercise on a stationary bicycle, relative to the pre-exercise state. Assume that a substantial change is >10%. **(1 point each; 3 points total).**

a) Oxygen content in arteries supplying leg muscles

Higher than at Rest      About the Same      Lower than at Rest

b) Oxygen content in veins draining leg muscles

Higher than at Rest      About the Same      Lower than at Rest

c) Affinity of hemoglobin for oxygen in veins draining leg muscles

Higher than at Rest      About the Same      Lower than at Rest

7) For each of the following muscles during exercise, indicate whether they would contract during inspiration or expiration, or would be quiescent (inactive) during both respiratory phases. **(1 point each; 4 points total).**

a) Genioglossal muscle (tongue protruder)

Inspiration      Expiration      Quiescent during both phases

b) External intercostal muscle

Inspiration      Expiration      Quiescent during both phases

c) Diaphragm

Inspiration      Expiration      Quiescent during both phases

d) Abdominal muscle

Inspiration      Expiration      Quiescent during both phases

8) For each disease condition below, indicate whether intrapleural pressure is higher, lower, or the same as in a normal individual. **(1 point each; 3 points total).**

a) Emphysema

Higher than Normal      Lower than Normal      Same as Normal

b) Fibrotic lung disease

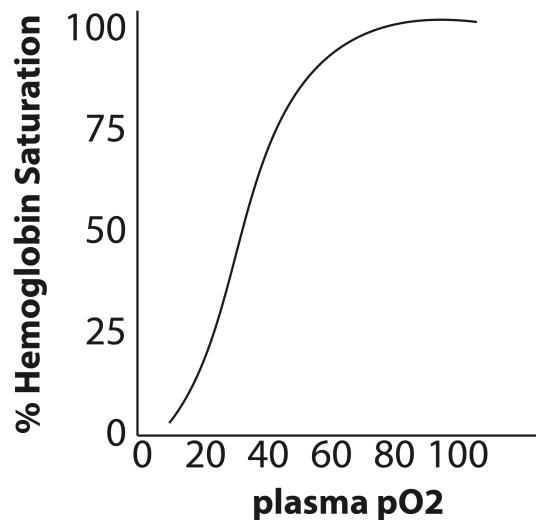
Higher than Normal      Lower than Normal      Same as Normal

c) Pneumothorax

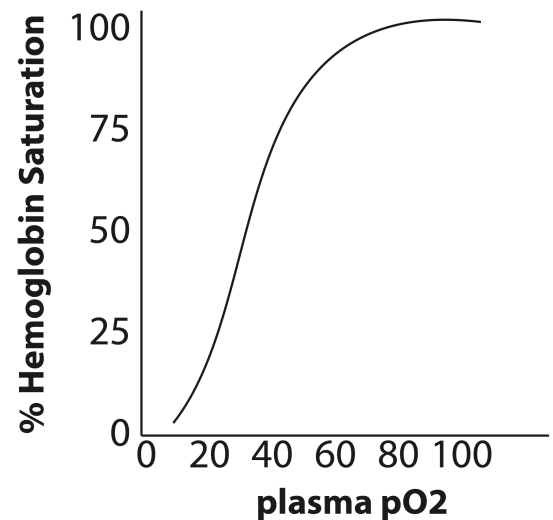
Higher than Normal      Lower than Normal      Same as Normal

9) “Standard” oxygen-hemoglobin dissociation curves are illustrated below. On the left, indicate how the curve changes during carbon monoxide poisoning. On the right, indicate how the curve changes in blood flowing through the capillaries of exercising muscle. **(5 points each; 10 points total).**

Carbon Monoxide Poisoning



Exercise



**10)** Indicate how the following physiologic changes alter the affinity of hemoglobin for oxygen (how much oxygen is bound to each hemoglobin molecule at a particular  $pO_2$ ). **(2 points each; 6 points total).**

**a)** Hyperventilation for 10 minutes

Higher Affinity

Similar Affinity

Lower Affinity

**b)** A high fever

Higher Affinity

Similar Affinity

Lower Affinity

**c)** Diabetic ketoacidosis (a form of metabolic acidosis)

Higher Affinity

Similar Affinity

Lower Affinity

**11)** A patient is admitted to the emergency department following two days of severe vomiting. Blood gas measurements reveal that the vomiting has caused a pH alteration in the blood. Should the resident treating the patient administer sodium bicarbonate to normalize their blood pH? Provide a brief justification for your answer. **(5 points).**

- 12) A child is born to a HIV positive mother following a 40-week uncomplicated gestational period. The mother was told that there is a chance that her child would contract HIV from her. She went to all of her prenatal care appointments and claims to have followed the doctor's orders throughout pregnancy. Immediately following birth, a first year OB-GYN resident tests the baby for IgG auto-antibodies indicative for HIV using ELISA (an assay that utilizes the binding capabilities of antibodies and fluorescence to identify the presence of a particular antibody).
- a) Will the baby be HIV positive or negative according to the test, or is it impossible to predict? Please support your answer with reasoning. **(5 points)**.
- b) According to clinical protocol, the mother has not been breast feeding her child and takes the seemingly healthy child to see a pediatrician who specializes in HIV one year after birth. The Pitt Med trained pediatrician says that they want to redo the ELISA to confirm the results of the first test. Why would the pediatrician doubt the results of the first ELISA test? **(5 points)**.

**13)** Match the statements below with the appropriate immune system component from the following list. Each option can be used once, more than once, or not at all. **(1 point each; 6 points total).**

1. Mannose Binding Lectins (MBL)
2. Toll-like receptor 4 (TLR-4)
3. Scavenger Receptors
4. Interleukin 1 (IL-1)
5. MHC-1
6. MHC-2

- a) Found on all nucleated cells in the human body and are responsible for presenting intracellular contents on the cell membrane.
- b) Directly acts on the hypothalamus (nervous system structure) to induce fever during infection.
- c) Soluble pathogen recognition receptor (PRR) that typically binds carbohydrate complexes in a particular orientation on bacterial membranes.
- d) Membrane bound pathogen recognition receptor (PRR) that recognizes pathogen associated molecular patterns (PAMPs) on many infectious species and leads to the upregulation of NF- $\kappa$ B.
- e) Found on phagocytic cells and are responsible for presenting pieces of phagocytosed pathogens to cells of the adaptive immune system.
- f) Recognize f-Methionine – Leucine – Phenylalanine of bacterial peptides.



- 14) A 22-year-old healthy man presents to you today in the clinic with a productive cough, fever, and shortness of breath most characteristic of a bacterial pneumonia. After talking to his mother, you learn that he had a seizure 2 days ago and vomited upon losing consciousness. This is the first time this has ever happened to this man. Because you are a good physician who studied hard in Honors Human Physiology and medical school, you know that *Klebsiella* (a gram-negative, extracellular bacteria that causes aspiration pneumonias) is one of the most likely causes of this man's current condition.

The mother of the patient also took Honors Human Physiology many years ago and says that her son must have a problem with his immune system because he is not producing antibodies against the *Klebsiella* after 2 full days of infection. Do you agree with the mother? Why or why not? **(5 points)**.

**15)** For the patient described in question 14, describe the role that each immune system element listed below plays in recognizing their pathogen or mounting a response to it. Assume that the patient has no immunological deficiencies. **(3 points each; 12 points total).**

a) Dendritic Cells:

b) CD4 T Cells:

c) B Cells:

d) Macrophages (3-5 days AFTER infection is resolved with antibiotics):

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