Exam Key

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_2: 100 mm Hg
pCO_2: 22 mm Hg
HCO_3^-: 10 Eq/L

Respiratory or Metabolic	Has Compensation Occurred?
Metabolic	Yes

b) pH: 7.3
pCO_2: 50 mm Hg
HCO_3^-: 27 Eq/L

Respiratory or Metabolic	Has Compensation Occurred?
Respiratory	No

c) pH: 7.32
pCO_2: 29 mm Hg
HCO_3^-: 14 Eq/L

Respiratory or Metabolic	Has Compensation Occurred?
Metabolic	Yes

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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_2 (in mm Hg)
100 (90-100 OK)

b) Arterial pCO_2 (in mm Hg)
40

c) Venous pO_2 (in mm Hg)
40

d) Venous pCO_2 (in mm Hg)
45

e) Arterial hemoglobin oxygen saturation (%)
100 (90-100 OK)

f) Venous hemoglobin oxygen saturation (%)
75

g) Arterial bicarbonate concentration (in Eq/L or mEq/ml)
24 (23-30 considered normal, and is OK)

h) Atmospheric pO_2 at sea level (in mm Hg)
160

i) Atmospheric pCO_2 at sea level (in mm Hg)
0 (0-1% OK)

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).***

Alveolar ventilation = 600 ml – (100 ml + 150 ml) = 350 ml/breath

350 ml/breath * 12 breaths/min = 4.2 L/min

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

Oxygen consumption = 250 ml O_2/minute
Oxygen content in arterial blood = 0.20 ml O_2/ml blood
Oxygen content in venous blood = 0.15 ml O_2/ml blood
Heart rate = 50 beats/min

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

CO=VO2 / (Ca-Cv)
CO=250 / (0.2-0.15) = 250 / 0.05 = 5000 ml/min

5000 ml/min / 50 beats/min = 100 ml/beat

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).***

Expiratory reserve volume and residual volume increase (full credit for just saying residual volume).

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

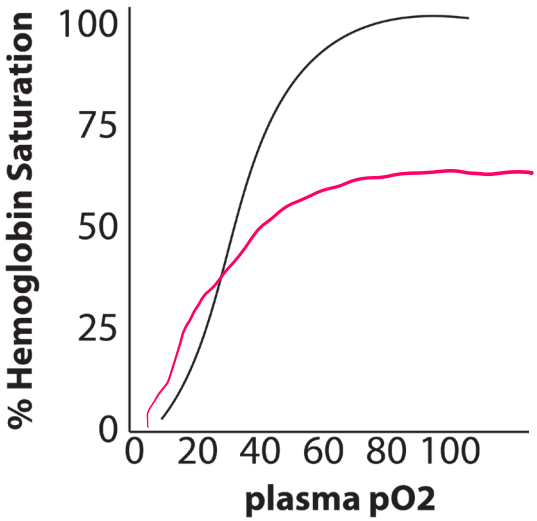
c) Pneumothorax

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).***

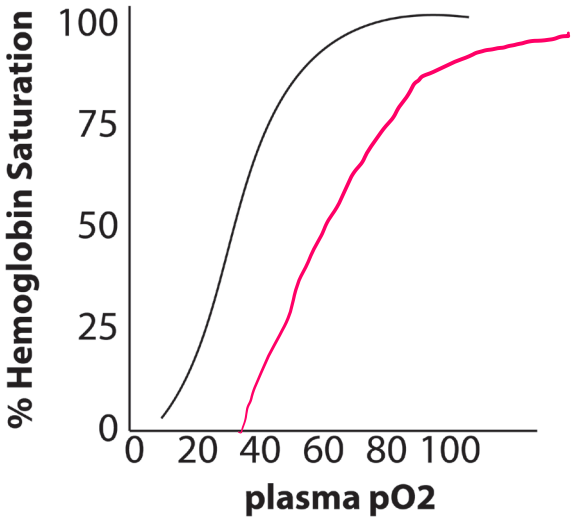
Carbon Monoxide Poisoning

Curve shifted down



Exercise

Curve shifted to right



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).***

NO! Vomiting will result in metabolic alkalosis. Giving bicarbonate will make the alkalosis worse.

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).***

The test will be positive because the baby will have IgG from the mother at this point. There is no way to tell if the child is HIV positive or negative by using ELISA at this point.

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).***

When the first test was conducted, the baby still had the mother's IgG. Since IgG from the mother only lasts about 6 months, the child would now be making their own IgG. Thus, ELISA can now detect whether or not the child has the HIV IgG auto-antibodies.

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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.
E

b) Directly acts on the hypothalamus (nervous system structure) to induce fever during infection.
D

c) Soluble pathogen recognition receptor (PRR) that typically binds carbohydrate complexes in a particular orientation on bacterial membranes.
A

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-kB.
B

e) Found on phagocytic cells and are responsible for presenting pieces of phagocytosed pathogens to cells of the adaptive immune system.
F

f) Recognize f-Methionine – Leucine – Phenylalanine of bacterial peptides.
C

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).***

The mother is wrong. Although the innate immune system began fighting the infection right away, the adaptive immune system takes 4-7 days to kick in. Antibodies will not start being produced until the adaptive immune system is activated.

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:

Phagocytoses the bacteria at the site of infection and travels to the lymph organs to present the pathogen to T cells via MHC-II/CD4 interactions.

b) CD4 T Cells:

Recognizes the presented pathogen from the dendritic cell with its TCR and subsequently activates B cells.

c) B Cells:

Undergoes a T cell-dependent response and starts to synthesize antibodies that are appropriate for fighting the pathogenic organism (probably IgM first and then IgG)

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

Responsible for clearing debris from the site of infection so that the organ can return to normal function.