MCB 136 PHYSIOLOGY
2nd Mid-term exam: Spring 1999

Name _____

A. MULTIPLE CHOICE (circle the most appropriate answer) 2 pts each

1. A membrane separates compartments 1 and 2 is freely permeable to water and Cl but not Na or HCO_3. If compartment 1 initially contains 10 mM NaCl + 140 mM $NaHCO_3$ and compartment 2 contains 160 mM NaCl, which of the following will occur?
   a. Compartment 2 will initially be electrically positive with respect to compartment 1.
   b. Water will flow from compartment 1 to 2.
   c. The concentration of Na in compartment 1 will become greater than that in compartment 2.

2. A patient was found to have an arterial blood pressure of 175/95 and a heart rate of 70 beats/min. Central venous pressure, cardiac output and stroke volume were all normal. Average arterial blood pressure was
   a. 163 mm Hg
   b. 140 mm Hg
   c. 122 mm Hg
   d. 100 mm Hg
   e. 95 mm Hg

3. For the patient in #2, what hemodynamic factor was most likely to have given rise to the higher than normal blood pressure?
   a. increased blood velocity in aorta
   b. increased arterial compliance
   c. decreased venous compliance
   d. increased systemic arteriolar resistance
   e. reduced pulmonary resistance

4. Blood flow through two coronary arteries was, due to an atherosclerotic blockage, measured to be half that through a parallel artery. Adenosine was administered to the patient. Adenosine
   a. is normally produced by the heart and other tissues
   b. is produced in greater amounts in actively exercising heart muscle
   c. is permeable through capillaries
   d. causes the same effects as nitric oxide on smooth muscle
   e. all of the above

5. For the patient in #4, adenosine would be expected to _____ blood flow to the blocked side and _____ blood flow to the patent side (I, increase; D, decrease; 0, no change).

a. I, I	c. D, I	e. D, 0
b. I, D	d. 0, D	f. 0, I

6. Compliance of the lungs in vivo is defined as the change in _____ (V, volume; T, tension) per unit change in expanding (inflating) pressure, and is _____ (I, increased; D, decreased; 0, not changed) if surfactant is depleted.

a. V, I	c. V, D	e. V, 0
b. T, I	d. T, D	f. T, 0

7. Concerning mechanical factors in breathing we can say that in the tidal range there is _____ (M, more; L, less; S, about the same) muscular work involved in breathing in, than in breathing out, and that forced expiration is _____ (M, more; L, less) diffficult than forced inspiration.

a. M, M	c. M, L	e. L, M
b. L, L	d. S, M	f. S, L

Name _____

8. With reference to the control of breathing: the increase in ventilation in exercise is proportional to an increase in _____ (PCO_2, arterial PCO_2; O_2, oxygen consumption); and the peripheral (arterial) chemoreceptors are stimulated by decreased _____ (PO_2, arterial PO_2; PCO_2, arterial PCO_2; H, hemoglobin content) in the arterial blood.

a. PCO_2, PO_2
b. O_2, PO_2
c. PCO_2, PCO_2
d. O_2, PCO_2
e. PCO_2, H
f. O_2, H

9. Also, with reference to control of breathing, afferent impulses carried in the vagus nerves _____ (D, do; N, do not) play a part in the control of breathing, and breathing _____ (C, can; N, can not) continue when the brain stem is the only functioning part of the brain.

a. D, C
b. D, N
c. N, C
d. N, N

10. In a healthy individual, if cardiac output were doubled we would expect that the residence time of blood in a pulmonary capillary to _____ and the pulmonary diffusion capacity for oxygen in the whole lung to _____ (I, increase; D, decrease; 0, not change).

a. D, I
b. I, D
c. D, 0
d. D, D
e. 0, 0
f. 0, I

B. TRUE-FALSE (insert a T or F in the space provided) 1 pt each

_____ 1. The pressure necessary to prevent volume flow as a function of solute concentration for a membrane bathed on one side by pure water and on the other by a solution containing different solutes will be larger for a permeant than an impermeant solute.

_____ 2. The rate of NET glucose flux from the lumen of a capillary suppying a muscle out to the tissue space will depend on the concentrations of glucose in the capillary and in the tissue space.

_____ 3. The main determinant of the rate of permeation of an uncharged molecule across a membrane is the hydraulic conductivity of the membrane.

_____ 4. Water is pulled into the capillaries (to counter the loss of water due to filtration) by the osmotic pressure of the glucose, amino acids, NaCl and $NaHCO_3$ in the capillary lumen.

_____ 5. Turbulent blood flow occurs during narrowing of the arterioles, through small holes in ventricles and during measurement of arterial blood pressure.

_____ 6. Administering a parasympathetic antagonist (atropine) would cause heart rate to decrease.

7. In the alveolar region of the lungs:
_____ the barrier to diffusion of gases prevents their equilibration with the blood.
_____ surfactant-secreting cells form a continuous epithelial layer lining the alveoli.
_____ if any fluid escapes from capillaries, it goes into the alveoli.
_____ macrophages are frequently found in the alveolar space.

8. Arterial hypoxemia (decreased arterial oxygen tension) is a consequence of:
_____ hypoventilation.
_____ low hemoglobin concentration.
_____ carbon monoxide poisoning.
_____ living at high altitude.

Name _____

9. Movement of fluid out of pulmonary capillaries:
_____ is increased if surfactant is deficient.
_____ is an entirely normal phenomenon counterbalanced by lymphatic flow.
_____ implies movement of fluid into the alveolar spaces.
_____ is necessarily increased in rate by an increase in pulmonary capillary pressure.

10. A number of compensatory changes for the low partial pressure of oxygen in inspired air at high altitude are listed below on the left. Are the mechanisms on the right in each case appropriate? T/F

_____ increased ventilation	carotid sinus receptor stimulation
_____ increased red blood cell count	increase in erythropoietin secretion
_____ hypocapnia	decreased tissue metabolism
_____ shift of dissociation curve of HbO_2	increase in 2,3-diphospho-glycerate (DPG) in red cells

C. CALCULATIONS, SHORT ANSWERS and GRAPHICAL INTERPRETATIONS

Some useful formulas are on the last page.

1. A 54 year old woman entered the hospital appearing slightly blue with severe shortness of breath and arterial blood pressure of 80/50. The physician determined that the left heart had very recently developed a lesion and was not able to pump normally, while the right heart continued to pump blood to the lungs at normal rates.

(a) Explain the reduced lung function, i.e. blue color and shortness of breath. Mention hemoglobin, fluid balance in the pulmonary capillaries and diffusion of respiratory gases. (4 pts)

(b) What structures in the aorta and in the brain are directly involved in sensing, and then interpreting, the reduced blood pressure? (2 pts)

(c) List the physiological changes to this hypotensive episode in the heart (1 pt)

smooth muscles of the arteriolar vessels of the GI tract (1 pt)

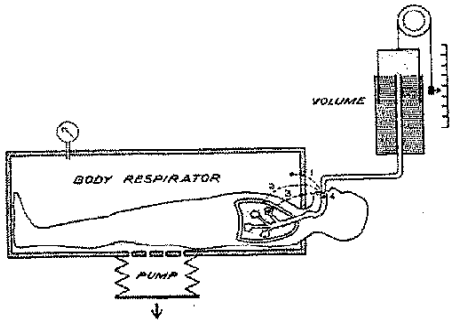
brain (1 pt)

smooth muscles of the systemic veins (1 pt)

Name _____

2. Compare fast twitch glycolytic muscle and slow twitch oxidative muscle with regard to their mechanisms for generating ATP. Mention relative contributions of creatine kinase, glycolytic reactions and oxidative phosphorylation. (4 pts)

3. A subject is put into an "artificial respirator" (as shown in the diagram) and mechanically ventilated at 8 liters/min. The anatomical dead space is estimated to be 150 ml. The stroke volume of the respirator (tidal volume) is set at 0.8 liters. The inspired gas contains 50% O_2. CO_2 production is 195 ml/min and O_2 usage is 240 ml/min. Alveolar PCO_2 is 24 mm Hg:



(a) Calculate alveolar ventilation rate (3 pts)

(b) Is the subject being hyperventilated? Cite your evidence. (3 pts)

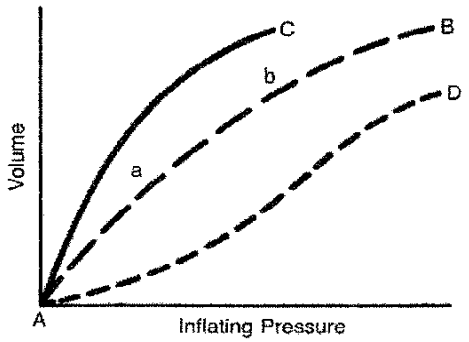
(c) Calculate the respiratory quotient (RQ). (2 pts)

4. An individual with a normal hemoglobin content has an arterial O_2 content of 20 ml O_2/100 ml blood and a venous O_2 content of 15 ml O_2/100 ml blood when he is breathing air. His cardiac output is 6 l/min, and his oxygen usage is 300 ml/min (Assume Hb carries 1.34 ml O_2/g, and 0.3 ml of O_2 dissolves in 100 ml of blood at PO_2 = 100mmHg. Respiratory measurements show a tidal volume of 500 ml/breath with a respiratory frequency of 12 breaths/min. PCO_2 was measured at 25 mmHg in expired air and 40 mm Hg in alveolar air.
(a) If we assume that arterial hemoglobin is 100% saturated, what is the % saturation of venous blood? (3 pts)

(b) Calculate his pulmonary ventilation to perfusion ratio. (4 pts)

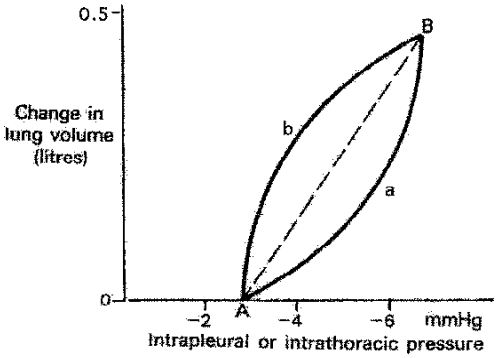
Name _____

5. The graphs at the right represent the change in volume when an isolated lung is inflated. The curve A-B represents a typical response for a lung which is normal and air-filled. Respond to the questions True or False, T or F (4 pts)



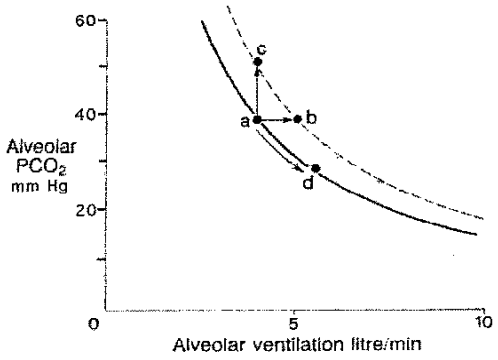
_____ the upper part, **b-B** represents the volume at which the lung is most compliant.
_____ during deflation, the same pathway would be followed in reverse (**B-b-a-A**).
_____ the curve **A-C** could represent expansion of the same lung when filled with saline instead of air.
_____ the curve **A-D** could represent a lung with more surfactant activity.

6. The diagram represents measurements made continuously during a single normal tidal breath, in and out, in a human subject at rest. Answer the following T or F. (5 pts)



_____ the curve **B-a-A** (to the right) represents expiration.
_____ zero on the Y axis would correspond to functional residual capacity.
_____ the volume change shown here can not be increased during exercise.
_____ the slope of the straight dashed line drawn from **A** to **B** measures the compliance of the lungs.
_____ the 'loop' shown would be 'fatter' if the person had increased airways resistance.

7. The graphs show the effect of alterations in alveolar ventilation on alveolar PCO_2. The solid curve refers to a typical healthy subject at rest; his alveolar ventilation and PCO_2 are shown at **a**. (4 pts)



_____ the arrow **a** to **b** could represent what happens when the subject increases his metabolic activity.
_____ the arrow **a** to **d** represents what happens during hyperventilation.
_____ the arrow **a** to **c** shows the ventilatory response to rising PCO2.
_____ the broken curve could refer to a different subject of larger size.