



## Exam Key

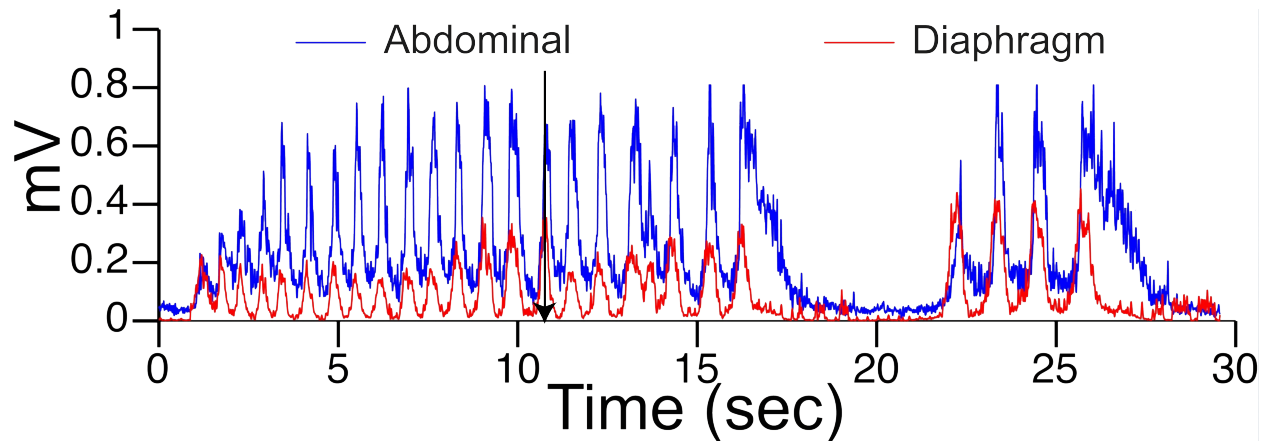
- 2) To avoid “the bends” a diver must decompress slowly. Briefly describe why a diver who surfaces too quickly after a dive experiences the bends. **(5 points)**.

If a diver has been submerged long enough for considerable nitrogen to be dissolved in his tissues, and then they suddenly return to the surface, the nitrogen begins to precipitate out of the tissues, forming bubbles that can produce damage. These bubbles can block blood vessels, resulting in tissue ischemia. Often, this ischemia affects muscles, resulting in the “bends.”

## Exam Key

3) The graph below shows the electrical activity of the diaphragm and abdominal muscles during a particular response.

a) Indicate the response that is occurring, and briefly describe the basis of your answer. **(2 points)**.



This is vomiting (or retching plus expulsion). The response is identified as series of co-contractions of the diaphragm and abdominal muscles, followed by a period when the abdominal contraction outlasts an initial co-contraction of the diaphragm.

b) At the timepoint indicated by the arrow, is the activity of Inspiratory-Augmenting neurons (I-Aug) in the ventral respiratory group greater or lower than during normal tidal inspiration? Provide a brief explanation for your answer. **(4 points)**.

The activity of I-Aug neurons is actively inhibited during vomiting (so the activity is lower than during tidal inspiration). Normally the pattern generator for breathing causes the activity of inspiratory and expiratory muscles to be active at different times. The respiratory pattern generator must be suppressed during vomiting to permit co-contraction of the inspiratory and expiratory muscles.

## Exam Key

- c) If the response illustrated above occurs many times in a day, would blood pH be affected? Circle if blood pH is higher (more alkaline), lower (more acidic), or unchanged following multiple repetitions of the response above. **(2 points)**.

Higher

Unchanged

Lower

Since stomach acid has to be replaced, more bicarbonate is pumped from the stomach into the bloodstream, resulting in metabolic alkalosis.

- 4) An individual has a spinal transection at the T1 spinal level. Would this lesion result in transpulmonary pressure being higher, lower, or the same during maximal inspiration? Provide a brief explanation for your answer. **(5 points)**.

In patients with a T1 transection, the intercostal muscles are paralyzed, but lung elastance does not change. Thus, there is a minimal change in transpulmonary pressure.

## Exam Key

- 5) You are conducting an experiment on an animal model that entails the electrical stimulation of cranial nerve IX (glossopharyngeal nerve) to activate axons in the nerve. In some cases you find that stimulation causes an increase in blood pressure, and in others stimulation produces a decrease in blood pressure. Why does stimulation of cranial nerve IX produce these diverse responses? **(8 points)**.

Cranial nerve IX contains the axons of both chemoreceptor and baroreceptor afferents. Stimulation of baroreceptors lowers blood pressure, whereas stimulation of chemoreceptors increases blood pressure. Depending on the response that predominates in a particular case, blood pressure can either increase or decrease.

- 6) A drug is injected into a pregnant woman that shifts her oxygen-hemoglobin dissociation curve to the right. This drug does not cross the placenta, and thus does not affect the fetus. Provided that the mother's hemoglobin remains saturated, would this drug impair oxygen delivery to the fetus? Discuss the basis for your answer. **(8 points)**.

There is no effect on the oxygenation of the fetus. The right shift would facilitate the offloading of oxygen from hemoglobin, so if there was an effect it would be beneficial to the fetus.

## Exam Key

- 7) A diver who is swimming just beneath the water's surface is breathing through a snorkel with a volume of 100 ml. The diver's breathing rate is 15 breaths/min, and each breath takes in 600 ml of air. Barometric pressure is 760 mm Hg, the diver's vital capacity is 4.5 liters, and expiratory reserve volume is 1.2 liters. Determine the following for the diver:

- a) Inspiratory reserve volume **(2 points)**

Vital Capacity = Tidal Volume + Inspiratory Reserve Volume + Expiratory Reserve Volume

$$4.5 \text{ L} = 0.6 \text{ L} + X + 1.2 \text{ L}$$

$$X = \text{Inspiratory Reserve Volume} = (4.5 - (0.6 + 1.2)) = 2.7 \text{ L}$$

- b) Total pulmonary ventilation **(2 points)**

$$(0.6 \text{ L/breath}) * 15 \text{ breaths/min} = 9 \text{ L/min}$$

- c) Alveolar ventilation **(2 points)**

$$((0.6 - (0.1 + 0.15)) \text{ L/breath}) * 15 \text{ breaths/min} = 5.25 \text{ L/min}$$

Note: 0.15 L is physiologic dead space

## Exam Key

- 8) Patients with chronic emphysema combined with chronic obstructive pulmonary disorder (COPD) often die from congestive heart failure. Explain why these diseases of the respiratory system result in congestive heart failure.

Your answer should indicate where blood would accumulate in the circulatory system, and the effect of this blood pooling. **(10 points)**.

Pulmonary arterioles dilate in accordance with  $pO_2$ . In patients with chronic emphysema and COPD,  $pO_2$  in the alveoli is low, resulting in an increase in resistance in the pulmonary circulation. (6 points).

This high afterload for the right heart will result in hypertrophy and stiffening of the right ventricle, so it fills less with blood. (2 points).

As a result, blood will pool in the peripheral veins, resulting in edema throughout the body. The edema is usually most pronounced in the lower leg, as the pooling is exacerbated by gravitational effects. (2 points).

## Exam Key

9) Discuss the two most important factors that contribute to regulating hydrostatic pressure in a capillary. Provide a brief rationale for your answers. **(10 points)**.

- 1) **Pre-capillary resistance: The most important regulator of pressure in the capillary is the resistance preceding the capillary.**
- 2) **Venous pressure behind the capillary: The pressure in a capillary must be higher than that in the venules draining the capillary. If venule pressure increases (for instance, due to gravitational forces following a change in posture), pressure will increase in the capillary until the capillary pressure exceeds venous pressure.**

**Other possible answers: blood pressure or contractility of left ventricle receive 2 points. These are contributing factors, but not the main factor.**



## Exam Key

- 10) In the table below, indicate how circulating levels of the following hormones are affected (increase ↑, decrease ↓, no change —) during spaceflight and severe hemorrhage (relative to the typical values at rest in the same individual). **(1 point per answer; 8 points total).**

Parameter	Spaceflight	Hemorrhage
Atrial natriuretic factor	↑ — ↓	↑ — ↓
Aldosterone	↑ — ↓	↑ — ↓
Angiotensin II	↑ — ↓	↑ — ↓
Vasopressin	↑ — ↓	↑ — ↓

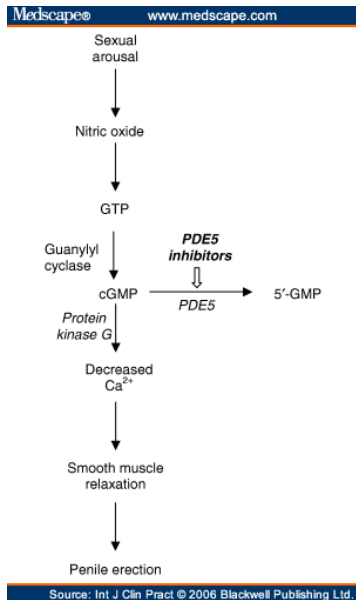
## Exam Key

- 11) During exercise, a number of changes in cardiovascular parameters occur. Briefly discuss the changes in the following parameters that are present during maximal exercise. **(2 points per answer; 18 points total).**

Parameter	Change (if any) During Exercise
Stiffness of Large Arteries	Stiffness increases
Venoconstriction	Higher (due to high sympathetic activity)
Resistance in Renal Arterioles	Higher (due to high sympathetic activity)
Resistance in Arterioles of Active Muscle	Lower (due to paracrine factors and epinephrine binding to $\beta_2$ receptors)
Systolic Blood Pressure	Much higher
Diastolic Blood Pressure	Unchanged or lower
Mean Blood Pressure	Slightly increased
Total Peripheral Resistance	Much lower (due to dilation of muscle arterioles)
Cardiac Output	Much higher (due to increases in preload, heart rate, and contractility)

## Exam Key

- 12) Some of the most lucrative drugs for drug companies have been phosphodiesterase type-5 inhibitors. Describe the physiological action of phosphodiesterase type-5 inhibitors (which mechanism is altered), and indicate why altering that mechanism provides for a useful medical treatment. **(6 points)**.



Phosphodiesterase-5 inhibitors prevent the degradation of cGMP in the corpus cavernosum of the male penis. cGMP stimulates the ATPase that removes  $Ca^{2+}$  from smooth muscle. As a result, the smooth muscle relaxes, and blood flow to the tissue increases. By inhibiting phosphodiesterase-5, increases in cGMP are maintained, and vasodilation is prolonged.