# MCAT-TEST Q&As

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**QUESTION 1**

It is critical for the human body blood to maintain its pH at approximately 7.4. Decreased or increased blood pH are called acidosis and alkalosis respectively; both are serious metabolic problems that can cause death. The table below lists the major buffers found in the blood and/or kidneys. Table 1 Buffer pKa of a typical conjugate acid:* + Histidine side chains

$HCO_3^- \rightleftharpoons CO_2$

$HPO_4^{2-}$

$\rightleftharpoons H_2PO_4^-$

Organic phosphates N-terminal amino groups

$\rightleftharpoons NH_4^+$

$NH_3$

6.1

6.3

6.8

7.0

8.0

9.2

$pK_a$

*For buffers in many of these categories, there is a range of actual values.

$pK_a$

The relationship between blood pH and the of any buffer can be described by the Henderson-Hasselbalch equation:

$pK_a$

pH = + log([conjugate base]/[conjugate acid]) Equation 1

$CO_2$

Bicarbonate, the most important buffer in the plasma, enters the blood in the form of carbon dioxide, a byproduct of metabolism, and leaves in two forms: exhaled and excreted bicarbonate. Blood pH can be adjusted rapidly by changes

$CO_2$

in the rate of exhalation. The reaction given below, which is catalyzed by carbonic anhydrase in the erythrocytes, describes how bicarbonate and interact in the blood.

$CO_2$

+ + Reaction 1

If the pH of blood were to increase to 7.6, what would be the likely outcome?

A. An increase in carbonic anhydrase activity
B. A decrease in carbonic anhydrase activity
C. An increase in the rate of $CO_2$ exhalation
D. A decrease in the rate of $CO_2$ exhalation

A. Option A

B. Option B

C. Option C

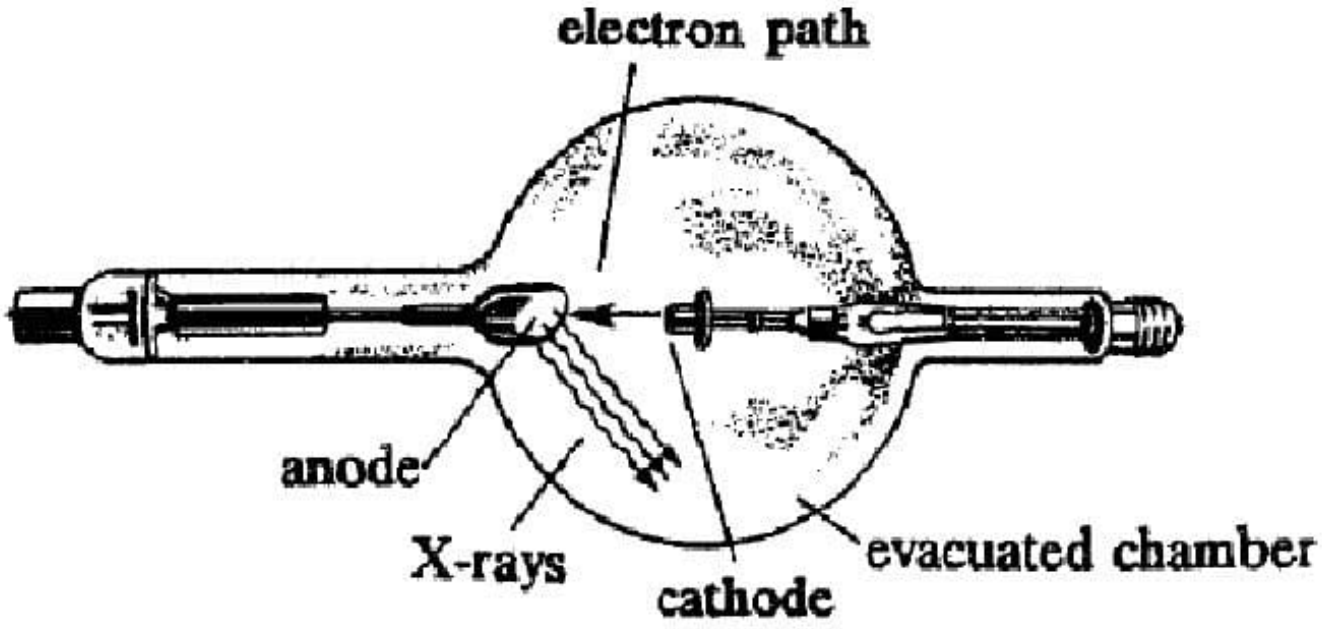
D. Option D

Correct Answer: D

If the pH of blood increases to 7.6, it becomes more alkaline, and the pH of blood must be kept at approximately pH 7.4. Since it is stated in the second sentence of the last paragraph that blood pH can be adjusted rapidly by changes in the rate of CO2 exhalation, choice A and choice B can be eliminated. In order to bring the pH of blood back to its normal value of 7.4, it must become more acidic; it becomes more acidic by increasing the concentration of H+ Reaction 1 has H+ as a product, and according to Le Chatelier\\'s principle, you should know that a reaction will proceed in a direction that will consume an added reactant or product. In other words, the concentration of a product can be increased by increasing the concentration of a reactant. If the concentration of carbon dioxide is allowed to increase, it will react to produce more H+, resulting in a lowering of the pH. The concentration of carbon dioxide will increase if it is not exhaled, making choice D the correct response.

**QUESTION 2**

X-rays are produced by a device which beams electrons with an energy between 103 and 106 eV at a metal plate. The electrons interact with the metal plate and are stopped by it. Much of the energy of the incoming electrons is released in the form of X-rays, which are highenergy photons of electromagnetic radiation. An example of such a device is shown below. Electrons are accelerated from the cathode towards the anode by an electric field.




There are two mechanisms by which the X-rays are produced within the metal. The first mechanism is called bremsstrahlung, which is German for "breaking radiation." X-rays are emitted by the electrons as they are brought to rest by

interactions with the positive nuclei of the anode.

The second mechanism occurs when an incoming electron knocks an inner electron out of one of the metal atoms of the anode. This electron is replaced by an electron from a higher energy level of the atom, and a photon making up the

energy difference is emitted.

X-rays are absorbed by a material when they pass through it. The amount of X-rays absorbed increases with the density of the material. In addition, lower energy X-rays are more likely to be absorbed than higher energy X-rays. (Note: 1 eV =

1.6 x 1019 J; Planck\\'s constant h = 4.1 x 10–15 eV•s; speed of light c = 3 x 108 m/s.)

What is the minimum potential difference required to produce a 0.06 nm X-ray from an electron transition in a metal?

A. 15,000 V

B. 20,000 V

C. 20,500 V

D. 21,500 V

Correct Answer: C

In the passage, we are told that an X-ray is emitted when an electron makes a transition from a higher to a lower energy level in an atom. This question asks us to calculate the minimum potential difference required to produce a 0.06-nm X-ray from an electron transition. First, we have to determine the energy of the X-ray produced. We use the equation E = hc/, where E is the energy, h is Planck\\'s constant, c is the speed of light in a vacuum, and is the wavelength. Substituting in, we get that E = (4.1 x 10-15 x 3 x 108 )/(0.06 x 10-9), which equals 20,500 electron-volts. This is the

energy of an X-ray whose wavelength is 0.06 nm, and it is therefore the minimum energy required to create an X-ray with a wavelength of

0.06 nanometers. This energy comes from accelerating electrons through a potential difference. Now, recall that 1 electron- volt is the energy of an electron accelerated through a potential difference of 1 volt. Therefore 20,500 electron-volts requires that an electron be accelerated through a potential difference of 20,500 volts. So this represents the minimum potential difference required to produce an X-ray with a wavelength of 0.06 nanometers, and answer choice C is correct.

**QUESTION 3**

Artificial kidneys have been used for almost 50 years to treat patients with different forms of renal failure. The artificial kidney (dialysis machine) removes unwanted substances from the blood by diffusion. A patient\\'s blood is passed through channels bounded by a porous, semi-permeable membrane that allows the free diffusion in both directions of all plasma constituents except the plasma proteins. Erythrocytes and other cellular components of blood cannot pass through the membrane. The other side of the membrane is exposed to the dialyzing fluid which carries away the unwanted materials. If the concentration of a material in the blood is greater than in the dialyzing fluid, there will be a net flow of the material from the plasma to the dialyzing fluid. If the concentration of a material in the blood is less than in the dialyzing fluid, there will be a net flow of the material from the dialyzing fluid into the blood. The composition of normal plasma, plasma in an individual suffering renal failure, and dialyzing fluid are shown in Table 1.

| Constituent | Normal Plasma (mEq/L) | Plasma w/ renal failure (mEq/L) | Dialyzing Fluid (mEq/L) |
|---|---|---|---|
| $Na^+$ | 142 | 142 | 133 |
| $K^+$ | 5 | 7 | 1.0 |
| $Cl^-$ | 107 | 107 | 105 |
| $HCO_3^-$ | 27 | 14 | 35.7 |
| Urate | 0.3 | 2 | 0 |
| **Constituent** | **Normal Plasma (mg/dl)** | **Plasma w/ renal failure (mg/dl)** | **Dialyzing Fluid (mg/dl)** |
| Glucose | 100 | 100 | 125 |
| Urea | 26 | 200 | 0 |
| Creatinine | 1 | 6 | 0 |

Table 1

Dialysis replaces some functions of the kidneys and attempts to correct the effects of renal failure. For example, patients with renal failure develop acidosis due to a buildup of metabolically produced acids in the circulation. Without dialysis,

the pH of the blood will drop and coma may occur. Dialyzing fluid contains a relatively high concentration of bicarbonate which diffuses into the circulation and neutralizes the acid.

Which of the following provides the best explanation for the urea plasma concentration in individuals with renal failure?

A. Urea filtration decreases

B. Urea absorption decreases

C. Urea filtration increases

D. Urea secretion increases

Correct Answer: A

Reading from Table 1, it is clear that the urea concentration in a patient with renal failure is much higher than that in a normal individual. Filtration of urea decreases, leading to decreased excretion and a higher urea concentration in the

plasma.

Choice B is incorrect because a decrease of absorption from the nephron tubule would tend to increase excretion and decrease the plasma urea concentration.

Choice C is incorrect because increased urea filtration would lead to increased excretion. Choice D is incorrect because increased secretion of urea into the nephron tubule would increase excretion.

**QUESTION 4**

The rich analyses of Fernand Braudel and his fellow Annales historians have made significant contributions to historical theory and research. In a departure from traditional historical approaches, the Annales historians, assume (as do Marxists) that history cannot be limited to a simple recounting of conscious human actions, but must be understood in the context of forces and material conditions that underlie human behavior. Braudel was the first Annales historian to gain widespread support of the idea that history should synthesize data from various social sciences, especially economics, in order to provide a broader view of human societies over time (although Febvre and Bloch, founders of the Annales school, had originated this approach).

Braudel conceived of history as the dynamic interaction of three temporalities. The first of these, the evenementielle, involved short-lived dramatic "events," such as battles, revolutions and the actions of great men, which had preoccupied traditional historians like Carlyle. Conjonctures was Braudel\\'s term for larger cyclical processes that might last up to half a century. The longue duree, a historical wave of great length, was for Braudel the most fascinating of the three temporalities. Here he focused on those aspects of everyday life that might remain relatively unchanged for centuries. What people ate, what they wore, their means and routes of travel -- for Braudel these things create "structures" which define the limits of potential social change for hundreds of years at a time. Braudel\\'s concept of the longue duree extended the perspective of historical space as well as time. Until the Annales school, historians had taken the juridical political unit the nation-state, duchy, or whatever as their starting point. Yet, when such enormous timespans are considered, geographical features may well have more significance for human populations than national borders. In his doctoral thesis, a seminal work on the Mediterranean during the reign of Philip II, Braudel treated the geohistory of the entire region as a "structure" that had exerted myriad influences on human lifeways since the first settlements on the shores of the Mediterranean Sea. And so the reader is given such arcane information as the list of products that came to Spanish shores from North Africa, the seasonal routes followed by Mediterranean sheep and their shepherds, and the cities where the best ship timber could be bought. Braudel has been faulted for the imprecision of his approach. With his Rabelaisian delight in concrete detail, Braudel vastly extended the realm of relevant phenomena; but this very achievement made it difficult to delimit the boundaries of observation, a task necessary to beginning any social investigation. Further, Braudel and other Annales historians minimize the differences among the social sciences. Nevertheless, the many similarly-designed studies aimed at both professional and popular audiences indicate that

Braudel asked significant questions which traditional historians had overlooked.

Which of the following statements would be most likely to follow the last sentence of the passage?

A. Few such studies, however, have been written by trained economists.

B. It is time, perhaps, for a revival of the Carlylean emphasis on personalities.

C. Many historians believe that Braudel\\'s conception of three distinct "temporalities" is an oversimplification.

D. Such diverse works as Gascon\\'s study of Lyon and Barbara Tuchman\\'s A Distant Mirror testify to his relevance.

Correct Answer: D

The author ends the paragraph by affirming the value and influence of Braudel\\'s approach; he cites the number of similarly-designed studies as evidence. The next sentence will most likely refer to these studies in some way and be similarly upbeat about Braudel\\'s work. Choice D fits the bill. Choice A, on the other hand, is wrong because it contradicts the positive tone the last sentence of the passage established. Choice B is incorrect because it does not continue the thought from the last sentence and is inconsistent with the main ideas of the passage as a whole. Choice C is wrong because it too is negative in tone when a positive sentence is appropriate.

**QUESTION 5**

An object rests on a plane, with an angle of incline, , an acceleration due to gravity, g, and a coefficient of friction ?between the object and the plane. Which of the following gives the acceleration of the object?

A. a = g sin ?

B. a = g (sin ? – cos ?)

C. a = g (cos ? – μ sin ?)

D. a = g (sin ? – μ cos ?)

Correct Answer: D

The force of gravity down the plane is given by Fg = mg sin ?.

The frictional force is given by Ff = μ mg cos ?.

Thus, we can set up the overall equation: Fnet = Fg – Ff.

Applying Newton\\'s Second Law, we can rewrite the equation as: ma = Fg – Ff.

Substituting the equations given for Ff and Fg we get: ma = mg sin ? – μ mg cos ?.

Canceling out “m” throughout the equation and factoring out the “g” leaves us with: a = g (sin ? – μ cos ?).

Thus, choice (D) is the right answer.