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QUESTION 1

Every atomic orbital contains plus and minus regions, defined by the value of the quantum mechanical function for electron density. When orbitals from different atoms overlap to form bonds, an equal number of new molecular orbitals results. These are of two types: or bonding orbitals, formed by overlap between orbital regions with the same sign, and antibonding * or * orbitals, formed by overlap between regions with opposite signs. Bonding orbitals have lower energy than their component atomic orbitals, and antibonding orbitals have higher energy. The electron pairs reside in the lower-energy bonding orbitals; the higher-energy, less stable orbitals remain empty when the molecule is in its ground state. A benzene ring has six unhybridized pz orbitals (one from each carbon atom), which together from six molecular orbitals, each one delocalized over the entire ring. Of the possible orbital structures for benzene, the one with the lowest energy has the plus region of all six p orbital functions on one side of the ring. The six electrons occupying the orbitals fill the three most stable molecular orbitals, leaving the other three empty. Molecular orbitals are filled from the lowest to the highest energy level. The number of bonds between atoms is determined by the number of filled bonding orbitals minus the number of filled antibonding orbitals; each antibonding orbital cancels out a filled bonding orbital. For a diatomic molecule, orbitals in the n = 2 energy level are filled as follows:

σ_{2s}, $\sigma^*{}_{2s}$, $\sigma 2p_z$, $\pi 2_{px}$ and $\pi 2_{py}$

$^*{}_{2px}$

p_z

(equal in energy), and * (equal in energy), *2 . (The designation of the three p orbitals as , , and are interchangeable.) Absorption of a photon can raise an electron to a higher-energy molecular orbital. The excited electron does not immediately change its spin, which is opposite to that of the electron with which it was previously paired. This singlet state is relatively unstable: the molecule may interact with another molecule, or fluoresce and return to its ground state. Alternatively, there may be a change in spin direction somewhere in the system; the molecule then enters the so-called triplet state, which generally has lower energy. The molecule now cannot return quickly to its ground state, since the excited electron no longer has a partner of opposite spin with which to pair. It also cannot return to the singlet state, because the singlet has greater energy. Consequently, the triplet state, which has two unpaired electrons in separate orbitals, is long-lived by atomic standards, with a lifetime that may be ten seconds or more. During this period, the molecule is highly reactive.

The quantum number that distinguishes the px orbital from the py orbital is called the:

A. azimuthal quantum number.

B. magnetic quantum number.

C. principal quantum number.

D. spin quantum number.

Correct Answer: B

This is straightforward question relying on your knowledge of quantum numbers. The first quantum number, n, is called the principal quantum number and determines which principal energy level the electron is in, n = 1, n = 2 etc. This does not help specify between the px and py orbital, thus it is not the answer we are looking for. The second quantum number is the azimuthal number designated by l. This determines the subshell s, p, d or f. The azimuthal quantum number can also be referred to as the angular momentum quantum number. Choice A is the azimuthal quantum number, and it does not help us distinguish the px orbital from the py orbital, so we can rule choice A out. The third quantum number, the magnetic quantum number specifies the particular orbitals within a subshell and is given by ml. Each of these orbitals can hold two electrons. There\\'s only one orbital in an s subshell, in a p subshell there are three, in a d subshell there are five, and in an f subshell there are seven. The three p orbitals are known as px, py, and pz. The magnetic quantum number allows you to differentiate between the px and the py orbital, so choice B is the correct answer. The fourth quantum number, known as ms, tells us whether the electron has a plus or minus spin. Each orbital when filled contains two electrons of opposite spins. Thus it is choice B, the magnetic quantum number, ml, that distinguishes the x, y, and z orbitals of the p subshell.

QUESTION 2

Our sense of smell is arguably the most powerful of our five senses, but it also the most elusive. It plays a vital yet mysterious role in our lives. Olfaction is rooted in the same part of the brain that regulates such essential functions as body metabolism, reaction to stress, and appetite. But smell relates to more than physiological function: its sensations are intimately tied to memory, emotion, and sexual desire. Smell seems to lie somewhere beyond the realm of conscious thought, where, intertwined with emotion and experience, it shapes both our conscious and unconscious lives.

The peculiar intimacy of this sense may be related to certain anatomical features. Smell reaches the brain more directly than do sensations of touch, sight, or sound. When we inhale a particular odor, air containing volatile odiferous molecules is warmed and humidified as it flows over specialized bones in the nose called turbinates. As odor molecules land on the olfactory nerves, these nerves fire a message to the brain. Thus olfactory neurons render a direct path between the stimulus provided by the outside environment and the brain, allowing us to rapidly perceive odors ranging from alluring fragrances to noisome fumes.

Certain scents, such as jasmine, are almost universally appealing, while others, like hydrogen sulfide (which emits a stench reminiscent of rotten eggs), are usually considered repellent, but most odors evoke different reactions from person to person, sometimes triggering strong emotional states or resurrecting seemingly forgotten memories. Scientists surmise that the reason why we have highly personal associations with smells is related to the proximity of the olfactory and emotional centers of our brain. Although the precise connection between emotion and olfaction remains a mystery, it is clear that emotion, memory, and smell are all rooted in a part of the brain called the limbic lobe.

Even though we are not always conscious of the presence of odors, and are often unable to either articulate or remember their unique characteristics, our brains always register their existence. In fact, such a large amount of human brain tissue is devoted to smell that scientists surmise the role of this sense must be profound. Moreover, neurobiological research suggests that smell must have an important function because olfactory neurons can regenerate themselves, unlike most other nerve cells. The importance of this sense is further supported by the fact that animals experimentally denied the olfactory sense do not develop full and normal brain function.

The significance of olfaction is much clearer in animals than in human beings. Animal behavior is strongly influenced by pheromones, which are odors that induce psychological or behavioral changes and often provide a means of communicating within a species. These chemical messages, often a complex blend of compounds, are of vital importance to the insect world. Honeybees, for example, organize their societies through odor: the queen bee exudes an odor that both inhibits worker bees from laying eggs and draws drones to her when she is ready to mate. Mammals are also guided by their sense of smell. Through odors emitted by urine and scent glands, many animals maintain their territories, identify one another, signal alarm, and attract mates.

Although our olfactory acuity can\\'t rival that of other animal species, human beings are also guided by smell. Before the advent of sophisticated laboratory techniques, physicians depended on their noses to help diagnose illness. A century ago, it was common medical knowledge that certain bacterial infections carry the musty odor of wine, that typhoid smells like baking bread, and that yellow fever smells like meat. While medical science has moved away from such subjective diagnostic methods, in everyday life we continue to rely on our sense of small, knowingly or not, to guide us.

Which of the following evidence does NOT support the author\\'s statement that smell has an important physiological function?

A. Olfaction and metabolic function are located in the same area of the brain.

B. Animals with impaired olfaction frequently exhibit abnormal brain function.

C. A considerable amount of human brain tissue is devoted to olfaction.

D. Human beings with impaired olfaction are usually able to behave and function normally

Correct Answer: D

This requires one to select the one statement that does not support the author\\'s statement that smell has an important physiological function. The best approach to this type of question is to consider the answer choices in order. Choice (A) suggests that evidence that olfaction and metabolic function are located in the same area of the brain would support the author\\'s contention that smell has an important physiological function. The proximity of olfactory and metabolic centers in the brain is mentioned in the third sentence of the first paragraph -- a fact that does indeed support the author\\'s claim to the important physiological function of smell. So (A) is incorrect. Choice (B) presents the hypothesis that animals with impaired olfaction often exhibit abnormal brain function. The last sentence of the fourth paragraph gives this fact as evidence of the importance of smell, so it\\'s certainly reasonable to apply this to the author\\'s belief that smell plays an important physiological role. Choice (C) says that a considerable amount of human brain tissue is devoted to olfaction. This is true and is mentioned in the second sentence of the fourth paragraph as evidence that the role of smell must be profound. Choice (D) gives the evidence that human beings with impaired olfaction are usually able to behave and function normally. This completely contradicts the author\\'s belief that smell has an important physiological function. If someone with an impaired sense of smell can function perfectly well, that is evidence against the author\\'s theory of the importance of smell. Therefore, choice (D) does not support the author\\'s statement.

QUESTION 3

A police officer carries out hundreds of traffic stops every year. When his supervisor is reviewing the officer\\'s records for the past year, he notices that the officer is equally likely to stop people of various genders, ages, and races. However, he is significantly more likely to write tickets for middle-aged white males with dark hair and eyes. When confronted with this fact, the officer truthfully states that he has no idea why that is, and that it must simply be a coincidence. Unbeknownst to the officer, this behavior is tied to the fact that these men look like his father, with whom he had an abusive relationship as a child. What psychological framework would directly address the unconscious bias in his behavior?

A. Behaviorist

B. Psychoanalytic

C. Cognitive behavioral

D. Humanistic

Correct Answer: B

Freud\\'s psychoanalytic framework deals with the interactions between the conscious and unconscious mind. Through talk therapy, free association, dream analysis, etc. patients are helped to see how their early childhood experiences shape their unconscious mind and how that then affects their adult lives. Thus choice B, psychoanalytic framework, would directly address this unconscious component of the officer\\'s behavior.

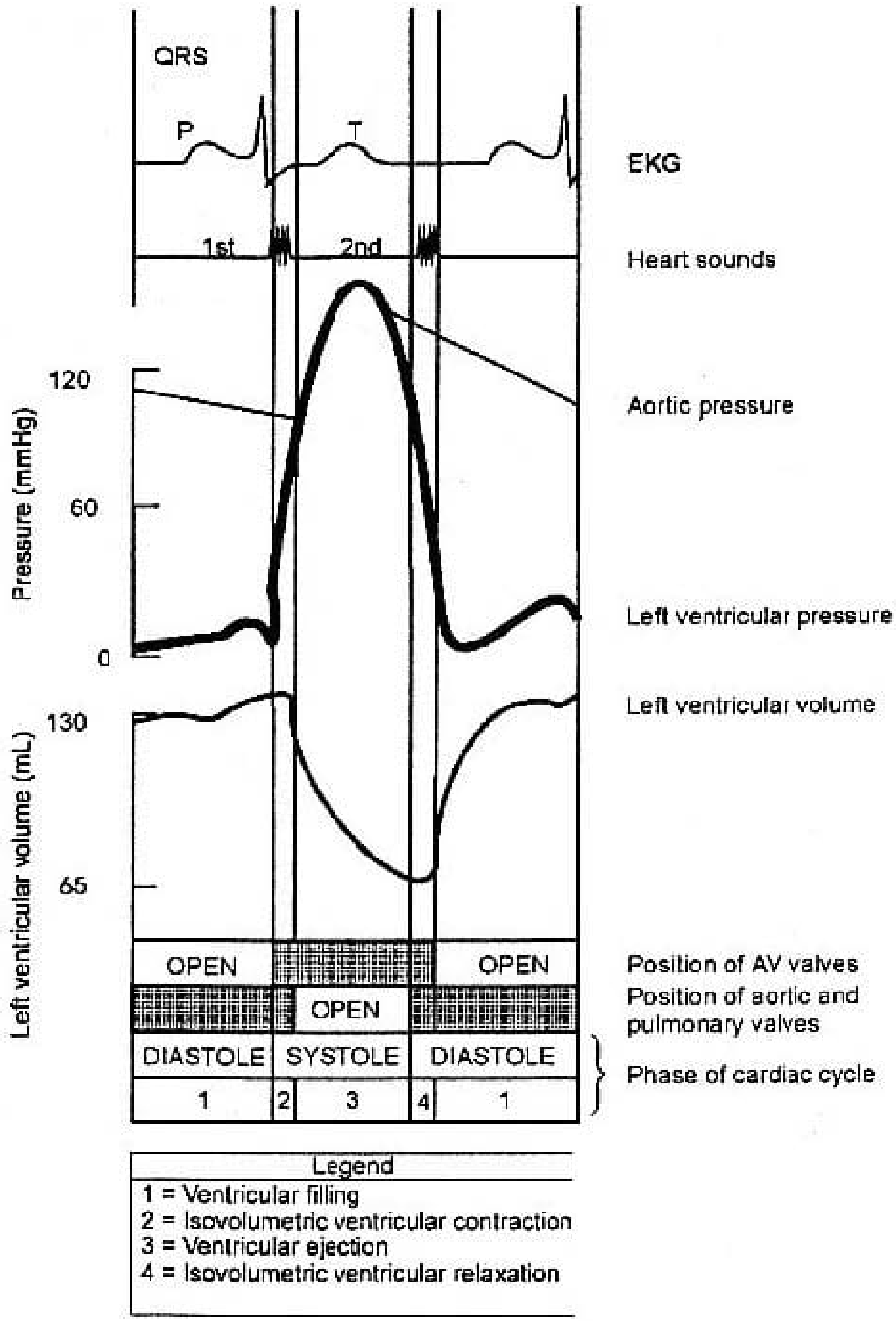
QUESTION 4

The process of depolarization triggers the cardiac cycle. The electronics of the cycle can be monitored by an electrocardiogram (EKG). The cycle is divided into two major phases, both named for events in the ventricle: the period of ventricular contraction and blood ejection, systole, followed by the period of ventricular relaxation and blood filling, diastole.

During the very first part of systole, the ventricles are contracting but all valves in the heart are closed thus no blood can be ejected. Once the rising pressure in the ventricles becomes great enough to open the aortic and pulmonary valves, the ventricular ejection or systole occurs. Blood is forced into the aorta and pulmonary trunk as the contracting ventricular muscle fibers shorten. The volume of blood ejected from a ventricle during systole is termed stroke volume.

During the very first part of diastole, the ventricles begin to relax, and the aortic and pulmonary valves close. No blood is entering or leaving the ventricles since once again all the valves are closed. Once ventricular pressure falls below atrial pressure, the atrioventricular (AV) valves open. Atrial contraction occurs towards the end of diastole, after most of the ventricular filling has taken place. The ventricle receives blood throughout most of diastole, not just when the atrium contracts.

Figure 1: Electronic and pressure changes in the heart and aorta during the cardiac cycle.



The wall of the left ventricle is at least three times as thick as that of the right ventricle. This feature aids circulation by assuring that:

A. blood entering the pulmonary artery is at a much higher pressure than blood entering the aorta.

B. blood entering the aorta is at a much higher pressure than blood entering the pulmonary artery.

C. the left ventricle has a higher blood capacity than the right ventricle at all times.

D. the right ventricle has a higher blood capacity than the left ventricle at all times.

Correct Answer: B

It is commonly known that as a rule, the size of a muscle is proportional to its strength. The heart, which is a muscle, contains a chamber which must pump blood into the aorta to perfuse the grand majority of the body\\'s tissues. Clearly, this chamber (= the left ventricle) must contain thicker muscle (= stronger) than a chamber that pumps blood only to the lungs (= the right ventricle through the pulmonary artery). The stronger chamber pumps blood with a greater force which means a higher pressure (recall from physics: P = F/A).

QUESTION 5

A person suffering from severe dehydration and starvation would NOT be expected to have elevated plasma concentrations for which of the following hormones?

A. Antidiuretic hormone (ADH)

B. Cortisol

C. Aldosterone

D. Insulin

Correct Answer: D

This question asks you to determine the body\\'s physiological response to the extreme conditions of dehydration and starvation. In such cases, the person would be expected to have low blood pressure and low nutrients (i.e. proteins, carbohydrates, and lipids). As a result, the body will respond by producing hormones that increase blood pressure and mobilize stored nutrients (glycogen, fat, etc.). ADH and aldosterone both increase blood pressure so they would be expected to appear in high plasma concentrations in response to the low blood pressure, eliminating choices A and C. Cortisol would be expected in high plasma to increase carbohydrate, protein, and fat availability, making B false. That leaves answer choice D. Insulin lowers blood glucose levels, which is expected to appear in the blood after a sugary meal. In the case of starvation, the body would respond by increasing blood glucose levels via the production of glucagon.