MCAT-TEST Q&As

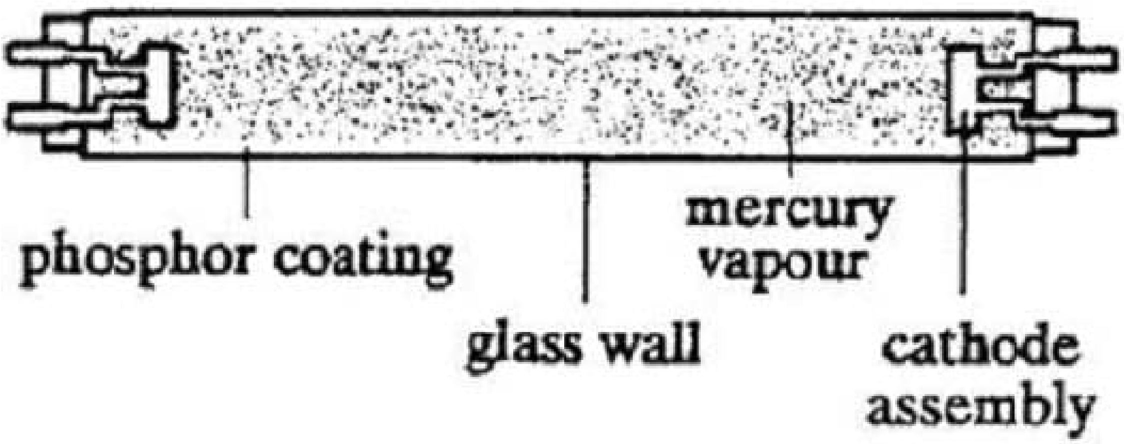
Medical College Admission Test: Verbal Reasoning, Biological Sciences, Physical Sciences, Writing Sample

QUESTION 1

When light in the ultraviolet region of the spectrum is shone on a type of material known as a phosphor, it fluoresces and emits light in the visible region of the spectrum. Lamps that utilize this property, known as fluorescent lamps, are very efficient light sources. The arrangement of a typical fluorescent lamp is shown below. The lamp is a glass tube whose inside walls are covered with a phosphor. The tube has an appreciable length-to-diameter ratio so as to reduce the power losses at each end, and it is filled with argon gas mixed with mercury vapor. Inside each end of the tube are tungsten electrodes covered with an emission material.

Electrons are liberated at the cathode and accelerated by an applied electric field. These free electrons encounter the gas mixture, ionizing some mercury atoms and exciting others. Since it requires more energy to ionize the atoms than to excite the electrons, more excitation than ionization occurs. When the excited electrons revert to their ground state, they radiate ultraviolet photons with a wavelength of 253.7 nm. These photons impinge on the phosphor coating of the tube and excite electrons in the phosphor to higher energy states. The excited electrons in the phosphor return to their ground state in two or more steps, producing radiation in the visible region of the spectrum. Not every fluorescent lamp emits the same color of radiation; the color is dependent on the relative percentages of different heavy metal compounds in the phosphor.

The fluorescent lamp shown operates at 100 volts and draws 400 milliamps of current during normal operation. Of the total power that the lamp consumes, only 25% is converted to light, while the remaining 75% is dissipated as heat. This energy keeps the lamp at its optimum working temperature of 40°C. In the lamp shown, the phosphor coating is calcium metasilicate, which emits orange to yellow light.



The photons emitted by the mercury vapor have energies:

A. equal to the energies of the electric current.

B. equal to the voltage across the tube.

C. equal to the energy differences between electron orbitals in the mercury atom.

D. less than or equal to the energy differences between the electron orbitals of the mercury atom.

Correct Answer: C

Photons are emitted from an atom when its electrons fall from an excited state to a lower energy state. Conservation of energy then tells us that the energy of the emitted photon must be equal to the energy of the excited state minus the energy of the lower state. Choice A is incorrect because the energies of the electric current have nothing to do with this process. Choice B is likewise unrelated to the physical process of an atom emitting a photon. Choice D violates conservation of energy.

QUESTION 2

Maternal lineage can be traced by sequencing the mitochondrial DNA because the mitochondrial genome is derived primarily from the mother. The best explanation for this phenomenon is that:

A. sperm have no mitochondria and thus cannot contribute to the mitochondrial genome of the offspring.

B. the zygote divides rapidly, diffusing the paternal mitochondria amongst many cells.

C. following penetration, the sperm derived mitochondria disintegrate within the egg.

D. all the genes coding for mitochondria are located on the X chromosome.

Correct Answer: C

Upon penetration of the egg, the sperm mitochondria fall apart and are not replicated when divisions begin. This question can best be answered by eliminating the wrong answer choices. Choice A is incorrect because sperm have large numbers of mitochondria used to drive locomotion. Choice B is incorrect because mitochondria are replicated prior to cell division. Also, this choice would not explain the presence of the maternal genome which should also be diffused by division. Choice D is incorrect because many of the genes coding for mitochondrial proteins are located in the mitochondrial DNA.

QUESTION 3

The atomic size of an atom is:

A. greater than the positive ion.

B. smaller than the positive ion.

C. greater than the negative ion.

D. equal to covalent radius.

Correct Answer: B

QUESTION 4

Band theory explains the conductivity of certain solids by stating that the atomic orbitals of the individual atoms in the solid merge to produce a series of atomic orbitals comprising the entire solid. The closely-spaced energy levels of the orbitals form bands. The band corresponding to the outermost occupied subshell of the original atoms is called the valence band. If partially full, as in metals, it serves as a conduction band through which electrons can move freely. If the valence band is full, then electrons must be raised to a higher band for conduction to occur. The greater the band gap between the separate valence and conduction bands, the poorer the material\\'s conductivity. Figure 1 shows the valence and conduction bands of a semiconductor, which is intermediate in conductivity between conductors and insulators.

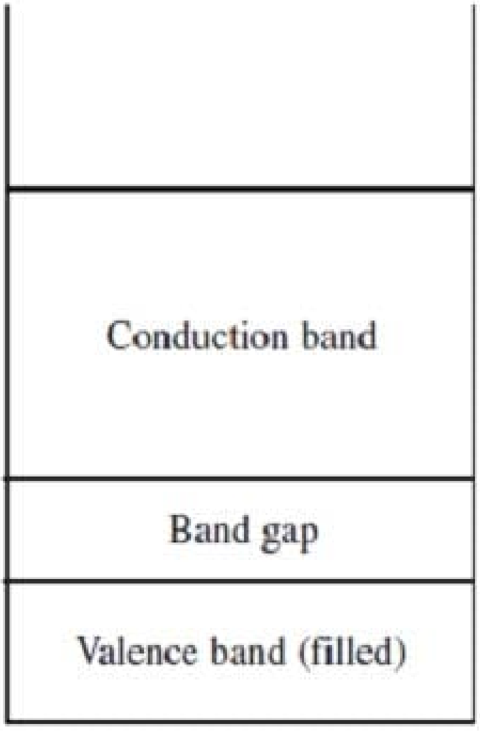


Figure 1

When silicon, a semiconductor with tetrahedral covalent bonds, is heated, a few electrons escape into the conduction band. Doping the silicon with a few phosphorus atoms provides unbonded electrons that escape more easily, increasing conductivity. Doping with boron produces holes in the bonding structure, which may be filled by movement of nearby electrons within the lattice. When a semiconductor in an electric circuit has excess electrons on one side and holes on the other, electron flow occurs more easily from the side with excess electrons to the side with holes than in the reverse direction.

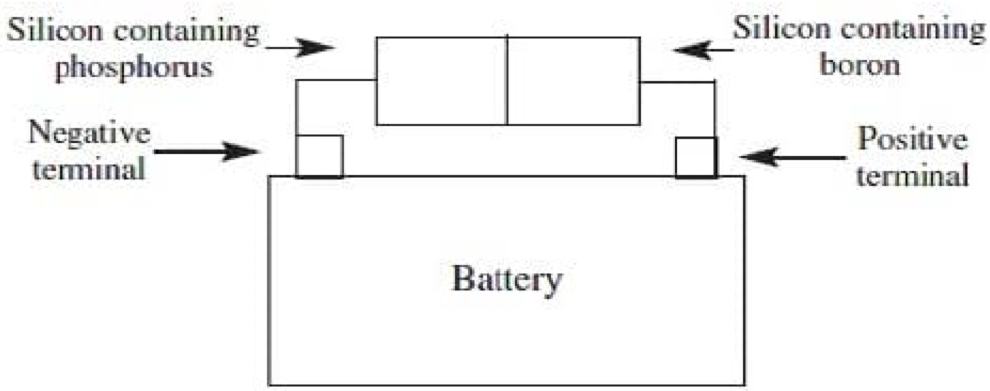


Figure 2 If the semiconductor orientation in Figure 2 were reversed so that the boron-doped silicon was on the left and the phosphorus-doped silicon on the right, what could be said about the electron flow of the new setup?

A. The electron flow is easier in the new direction than in that of Figure 2.

B. The electron flow is the same in either direction.

C. The electron flow is more difficult in the new direction than in that of Figure 2.

D. The electrons cannot flow in the new setup.

Correct Answer: C

The passage provides almost all the necessary information to answer this question. The only piece of background information needed is that electrons flow from the negative terminal to the positive terminal. The passage states that phosphorus-doped silicon has more electrons than pure silicon and that boron-doped silicon has fewer electrons than pure silicon. In addition, it is stated that electrons flow more easily from a side with excess electrons -- the phosphorus-doped silicon -- to a side with fewer electrons -- the boron-doped silicon. So, if the semiconductor orientation were switched, electron flow would not be as easy as the original configuration. Choice C is therefore the correct response.

QUESTION 5

Several models have been developed for relating changes in dissociation constants to changes in the tertiary and quaternary structures of oligomeric proteins. One model suggests that the protein\\'s subunits can exist in either of two distinct conformations, R and T. At equilibrium, there are few R conformation molecules: 10 000 T to 1 R and it is an important feature of the enzyme that this ratio does not change. The substrate is assumed to bind more tightly to the R form than to the T form, which means that binding of the substrate favors the transition from the T conformation to R.

The conformational transitions of the individual subunits are assumed to be tightly linked, so that if one subunit flips from T to R the others must do the same. The binding of the first molecule of substrate thus promotes the binding of the second and if substrate is added continuously, all of the enzyme will be in the R form and act on the substrate. Because the concerted transition of all of the subunits from T to R or back, preserves the overall symmetry of the protein, this model is called the symmetry model. The model further predicts that allosteric activating enzymes make the R conformation even more reactive with the substrate while allosteric inhibitors react with the T conformation so that most of the enzyme is held back in the T shape.

Experiment Evaluating Non-Symmetry Model Enzymes

Experiments were performed with enzyme conformers that did not obey the symmetry model. The data is summarized in Figure 1.

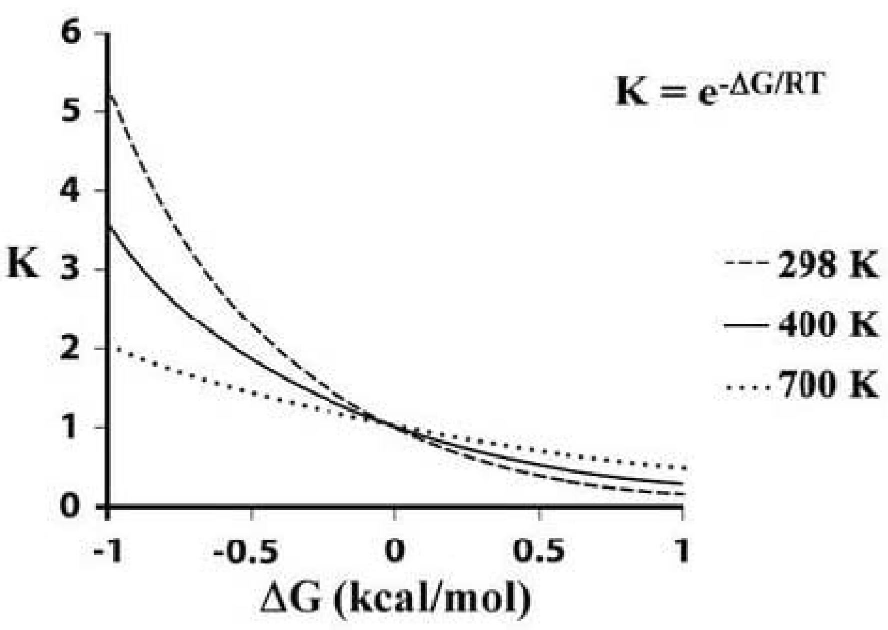


Figure 1: Equilibrium distribution of two conformers at different temperatures given the free energy of their interconversion. (modified from Mr.Holmium). What assumption is made about the T and R conformations and the substrate?

A. In the absence of any substrate, the T conformation predominates.

B. In the absence of any substrate, the R conformation predominates.

C. In the absence of any substrate, the T and R conformations are in equilibrium.

D. In the absence of any substrate, the enzyme exists in another conformation, S.

Correct Answer: A

Explanation: Paragraph 1. Information concerning the relative amounts of T and R conformations present before substrate is added is given in the passage.