MCAT-TEST Q&As

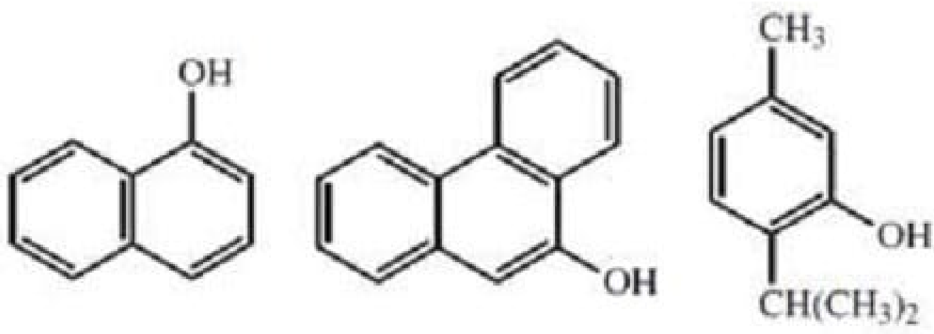
Medical College Admission Test: Verbal Reasoning, Biological Sciences, Physical Sciences, Writing Sample

Pass MCAT MCAT-TEST Exam with 100% Guarantee

Following Questions and Answers are all new published by MCAT Official Exam Center

QUESTION 1

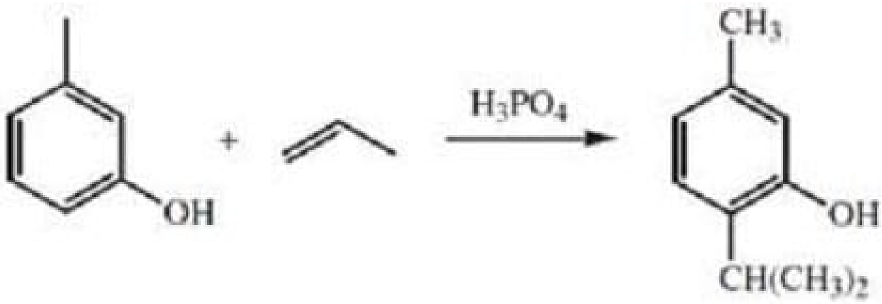
Compounds containing a hydroxyl group attached to a benzene ring are called phenols. Derivatives of phenols, such as naphthols and phenanthrols, have chemical properties similar to those of phenols, as do most of the many naturally-occurring substituted phenols. Like other alcohols, phenols have higher boiling points than hydrocarbons of similar molecular weight. Like carboxylic acids, phenols are more acidic than their alcohol counterparts. Phenols undergo a number of different reactions; both their hydroxyl groups and their benzene rings are highly reactive. A number of chemical tests can be used to distinguish phenols from alcohols and carboxylic acids.



naphthol phenanthrol thymol

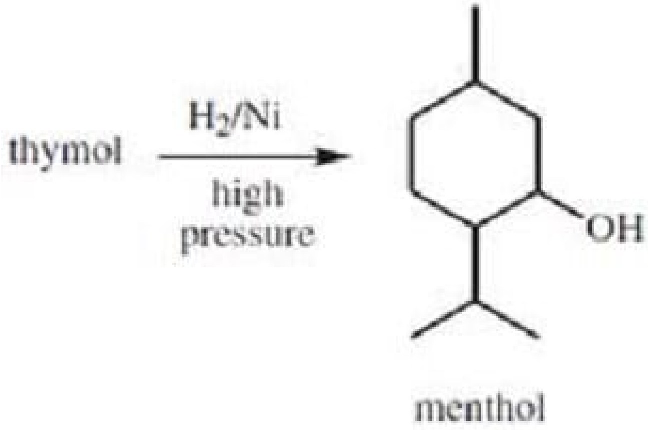
Thymol, a naturally occurring phenol, is an effective disinfectant that is obtained from thyme oil. Thymol can also be synthesized from m-cresol, as shown in Reaction A below. Thymol can then be converted to menthol, another naturally-occurring organic compound; this conversion is shown in Reaction B.

Reaction A

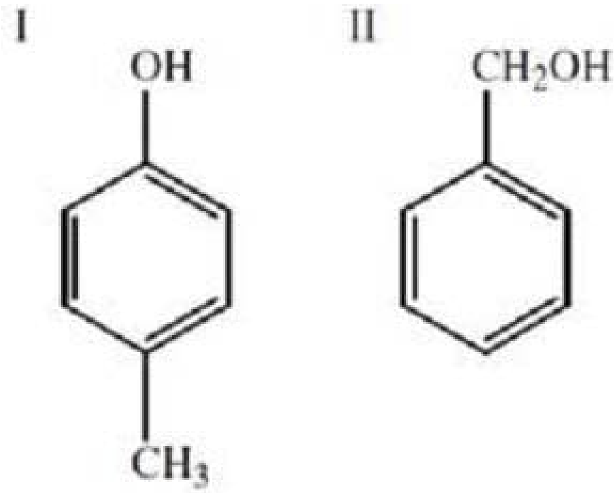


m-cresol thymol

Reaction B



What simple chemical test could be used to distinguish between the following two compounds?



A. Compound II's solubility in $NaHCO_3$
B. Compound I's solubility in NaOH
C. Compound I's ability to decolorize a bromine solution
D. Compound I's solubility in $NaHCO_3$

A. Option A

B. Option B

C. Option C

D. Option D

Correct Answer: B

Compound I is para-cresol or para-methylphenol, and Compound II is benzyl alcohol, which behaves more like an aliphatic alcohol than a phenol. We can take advantage of this fact in order to distinguish between these two compounds. One of the easiest ways to do this is by their solubility behavior, which is also an easy way of separating them out of a mixture. Phenols are appreciably acidic, so they are quite soluble in aqueous sodium hydroxide. Alcohols, including benzyl alcohol, are NOT acidic and won\\'t be soluble in aqueous sodium hydroxide. Now there is one exception; very small alcohols, with fewer than five carbons, are water-soluble, so they would dissolve in ANY aqueous solution. However, benzyl alcohol is too big a molecule to be water-soluble, so it won\\'t be soluble in sodium hydroxide solution. So, the solubility of paracresol, Compound I, in aqueous sodium hydroxide would provide an effective test to distinguish between the two compounds, and thus choice B is the correct answer. Notice that this means you could separate a mixture of these two compounds by dissolving it in an organic solvent, and then extracting the solution in a separatory funnel with aqueous layer. Choice C is wrong, because compound I won\\'t react with a bromine solution and decolorize it. Both compounds will react under stronger conditions, namely, the presence of a Lewis acid, but bromine in solution is too mild a reagent to react with the stable aromatic ring. Therefore, compound I, and compound II for that matter, won\\'t decolorize bromine solution and choice C is incorrect. Choice D is incorrect because neither of the two compounds will be soluble in sodium bicarbonate. Sodium bicarbonate is a weak base, but since phenols are fairly weak acids, it takes a fairly STRONG base to make a phenol give up its acidic proton. Thus, para-cresol won\\'t dissolve in sodium bicarbonate. As we\\'ve said, benzyl alcohol is an even weaker acid than para-cresol, so it certainly won\\'t dissolve in sodium bicarbonate. And since neither compound will be soluble in sodium bicarbonate, sodium bicarbonate can\\'t be used to distinguish between them.

QUESTION 2

The bonding that explains the variation of the boiling point of water from the boiling point of similarly structured molecule is:

A. van der Waals forces.

B. covalent bonding.

C. hydrogen bonding.

D. ionic bonding.

Correct Answer: C

QUESTION 3

Many nutrients required by plants exist in soil as basic cations:

$Mg^{2+}, Mn^{2}, \text{and } Ca^{2}.$

A soil\\'s cation-exchange capacity is a measure of its ability to adsorb these basic cations as well as exchangeable hydrogen and aluminum ions. The cation-exchange capacity of soil is derived from two sources: small clay particles called micelles consisting of alternating layers of alumina and silica crystals, and organic colloids.

$A1^{3+}$

Replacement of + and + by other cations of lower valence creates a net negative charge within the inner layers of the micelles. This is called the soil\\'s permanent charge. For example, replacement of an atom of aluminum by calcium within a section where the net charge was previously zero, as shown below, produces a net charge of ?, to which other cations can become adsorbed.

$\boxed{O^{2-}A1^{3+}OH^{-}} \rightarrow \boxed{O^{2-}CA^{2+}OH^{-}}$

Figure 1

A pH-dependent charge develops when hydrogen dissociates from hydroxyl moieties on the outer surfaces of the clay micelles. This leaves negatively-charged oxygen atoms to which basic cations may adsorb. Likewise, a large pH-

dependent charge develops when hydrogen dissociates from carboxylic acids and phenols in organic matter.

In most clays, permanent charges brought about by substitution account for anywhere from half to nearly all of the total cation-exchange capacity. Soils very high in organic matter contain primarily pH-dependent charges. In a research study,

three samples of soil were leached with a 1 N solution of neutral KCl, and the displaced A13+ and basic cations measured. The sample was then leached again with a buffered solution of BaCl2 and triethanolamine at pH 8.2, and the

displaced H+ measured. Table 1 gives results for three soils tested by this method.

Table 1

	(meq/100 g)				Total Cation Exchange Capacity
	pH	Al^{3+}	Basic Cations	H^+	
Sample I	4.5	11.7	1.9	34.0	47.6
Sample II	5.3	1.6	16.3	19.5	37.4
Sample III	6.0	0.5	9.8	7.8	18.1

Due to the buffering effect of the soil\\'s cation exchange capacity, just measuring the soil solution\\'s pH will not indicate how much base is needed to change the soil pH. In another experiment, measured amounts of acid and base were added to 10-gram samples of well-mixed soil that had been collected from various locations in a field. The volumes of the samples were equalized by adding water. The results were recorded in Figure 2.

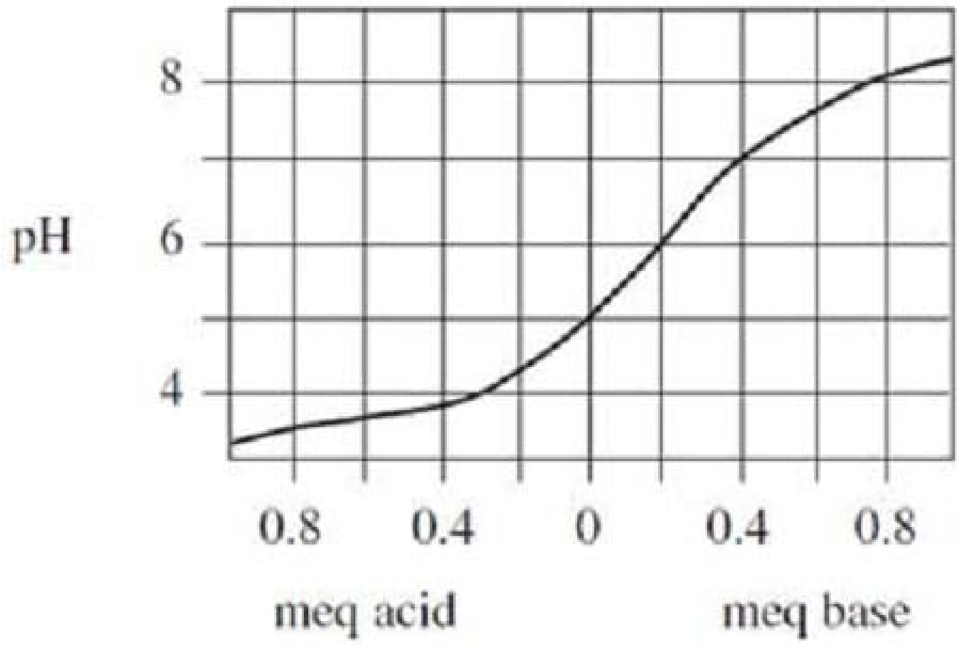


Figure 2.

Solution X boils at 100.26°C and solution Y boils at 101.04°C. Both solutions are at atmospheric pressure and contain the same solute concentration. Which of the following conclusions can be drawn?

A. The freezing point of solution X is lower than that of solution Y.

B. The vapor pressure of solution X is higher than that of solution Y at 100.26°C.

C. C. Solution X and solution Y are immiscible.

D. The vapor pressure of solution X is lower than that of solution Y at 100.26°C.

Correct Answer: B

This question deals with the colligative properties of solutions. It brings up several critical points about solutions. One is that the presence of a solute in a solution ALWAYS raises the boiling point and lowers the freezing point, compared to the boiling and freezing points of the pure solvent. The more concentrated the solution, the higher the boiling point and lower the freezing point will be. Thus it is clear that choice A is incorrect; since Solution Y\\'s boiling point is higher than Solution X\\'s, its freezing point must be lower as well. Since there isn\\'t actually enough information to say that this answer is right or wrong since you don\\'t know the original freezing point or freezing point depression constant for either solution, there must be a better answer. The second important concept is that of vapor pressure, which is the topic of both answers B and D. A solution boils when its vapor pressure is equal to the atmospheric pressure, solution Y must have had a lower vapor pressure to begin with. Choice B is therefore correct, and choice D incorrect. Choice C concerns the solubility of the two solutions in each other. Again, we don\\'t have enough information to say that this answer is correct. After all, we know nothing about the two solvents of solutions X and Y, only that they have the same concentration of solute in them and what the resultant boiling points are.

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.

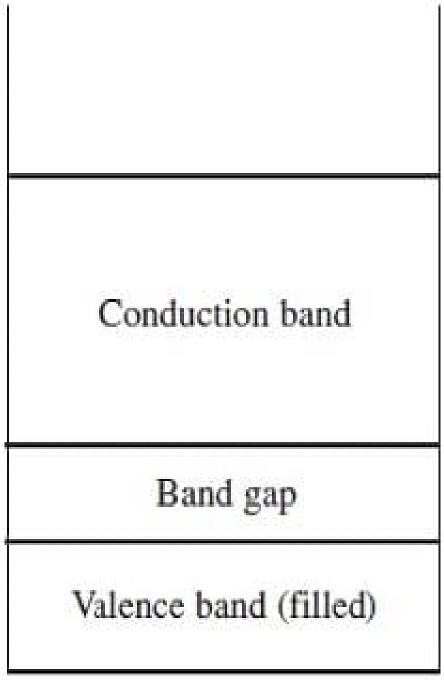


Figure 1

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.

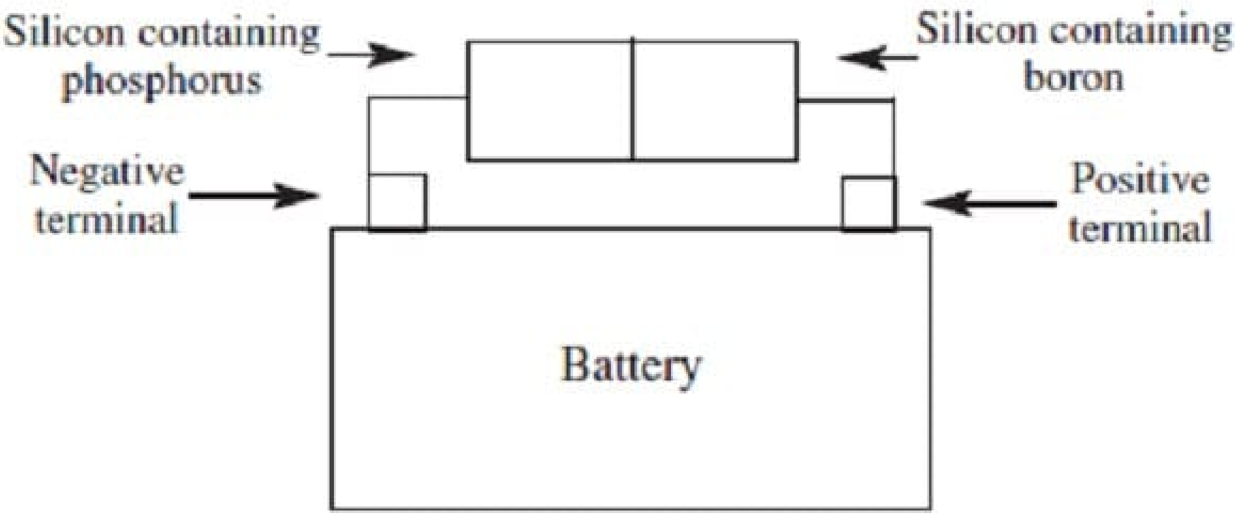


Figure 2

Why is iron a good conductor of electricity?

A. Its 3d electrons only partially fill the valence band.

B. The band gap is small.

C. The 4s and 3d orbitals form a filled valence band.

D. The energy levels of the atomic orbitals are closely separated.

Correct Answer: A

The passage mentions that metals have partially filled valence bands. This means that there are low energy unoccupied atomic orbitals in metals through which electrons may move freely. Therefore, the valence band for metals is the conduction band, and consequently, there is no band gap. Metals such as iron are good conductors of electricity because of these unoccupied low energy orbitals. All of this information is contained in the passage and requires little or no background knowledge. Choice A is therefore the correct response. Choice B is incorrect because metals, unlike semiconductors, do not have a band gap. Choice C is wrong because iron\\'s 3d orbital is not filled; it has only six electrons, not ten. Choice D is true of many solids including metals, semiconductors, and insulators, but it does not answer the question and so is incorrect.

QUESTION 5

A charged particle is placed in an electrical field E. If the charge on the particle is doubled, the force exerted on the particle by the field is:

A. doubled.

B. halved.

C. quadrupled.

D. unchanged.

Correct Answer: A