MCAT Chemistry and Physics 1 Homework

Passage 1 (Questions 1-4)

This passage is a perfect example of how the MCAT will group multiple topics together in a passage. You are being tested over the concepts of gravity, momentum, and kinematics (projectile motion). You should already have the equations for these topics rolling around in their head while reading the passage and answering the questions.

Passage Outline

Paragraph 1: Measuring acceleration due to gravity

Experiment 1: Free fall; measure velocity and change in momentum

Experiment 2: Projectile motion

Question 1: A

In order to answer this question, one must first determine what values g is dependent on. Set $mg = GM_e m_o/r^2$, and cancel out mo on each side to get $g = GM_e/r^2$. Thus, g only depends on the constant G, the mass of the earth, and the distance between the center of masses. **Roman Numeral I** is the only choice that matches our prediction, so our answer is **Choice A**.

Roman Numeral II: As shown above, the mass of the object cancels out, so g is not dependent on it

Roman Numeral III: Throwing the ball horizontally instead of vertically does not change g (it is still the same), so this can be eliminated as well

Question 2: D

According to the conservation of linear momentum, momentum is not lost, just transferred from one object to another. Thus, we can write an equation for the beginning momentum of the ball compared to the end momentum of the ball and what it collides with (the earth). $m_{ball}v_{ball} = m_{ball}v_{ball} + m_{earth}v_{earth}$ thus the change in momentum the ball experiences is due to only the mass of the ball, the velocity of the ball, the mass of the earth, and the velocity of the earth. This eliminates **Choice A**, **Choice B**, and **Choice C**, leaving **Choice D**as the correct answer.

Question 3: C

Since air resistance opposes g, and air resistance is not accounted for, then the students' measurement of g will be LESS than its actual value, since their value of g is really (g - air resistance). **Choice A** and **Choice B** can be eliminated. **Choice D** states that air resistance decreases the time it takes for the ball to fall from the window to the ground, which is the opposite (air resistance increases the amount of time the ball takes to hit the ground). Therefore, **Choice D** can be eliminated. This leaves us with the correct answer of**Choice C**, which states that air resistance decreases velocity.

Question 4: B

First of all, we are dealing with Experiment 2 and projectile motion, so we should only focus on the values given in Experiment 2. We are told in the question stem that we want to find the maximum height *above the window* reached by the plastic ball. This

means we do not need to take into consideration the height of the window, and that V_y is going to be equal to 0, since we are finding the *maximum height* of the ball. We are told in the passage that V_0 is equal to 4 m/s. We are going to have to find the y-component of velocity to plug into the appropriate equation. The y-component is equal to 4(sin30). We are told in the question stem (but you should already know) that sin30 is equal to .5, so 4(.5) = 2 m/s. This means V_{0y} = 2 m/s. We are also told in the question stem that a = 9.8 m/s^2, but we know to estimate a to 10 m/s^2 to solve this problem. What is the kinematics equation we can use that includes Vy, Voy, a, and Δy? $V_y{}^2 = V_{oy}{}^2 + 2a\Delta y$! Plug in the appropriate values, and you end up with $0 = 2^2 + 2(-10)\Delta y$. This simplifies to $20\Delta y = 4$, which simplifies to Δy = .2m, which in terms of centimeters is 20cm. The closest (and correct) answer can be identified as **Choice B**.

(A): Miscalculation- This is half the value of the correct answer

(B): Miscalculation- This is 3/2 the value of the correct answer

(D): Miscalculation- This is triple the value of the correct answer

Passage 2 (Questions 1-8)

This is a prime example of how the MCAT incorporates biological topics into (typically) non-medical topics such as Physics. You are likely to see similar physics passages on the MCAT that tend to lean towards medicine (since you are all aspiring doctors!). Make sure you can blend topics together, and don't compartmentalize information too separately. Chunk specific pieces of information together based upon what topics can be aggregately tested over given the type of information that is presented in the

passage. In simply seeing a picture of an ear in the physical sciences section, the topics of sound, electrical conductance, and pressure should already be floating around in your head.

Passage Outline

Paragraph 1: SOM- infection leads to fluid buildup, can lead to COM; sound travel in the ear

Figure 1: Anatomy of the ear

Paragraph 2: Pressure release, pressure buildup in the ear (can lead to COM); COM prevention

Figure 2: Structure of a grommet

Question 1: B

Since flow rate is constant, one can use the continuity equation for fluids, $A_1v_1 = A_2v_2$. Area and velocity are inversely proportional, so by increasing the cross-sectional area of the hollow portion of the grommet tube, fluid velocity will be reduced. Hence, **choice (B)** is correct.

(A): Velocity would decrease, not increase

(C): Velocity would decrease, not remain the same

(D): You can determine that the velocity would decrease using the continuity equation for fluids

Question 2: B

The equation for decibel level is as follows: $B = 10 * \log(I/I_o)$. In this problem, the ratio of I/I_o is 100. Therefore, $B = 10 * \log(100) = 10 * 2 = 20$ dB, so **choice (B)** is correct.

(A): Miscalculation- This would be the answer if the hearing aid amplified the sound by 10 times

(C): Miscalculation

(D): Miscalculation

Question 3: B

The speed of any wave is dependent on the medium that it is traveling through. When comparing media of different phases, such as liquids and gases, then speed is proportional to the square root of the bulk modulus. Bulk modulus is a measure of compressibility; the less compressible a medium is, the greater the bulk modulus. Liquids are less compressible than gases, so they will have a greater bulk modulus. A greater bulk modulus translates into a greater speed of sound. In this question, the speed of sound through air in the ear canal is compared to the speed of sound through fluid in the cochlea. Since the speed of sound is greater in liquids than in gases as previously determined, the speed of sound will be greater in the cochlea. Hence, **choice (B)** is correct.

(A): Sound waves travel slower in the ear canal

(C): Sound waves travel slower in the ear canal

(D): Sounds waves do travel in the ear canal

Question 4: D

The purpose of the paragraph must encompass all of the information within that paragraph. In this case, the paragraph explains in detail how COM arises as a result of chronic infection. **Choice (D)** matches this idea and thus is correct. **Choice (A)** is wrong because Eustachian tubes were not the focal point of the paragraph, but just an important factor in the development of COM. **Choice (B)** is incorrect because swallowing was only discussed to illustrate how a healthy ear works to better clarify how COM arises. Finally, **choice (C)** is wrong because the paragraph was not about eardrum perforation in general, but specifically about COM.

Question 5: C

Intensity is equal to power divided by area, measured in watts/m^2. Since there is an inverse square relationship between intensity and distance, decreasing the distance by 10 times will increase the intensity by 100 times. Thus, **choice (C)** is correct.

(A): Miscalculation- Intensity increases as one moves closer to the source

(B): Miscalculation

(D): Miscalculation

Question 6: C

The sudden spike in pressure is due to the incompressible property of fluids. When the volume of fluid in the middle ear exceeds the volume available, pressure against the walls of the middle ear will rise since the fluid has nowhere to go. Another way of saying that fluids are incompressible is to say that they have a constant density, or a constant

ratio of mass to volume. **Choice (C)** fits well and is correct. **Choices (A), (B), and (D)** are all reasons why the pressure increase is unavoidable, but they do not adequately explain the primary driving force of the significant pressure increase.

Question 7: D

The fourth paragraph describes one preventative measure that can be taken to reduce the possibility of acquiring COM. **Choice (D)** matches well and is correct. **Choice (A)** is extreme. The passage does not say that aerating the middle ear is guaranteed to cure COM. **Choice (B)** is also wrong because most individuals do not develop COM and also do not take preventative measures. **Choice (C)** is out because the myringotomy followed by insertion of a grommet is presented as a preventative measure, not as a primary means by which to treat COM.

Question 8: C

At an increased altitude, the column of air above the man is decreased. As a consequence, atmospheric pressure is lower than it would be at ground level. The sudden shift in external pressure occurs before the middle ear can equilibrate. Since air will move from a high pressure environment to a low pressure environment, the air will quickly leave the middle ear upon swallowing causing the characteristic "popping" phenomenon. Therefore, **choice (C)** is the correct.

(A): The Eustachian tube opens to relieve pressure, it does not remained closed

(B): The Eustachian tube opens to relieve pressure, it does not remained closed

(D): External pressure is lower at a high altitude and air is rushing out of his middle ear

Passage 3 (Questions 1-7)

This is a typical organic chemistry passage that gives some background information about a particular organic compound, and then describes its synthesis and derivatives. Pay particular attention to paragraphs 3 & 4, as well as the figure. Paragraphs 1 & 2 contain very little for potential question stems relating to overriding organic chemistry topics, so anticipate, at the most, 1 or 2 questions that regard reading comprehension here only.

Passage Outline

Paragraph 1: Styrene uses and odor

Paragraph 2: Health risks of styrene consumption

Paragraph 3: Styrene synthesis

Paragraph 4: Compound E properties

Figure 1: Syntheses and derivatives of styrene

Question 1: D

The compound with the least intermolecular forces will have the lowest melting point. Comparing the structures: compound A participates in hydrogen bonding using its hydroxyl group, compound D has an ester and will exhibit dipole/dipole interactions, compound E has a ketone group and will exhibit dipole/dipole interactions, and compound F has no particularly polar groups and therefore will exhibit dispersion forces.

Since dispersion forces are the weakest of the intermolecular forces, Compound F will have the lowest melting point and so consequently, **choice (D)** is correct.

(A): Compound A exhibits hydrogen bonding with its hydroxyl group, which is a stronger intermolecular force than dispersion forces

(B): Compound D exhibits dipole/dipole interactions with its ester group, , which is a stronger intermolecular force than dispersion forces

(C): Compound E exhibits dipole/dipole interactions with its ketone group, which is a stronger intermolecular force than dispersion forces

Question 2: D

Whenever irradiation occurs (indicated by **hv** in Figure 1), this indicates a radical intermediate. This particular reaction is the free radical bromination of an alkane. In effect, a hydrogen atom attached to the carbon adjacent to the ring is replaced by a bromine atom. Therefore, **choice (D)** is correct.

(A): The intermediate will not contain a carbon atom with free electrons

(B): The intermediate will not contain a carbocation

(C): The intermediate will not contain a cyclic bromonium ion

Question 3: D

At a glance, it is clear that acetic acid is added to compound A (then deprotonated) to form compound D. The key to answering this question is recognizing that H_2SO_4 is acting as an acid catalyst. H_2SO_4 is a strong acid and will readily dissociate providing a protic solution. It is then necessary to determine what is protonated. H^+ will gravitate to

the most electronegative atoms; in this case, oxygen wins out. As for which oxygen, the carbonyl oxygen carries the most electron density, so it will pick up the proton. Hence, **choice (D)** is correct.

(A): Protonation via H_2SO_4 occurs first

(B): Protonation via H_2SO_4 occurs first

(C): Protonation will occur first with acetic acid, since it is more electronegative than the hydroxyl group on Compound A

Question 4: D

The hydroxyl group on compound A is converted to a ketone. Therefore, the question is asking which reagents will NOT oxidize a secondary alcohol to a ketone. The only reagent that cannot do this is Tollen's reagent. Tollen's reagent is only weakly oxidizing and is used to oxidize aldehydes to carboxylic acids. Hence, **choice (D)** is correct.

(A): CrO_3 is a strong oxidizing agent and will convert a secondary alcohol to a ketone

(B): $K_2Cr_2O_7$ is a strong oxidizing agent and will convert a secondary alcohol to a ketone

(C): PCC is a mid-level oxidizing agent and will convert a secondary alcohol to a ketone. When oxidizing a primary alcohol, PCC will convert it to an aldehyde rather than a carboxylic acid as would CrO_3 and $K_2Cr_2O_7$

Question 5: C

The strongest acid will have the highest Ka as it will dissociate the most. Since pKa is inversely related to Ka, the strongest acid will have the lowest pKa. The strongest acid here is H_2SO_4 and the weakest acid is CH_3CH_2OH; CH_3COOH is in the middle.

Because CH_3COOH is a stronger acid than CH_3CH_2OH, it must have a lower pKa; therefore, **choice (C)** is correct.

(A): Acetic acid is a stronger acid than ethanol and has a higher Ka

(B): Sulfuric acid is the strongest acid listed and has the lowest pKa, not acetic acid

(D): Ethanol is the weakest acid listed and has the highest pKa, not sulfuric acid

Question 6: D

The second paragraph examines the health effects of styrene on humans. The author does not suggest that styrene usage should be limited; **choice (C)** is out. The author does not discuss the treatment of those affected by styrene, so **choice (B)** is incorrect. Finally, only a single sentence in the paragraph addresses the difference in reactivity between the two isomers of styrene; this is clearly not the focal point of the second paragraph so **choice (A)** is incorrect. **Choice (D)** accurately describes the main point of the paragraph without being too specific and thus is correct.

Question 7: A

A passage outline should capture the main idea of each paragraph. It should NOT be focused on the details since only a small percentage of the content in each passage is tested. This paragraph describes two ways to synthesize styrene in the lab. Therefore, the map should be some restatement of this idea. **Choice (A)** hits the mark. **Choice (B)** suggests four pathways to styrene synthesis, which is not supported by the passage. Choice **(C)** is incorrect because the smell of the precursors to styrene is only a detail, not the conclusion of the paragraph. **Choice (D)** is way too specific to be useful.

Question 1: A

This is a trick question that is often asked on the MCAT. $W = Fd\cos\Theta$; therefore, the angle between displacement of an object and the applied force needs to be something other than 90 degrees in order for work to be done by or on an object. Since the satellite is experiencing uniform circular motion, force and displacement make an angle of 90 degrees with one another. Therefore, **Choice A** is the only viable answer.

(B): Miscalculation- There is no work done by gravity

(C): Miscalculation- There is no work done by gravity

(D): Miscalculation- There is no work done by gravity

Question 2: A

This question should be triaged, as it takes a good deal of time. We are asked for the amount of time it takes for an incident particle of He to reach the target. Thus, we will have kinematics involved in this problem. We are also given a value of 2 MeV (2 x 10^6 eV) for the energy of the helium ions, 4 amu as the mass of a He ion, and 15cm (.15m) for the distance from the sample. How can we relate energy, distance, mass, and time? Through velocity! $KE = mv^2/2$, and d = velocity x time. Starting with energy, translate units of eV to units of Joules (SI units) through the given conversion of 1 eV = 1.6 x 10^{-19} J. This gives us a total of 3 x 10^{-13} J. In order to find KE, we must also find the mass of the He ions. Use the conversion 1 amu = 1.66 x 10^{-27} kg and the value of 4 amu/He ion, and you come to a total of 6 x 10^{-27} kg (SI units). Plugging in these values to find velocity, you come to 3 x 10^{-13} J = 6 x 10^{-27} kg x $v^2/2$. This simplifies to v = 1 x

10^7. Our next step is to plug this into the equation for time we stated earlier, d = velocity x time. This comes to .15 = (1 x 10^7)x(t), which simplifies to .15/(1 x 10^7) = t. t comes out to 1.5 x 10^{-8}, which matches to **Choice A**.

(B): Miscalculation

(C): Miscalculation

(D): Miscalculation

Question 3: B

The name 6, 6-dicholorohexanal tells us that this is a 6 chained carbon species, with two chlorine groups at carbon #6, and an aldehyde group at carbon #1. **Choice A** can be eliminated because there is no alcohol group in this molecule. **Choice C** can also be eliminated because there is no carboxyl group in this molecule. Now, all that is left to do is to compare **Choice B**, the carbonyl group, with **Choice D**, the chlorine groups. Carbonyl compounds are more reactive than halogenated compounds, so **Choice D** can be eliminated, leaving **Choice B** as the correct answer.

Question 4: C

This is a discrete question that is solely based on graph interpretation. The x-axis exhibits the number of carbons in the alkane chain, and the y-axis exhibits the temperature in degrees Celsius. If one draws a line from the midpoint between 0 and -100 degrees Celsius, one intersects the line of boiling point at $n=3$ carbons, and the line of melting point at $n=7$ carbons. This means that a carbon chain that consists of less than three carbons will be a gas at -50 degrees Celsius, and a carbon chain that consists of more than seven carbons will be a solid at -50 degrees Celsius. Thus,

carbon chains that consist of *n=3* to *n=7* carbons will be in the liquid state at -50

degrees Celsius. The only answer that fits our prediction is **Choice C**.

(A): Ethane will be a gas at -50 degrees Celsius

(B): Octane will be a solid at -50 degrees Celsius

(D): Octane will be a solid at -50 degrees Celsius; urethane is a different functional

group altogether

Question 5: B

There are two opposing forces when an object is in free fall: an object's weight (pointed

down), and air resistance (pointed up). The equation for air resistance is kv^2, so air

resistance increases with velocity. Once a velocity is reached such that $kv^2 = mg$, then

there is no net acceleration, since the force of air resistance is canceling out the force of

gravity. This is called terminal velocity, and matches with **Choice B**.

(A): The object reaches terminal velocity during its free fall

(C): False; air resistance increases with velocity and opposes acceleration due to

gravity

(D): False; air resistance increases with velocity and opposes acceleration due to

gravity

Question 6: C

There are three things to take into account when measuring relative boiling points:

molecular weight, hydrogen bonding, and branching. The higher the molecular weight,

more hydrogen bonding, and less branching a molecule exhibits, the higher the melting

point. Branching will not be a factor in this problem, so we will focus on molecular weight and hydrogen bonding. **Choice A**, water, exhibits hydrogen bonding, but has a low molecular weight. **Choice B**, methane, has both a low molecular weight and does not exhibit hydrogen bonding. **Choice C**, acetic acid, exhibits hydrogen bonding and has a higher molecular weight than water. **Choice D**, acetone, has a high molecular weight, but it is lower than acetic acid and it does not exhibit hydrogen bonding. Thus, **Choice C**, acetic acid, is correct.