

MCAT^{*}

Practice Test 1

Explanations

KAPLAN



**TEST PREP AND
ADMISSIONS**

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1 H 1.0																	2 He 4.0
3 Li 6.9	4 Be 9.0											5 B 10.8	6 C 12.0	7 N 14.0	8 O 16.0	9 F 19.0	10 Ne 20.2
11 Na 23.0	12 Mg 24.3											13 Al 27.0	14 Si 28.1	15 P 31.0	16 S 32.1	17 Cl 35.5	18 Ar 39.9
19 K 39.1	20 Ca 40.1	21 Sc 45.0	22 Ti 47.9	23 V 50.9	24 Cr 52.0	25 Mn 54.9	26 Fe 55.8	27 Co 58.9	28 Ni 58.7	29 Cu 63.5	30 Zn 65.4	31 Ga 69.7	32 Ge 72.6	33 As 74.9	34 Se 79.0	35 Br 79.9	36 Kr 83.8
37 Rb 85.5	38 Sr 87.6	39 Y 88.9	40 Zr 91.2	41 Nb 92.9	42 Mo 95.9	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La *	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.0	89 Ac †	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (264)	108 Hs (269)	109 Mt (268)	110 Ds (269)	111 Rg (272)	112 Uub (277)	113 Uut (284)	114 Uug (289)	115 Uup (288)	116 Uuh (292)	117 Uus (291)	118 Uuo (293)

* 58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
† 90 Th 232.0	91 Pa (231)	92 U 238.0	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)

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PHYSICAL SCIENCES EXPLANATIONS

Passage I (Questions 1–5)

1. (A)

By definition, oxidation occurs at the anode and reduction occurs at the cathode. Therefore, the question boils down to whether the cadmium solid is being oxidized or reduced in the reaction. A substance that is being oxidized loses electrons, and a substance that is being reduced gains electrons. Looking at the two half-reactions, Reactions 1 and 2, cadmium has gone from a zero oxidation state to a +2 oxidation state in Reaction 1. Cadmium has lost two electrons and so has been oxidized. Since cadmium is being oxidized during discharge it serves as the anode, which is choice (A). Choice (B) is wrong by definition, and choice (C) is wrong because the passage stated that the electrolyte was KOH. Choice (D) must be wrong because the cadmium only loses electrons in the reaction. For it to be both the anode and the cathode, it would have to gain them, too. The key to this question really is remembering four things: oxidation is the loss of electrons; reduction is the gain of electrons; oxidation occurs at the anode; and reduction occurs at the cathode.

2. (A)

The voltage of an electrochemical cell is equal to potential of the cathode minus that of the anode when the two half-reactions are written as *reductions*. So, that requires you to know which serves as the cathode and which serves as the anode, as has already been done for you. Looking at Table 1, the cathode reaction is the second one from the top, with a value of +0.49. The anode reaction is the second one from the bottom, with a value of –0.81. Subtracting –0.81 from 0.49 gives an expected voltage reading of 1.30 volts, which is choice (A). In the battery industry, this is called the open circuit voltage. If a NiCad battery did not have this voltage, a manufacturer would recognize that the battery is defective and would discard it.

3. (C)

The explanation to question 1 discussed how to identify the oxidized and reduced species. The oxidized material is the one that has lost electrons and the reduced

material is the one that has gained electrons. Electrons appear to the right of the reaction in Reaction 1, which means electrons are lost from cadmium. That eliminates choice (D). Electrons appear on the left of the reaction in Reaction 2, which means that electrons are gained by the nickel dioxide. That means that nickel dioxide, choice (C), is reduced. You could eliminate choices (A) and (B) immediately because nickel hydroxide and cadmium hydroxide are the products of the half-reactions in a nickel cadmium battery. As products, they are neither oxidized nor reduced; they are formed.

4. (C)

Remember, oxidizing agents get reduced and gain electrons, and reducing agents get oxidized and lose electrons. This question requires you to find the answer choice representing the strongest oxidizing agent. So, consult Table 1 to see which answer choice has the largest reduction potential. In doing this, you can see that nickel dioxide, choice (C), with a reduction potential of 0.49 volts, is the only one that has a positive potential. So, choice (C) is the correct response.

5. (B)

A positive cell potential indicates that the reaction, as written, will proceed spontaneously and have a negative change in free energy. $\Delta G = -nFE$. This is something you should commit to memory. This equation shows that if a reaction is spontaneous, it must have a negative ΔG ; in other words, the cell potential must be positive. So, choice (B), “spontaneous, and ΔG for the reaction is negative,” is the correct response. Choice (A) is wrong because a spontaneous reaction has a negative change in free energy. Choice (C) is wrong because thermodynamics can only predict whether or not a reaction will occur—it cannot predict how fast it will occur. Remember, thermodynamics predicts the possibility of a reaction, and kinetics predicts how fast it will occur. Choice (D) is wrong because a nonspontaneous reaction has a positive ΔG .

Passage II (Questions 6–11)

Passage II describes how an absorption spectrum is taken for a sample using a spectrophotometer. While reading this passage, try to follow the light path through the block diagram in Figure 1. Hint: don't wait until after you have read the whole passage to look at the figures;

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look at the figures as they are referred to in the passage. The second figure shows the output data of the detectors and how they are combined. Figure 2a shows the output from the first detector, Figure 2b shows the output from the second detector, and Figure 2c shows the difference spectrum.

6. (B)

To answer this question, do a little reasoning. The question stem states that when an electron makes a transition from an excited state to the ground state, more than one frequency of light may be emitted. If multiple frequencies of light are being emitted, then multiple photons are being emitted. The energy of each photon is proportional to the frequency of the light. And when an electron makes a transition from a higher energy level to a lower energy level, a photon of energy equal to the energy difference between the levels will either be emitted or absorbed.

So, for each photon emitted, the electron must “jump down” to a lower excited state until it reaches the ground state. Looking briefly over the answer choices, note that choice (B) states that an electron can drop to a lower excited state before it drops to the ground state. The electron can go directly to the ground state, in which case a single photon is emitted. If, however, the electron first drops to a lower excited state, and then from the lower excited state jumps to the ground state, then two photons corresponding to lower energy differences and lower frequencies will be emitted. So, choice (B) is most likely the correct answer. If this were the actual MCAT, you should have skipped down to the next question and only come back to this question if you had time when you got to the end of the Physical Sciences section. However, for the sake of completeness below we will review the other answer choices.

Choice (A) states that the additional frequencies are due to proton transitions. The question stem explicitly states that we are dealing with an electron transition. The protons in the nucleus are not involved in the electron transitions. The electron cannot give any of its energy to a proton. So choice (A) is incorrect. Choice (C) states that the number of frequencies of light emitted is proportional to the mass of the atom. This is false. From our previous reasoning, the number of frequencies of light depends upon the number of different kinds of jumps the electron can make in returning to the ground state. So choice (C) is wrong.

Choice (D) states that an emitted photon may decay into two photons of lower energy. Well, photons don't spontaneously decay into two lower energy photons. There has to be an interaction with matter for a photon to change in energy. This answer choice is claiming that a photon decays on its own after it has been emitted as a result of an electron transition. This doesn't happen. So, choice (D) is also incorrect. Therefore, choice (B) is in fact the correct answer.

7. (C)

The question requires you to identify the factors that influence the depth of the absorption drops. First, you should address the source of these drops. The drops occur when the light from the monochromator is at just the right frequency to excite an electron in the sample atom or molecule to a higher state. In exciting the electron, a photon is absorbed, leaving the intensity of light entering detector 1 lower than the intensity was before going through the sample. The passage states that the detector's response is directly proportional to the intensity of light. The intensity of light is proportional to the number of incoming photons. Since there are fewer photon incidents on the detector as a result of absorption, the signal out of the detector is lower. This drop in the intensity of light reaching detector 1 is defined in the second paragraph of the passage to be an absorption drop. The more photons that are absorbed, the fewer photons will reach the detector, and the greater will be the absorption drop.

Statement I states that the amount of the absorbing species in the sample will influence the depth of the absorption drops. As the number of absorbing species increases, the number of sites available for absorption increases. Therefore, the incoming photons will have a greater probability of being absorbed. More photons absorbed means fewer photons transmitted to the detector. And when there is a smaller number of photons reaching the detector, there is a smaller output signal and a deeper absorption drop. Therefore, statement I is correct, and answer choice (B), which says II only, can be discarded.

Statement II suggests that the number of grooves per millimeter in the monochromator grating will influence the depth of the absorption drop. The monochromator is only used to isolate a particular wavelength. Absorption drops are caused by the sample absorbing photons. Changing the number of grooves per millimeter on the

grating doesn't affect how the sample will react with the incoming light, so this statement cannot be true. Since statement II is false, we can eliminate choice **(D)**, which includes that statement, and this provides more evidence that choice **(B)** is wrong.

Statement III suggests that one could influence the depth of the absorption drops by increasing the distance that light travels through the sample cell. Increasing the distance that light travels through the sample cell effectively increases the number of potential sites that a photon could encounter. As you increase the length of the sample cell in Figure 1, the photon would pass through a greater distance. Therefore, it would spend more time in the sample and would encounter a larger number of absorbing molecules or atoms. This increases the likelihood that the photon will be absorbed, which increases the depth of the absorption drop. So, statement III is also correct. Therefore, the correct answer is choice **(C)**, I and III only.

8. (C)

This question involves both the application of information from the passage and a calculation. We are asked to find the maximum kinetic energy of the electrons emitted by the detector. The passage states that the detectors use the photoelectric effect in converting incident photons into an electronic signal. In the note at the end of the passage, we are given a formula involving the photoelectric electrons, and, the question stem gives the frequency of the incident photons and the work function of the surface of the detector. The formula in the note relates what we are given with what we are asked to find. In the formula, the maximum kinetic energy of the electrons is equal to $hf - \phi$. We are given that h is equal to 4.1×10^{-15} electron-volt-seconds in the note. So the maximum kinetic energy is equal to 4.1×10^{-15} times the frequency of the photons minus the work function of the surface of the detector. This gives 4.1×10^{-15} times 10^{15} minus 3 eV, which is equal to 1.1 eV. So, the maximum kinetic energy of the photoelectric electrons is equal to 1.1 eV, which is answer choice **(C)**.

9. (B)

This question requires the use of your reasoning skills along with the information in the passage. The question stem asks why a monochromator is needed in the spectrophotometer system. Choice **(A)** states that we need the monochromator to focus the radiation into a

beam. The passage states that the iris diaphragm is used to form the light into a beam. So, choice **(A)** must be incorrect. Choice **(B)** states that the monochromator is used to correlate the wavelength of light with the amount of absorption. The monochromator is used to isolate a single wavelength of light each time we run the experiment. So, each time only one wavelength of light goes through the sample and hits the detector. This enables us to relate the intensity of light hitting the detector to the wavelength of light being absorbed, and thus correlate the amount of absorption with the wavelength of the light. This suggests that choice **(B)** is the correct answer.

Choice **(C)** states that the monochromator is used to split the beam of radiation into two beams. The passage states that this is the function of the beam splitter. So, choice **(C)** must be incorrect. Choice **(D)** states that the monochromator is used to distinguish the absorption from background noise. The monochromator would not eliminate any background noise. It just isolates a single wavelength. The noise would have to be eliminated at the detector stage of the experiment. In fact, the noise is eliminated by subtracting the signal out of detector 2 from the signal out of detector 1. So, choice **(D)** is also incorrect.

10. (D)

This question asks you to identify the reason that a difference spectra is taken. A difference spectra is represented in Figure 2c, and it is the data coming from detector 2 subtracted from the data coming from detector 1.

The light incident on the second detector comes directly from the monochromator; it does not go through anything else. Looking at Figure 2b, which is the output of detector 2, notice there are variations in intensity. These variations are caused by noise inherent in the light source and monochromator. Besides affecting the output signal produced by detector 2, this noise will also pass through the sample and be detected by detector 1. So, there is one output that is just noise and another output that is noise *plus* relevant data. Subtracting the output which is just noise from the output (which is noise plus data) gives an output of just relevant data.

Let's look at the answer choices. Answer choice **(A)** suggests that it ensures the light source irradiates both detectors with the same intensity. If both detectors

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measured the same intensity, you would get the same signal coming out of each detector. The point of taking a difference spectrum is that due to the absorption there will be a difference in intensity. Besides, subtracting the detector 2 data from the detector 1 data has nothing to do with how the light source irradiates the detectors. So, answer choice **(A)** is incorrect.

Choice **(B)** suggests that we take a difference spectrum to get a smooth flat baseline. That is an attractive answer choice, because from Figure 2c you can see that the overall baseline is flatter and smoother than either Figure 2a or 2b. So, when you take a difference spectrum you do get a flatter, smoother baseline. That's not the point, though—it's to extract pure signal from our output, which contains both noise and signal.

Choice **(C)** suggests that one could use a difference spectrum to remove absorption drops from any contamination from other substances in your sample. This doesn't make any sense. The data we collect from detector 2 just contains the output from the monochromator. How could one use this to remove absorption drops from other substances? So choice **(C)** turns out to be incorrect.

Choice **(D)** suggests that the reason we take a difference spectrum is to distinguish the absorption from the background noise. This is correct, and since none of the other answer choices are better, answer choice **(D)** is the correct answer.

11. (A)

You must determine which energy level configuration would correspond to the spectrum presented in Figure 2c. Immediately eliminate answer choices if you are familiar with the general characteristics of energy level diagrams. In energy level diagrams the spacing between adjacent lines gets progressively smaller as the energy increases. This eliminates choices **(B)** and **(D)**. So, right from the start you have increased your chances of getting the correct answer by 50%. Notice that in Figure 2c, there are three different absorption drops, and we know the wavelength at which the absorption drops occur.

Remember the formula $E = hf$, where E is the energy, h is Planck's constant and f is frequency. Try to get this formula in terms of wavelength. We can use the equation $c = f\lambda$, where c is the speed of light, f is again

the frequency, and λ is the wavelength, to find that $f = c/\lambda$. So, substituting into the equation $E = hf$, one finds that $E = hc/\lambda$. Notice that we are given the product of hc in the parenthetical note at the end of the question, and we know the individual wavelengths from Figure 2c.

If you plug the individual wavelengths into the formulayou would see the difference in energy between two energy levels. In fact, this is the difference between the ground state and higher energy level because the majority of the atoms are in the ground state at any one time. So, in general, any transitions that occur will occur from the ground state.

There are three absorption drops. These correspond to three energy transitions from the ground state. We expect three energy levels above the ground state to be represented in the diagrams. On that basis alone, we can eliminate answer choice **(D)** because it shows only two energy levels above the ground state. Now to calculate the answer:

As an example, use the absorption drop corresponding to a wavelength of 590 nanometers. Since the prefix "nano" means multiply by 10^{-9} , 590 nanometers is equal to 590×10^{-9} or 5.9×10^{-7} meters. Plugging into the formula $E = hc/\lambda$, $E = 1.24 \times 10^{-6}$ over 5.9×10^{-7} . If we round the 5.9 in the denominator up to 6, then we find that $E = 0.2 \times 10$, or 2 electron-volts. It is not exactly 2—it is probably a little more due to rounding up the denominator, but this is a decent approximation. The 2 electron-volts corresponds to the energy difference between the ground state and a higher energy level. Notice that choice **(C)** doesn't have an energy level at 2 electron-volts higher than the ground state. Therefore, this cannot be the correct answer. As we have eliminated choices **(C)** and **(D)**, we must choose between **(A)** and **(B)**.

Next, calculate the transition corresponding to a wavelength of 330 nanometers. Again, 330 nanometers equals 3.3×10^{-7} meters. Plugging this value into the formula $E = hc/\lambda$, the energy difference is 1.24×10^{-6} over 3.3×10^{-7} . Round 3.3 to 3 to make the math easier. So, we find that E is roughly 4 electron-volts. Since we rounded the denominator down, we expect the answer to be slightly less than this. So, for this transition we would expect a line at slightly less than 4 electron-volts. So, the correct answer must be choice **(A)**.

To double check, look quickly at the last absorption peak to see if it too fits into the model presented by answer choice **(A)**. The wavelength is 285 nanometers. Notice that this is smaller than our previous wavelength of 330 nanometers. In our energy formula, wavelength is in the denominator. Decreasing the wavelength from 330 nanometers to 285 nanometers, we expect the energy level transition from 285 nanometers will require more energy than the energy level transition from 330 nanometers. We should see an energy level a bit higher than the energy level corresponding to the 330 nanometers. Well, in answer choice **(A)** we do see an energy level at slightly higher than 4 electron-volts—that must be the energy level corresponding to the 285 nanometer absorption drop. In fact, when you go through the calculation you would find that the line corresponds to 4.4 electron-volts. Again, answer choice **(A)** is correct.

Discrete Questions

12. (B)

This question tests Le Châtelier's Principle. As applied to temperature, this principle says that raising the temperature in a reversible reaction will shift the equilibrium in whichever direction results in the absorption of heat. Choices **(A)** and **(D)**, which show negative enthalpy values and are, therefore, exothermic, can be immediately rejected, because raising the temperature will favor the reverse reactions, which are endothermic. Choices **(B)** and **(C)**, which are endothermic reactions, are strongly favored by high temperatures. To select between these two choices, you need to know which reaction is likely to be enhanced by an increase in pressure. Le Chatelier's Principle says that in reversible reactions, raising the pressure shifts the equilibrium so as to decrease the number of moles produced, and vice versa. Note that in all the forward reactions given, including those in choices **(B)** and **(C)**, the number of moles of products is half the number of moles of reactants, so upon the face of it, all the forward reactions seem likely to be enhanced by increased pressure. However, it is important to remember that pressure changes don't affect the liquid and solid phases, so for the reaction to be enhanced by pressure it must proceed in the gaseous phase. This is true for choice **(B)** and not for choice **(C)**, and so the reaction in choice **(B)** is the only one that is enhanced by both high temperature and pressure.

13. (B)

This question provides the length, resistance, and current, and we are asked to find the power dissipated in an electrical line. We are given extraneous information—we do not need to know the length of the line. This sometimes happens on the MCAT, so don't worry if you don't need all the information given to answer the question. The equation that relates these parameters is a familiar one: $P = i^2R$, where P is the power dissipated, i is the current, and R is the resistance. We are given values for all these quantities in the question stem. Now we can go ahead and substitute into our equation, and we get that $P = 10^2 \times 0.25$, or $P = 25$ watts. Thus answer choice **(B)** is correct.

14. (D)

This question stresses the differences between ideal and nonideal gases. An ideal gas is a hypothetical gas whose molecules have no intermolecular forces and take up no space. Generally speaking, at high temperature and low pressure, all gases exhibit physical properties close to those of an ideal gas. For example, at constant temperature the pressure and volume of a real gas are essentially inversely proportional, in accordance with Boyle's Law. However, at pressures significantly higher than the normal atmospheric pressure, and at temperatures significantly lower than standard conditions, gases tend to show sizable deviations from this ideal behavior. When the pressure of a gas becomes 100 times greater than the normal atmospheric pressure, as in this question, the inverse proportionality between pressure and volume given by Boyle's law is no longer maintained, and, therefore, the volume changes will not show as clear an inverse relationship between the pressure and volume changes, as that given by choice **(A)**. Choice **(C)** can also be eliminated, since the reason for rejecting choice **(A)** is the deviation from Boyle's Law. Choice **(B)** is also wrong, as, at this high pressure, the molecules are close enough together that the volume taken up by individual molecules has to be taken into account. Choice **(D)** is correct; since higher pressure brings the molecules closer to each other, they become subject to stronger intermolecular Van Der Waals forces.

15. (A)

This question requires you to interpret information given in the table, and apply it to determine which of the three statements are true. The table provides the density,

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Young's modulus, and the ultimate strength for three different materials: aluminum, glass, and bone.

Statement I suggests that a greater force is required to rupture an aluminum rod than a glass rod. What determines the breaking point of a material? The answer is the ultimate strength. From the table we find that aluminum has an ultimate strength of 110×10^6 newtons per meter squared, and that glass has an ultimate strength of 50×10^6 newtons per meter squared. Since aluminum has a greater ultimate strength, it requires a larger force to rupture it. Thus statement I is true. So, eliminate answer choice **(C)**.

Statement II suggests that a unit mass of bone would occupy a greater volume than a unit mass of glass. The table gives the densities of both bone and glass. Recall that density is equal to mass over volume. So rearranging: volume equals mass over density. If the mass term remains constant, then volume is inversely proportional to the density. According to the table, glass has a greater density than bone, which implies that a unit mass of glass will occupy less volume than a unit mass of bone. This is what statement II suggests, and so this statement is true also. So, eliminate answer choice **(B)**, leaving answer choices **(A)** and **(D)**.

Statement III suggests that when both bone and aluminum are subjected to equal stresses, bone will experience a greater strain. To determine whether this statement is true or not, recall Young's modulus, which is given in the question stem. Young's modulus is equal to stress over strain. Rearranging this equation, strain equals the stress over Young's modulus. Since both materials are subjected to the same stress, strain is inversely proportional to Young's modulus. Therefore the material that has the lower Young's modulus will experience the greater strain, and in this case it is aluminum. This implies that aluminum will experience a greater strain than bone for the same stress, and so statement III is not true. Thus the correct answer to this question is choice **(A)**.

16. (D)

The normality of a solution is the number of equivalents of solute per liter. Since hydrogen chloride releases one equivalent of protons per mole—that is, one mole of HCl can release one mole of protons—the normality of an HCl solution is equal to its molarity. So you need

information which, together with the solution's density, could be used to derive its molarity.

The molarity of a solution is the number of moles of solute per liter of solution. The only information provided is the density of the solution in grams per liter. Choice **(A)**, the mass of the added HCl, is not adequate for calculating molarity because the original volume of solvent to which this has been added is not given; therefore, you can't determine what proportion of the given density is attributable to the HCl and what proportion to the solute. Choice **(B)**, the volume of the solution, is also insufficient. From the density, one could determine the mass of the solution, but not how much of the mass could be attributed to the solute or solvent. Choice **(C)**, the equivalent weight of the dissolved HCl, would be adequate if the volume of the solution was given. That leaves choice **(D)** as the only possible correct answer.

The percent composition of the solution by mass indicates how many grams of HCl are present in a certain number of grams of solution. Using the density of the solution in grams per liter, you can determine the molarity. If a solution is 36% HCl by mass, it has 36 grams of HCl in every 100 grams of solution. Divide this by 36 grams of HCl per mole to get 1 mole of HCl per 100 grams of solution. Then we multiply this figure by the density of the solution grams per liter. Suppose this solution has a density of 1,060 grams per liter. Multiplying gives the number of moles of HCl per liter; in this case 10.6 moles per liter. This is the molarity of the solution, which is the same as the normality. So, choice **(D)** is correct.

Passage III (Questions 17–23)

17. (A)

The question asks which of the telescopes described would complete an observation of a star 800 kiloparsecs away in the least amount of time. What determines how long an observation will take? Notice the last sentence of the second paragraph. It says that the greater the light-gathering power, the faster the telescope will collect the minimum number of photons necessary to make an observation. There was another clue given in the question stem.

You are looking for a star that is very distant. A distant star will be a faint point source (from the third paragraph), and for faint point sources, only light-gathering power is important. Thus we want the telescope with the greatest light-gathering power. The passage states that light-gathering power is proportional to the square of the diameter of the objective. Therefore, the telescope with the greatest diameter will have the greatest light-gathering power. From the table, telescope A is the largest, with a diameter of 5 meters. Thus, it has the greatest light-gathering power and would complete the observation in the shortest time. Therefore, answer choice **(A)** is correct.

Please take a moment to understand why observing time is proportional to light-gathering power. Light-gathering power is proportional to the diameter squared. The diameter squared is effectively the collecting area of the telescope. A larger diameter telescope will have a larger collecting area and so more photons will be collected per unit time. So the largest diameter telescope, which in our table is telescope A, will make the fastest observation.

18. (C)

This is a relatively straightforward calculation problem. You must identify the light-gathering power of telescope A as compared to the light-gathering power of the human eye. The passage states that the light-gathering power is proportional to the diameter of the objective squared. So the light-gathering power of telescope A compared to the eye is the diameter of the objective of telescope A divided by the diameter of the eye all squared. From the table, notice the diameter of the objective of telescope A is 5 meters. The question stem states that the eye has a diameter of 0.5 centimeters or 5×10^{-3} meters. So the light gathering power is $5/(5 \times 10^{-3})$ all squared or 10^3 squared, which equals 10^6 ; this is answer choice **(C)**.

19. (C)

This is a Roman numeral question asking which of the statements are reasons why large telescopes are most often reflecting telescopes. All of the information needed to answer this question is contained in the first paragraph of the passage. Statement I suggests that lenses magnify an image more than mirrors. The passage does not support this statement. We know that magnification is the focal length of the objective over the focal length of the eyepiece. There is no

intrinsic limit on the focal length of lenses or mirrors. There are mirrors with smaller focal lengths than lenses and vice versa. This is, perhaps, the only physics knowledge you need to answer the question. Since statement I is false, eliminate answer choices **(A)** and **(D)** because they contain statement I.

The remaining answer choices, **(B)** and **(C)**, both contain statement II. Therefore, statement II must be correct, and we need only evaluate statement III. statement III suggests that larger lenses produce greater aberration. The passage states that lenses are affected by chromatic aberration, and as a consequence, reflectors are preferred. This implies that statement III is correct, and by using the Roman numeral strategy, we know statement II is correct. Therefore, the correct answer is choice **(C)**, II and III only.

For the sake of completeness, why is statement II is correct? It states that large lenses cannot hold their shape. The first paragraph of the passage we are told that large lenses deform under their own weight. These two statements are just different ways of expressing the same idea, so that's why statement II is correct. As an aside, the reason that large lenses cannot support their own shape is that glass is not a true solid but rather a super viscous fluid. A super viscous fluid appears to be a solid, but the molecules in the fluid are actually able to move around very slowly. Over a period of time this kind of movement will produce a distortion in a glass lens.

20. (B)

The question asks about the advantages of large telescopes over small telescopes. Answer choice **(A)** states that large telescopes magnify distant star images more. The passage says that a distant star is a faint point source. Is there any reason why large telescopes magnify point sources more? Magnifying a faint point source does not increase the detail seen by the observer and therefore magnification is not an important factor. From this you might conclude that large telescopes don't magnify star images more. This is a tempting answer choice though. Intuitively, you might think that a bigger telescope means a bigger magnification. However, this is not the reason that astronomers want large telescopes. So, choice **(A)** is wrong.

Answer choice **(B)**, on the other hand, is the correct answer. A larger telescope shortens the observing time. This is because large telescopes have objectives with

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large diameters. This means that more photons are collected per unit time. As an analogy, say you have a large bucket and a small bucket. You need to collect a certain amount of water. If you leave both buckets out in a rain storm, the larger bucket will collect a given amount of water quicker. You can think of the telescope as a bucket in a photon storm. The larger the telescope, the larger the bucket, and the quicker a given number of photons is collected.

Choices **(C)** and **(D)** can be eliminated right away because they have no basis in the passage and they make no sense. Answer choice **(C)** states that large telescopes track better. Tracking means that the telescope follows the star as the night wears on. So, it would be advantageous to have accurate tracking. However, there is no intrinsic characteristic of a large telescope to suggest it would track better. As for the reason of dynamic range, presented in choice **(D)**, it is not true. Dynamic range is not a term applied to telescopes. It is applied to astronomical detectors and is not germane to the solution. It can be eliminated because it was not mentioned in the passage, and there are other answers that make more sense. Again, the correct answer is choice **(B)**, larger telescopes shorten the observing time necessary to complete an observation.

21. (C)

This question asks you to identify which telescope would enlarge the Andromeda galaxy the most. The first question to ask is, "What type of object is a galaxy?" In the passage galaxies are given as an example of extended objects. Because the distance to the Andromeda galaxy is not given, we can't tell whether it's faint or bright. But that doesn't really matter, because the question asks which telescope would enlarge the image the most. The telescope that has the largest magnification will enlarge the image the most. From the table, recall that telescope E has the largest magnification. Therefore, the correct answer choice is **(C)**.

In addition, recall that magnification is proportional to the focal length of the objective, so you could have chosen the telescope with the largest focal length, giving telescope E. If you chose answer choice **(D)**, which states that all telescopes would provide the same magnification, you might have been confusing extended and point objects. Point sources are dimensionless points of light to a first approximation. As such, they do

not get larger and more detailed with increasing magnification. Again, the correct answer is choice **(C)**.

22. (A)

The question asks why the use of mirrors decreases the degree of chromatic aberration. The passage states that chromatic aberration affects large lenses. Also, when chromatic aberration occurs, the light that forms the image is not brought to an exact focus at a single point. If light is not brought to an exact focus, that means that the light is spread over an extended area. What could possibly cause the light to be smeared in that fashion?

Answer choice **(A)** states that the angle at which light is refracted by a lens is dependent on the wavelength, while the angle at which light is reflected by a mirror is constant and is *not* affected by wavelength. Recall that the angle of refraction is dependent on wavelength from the case of a simple glass prism. When white light hits a prism it breaks down to its component colors; each color represents a different wavelength. Since light of different wavelengths is refracted at different angles, you can see all the different colors separately. This is the basis of dispersion. If the incoming light is bent at slightly different angles, that would cause the focal point to become an extended area. If the angle at which the incident light is reflected is constant, all the light will be focused at the same point. Even the name—chromatic aberration—gives a clue as to its origin. The word "chromatic" implies color, and color is determined by wavelength. Chromatic aberration occurs when the focal point of the red light is at a slightly different spot than the focal point of the blue light. Thus the image is smeared out. So choice **(A)** is the correct answer.

Answer choice **(B)** says that a mirror absorbs less light in reflecting than a lens absorbs in refracting. This is also a true Statement. However, what would happen to an image if more light was absorbed? If the lens absorbed more light, fewer photons would be present to form the image. That would make the overall image dimmer, but it would not spread out the image. Therefore, this can't be the correct answer.

Answer choice **(C)** says that mirrors are easier to grind accurately than lenses, and thus mirrors are less flawed. This is also a true Statement. A mirror has only one surface to polish because light gets reflected only off the front side of the mirror. In a lens, however, light travels through the whole lens. Both sides of a lens therefore

must be polished. But grinding flaws will not uniformly smear the image over an extended area. A random flaw in one part of the mirror would create aberration, but it would not be a uniform smearing out of the light like chromatic aberration. So, choice **(C)** is wrong.

Answer choice **(D)** states that the changes in temperature during an evening affect mirrors less than lenses. This is another true Statement that has nothing to do with chromatic aberration. In general mirrors are thinner than lenses. As such, they come to equilibrium with the surrounding environment faster than lenses. The advantage of this is that it cuts down on turbulence near the telescope. However, it would not cause the light to smear out. Therefore, it is not the correct answer to the question. Again, the correct answer is choice **(A)**.

23. (A)

Each answer choice has two parts. The first part tells what would happen to an image as the magnification is increased. This may or may not be true. The second part indicates the reason the image would change in this way. The reason itself may or may not be true. The challenge is to identify the answer choice which correctly states both what happens to the image and why it happens.

This question really tests how well you understand magnification. Magnification is a measure of how much larger an image is than the object. From the passage, one can calculate the magnification by dividing the focal length of the objective by the focal length of the eyepiece. Therefore, by making the focal length of the eyepiece shorter and shorter, one should be able to increase the magnification indefinitely. But, that would not be useful. Magnification is only useful when it reveals more detail and features of whatever it is you are observing—in this case, a galaxy.

Increasing the magnification spreads the image over a larger area. Since this means the same number of photons are spread over a larger area, the image will get dimmer. Eventually the image will become so dim that you will not be able to see it. Answer choice **(A)** is correct, because it correctly states what would happen to the image and why it would happen.

Answer choices **(B)** says the image size would remain the same. The very meaning of magnification is making the image larger. So, the image will get larger and answer choice **(B)** must be incorrect.

Answer choice **(C)** says that the image would get larger, indefinitely remaining at the same overall brightness. This is impossible because the object has a finite brightness and therefore radiates a finite number of photons per second. As those same number of photons cover a larger area, the brightness obviously has to fade. Therefore, answer choice **(C)** is incorrect.

Answer choice **(D)** has the correct sequence of events—the image will get larger and dimmer until it eventually fades completely. However, this is not due to any dispersion effect. Dispersion is the spreading out of light into its component colors as it passes through a lens. Therefore, this answer choice is incorrect because it gives the wrong reason for what happens to the image.

Passage IV (Questions 24–29)

24. (A)

The given examples of different ores show that ore molecules contain metal atoms bonded to atoms of an active nonmetal or group of nonmetals. In such compounds, metals will always have positive oxidation numbers, since they are less electronegative than nonmetals. Hence, for a metal to be extracted from its ore, its oxidation number must be decreased to zero—in other words, the metal must be reduced. Under certain conditions, elements that are less electronegative than the nonmetal contained in an ore can act as reducing agents. Elements that are more electronegative than the nonmetal contained in the ore are unable to carry out this reduction under any conditions. So, the question asks which choice is more electronegative than oxygen, which is the nonmetal component of lead oxide. One of the best ways to compare electronegativities is to use the periodic table. All the choices given are *p*-block elements of the second period. Since the electronegativity of *p* elements always increases from left to right across a period, boron, carbon, and nitrogen are less electronegative than oxygen; so, it should be possible for any of them to extract lead from its oxide. Fluorine, on the other hand, is *more* electronegative than oxygen and cannot extract the lead from lead oxide. Thus the correct answer is choice **(A)**.

25. (C)

This question requires some concentrated reasoning. According to the passage, electrolytic extraction

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proceeds in three principal steps: first, thermal destruction of the crystalline lattice; second, solvation of the freed metal cations; and finally, electrolytic reduction of the cations. From the passage, you know that significant amounts of energy are applied during Steps 1 and 3 (thermal energy and electrical energy, respectively); so these are both endothermic processes. Solvation reactions, such as Step 2, may be either endothermic or exothermic (more often exothermic). The question stem *tells* you that Step 1 has a positive enthalpy and Step 2 has a negative enthalpy. The two enthalpies have almost equal magnitudes, which means that the energy released by the one step is about equal to the energy absorbed by the other. The energy changes of these two steps will nearly cancel each other out, and will therefore not contribute significantly to the energy balance of the overall process. The lattice energy of the ore, choice **(A)**, and the solvation energy of the cations, choice **(B)**, are the enthalpies of Steps 1 and 2, respectively, so both of these choices are incorrect. Instead, the rate must be determined by the third step, the electrolytic reduction. Since the energy that drives this reaction therefore comes from the driving force of Step 3, the extraction rate must be determined by the magnitude of that electric potential applied to the electrolytic cell. So, choice **(C)** is correct. As for choice **(D)**, the metal cations are only involved in the solvation, so their size could only affect the solvation energy, which won't contribute significantly to the energy balance.

26. (B)

The question provides the standard free energy value, that is, the standard ΔG value, also known as the ΔG° value, for this reaction. This is the free energy of the reaction under standard conditions; so, in order to determine how the reaction will proceed, look at the sign of that standard free energy value. The fact that the standard free energy change of the forward reaction is positive means that, under standard conditions, the forward reaction is nonspontaneous, but the reverse reaction is spontaneous. Therefore, standard conditions will favor the reverse reaction, and the correct answer is choice **(B)**.

27. (B)

Choice **(A)** states that the free energy of formation is independent of the absolute temperature. According to the Gibbs equation, the free energy change, ΔG , equals the enthalpy change, ΔH , minus the product of the

absolute temperature, T , times the entropy change, ΔS . Thus, the free energy change must be dependent on the absolute temperature, and choice **(A)** is wrong. Now, look at choice **(B)**. When iron, which is solid, and oxygen, which is gaseous, react to form ferric oxide, which is also solid, the entropy of the system decreases, since the entropy of a solid is lower than the entropy of a gas. In other words, this reaction produces a negative entropy change. Substituting this negative ΔS into the right side of the Gibbs equation makes the product $T\Delta S$ into a positive value. This means that, as T increases, ΔG will become less negative and the reaction will become less spontaneous. Thus choice **(B)** is correct; the negative entropy value of ΔS is what causes the free energy of formation to become less negative at higher temperatures. Choice **(C)** is wrong because at low temperatures the product of $T\Delta S$ becomes extremely small, and the value of ΔH then becomes *more* rather than *less* dependent on the value of ΔG . Choice **(D)** is wrong because an increase in entropy, multiplied by the absolute temperature and subtracted from ΔH , would make the value of ΔG more negative, not more positive. Again, the correct answer is choice **(B)**.

28. (D)

The correct choice is **(D)**. This question requires you to use the Ellingham diagram that's given in the passage. This diagram shows that at approximately 1000 Kelvin, the line corresponding to the free energy of formation of ferric oxide (which has a positive slope) crosses the line corresponding to the free energy of formation of carbon monoxide (which has a negative slope). This means that of all temperatures above 1000 K, the free energy of formation of carbon monoxide is more negative than that of ferric oxide. In thermodynamic terms, the more negative free energy of formation implies that above 1000 K, carbon monoxide will form in preference to ferric oxide. In other words, these conditions favor the formation of carbon monoxide and the decomposition of ferric oxide, which is exactly what takes place during extraction (Reaction 1). Therefore, elemental carbon is most likely to reduce ferric oxide at temperatures higher than 1000 K; so, choice **(D)** is the correct answer.

29. (D)

From the diagram, you can see that above about 1000 K, carbon dioxide has a lower free energy of formation than does ferric oxide. This means that the production of carbon dioxide from ferric oxide will be negative, so

the reaction will occur. However, at these temperatures, the free energy of formation of CO is even lower than that of CO₂. This means that the formation of carbon monoxide is favored over the formation of carbon dioxide, and so the former reaction will predominate. What happens is that some carbon dioxide is formed, but it is immediately reduced to carbon monoxide by the carbon in the reaction mixture. However, if the system is cooled, as suggested by choice **(D)**, the carbon monoxide will be converted back to carbon dioxide. Thus choice **(D)** is correct. What we have just shown is that carbon dioxide formation is affected by temperature, but in a complex way—it isn't accurate to say that it's either directly or indirectly proportional to temperature, since the relation is different at different temperatures; so, choices **(A)**, **(B)**, and **(C)** are all incorrect.

Discrete Questions

30. (B)

In this question, we asked to determine the net force acting on the negative charge. Coulomb's law, $F = kq_1q_2/r^2$, states that the magnitude of the force on one charge due to a second charge is proportional to the magnitude of the second charge and inversely proportional to the square of the distance between the two charges. The two positive charges are equal so their magnitudes are the same, and the distance of each positive charge from the negative charge is the same because the negative charge is midway between them. Therefore, each positive charge exerts the same magnitude force on the negative charge. You must determine the direction of the force that each positive charge exerts on the negative charge. Since both charges acting on the negative charge are positive and unlike charges attract, the positive charges will both attract the negative charge. So, the positive charge on the right will exert a force on the negative charge which points toward the right, and the positive charge on the left will exert a force on the negative charge which points toward the left. So, the two forces point in opposite directions, and they are equal in magnitude. Therefore, they cancel each other out. So, the net force on the negative charge is zero, and the correct answer choice is choice **(B)**.

31. (C)

As HCl is added to the potassium phosphate solution, the phosphate ion is converted to hydrophosphate,

which contains one proton, and then to dihydrophosphate, with two protons. The question asks for the dissociation constant of dihydrophosphate: that is, its acid constant or K_a . This constant is found by multiplying the hydrogen ion concentration of the solution by the hydrophosphate concentration, and dividing this value by the dihydrophosphate concentration. The K_a of a substance, as you should know, is equal to the hydrogen ion concentration when the substance is 50% dissociated. The reason this is true is that, when the hydrophosphate concentration in the numerator is equal to the dihydrophosphate concentration in the denominator, the two factors will cancel each other out, and the K_a will then be equal to the only remaining factor, which is the hydrogen ion concentration.

The question states that the pH of the buffer region is X . A buffer region is a pH range in which the species in question is about 50% dissociated. If the pH in this region is X , then the hydrogen ion concentration will be 10 to the minus X , as pH is the negative log of the hydrogen ion concentration. And if the hydrogen ion concentration in this region is ten to the minus X , then the dissociation constant, which is equal to the hydrogen ion concentration, will also be ten to the minus X . So, choice **(C)** is correct.

You could also have solved this problem by plugging values into the Henderson-Hasselbach equation, if you have that equation memorized. But it is better to understand how pK_a 's work; then you won't have to worry about forgetting the equation.

32. (C)

The question presents an equation that describes a sinusoidal wave, and we are asked to determine the amplitude and speed of the wave. For this question, compare the equation given in the question stem to the general wave function, which is $y = Y \sin(kx - \omega t)$, where y is the displacement of the wave at a time t , Y is the maximum displacement of the wave, k is the angular wave number, ω is the angular frequency, and x is the displacement in the direction of the wave's motion. We find that $Y = 0.01$ meters, $k = 50$ inverse meters, and $\omega = 2$ radians per second. Now, we know that Y is the amplitude of the wave, which in our case is 0.01 meters. This allows us to eliminate answer choices **(A)** and **(D)**, leaving us with answer choices **(B)** and **(C)**.

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To determine which of the remaining two answer choices is correct, we must calculate the speed of the wave. The speed of the wave v is given by the equation $v = \omega/k$. So, $v = 2/50$, which equals 0.04 meters per second. Therefore, the correct answer to this question is choice **(C)**.

33. (A)

Generally speaking, all p -elements—that is, elements with partially filled valence p subshells—are fairly effective oxidizing agents. However, the oxidizing capacity of a p -element is directly proportional to the number of electrons in its p subshell. Since the maximum number of electrons the p subshell can hold is six, choice **(A)**, whose valence p -subshell contains five electrons, is the strongest oxidizing agent. Choice **(D)**, which has only one valence p -electron, is wrong, as is choice **(B)**, which has no valence p -electrons. In fact, choice **(B)**, which as an incompletely filled $3d$ subshell, is a typical transition element; such elements are generally poor oxidizing agents. In fact, it would be easier for this atom to lose its d shell electron, thus becoming oxidized itself. That would make it a reducing agent. Finally, choice **(C)**, which has an incompletely filled s subshell, is a typical s -element; such elements are the strongest reducing agents, so this choice is wrong.

34. (D)

This question asks us to identify a uniform magnetic field. Well, a uniform magnetic field is one that has the same magnitude and direction everywhere. Use the diagrams to figure out which field is uniform. The lines in the diagrams are actually the magnetic field lines; they indicate how the magnitude and direction of the magnetic field changes over a large number of points. The relative density of the magnetic field lines tells us something about the magnitude of the magnetic field. Where field lines come closer together, the magnitude of the field is *increasing*. Where the field lines move farther apart from each other, the magnitude of the field is *decreasing*. In other words, a change in the magnitude of a field is indicated by diverging or converging field lines. Since a uniform magnetic field is one that has the same magnitude everywhere, uniform field lines will be at a constant distance from each other. As for direction, the magnetic field itself is tangent to the field line at each point. Since a uniform magnetic field has the same direction at every point, the field lines must run in the same direction all over. Putting all that information

together, we can say that for a uniform field the field lines will be equally spaced parallel straight lines.

Inspecting all the answer choices, answer choice **(D)** is the correct answer. Here, all the field lines point in the same direction, left to right. Also, all the lines are parallel to each other; their relative distance to one another is constant. Since parallel straight lines meet both conditions for a uniform field, answer choice **(D)** is the correct answer.

In answer choice **(A)**, the magnitude of the magnetic field changes. Close to the center, the lines are close together; as you move away from the center, the lines get farther apart. This tells us that the magnitude decreases as you move away from the source. Moreover, the lines point in different directions. So this field has neither a constant magnitude nor a constant direction. Answer choice **(B)** shows a wire with multiple concentric circles. This represents the magnetic field lines around a current-carrying wire. Above the wire the field is coming out of the page, and below the wire the field is going into the page. Since the field direction is changing, this cannot be a uniform magnetic field. Answer choice **(C)** shows the magnetic field lines around a bar magnet. Notice that again, the direction of the field is changing. Also, as the lines move away from the poles of the magnet, they get farther apart. So, the magnitude is also changing. Again, choice **(D)** is the correct answer.

Passage V (Questions 35–40)

35. (B)

This question asks you to identify the changes in the substances shown in Figure 1, as the temperature is increased at a constant pressure. Remember that PT phase diagrams describe what phases a substance will be in at varying temperatures and pressures. When one is held constant, look at what transitions occur along one line. In this case, where pressure is held constant and temperature is increased, follow the phase changes across the figure to the right. So, since the question said that materials A and B were in containers open to the air, meaning an atmospheric pressure of 1 atmosphere. That lies somewhere between the two triple-point pressures given in the figure, so we'll just move to the right between those pressures. At lower temperatures,

material A is in the solid phase and then somewhere before 216 K, it crosses the phase barrier into the gas phase. This means that it goes directly from solid to gaseous form, or undergoes sublimation. The only answer choice that has A sublimating is choice **(B)**, so that's the right answer. Material B also starts in the solid phase, but it crosses the phase barrier to liquid and then the barrier to gas. So solid B melts, and then boils.

36. (A)

This question deals with solid-liquid equilibrium. Some of the answer choices that can be eliminated quite easily. Crystallization is favored by low temperatures, not high temperatures, so choice **(B)** is wrong. Adding a concentrated sodium chloride solution to the liquid phase would lower the freezing point, by the colligative property of freezing-point depression; this would suppress crystallization, so choice **(D)** is also wrong. Choosing between **(A)** and **(C)**, raising or lowering the pressure, is tricky. The best place to look for this information is in Figure 1. The phase boundary between solid and liquid for material A slopes to the right. That means that if you held the temperature of a sample of liquid A constant and raised the pressure, you would eventually cross the phase boundary into solid. So, crystallization of A is favored by raising the pressure. Conversely, the solid/liquid phase boundary of B slopes to the left. Which means that if you held the temperature of a solid sample of B constant and raised the pressure, you would eventually cross the boundary into liquid. So, melting is favored by an increase in pressure for material B. Therefore, choice **(A)** is the correct answer, and choice **(C)**, which is the opposite of choice **(A)**, is wrong.

Note that increased pressure favors the denser phase. So, solid A is denser than liquid A and liquid B is denser than solid B. The slopes of the phase boundary lines on PT diagrams can give you some comparative information about the density of a material's phases.

37. (A)

This question requires you to look at Figure 1 and determine what phases the two substances will be in under prescribed conditions. Estimate where the specified temperatures and pressures would lie on the phase diagram and then name the phase. A pressure of 2 atm and a temperature of 220 K, as in choice **(A)**, is between the two triple-point pressures and temperatures. We are in the gas phase area of A and

the solid phase area of B, and that matches the answer choice. So, choice **(A)** is correct.

Choice **(B)** is a temperature of 280 K, which is just to the left of substance B's triple-point temperature, and a pressure of 6 atm, which is above substance A's triple-point pressure. This set of conditions is in the liquid phase area for both substances, which does not match the answer choice.

Choice **(C)**, 100 K and 5 atm, is on the far left side of the diagram just under the triple-point pressure line for substance A. This is well within the solid phase area for both substances, so choice **(C)** doesn't correctly describe the state of both substances.

Finally, choice **(D)**, with a temperature of 300 K and 4 atm is on the far right of the graph, about four-fifths of the way to substance A's triple-point pressure. Now, because it is so close to the end of the temperature line, it is hard to tell exactly what substance B is, but substance A is obviously a gas, which doesn't match the second part of choice **(D)**, so it must be wrong. Thus choice **(A)** is the only correct answer.

38. (C)

This question is asking you to identify which material will be a gas at the indicated pressure and temperature. Remember that solids and liquids are fairly incompressible and will not have their volume changed significantly by a change in pressure. However, according to Boyle's law, the volume of an ideal gas is inversely proportional to the pressure. Thus, from the question stem, you are looking for a gas with relatively ideal behavior. With that in mind, choices **(A)** and **(B)** can be rejected right away because under triple-point conditions, all three phases would exist in a state of dynamic equilibrium. The volume of this mixture will not be affected by temperature nearly as much as a pure gas. In fact, if you change the pressure at all, you would no longer have either substance in its triple-point conditions since the triple-point temperature and pressure is a unique situation. In choice **(D)**, material B is at its triple-point *pressure*, but well below the triple-point *temperature*. According to the diagram, these conditions make material B a solid, so choice **(D)** is wrong. Choice **(C)** puts material A at very high temperature and atmospheric pressure. Heating material A up to 1000 K at atmospheric pressure will shift the equilibrium sharply toward the gaseous phase. So, under the conditions of

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choice **(C)**, the sample of material A will be entirely gaseous, and will therefore exhibit behavior that can be predicted by the Ideal Gas Law. This includes a reduction in volume when the pressure is increased. Thus choice **(C)** is the correct answer.

39. (D)

To answer this question, remember that the terms *critical temperature* and *critical pressure* refer solely to the liquid-gas equilibrium, and therefore the critical point corresponding to these values must be located somewhere on the curve BD that separates the liquid and gas phases. Moreover, the passage says that when the temperature or pressure exceeds its critical value, the liquid and gas phases can no longer coexist. Therefore, curve BD, representing the liquid-gas equilibrium, cannot extend beyond the critical point. In other words, the critical point corresponds to the terminal point of curve BD—that is, Point D. So, choice **(D)** is the correct answer.

40. (B)

The triple point is the unique pressure and temperature where all three phases of the substance are in equilibrium. It would make sense then, that the triple-point is the point where the three phase boundaries, solid/liquid, solid/gas, and liquid/gas, connect. In Figure 1, those are the points that are indicated by the dotted lines. In the diagram for question 39, that is point B. In fact, you really only had three choices for this question, since you know that point D was the critical point from question 39. Point B is the only one that comes into contact with three distinct phases, so it is the only one that makes sense as the triple point.

Passage VI (Questions 41–45)

The last passage in this section, Passage VI, is another physics passage. It describes an experiment to measure the universal gravitational constant G . This is called the Cavendish experiment. The concepts covered are basically mechanics, along with some graph interpretation.

41. (A)

This question asks to determine what would happen to the value obtained for the universal gravitational constant if the Cavendish experiment was performed on the

moon where the acceleration due to gravity is $1/6$ that on Earth. Remember that the force of attraction between two objects is the same whether they are on the moon or on Earth and is independent of the acceleration due to gravity. The equation for the force F between two objects is $F = Gm_1m_2/r^2$, where G is the universal gravitation constant, m_1 and m_2 are the masses of the two objects, and r is the distance that separates them. Since the force, the mass of the two objects, and the distance separating them doesn't change, the value of the universal gravitation constant must also remain constant. Thus the correct answer choice is **(A)**. Another way to approach this problem is to remember that we are dealing with the universal gravitation constant, and this implies that this constant is the same at all points in the universe.

42. (D)

To do this question, remember Newton's law of gravitation. This states that the force between two masses m_1 and m_2 , separated by a distance r equals Gm_1m_2/r^2 , where G is the universal gravitation constant. The question stem states that the mass of the large lead balls is halved, and the distance between the large and the small balls is doubled. Knowing this, the question asks to determine the ratio of the original to the final gravitational forces between the two balls. Let the mass of the larger ball be m_1 and the mass of the smaller ball be m_2 . The initial force F_i between the two balls is given by the equation $F_i = Gm_1m_2/r^2$. The mass of the larger ball decreases by half to $m_1/2$, and the distance between the balls doubles increasing to $2r$. Substituting these values into Newton's law of gravitation, the final force is $F_f = G(m_1/2)m_2/(2r)^2$. Simplifying, $F_f = Gm_1m_2/8r^2$. Dividing the initial force by the final force and canceling out the G , m_1 , m_2 and r^2 terms: $F_i/F_f = 8$. In other words, the initial force is 8 times the final force, and so the ratio of the initial force to the final force is 8:1, which is answer choice **(D)**.

43. (B)

The passage gives two equations. The first equation relates the torque exerted by the fiber to the torsional constant k , and the angular displacement θ . The second equation relates the torque exerted on the Cavendish balance due to the gravitational attraction, to the mass of the large spheres M , the mass of the small spheres m , the length of the rod connecting the

two small spheres L , and the distance between the large and small spheres r . When the Cavendish balance is in equilibrium, the torque exerted by the twisted fiber is just balanced by the torque due to the gravitational attraction. Setting these two equations equal to each other, $k\theta = GMmL/r^2$. Rearranging this to get an equation in terms of the angular displacement θ , we get that $\theta = GMmL/kr^2$.

Which answer choice would increase the magnitude of the angular displacement of the torsion balance from the rest position? Answer choice **(A)** suggests that increasing the distance r between the large and small spheres would increase the magnitude of the angular displacement. According to the equation, we see that the r term is in the denominator of the equation. So increasing this would decrease the angular displacement. Therefore, answer choice **(A)** is incorrect.

Answer choice **(B)** suggests that decreasing the torsional constant k of the fiber would increase the magnitude of the angular displacement. According to the equation, this term is also in the denominator, so decreasing this would increase the magnitude of the angular displacement, and so **(B)** is the correct answer.

Answer choice **(C)** suggests that decreasing the length of the bar of the Cavendish balance would increase the angular displacement. This is not the case since the L term is in the numerator of our equation. Decreasing L would decrease θ . The same reasoning applies for answer choice **(D)**, since the term for the mass of the large spheres is also in the numerator of the equation. Decreasing M would also decrease θ .

44. (D)

There are two starting points to this question. You may have known that the conventional units of the universal gravitation constant are newton meters squared per kilogram squared, and from that gone on and determined which of the other answer choices were also dimensionally correct units—which of the other units would be equivalent to the conventional unit of newton meters squared per kilogram squared. If you did not remember the conventional units of G , you could have worked it out by using the familiar Newtonian equation that defines the gravitational force F to be Gm_1m_2/r^2 , where m represents mass, and r distance. If we rearrange this equation to get an equation in terms of G : $G = Fr^2/(m_1m_2)$. Substitute in the units for

each of our variables: F is in newtons, r is in meters, and the masses m_1 and m_2 are in kilograms. So the units of G must be newton meters squared per kilogram squared, and this is the same as choice **(A)**, and so this can't be the correct answer.

Which of the other answer choices are also units of G ? It easiest to express the units of G in their most elemental form. Meters and kilograms are both fundamental units, so all that has to be converted is the newton. Remember that a newton is equivalent to a kilogram meter per second squared. If you didn't, you should remember that newton is the unit of force. Force equals mass times acceleration according to Newton's second law. Since mass has units of kilograms and acceleration has units of meters per second squared, the unit of force must be equivalent to kilogram meter per second squared. Earlier we found that G had units of newton meters squared per kilogram squared. Substituting for newtons into our original units of G , we find that we can also express the units of G as meters cubed per second squared per kilogram. This is the same as answer choice **(B)**, and so this can't be the correct answer either.

If we look at the remaining two answer choices, we see that both of them have the unit of joule in them. The joule is equivalent to a newton meter. You could have figured this out from the equation for work since work is measured in joules. The equation for work is force times distance, and since force is measured in newtons and distance in meters, work must have units of the newton meters. Knowing this we can go on and convert answer choice **(C)** into its elemental units. A joule meter per kilogram squared is equivalent to a newton meter squared per kilogram squared. That's the same as answer choice **(A)**, which we had previously eliminated.

By process of elimination, we find **(D)** is the correct answer. Since we already found that a joule is a newton meter, answer choice **(D)** becomes newton meter cubed per kilogram. We also found that a newton is a kilogram meter per second. Now answer choice **(D)** becomes meters to the fourth power per second squared. These are the most elemental units of length and time. They do not correspond to answer choice **(B)**, which are also in these most basic units. Since we've already said that answer choice **(B)** represents a unit of G , answer choice **(D)** cannot be a unit of G , and hence it is the correct answer.

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45. (B)

The question asks you to determine which of the graphs most accurately depicts the variation of the gravitational acceleration as the distance from the surface of the Earth increases. To do so, use Newton's law of gravitational attraction. In equation form this is $F = Gm_1m_2/r^2$. For an object of mass m above the surface of the Earth, the force between the object and the Earth is equal to GmM_e/r^2 , where G is the universal gravitation constant, M_e is the mass of the Earth, and r is the distance of the object from the Earth's center. Now, equate the force of gravitational attraction to the force causing the gravitational acceleration. The force causing the gravitational acceleration equals ma , where m is the mass, and a is the acceleration. So, equating our two equations: $ma = GmM_e/r^2$. Canceling the m terms: $a = GM_e/r^2$. Since the mass of the Earth doesn't change and G is a constant, a is proportional to $1/r^2$.

Next, predict the shape of the graph of a versus $1/r^2$ by substituting the values of zero and infinity into $1/r^2$. If we put in that $r = \text{zero}$, then the acceleration a will tend to infinity, since 1 over 0 is infinity. However, if we put in that $r = \text{infinity}$, then the acceleration will tend to zero. Only one graph shows an acceleration that tends to infinity when the distance tends to zero, and an acceleration that tends to zero when the distance tends to infinity. This is graph **(B)**, which is indeed the correct answer.

VERBAL REASONING EXPLANATIONS

These are the explanations to the Verbal Reasoning section of the MCAT Practice Test. When you take the MCAT, spend no more than eight or nine minutes on each passage and the questions that accompany it. And if you have time left over when you complete a section, go back and double-check your answers.

Passage I (Questions 46–54)

The first passage is a passage about the Johnstown Flood. It's a simple historical narrative, covering events leading up to, during, and after the flood, with one twist: a strong opinion on where to put the responsibility for the flood. According to the author, the flood, so disastrous to the citizens of Johnstown, was in large measure caused by faulty repairs on the dam of a lake owned by a few rich businessmen. In paragraph 1, the author briefly but graphically describes the flood, and sets up the rich versus poor conflict. Paragraph 2 details the circumstances by which the rich businessmen had come to own the lake, and the nature of the repairs they made on the South Fork Dam. Paragraph 3 describes how, after a day and night of torrential rain in the Spring of 1889, the dam gave way, emptying the entire lake in under an hour. In paragraph 4, we learn that the people of Johnstown had neither enough warning nor the means to evacuate the area before the great wave of water hit them. This paragraph also details the activities of the army of relief workers that descended on Johnstown in the aftermath of the flood. In the final paragraph, the author goes back to the rich versus poor conflict, saying that the South Fork Club, which owned the dam, contributed almost nothing to the relief effort, and ultimately escaped liability for the flood.

That's the basic outline of the passage. It's not too difficult, as there is no rhetoric and no mass of technical detail; but it is an opinionated passage. You get the feeling that the author agrees with the press and public that the South Fork Club bore a major responsibility for the destruction, and at the end of the second paragraph even the author himself calls the repair work commissioned by the South Fork Club

“slipshod.” With all of that in mind, let's take a look at the questions.

46. (B)

This question asks for the central thesis. This is a Main Idea question, and the correct answer, choice (B), is a restatement of the final sentence of paragraph 1. The author argues that, since the lake that flooded the town was owned by a few rich businessmen who had neglected to keep the dam in good repair, the disaster became a symbol of the class conflict of the era. Choice (A) takes a minor detail from paragraph 1 and tries to inflate it into the main idea. Surely, if choice (A) had been correct, the passage would have presented more information on the San Francisco earthquake. But all we learn about that disaster is that more people died in Johnstown than in San Francisco. After this sentence, San Francisco is never mentioned again. So, a comparison of the destruction caused by the two events is *not* the main idea of this passage. Not only is choice (C) not the main idea of the passage, it is never asserted in the passage. According to the author, it's not that nineteenth-century engineering techniques were unable to prevent the dam from breaking. The dam broke under the force of the torrential rainfall because the repairs were slipshod and done without an engineer's supervision. And choice (D) distorts a detail from the fifth sentence of paragraph 4. The author says there that the army of 7,000 relief workers “eventually threatened to overwhelm” Johnstown. But this is more the author's attempt to dramatize the dimension of the relief efforts than it is an indictment of those efforts. As the rest of the paragraph makes clear, the relief workers did a lot more good than harm to Johnstown. So, choice (B) is the correct answer.

47. (C)

This is an Inference question about whom the author thinks bore the ultimate responsibility for the flood. It should be pretty clear by now that the author placed the blame on the members of the South Fork Club, which paid for the shoddy repairs on the dam. This makes choice (C) correct. Evidence supporting this inference can be found in the final sentences of paragraphs 1 and 2, and in the bulk of the final paragraph. The citizens of Johnstown, choice A, were the victims of the flood, not the perpetrators. Choice (B) is wrong because the author never infers that the dam was unsafe at the time of its construction. The fourth sentence of paragraph 2

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states that the South Fork Club hired workmen to make repairs because the dam was “deteriorating,” which means that it needed repair, not that it had been unsound originally. And choice **(D)** restates the verdicts of the juries in the lawsuits brought against the Club. The final sentence of the passage says that the juries decided the flood was an act of God, not of man. Clearly, the author disagrees. So, choice **(C)** is correct.

48. (B)

This is an Explicit Detail question, in Roman numeral format. Let’s evaluate the statements one at a time. Statement I says that, according to the passage, the Johnstown Flood was the worst natural disaster in American history. This statement is false, because the author only compares the flood to one other disaster in American history, the San Francisco earthquake. We simply don’t know from the passage whether or not the flood was the worst disaster in American history, so Statement I will *not* be part of the correct answer. This allows us to eliminate choices **(A)** and **(C)**, which both include statement I. Notice now that both choices **(B)** and **(D)** include statement II, so it *must* be true. Let’s look at it quickly, anyway, just to be thorough. It says that the flood generated an enormous amount of attention in the press. This is substantiated in the fifth sentence of paragraph 4, which begins, “Exhaustive press coverage of the disaster...” OK, what about statement III? It says that the Johnstown Flood eventually brought about changes in engineering regulations. This may or may not be true, but there is certainly no evidence for it in the passage. So, statement III is incorrect, and choice **(B)**, statement II only, is the correct answer.

49. (A)

This is another Inference question. You’re looking for an indication that the author thinks the South Fork Dam might have remained intact if only... what? Let’s take a look at paragraph 3, which describes the destruction of the dam. The first sentence says that heavy rains raised the level of the lake at the incredible rate of six inches per hour. This immediately points to choice **(A)** as the correct answer. The author suggests that, despite the lousy repair job, the dam might have held if the rains hadn’t been so heavy. And a quick check of the other choices confirms **(A)** as the best answer. Choice **(B)** has things all mixed up. If the dam had not been situated above an Allegheny valley, it would still have given way; the only difference is that valley residents

would not have been killed. The topography below the dam is irrelevant to the question stem. The dam broke because it was inadequately repaired *and* because enormous amounts of water fell into the lake in a big hurry and for a sustained period of time. Choice **(C)** is also immaterial. The Club members may have been warned of the potential for disaster (although this is not stated in the passage), but the fact remains that they decided on, and paid for, incompetent repairs, which led to the dam giving way when the rains came. And choice **(D)**, finally, is a distortion of the second sentence of paragraph 4. If communication between South Fork and Johnstown had been possible, it might have saved a few lives. But it would not have prevented the dam from giving way. So, choice **(A)** is the correct answer.

50. (D)

This question is a relatively easy Explicit Detail question. The correct answer will be a topic related to natural disasters that is *not* mentioned in the passage. Choice **(A)**, destruction of property, and choice **(B)**, loss of life, are explicitly mentioned in the second and third sentences of the passage, so they are eliminated. Relief efforts, choice **(C)**, are discussed at some length in the last four sentences of paragraph 4, and the first sentence of paragraph 5. That leaves choice **(D)** as the correct answer. The author never mentions under what circumstances commerce or business resumed in Johnstown after the flood. So, choice **(D)** is correct.

51. (B)

This is another Explicit Detail question. It asks what the phrase “scant regard” in the third sentence of paragraph 5 refers to. Let’s take a look at that sentence. The author says that press and public were angered by the fact that the slipshod dam repairs had been made for the benefit of a few rich people with such scant regard for “the risk to the humble toilers in the valley below.” So the sentence is contrasting the rich folk at play on the lake with the humble workers in Johnstown. Having “scant regard” for someone means not caring about the person, or feeling indifferent toward the person—which points to choice **(B)** as the correct answer. As for the other choices: regulations and their enforcement by the Pennsylvania state government are not mentioned at all in the passage, so choice **(A)** cannot be the right answer. Choice **(C)** calls the journalists covering the disaster “callous,” which is similar to indifference or lack of feeling. But the third sentence of the final paragraph tells you that the press was “outraged” that the

inadequate dam repairs had been made so a few rich people could go fishing. So, according to the passage, journalists covering the disaster were *not* callous; therefore, choice **(C)** is eliminated. And choice **(D)** is wrong because the phrase “scant regard” is obviously meant to refer to those people who ordered the repairing of the dam, which occurred *before* the disaster—in other words, before the relief workers ever arrived. Choice **(D)** plays on the author’s remark, in the previous paragraph, that the army of relief workers “threatened to overwhelm” Johnstown. This phrase does not imply that the relief efforts were “misdirected,” as choice **(D)** suggests. Rather, it is a bit of hyperbole, an exaggeration to point up the fact that, although 2,000 people died, more than 7,000 people showed up to help the survivors. So, choice **(D)** is wrong and choice **(B)** is the correct answer.

52. (D)

This question asks you to pick the choice that correctly identifies an assertion made in the passage. In a question like this, the first strategy you should employ is to scan the choices quickly, looking for one that leaps out as correct. In this question, the clear winner is choice **(D)**, the assertion that the flood took most people in Johnstown by surprise. This assertion is made in the second sentence of paragraph 4, which says that “most” Johnstown residents “had no idea what was coming.” As for choice A, the second sentence of the passage says that “the flood laid waste to Johnstown and several neighboring towns,” so Johnstown was *not* the only community destroyed by the flood. And while it’s possible that Johnstown suffered similar disasters before 1889, the passage does not assert that this is so, so choice **(B)** is false. Finally, choice **(C)** is contradicted by the first sentence of the final paragraph, which says that one carload of supplies shipped to Johnstown carried blankets contributed by the South Fork Club. So while the Club’s contribution was shamefully minimal, it’s not true that they failed to contribute entirely.

53. (B)

You’re asked to infer what the author believes about the verdicts in the lawsuits that were brought against the South Fork Club. The relevant part of the passage is the final paragraph, where the author relates that public outrage over the inadequate dam repairs resulted in several lawsuits against the Club. In the final two sentences, we learn that all the verdicts

absolved the Club of liability, attributing the disaster to an act of God. Now we know from the second paragraph that the author believes the dam repairs were inadequate. So, we can infer that the author would have sided with those who brought the lawsuits against the Club. In other words, we can infer that the author probably thinks the verdicts in those lawsuits were incorrect, unfair, and unjust. Putting it more strongly: for the author, as for most of the public, the not-guilty verdicts probably represented a miscarriage of justice, since justice would have found the Club guilty of wanton disregard for human safety. Choice **(B)**, then, is correct. A quick look at the other choices confirms **(B)** as the right answer. Choice **(A)** is wrong because there’s nothing in the passage to suggest that the Johnstown Flood resulted in social change. A handful of rich people had helped cause the disaster, and they went unpunished. Choice **(C)** is wrong because the second and third sentences of the final paragraph indicate that most journalists were very angry at the South Fork Club, and wanted to see them pay for what had happened. Since the verdicts absolved the Club of any blame, one can conclude that the verdicts did *not* represent the opinions of the journalists. And choice **(D)** is wrong because the verdicts symbolized the power of the ruling economic elite, not the emerging populist movement. Choice **(D)** distorts the author’s statement, in the final sentence of paragraph 1, that the flood symbolized the “sharp class differences that persisted in America and the emergent populist current that challenged them.” In the case of the lawsuits, the populist challenge clearly failed. So the verdicts did not symbolize the power but rather the *lack* of power of the populists. Choice **(B)**, then, is the correct answer.

54. (C)

The final question on this passage is an Explicit Detail question in the “all of the following EXCEPT” format. This means that the right answer will be something that was *not* listed in the passage as an activity of the disaster relief workers. The wrong answers, choices **(A)**, **(B)**, and **(D)**, are all listed in the final sentence of paragraph 4 as things the relief workers did: carting off debris or wreckage, choice **(A)**; distributing food, choice **(B)**; and erecting temporary housing, choice **(D)**. This leaves choice **(C)** as the correct answer. Nowhere does the author mention medical care being administered to the sick and injured, only that the survivors identified and buried the dead. While it might be true that first-aid was administered, the passage does not say so.

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Passage II (Questions 55–60)

The next passage is about a movement in art history known as Dada, which lasted from about 1917 to 1922. In the opening paragraph, the author states that while most movements—such as Impressionism or Pop-Art—have an easily identifiable theme or style, Dada is harder to pin down. However, the author feels that the common link among most Dada activities was the despair and anger that Dada artists felt over World War I. Their reaction was to strike out against traditional art and bourgeois society.

In the second paragraph, we learn where the Dada movement was founded, how it got its name, and what kind of activities Dadaists participated in. Paragraph 3 describes Dada's anti-art manifesto, and credits French artist Marcel Duchamp with having been an important influence on the theories and techniques of Dada. Paragraph 4 tells you about the activities of two German Dadaists, Max Ernst and Kurt Schwitters. Paragraph 5 details some of the ways in which Dadaists experimented with the elements of chance and accident in creating works of art. The final paragraph chronicles the passing of Dada, and briefly notes some of its lasting contributions to art.

There's nothing too difficult here. The passage is straightforward and well organized, and the concepts are fairly simple. Now, we've said time and time again that most MCAT Verbal Reasoning passages are organized around a main idea, which is usually stated in the first 10–15 lines of the passage. This passage is no exception to that rule. The main idea, expressed in the first several sentences of paragraph 1, is that while most art movements have a distinctive style, Dada did not, but it was nevertheless characterized by the nihilistic response of Dadaists to World War I. Nihilism, as you may have inferred from the passage, is the belief that conditions in a society are so bad that destruction for its own sake is better than any constructive program of repair or reform. And with that in mind, let's take a look at the questions.

55. (D)

The first question in this set asks for the main idea of paragraph 1. As we already discussed in reviewing the structure of the passage, the first paragraph is where the author establishes that, although Dada was unlike

most movements in art history in that it seemed to have no identifiable style or theme, it was nevertheless characterized by and born out of the despair and anger of artists over World War I. This is the gist of the first paragraph, which points to choice **(D)** as the correct answer. Each of the incorrect choices takes a detail from the first paragraph and distorts its significance, to pass as the paragraph's main idea. Choice **(A)** says Dada is unique among art movements in that it has no characteristic theme or style. The author says that *most*, not *all*, other movements have a characteristic theme or style; the author never suggests that Dada is the *only one* without it. Also, choice **(A)** fails to take into account the author's contention that World War I was important in bringing Dada about. Choice **(B)** says the first paragraph's main idea is to tell you the best way to analyze a movement in art history. This one should have been even easier to discard than choice A. It says nothing about Dada or World War I; it's much too generalized and too vague to represent the main idea of the paragraph. And choice **(C)** speculates about what might have happened to traditional European art if World War I had not taken place. Again, here we have a choice that ignores the Dada movement, which is clearly central to the author's main idea. Choice **(C)** may be a plausible statement, but it does not express the central argument of paragraph 1; so, choice **(D)** is the correct answer.

56. (A)

This is an Implied Detail question, and the question stem's reference to Dada's anti-art manifesto should have sent you back to paragraph 3, where that manifesto is discussed. At the top of the paragraph, the author says that according to Dada, art and artists were now free from traditional forms, subjects, and standards. In the second sentence, the author says that "anything could be a work of art, if an artist called it art; at the time, this was a revolutionary concept." Well if this was a revolutionary concept *at the time*, then you can infer that it probably is *not* a revolutionary concept anymore—remember, the Dada movement occurred 70 years ago. This means that choice **(A)** is correct: the author implies that Dada's anything-goes definition of art is no longer considered as revolutionary as it was back in the year 1917. What about the other choices? Choice **(B)** is completely unwarranted. In the passage there is simply no mention or suggestion of an intellectual revolution developing in the decades leading up to Dada. Choice **(C)** puts the cart before the

horse. According to the passage, Dada did not have an influence on the work of Marcel Duchamp; it was Duchamp whose pre-war work had an influence on Dada. If you picked this one, you were probably reading carelessly. Keep a good pace as you move through the passage, but don't rush! Finally, choice **(D)** is similar to correct choice A, but goes too far. The fact that Dada's anti-art manifesto was considered revolutionary *at the time* does not imply that it is now considered totally irrelevant. Be wary of choices that state things in such a definitive way—they are often exaggerations.

57. (C)

This question asks you to correctly name the artist who was a “precursor” of Dada. Since a precursor is someone who comes before and points the way, you're looking for the artist who, before the Dada movement, did work that influenced the Dada movement. The correct answer, choice **(C)**, is taken from the third sentence of paragraph 3, where the author says that “Dada owed a debt to Marcel Duchamp.” As the passage makes clear, the work and revolutionary theories of this French artist had made a scandalous impact on the art world in 1913, three or four years *before* Dada came into being. And not only did Duchamp use nontraditional materials and subjects in his art, but he also proposed theories that enraged conventional thinkers. So, Marcel Duchamp, choice **(C)**, is the correct answer. As for the wrong answers, Hugo Ball, choice **(A)**, was not a precursor but a *founder* of Dada. There is a definite distinction between the words “precursor” and “founder”: a founder is present at the origin of something; a precursor is there *before* the beginning. Kurt Schwitters, choice **(B)**, and Max Ernst, choice **(D)**, are German Dadaists discussed in paragraph 4. Schwitters, like Marcel Duchamp, used found objects in his work. But the author does not say that Schwitters was doing this *before* the Dada movement. Duchamp, on the other hand, is said to have made his groundbreaking sculpture in 1913. So, again, he was the man we were looking for. And Max Ernst, to finish up, was a German Dadaist who excelled at a technique called photomontage. Now the author mentions that Ernst would later become a leading painter of the Surrealist school, so perhaps we can say that his work at the time of the Dada movement made him a precursor of Surrealism. But the question asks for a precursor of the Dada movement.

58. (D)

This question asks you to pick the choice that is *not* mentioned in the passage as a Dada-related artistic activity. Getting the right answer is a matter of simple elimination. Choice **(A)**, poetry, is mentioned as a Dada activity in paragraphs 1, 2, and 5. Two of Dada's founders, Hugo Ball and Tristan Tzara, were poets, and we know that they experimented with simultaneous poetry readings and poems composed by chance. So choice **(A)** is no good. Choice **(B)**, photomontage, is a technique that was used with particular effectiveness by German Dadaist Max Ernst; this is discussed in the first sentence of paragraph 4. So, choice **(B)** is also eliminated. Choice **(C)**, sculpture, is also mentioned in relation to Dada. In paragraph 4, we learn that German Dadaist Kurt Schwitters created sculptures using found objects and rubbish. Choice **(D)**, however, *is* what we're looking for. There is no mention whatsoever in the passage of dance as a Dada-related activity. So, choice **(D)** is the correct answer.

59. (D)

This question asks you to take the main idea of the fifth paragraph and pick the answer choice that would help support it. In order to do so, we have to have a firm handle on what the main idea of paragraph 5 actually is. So let's take a look at it. The main idea of paragraph 5 is stated clearly in its first few lines. Experimentation with the laws of chance in creating works of art was a crucial and original element of Dada. That's the main idea in a nutshell. The remainder of the paragraph merely supports this argument by providing examples of Dadaists taking advantage of accidents and random organization to make drawings and poems. So, getting back to the question, we're looking for the choice that would support the main idea that experimentation with chance was a “fundamental and pioneering aspect of the Dada movement.” Well, if this kind of experimentation was a *pioneering* aspect of Dada, then this implies that *before* Dada, nobody had thought to try it. In other words, the author could have supported the main point of paragraph 5 by arguing that, before Dada, nobody had conducted experiments with chance in art. This is reflected in correct choice **(D)**. As for the wrong answer choices, choice **(A)** suggests that we can support the idea that chance was unique and fundamental to Dada by noting that random elements appear in the works of Surrealist painters. The problem here is that the Surrealist movement came *after* the

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Dada movement. As the author notes in the first sentence of the final paragraph, after 1922 Dada gave way to other schools, notably Surrealism and Abstract Expressionism. So the appearance of random elements in the works of Surrealist painters neither supports nor refutes the author's contention that Dadaists pioneered in experimentation with chance in art. Choice **(B)** directly contradicts the main idea of paragraph 5. The author's argument is that the Dadaists were the *first* artists to deliberately incorporate random elements in creating works of art. If chance has "always" been an important element in artistic creation, then the Dadaists would not have been pioneers. Finally, choice **(C)** suggests that Arp and Tzara, mentioned in the fifth paragraph as exemplary of Dadaists employing the element of chance in art, were defying the conventions adhered to by other Dada artists—which certainly does not support the author's main point; if anything, it weakens it. If Arp and Tzara were alone among Dadaists in this kind of experimentation, chance would not seem to be a fundamental aspect of Dada. So, choice **(C)** is wrong. Once again, then, choice **(D)** is the only answer choice that strengthens the author's argument and is correct.

60. (C)

The last question is an Explicit Detail question. Why does the author mention simultaneous poetry readings accompanied by noise music? What point is being supported? Well, these activities are discussed in paragraph 2, as part of the goings on at the Cabaret Voltaire, known as the birthplace of Dada. Let's take a look at paragraph 2. The author begins by explaining how the name Dada was chosen, and that it meant hobby horse. We learn that Dada founders liked the very childishness of the word, that they considered it fitting for their Dada activities. The author then says that indeed, performances at the Cabaret featured "a significant element of foolery." The remainder of the paragraph describes these performances, of which the simultaneous poetry readings and noise music are one example. So, the author mentions the poetry readings and noise music in order to support the point that activities at the Cabaret Voltaire often invoked the childish spirit inherent in the word Dada. This is restated in correct choice **(C)**. Choice **(A)** is completely off-base. The author never argues that Dadaists no longer considered poetry without music a viable art form. Evidence to the contrary is presented in the final sentences of paragraphs 2 and 5: neither the experiments with collective writing nor Tzara's "chance"

poetry seem to have been done with musical accompaniment. Choice **(B)** is a red herring. The Cabaret Voltaire may have been a center of political satire in Switzerland, but this is not supported by the particular detail regarding simultaneous poetry readings accompanied by noise music. We are not told that the poetry contained any satirical content. Of course, the third sentence of the second paragraph does suggest that political commentary was an element in Cabaret performances, but in the satirical songs that were performed at the Cabaret, not in the poetry accompanied by noise music. And choice **(D)** is too vague to be any help. World War I signalled the beginning of the Dada movement, but the author never says that the war put an end to serious poetry. Presumably, many traditional poets who were not part of the Dada movement continued to write their poetry during and after the war.

Passage III (Questions 61–67)

As this next passage makes clear in its very first sentence, it is about the unusual struggle between tarantula spiders and digger wasps. The passage is organized in a very straightforward way. The first paragraph explains why the conflict is so unusual; the second and third paragraphs provide background information on tarantulas and digger wasps; and the fourth, fifth, and sixth paragraphs describe the actual struggle between these adversaries and the results of that struggle.

The first paragraph asserts that the struggle between tarantulas and digger wasps is unusual because the outcome is always the same: the wasp always defeats the spider in a battle in which the spider doesn't appear to even attempt to defend itself until it's too late. The second and third paragraphs briefly discuss the characteristics of tarantulas and digger wasps, respectively. In the second paragraph we're told that, because the tarantula is a nocturnal creature which spends most of its time underground, its senses of sight and sound are very poor. On the other hand, here we are also told that the tarantula's sense of touch is extremely acute, with the last half of this paragraph describing its reaction to various forms of physical contact. The third paragraph describes the digger wasp. There the author asserts that, although male digger wasps are vicious and fearsome predators, the real

threat to tarantulas comes from pregnant female digger wasps whose eggs must be nourished by the bodies of paralyzed tarantulas. The fourth, fifth, and sixth paragraphs sketch the sequence of events in the struggle between tarantulas and female digger wasps and describe the results of that struggle. The fourth paragraph states that female digger wasps lay only a few eggs and describes their search for the tarantulas necessary to sustain those eggs. There, we are also told that female wasps must find the correct species of tarantula for their eggs. When female wasps find the correct tarantula, according to the last sentence of this paragraph, they move off to dig its grave. The fifth paragraph describes the actual confrontation of tarantula and wasp, informing us that the wasp is always able to pin the spider in such a way that the spider's soft underbelly is exposed to the wasp's poisonous stinger, leading to the spider's inevitable paralysis. Finally, the sixth—and final—paragraph discusses the aftermath of the battle. The wasp drops the paralyzed tarantula into the grave, fastens her egg to the spider's stomach, and fills in the grave, providing her offspring with all the nourishment and protection it needs to reach adulthood.

Even though this is a fairly simple, descriptive passage, it contains many details. Remember, don't try to memorize all of the details in a passage; just get a feel for where details are located by getting a sense of the passage's structure. This will allow you to quickly relocate any details you may need to answer the questions. With that in mind, let's move on to the questions.

61. (D)

This is an Inference question concerning male digger wasps. Remember that it is the female, not the male wasp that is the main concern of this passage. But male digger wasps are mentioned briefly in the last sentence of the third paragraph, so look there for the information necessary to answer this question. In this sentence we're told that, although male digger wasps are vicious and dangerous predators, pregnant female digger wasps pose the real threat to tarantulas. The implication of this statement is that male digger wasps don't pose much of a threat to tarantulas, so choice **(D)** is the correct answer to this question. The fact that the last sentence of the third paragraph refers to male digger wasps as agile and dangerous predators strongly suggests that they have the ability to kill tarantulas when necessary,

so you should not have inferred choice **(A)**. Choices **(B)** and **(C)** are incorrect inferences because they both apply to pregnant female digger wasps, not males. In the last sentence of the fifth paragraph we are told that it is actually the pregnant female wasp that paralyzes tarantulas by thrusting her poisonous stinger into the tarantula's belly, making choice **(B)** wrong. And, information contained at the end of the fifth paragraph suggests that each female digger wasp preys on a particular species of tarantula, making choice **(C)** also incorrect in relation to male digger wasps.

62. (B)

This is a Scattered Detail question regarding the behavior of digger wasps. It is "scattered" in the sense that the question stem doesn't give you any information about a particular aspect of digger wasp behavior, meaning that you may have to scan paragraphs 3–6 where various aspects of digger wasp behavior are discussed. The best way to tackle a question of this sort is to go through the answer choices one by one to determine which aspect of digger wasp behavior is *not* explicitly discussed in the passage. Of course, if you are lucky, one of the answer choices might just jump out at you as something that was not discussed in the passage. At any rate, on to the choices now. The first sentence of the fourth paragraph states that pregnant female digger wasps lay one egg every few days for a week or two, so their schedule of egg laying is discussed in the passage and choice **(A)** does not answer this question. Nowhere in the passage is anything stated or suggested about the methods digger wasps use to defend themselves from predators, so their system of self-defense, choice **(B)**, is *not* discussed in the passage. This choice may have jumped out at you, or maybe you had to think about it. At any rate, it is the correct answer to this question. Just to be thorough let's check the last two choices, in case you didn't choose choice **(B)**, and verify that they are indeed discussed in the passage. The last two sentences of the sixth paragraph assert that after paralyzing a tarantula, the pregnant female digger wasp drags it to the bottom of a grave, attaches an egg to the spider's stomach, and fills in the grave, providing the egg with the nourishment and protection necessary to reach adulthood. In other words, the passage discusses in some detail precisely how digger wasps nurture their larvae, thus making choice **(C)** wrong. And, the last sentence of the fifth paragraph tells us that a female digger wasp paralyzes a tarantula by thrusting

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its poisonous stinger into the spider's belly. Therefore, the digger wasp's means of paralyzing a tarantula is discussed in the passage, making choice **(D)** incorrect. Again, choice **(B)** is the correct response.

63. (C)

This is an Inference question regarding the author's characterization of the struggle between the tarantula and the digger wasp as "unusual." So, why does the author consider this struggle so unusual? The author's perspective on this point is expressed in the first paragraph of the passage. In the second sentence of the first paragraph, the author states that this struggle is unusual because of its outcome: the digger wasp always defeats the mighty tarantula spider, choice **(C)**. So choice **(C)** is our answer. Choice **(A)** is clearly a false statement. According to information at the end of the fifth paragraph and the beginning of the sixth, the female digger wasp paralyzes, but does not kill, the tarantula before burying it; so, choice **(A)** is wrong. While choices **(B)** and **(D)** are true statements, neither is a reason the author considers the struggle between tarantula and digger wasp particularly unusual. The last half of the sixth paragraph asserts that female wasps use tarantulas to nourish their offspring, but nowhere does the author express the sentiment that this is unusual behavior in the insect world. Moreover, it is not the reason the author identifies in the second sentence of the first paragraph as the reason he considers the struggle unusual. So, choice **(B)** is wrong. And the last sentence of the fifth paragraph reveals that wasps subdue, but do not kill, tarantulas. But, again, the author gives no indication that this behavior is unusual in the insect world, and it is not the reason he specifies in the first paragraph as his reason for finding the struggle peculiar.

64. (D)

This is another Detail question, this time in Roman numeral format. In the second sentence of the sixth paragraph we're told that, after the female wasp drags the paralyzed tarantula to the bottom of the grave, she lays her egg, attaches it to the spider's stomach, and fills in the grave. In other words, the wasp larvae do indeed mature underground, making statement I a true statement. Since statement I is true, we can eliminate choice **(B)**, III only, leaving us to concentrate on choices **(A)**, **(C)**, and **(D)**. On to statement II. The last sentence of the fifth paragraph plainly states that it is the female digger wasp that paralyzes the tarantula. And the second

sentence of the sixth paragraph plainly states that the female wasp attaches its egg to the tarantula's stomach after the spider has been paralyzed. So, statement II is a false statement. It is the pregnant mother wasp, not the larva, that paralyzes the tarantula. Knowing that II is false, we can then eliminate choice **(C)** and concentrate on choices **(A)** and **(D)**. To choose between them, we must consider whether or not Statement III is true of wasp larvae. The last paragraph of the passage suggests that once the egg is attached to the tarantula's stomach and the grave is filled in, the wasp larva has all of the nourishment it requires. This implies that one tarantula is all the larva has or needs for its nourishment, making statement III a true statement. Since both statements I and III are true while statement II is not, the correct answer is choice **(D)**.

65. (A)

This is an Inference question, inquiring this time about the characteristic of female digger wasps that allows them to consistently overcome tarantulas. The actual battle between female digger wasps and tarantulas is discussed in the fifth paragraph. The fourth sentence of that paragraph states that, at a certain point in the battle, the female wasp is able to carefully maneuver so as to pin the tarantula, and does so in such a way that the tarantula's soft underbelly is exposed to the wasp's poisonous stinger. Once this occurs, the wasp simply stings the tarantula into paralysis. On the basis of this description, it is reasonable to infer that the wasp always wins because of its agile maneuverings, so we can conclude that the wasp is more agile, choice **(A)**. The passage neither states nor suggests that the female wasp is more vicious, choice **(B)**. It's the male digger wasp that is described as "vicious" in the third sentence of the third paragraph of the passage, so **(B)** is wrong. Nothing is said about the strength of the female wasp and the fact that its agile maneuverings are emphasized in the description of its aggression suggests that strength is not the key to its success, making choice **(C)** wrong too. And there's nothing in the passage about the intelligence of either of these insects, so there's no basis for choosing choice **(D)**. Again, the fact that the careful maneuverings of the wasps are emphasized suggests that its success must be credited to agility and not intelligence.

66. (B)

This is an Inference question concerning a hungry tarantula's behavior when its body is touched. The tarantula is the main subject of the second paragraph of the passage. The tarantula's reaction to various kinds of contact is described in the last half of that paragraph. Toward the end of that paragraph we learn that tarantulas move off a short distance when their bodies are touched; they make no aggressive moves as a result of this type of physical contact. As the passage says, "If their bodies are touched, they move off a short distance at a leisurely pace; no threatening behavior is elicited by this kind of contact." Note that this appears to be true whether or not they are hungry, as long as only the tarantula's body is touched. The seventh and eighth sentences state that the tarantula's body hairs have to be touched in order for it to attack, even when it's hungry. Therefore, if a cricket touched the body of a hungry tarantula it would not be molested in any way, choice **(B)**; the tarantula would back off. As mentioned just a moment ago, for a hungry tarantula to kill and consume a cricket it would be necessary for the cricket to touch the tarantula's sensitive body hairs, not its body, so choice **(A)** is wrong. And, the passage neither states nor suggests that any type of contact would cause a tarantula to sting and bury a cricket underground, choice **(C)**. This choice confuses the attack behavior of the female digger wasp with that of tarantulas. "Stalked and ambushed," choice **(D)**, simply comes out of the blue. Nothing in the passage suggests such behavior would be characteristic of the tarantula. On the contrary, the second half of the second paragraph suggests that tarantulas attack quickly and, therefore, probably do not stalk and ambush, but simply strike. Again, choice **(B)** is the correct response.

67. (C)

The last question in this set is a Detail question asking about the sequence of events followed by the female digger wasp in her attack on the tarantula. The sequence she follows is described in paragraphs 4–6, so scan these paragraphs for the correct order of events. According to the last sentence of the fourth paragraph, the first action taken by a pregnant female wasp after locating the correct species of tarantula is to move off and dig a grave for the spider. Her next step, described in the first sentence of the fifth paragraph, is to reexamine the tarantula in order to confirm that it is indeed of the correct species. Then, according to this

same paragraph, the female wasp paralyzes the tarantula. According to the sixth paragraph, after paralyzing the tarantula, the wasp drags the spider to the bottom of the grave, attaches its egg to the spider, and fills in the grave. Thus the correct answer to this question is choice **(C)**, the one choice that states these events in correct order. All of the other choices, therefore, are logically eliminated. When you take a closer look at the other choices, you might realize that choice **(A)** is wrong in suggesting that the wasp reexamines the spider after it has paralyzed it. That's wrong. The wasp double-checks, or reexamines, the spider before it decides whether or not to sting and paralyze it. Choice **(B)** is wrong in suggesting that the wasp paralyzes the spider, then digs its grave, and then reexamines it. In fact, as we learn from the end of the fourth paragraph and beginning of the fifth, the wasp digs the grave first, then reexamines the spider and then decides whether or not to sting, and thereby, paralyze the spider. Finally, choice **(D)** is wrong in suggesting that the wasp first paralyzes, then reexamines the spider, and then digs its grave.

Passage IV (Questions 68–74)

Medieval stained glass is a subject that you probably don't know much about and which almost certainly interests you even less, but at least the passage is fairly short. The first paragraph introduces the main topic: threats to the continued existence of stained-glass windows. The second paragraph expands on this theme, telling us that extreme weather and human behavior have historically been the major threats to the windows. We are also told that today air pollution has become the gravest threat to the windows. The third paragraph tells us a little about how stained-glass windows are constructed and how air pollution affects them, by trapping moisture against the glass and by serving as a corrosive force, leading to gradual decomposition. The fourth paragraph tells us that efforts have been made over the centuries to safeguard and restore the windows, but that these efforts generally have been ineffective. Now, though, one reasonably effective preservation method exists—double glazing. This paragraph then describes double glazing in detail, including how it works and what its limitations are. The final paragraph briefly discusses an even better solution to window decomposition, climate control, but notes that this solution is too expensive to

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be practical, so double glazing remains the best solution at the moment. Now, on to the questions.

68. (B)

This question deals with the primary purpose of the passage. As with most passages, the main point of this passage is conveyed in its first few sentences. The short first paragraph of this passage, particularly its last two sentences, should have led you directly to choosing the answer having to do with threats to the windows, choice **(B)**. While the passage describes the construction of stained-glass windows, choice **(A)**, and considers the advantages and disadvantages of double glazing, choice **(D)**, these are secondary issues which are introduced in order to expand on the topic of threats to stained-glass windows. As for choice **(C)**—well, the author does say that the windows have been known for their spectacular beauty, but that hardly amounts to critiquing the value of stained-glass windows as an art form; so, choice **(C)** is incorrect.

69. (B)

This is an Application question, asking you to apply the knowledge you gained from the passage to a problem. In this case, the problem involves determining what type of individual most likely wrote this passage. Of the types of professions listed, an art historian would be most likely to write about the stained-glass window art form and threats to its continued existence, so choice **(B)** is our answer here. Choice **(A)**, an architect, choice **(C)**, an engineer, and choice **(D)**, a chemist, can all be eliminated on the grounds that the passage is not particularly technical. There is not enough detail regarding the design of cathedrals and windows for an architect to have been a likely writer, not enough detail regarding the chemical processes of decomposition for a chemist, and not enough detail regarding the construction of the windows for an engineer. Nor is it likely that architects, chemists, or engineers would have detailed knowledge of the history of windows and threats to their future.

70. (C)

This is a Detail question about the deterioration of the windows. Choice **(A)** suggests that the deterioration is due to poor construction and craftsmanship. Well, the first sentence of the third paragraph does say that the “delicate construction of stained-glass windows explains their vulnerability,” but in doing so—and in

going on to discuss the meticulous handiwork that goes into making these windows—hardly implies that careless construction is responsible for their deterioration. Delicate construction and meticulous craftsmanship can account for vulnerability without being responsible for deterioration. Choice **(B)** is wrong for two reasons. First, window decomposition has not been eradicated and, second, climate control is not in widespread use. The last paragraph makes these points. The last paragraph of the passage says that it’s too expensive for that. Choice **(C)** suggests that the deterioration of windows has been lessened through the use of double glazing. Double glazing is discussed in the fourth paragraph, where it is referred to as a relatively effective means of preserving stained-glass windows. So choice **(C)** is consistent with the content of this passage and looks like a good answer choice. But to be thorough, let’s consider the remaining choices as well. Choice **(D)** directly contradicts information contained in the passage; the last sentence of the fourth paragraph tells us that the heating of cathedrals has contributed to the damage of stained-glass windows. Again, only choice **(C)** is consistent with this passage and is the correct answer.

71. (D)

This is an Implied Detail question involving double glazing. Choice **(A)** is wrong because double glazing prevents moisture damage only from the exterior environment. The last sentence of the fourth paragraph tells us that double glazing does not alleviate the problem of condensation, so damage caused by moisture remains a problem. Choice **(B)** refers to a detail mentioned in the fifth paragraph in relation to climate control, not double glazing, so it is also incorrect. Choice **(C)** also refers to a detail mentioned in relation to climate control, not double glazing, so it’s wrong, too. Choice **(D)**, however, looks good. It is implied by information in the fourth paragraph. The fourth sentence of this paragraph tells us that while double glazing protects the windows from external threats, it does not protect the windows against threats from within cathedrals. From that, we can conclude that double glazing is only partially effective and **(D)** is correct.

72. (B)

This is a question regarding the tone of the passage. It’s fairly evident from the passage that the author is concerned about the windows and their continued

existence. The author refers to their spectacular beauty in the very first sentence of the passage. Later, in the second sentence of the fourth paragraph, the author begins by saying that “fortunately” a relatively effective means of preserving the windows has been found in the double glazing method. And in the last sentence the author is apparently hoping for a practical solution to the deterioration of the windows. If you missed these clues to the author’s attitude, you still should have been able to arrive at correct choice **(B)**, approving, by eliminating the other four choices. The tone of the passage would hardly indicate that the author is disinterested, choice **(A)**. On the contrary, he seems concerned. And the author does not seem cynical, choice **(C)**, or bitter, choice **(D)**, even over the fact that no fully satisfactory and practical means of preserving the windows has been found yet. In the last paragraph, the author continued to hope for better—that doesn’t sound cynical or bitter.

73. (D)

This is a Detail question. In the last half of the third paragraph we are told that air pollutants affect stained-glass windows in two ways: 1) They serve as corrosive elements, wearing away or obscuring detail; and 2) they form a crust on the windows which traps moisture against those windows. Thus the correct answer to this question is choice **(D)**, air pollutants contribute to the decomposition of stained-glass windows by trapping moisture against the windows. As for the wrong choices, choice **(A)** is wrong because the passage tells us nothing specific about how air pollutants affect the comes—those thin strips of lead which hold the pieces of colored glass in place; it simply tells us about the function they perform. And there is nothing in the passage about pollution trapping pockets of air around the windows, so choice **(B)** is wrong. Although severe weather is mentioned in the passage as a grave threat to stained-glass windows, poor weather conditions are not caused by air pollution, so choice **(C)** is wrong.

74. (D)

This is an Inference question. The question stem is quite general—it doesn’t lead you to any particular part of the passage with key words or any other hints. The best way to go about answering this kind of question is to simply go down the list of answer choices, considering the merits of each and looking for one that is consistent with the content and tone of the passage. The passage says nothing to imply that the popularity of stained-glass

windows as an art form is waning, so we cannot infer that people are becoming less interested in them and choice **(A)** is incorrect. Choice **(B)** directly contradicts information contained in the passage. On the contrary to declining, threats to stained-glass windows are increasing. The last sentence of the first paragraph makes that quite clear in saying that today the windows face greater stresses than ever before; so, **(B)** is wrong. And the passage gives us no information about any method for restoring the grisaille, so nothing can be inferred about it; thus choice **(C)** is also wrong. The final paragraph explicitly states that climate control would halt decomposition, but that it is currently not viable on financial grounds. The last paragraph also tells us that the best we can hope for is to retard the process of window decomposition and implies that double glazing is the best method for accomplishing that task. So, choice **(D)** is the correct answer.

Passage V (Questions 75–82)

The next passage is about the star classification system devised by Walter Baade. The first paragraph serves as introduction to Baade and his idea of star classification. The second and third paragraphs describe Baade’s categories of “Population I” (blue, hot stars) and “Population II” (red, and relatively cool stars—much less bright than Population I stars). Paragraphs 4 and 5 provide the evidence for Baade’s classification—that is, they support his hypothesis—based on the distribution and chemical composition of red giants. The final paragraph serves as conclusion and update—telling us that while Baade’s basic insights still hold credibility, more recently spectrographic analysis has led to the discovery of greater variation among stars and has encouraged astronomers to reclassify stars—this time into five different populations. The passage concludes by suggesting that all of these classifications have evolved for the sake of the convenience of those who study them.

75. (B)

This question asks about the primary purpose of the passage. So the answer choice you’re looking for should be generous enough to include all of the categories of information provided in the passage. This consideration eliminates choice **(A)**, determining the age of stars, and choice **(C)**, differentiating between Populations I and II, both of which refer to one aspect of the passage’s purpose, but are too narrow to function as primary. **(D)** is

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inaccurate; the theories presented do *not* contradict each other and cannot be described as competing. But **(B)** is a solid choice. All the information in the passage relates to Baade's system of stellar classification and the author presents supporting evidence in paragraphs 4 and 5.

76. (C)

You're asked to look for the *exception*, the one that is *not* characteristic of Population I stars. Choice **(C)** should have jumped out at you as characteristic of Population II, not Population I stars. Paragraph 2 explicitly states Population I stars occurred in the arms of spiral galaxies, while Population II stars were most common between the arms. Since **(C)** is *not* true of Population I stars, it is the correct choice. Choice **(A)** is supported as a characteristic of Population I stars by the statement in paragraph 3, that according to Baade, Population 1 stars are probably very young. And choices **(B)** and **(D)** are supported by the first two sentences of paragraph 2.

77. (D)

The second sentence of the third paragraph tells us that the rate at which a star consumes its nuclear fuel is directly proportional to its brightness. So with masses being equal, we can conclude that the star which is brighter will use up its fuel first, making choice **(D)** the correct answer. Choice **(A)** ignores the proportionality between brightness and rate of consumption. **(B)** contradicts the premise that both stars have the same mass—you should infer that more fuel means more mass. Choice **(C)** is an incorrect inference from paragraph 2. The fact that the brightest Population I stars are far brighter than any Population II stars, does *not* mean that the brighter *must* be in Population I.

78. (A)

This question presents a paraphrase of the information given in the second and third sentences of the fourth paragraph. Only choice **(A)** presents the correct occurrence: when the helium core amounts to about one-tenth of a star's mass, the star will expand and its outer layer will cool. Choices **(B)**, **(C)**, and **(D)** are ruled out by the start of the next sentence which tells you that the star has now become a red giant. The fact that the red giant phase may last many millions of years makes **(B)** a poor inference, while **(C)** and **(D)** refer to events following this long period.

79. (B)

Since we know that both Populations I and II contain red giants, statement I must be incorrect. The definition of a giant includes the idea of a cooler surface—remember the discussion of question 78 a moment ago. So, statement II must be correct. In paragraph 4 we are told that a star becomes a red giant when the star becomes unstable and expands, ruling out statement III. Only statement II, then, is correct, making choice **(B)** the correct answer.

80. (D)

In this question, you're asked to identify the statement for which the passage does *not* provide support. That is, you are asked to find the exception. Sentence 4 of paragraph 4 and sentence 3 of paragraph 5 provide the information paraphrased in choice **(A)**. **(B)** is a paraphrase of sentence one in paragraph 5. The idea that Population II stars are older than Population I stars, choice **(C)**, is set up in the third paragraph and reiterated throughout the passage. Choice **(D)**, however, is contradicted by the last paragraph. While astronomers still accept Baade's basic insight, they today classify stars into *five* groups, not two, so **(D)** is the exception, and is correct.

81. (D)

The fourth sentence of paragraph 5 clearly states that the dust and gas out of which new stars are produced is becoming ever richer in heavier elements. Choice **(D)** is directly inferable from that. Choice **(A)** is illogical because the present Population I contains what are thought to be very young stars. **(B)** and **(C)** are wrong because the passage supports only the idea that *some* young stars, not *all*, are very hot and massive. Remember, the fact that they are made from heavier elements does not imply that have a greater total mass. Again, the correct answer is choice **(D)**.

82. (D)

This question asks you to identify a statement that seems like an assertion the author would probably make. Since the passage offers no evidence as to whether it's easy to place a star into one of the five populations, there's *no* support for choice **(A)**. The word "rejected" in choice **(B)** suggests a wholesale repudiation. This is contradicted by the first sentence of paragraph 6, which states that while the details of his system may have been altered, Baade's basic insights

has been sustained. As for choice **(C)**, nowhere does the passage suggest that the spiral arms of the galaxy will eventually have no interstellar dust and the assertion can be discounted on the basis of information provided by the author. If every star is eventually going to explode, scattering its elements in the form of dust and gas, then there will *always* be plenty of dust in the galaxies. On now to choice **(D)**. Remember that the very last sentence of the passage suggest that both systems of stellar classification were largely a matters of convenience. It's a logical inference that, if the systems are most important because their classes are convenient, their primary utility is in facilitating the study of stars. So choice **(D)** is correct.

Passage VI (Questions 83–90)

Next up is a short passage about the culture of the Gullah communities on the Sea Islands off the southeast coast of the United States. The first paragraph introduces Gullah culture as a mix of African and American elements and suggests that recent developments in tourism and commercialism have affected the culture, bringing in influences that have changed the unique and formerly isolated Gullah. The second paragraph is all about Gullah family and kinship structures, all based on the extended family, as in West Africa. The third paragraph details Gullah religious practices which show the contrasting influences of both West African and Southern American elements. With that very basic structure in mind, let's go on to the questions.

83. (C)

The question asks for the best title for the passage, which is simply another way of getting at the central thrust and the main idea of the passage. The second and third sentences of paragraph 1 indicate that the unique identity of Gullah culture are attributable to the combined influences of African and American elements. Remember also that paragraph 2 explores African influences on social practices; paragraph 3 considers both African and American aspects of religious beliefs and practices. Thus, choice **(C)** sums up the author's focus and is correct. Choice **(A)** focuses on a topic discussed only in part of paragraph 3, so it's too specific to be the title for the passage as a whole. **(B)** makes a claim the author doesn't advance—"Heir's Land" is discussed only as one aspect of Gullah

culture, not the *key* to it. In the same way as **(A)**, **(D)** takes up a topic mentioned only in paragraph 2, where it is discussed in relation to the broader question of the mix of cultural influences.

84. (B)

This question asks you to identify the one choice that is *not* an element of the unique Gullah culture. The first sentence of paragraph 1 says that the Gullah retained a unique identity before the recent encroachments of tourism and commercialism. And the last sentence of the paragraph adds that the Gullah heritage was able to sustain their culture, at least until recently. So, we do not know if Gullah culture will withstand this new threat. At any rate, we cannot speak of successful resistance, choice **(B)**. The other choices are inferable from paragraph 1. Choice **(C)** is stated in the first sentence; Choice **(A)** paraphrases the reference to the Gullah as "an almost exclusively Black community" in sentence 2. And choice **(D)** is inferable from the statement in sentence 2 that the Gullah preserved African traditions. Again, choice **(B)** is correct.

85. (D)

This question also asks for the exception. Here, you want the choice that is *not* an indicator of African influences on Gullah culture. Paragraph 3 is built on a contrast between elements of Gullah religion that bespeak an American heritage and those that are African in origin. Immediately following the statement that Gullah religious practices at least superficially reflect an American heritage, the author cites the role of Baptist and Methodist churches as essentially social institutions. Inferably, then, the social role of the churches is an American and not an African element of the culture, pointing to choice **(D)** as the correct answer. The other choices are all African elements in Gullah culture. The first sentence of paragraph 2 offers the extended family, choice **(A)**, as an example of West African influence on Gullah social life. In paragraph 3, we are told that the Gullah conception of the body spirit is similar to West African belief, so that takes care of choice **(B)**. As for choice **(C)**, we are told in paragraph 3 that membership in the extended family, itself an African element, affects property rights—the system of "heir's land" is cited as an example. While it's not clear that heir's land itself existed in Africa, the method of acquiring land has been indirectly influenced by the African institution of the African extended family.

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86. (C)

Remember that the author states in the second paragraph on kinship structures that heir's land is a way for family members to acquire land through an unwritten contract without paying for it. Any contract is by nature an agreement, and since this kind of agreement is not on paper, it follows logically that it is orally communicated. So, choice (C) is correct. Choice (A) is way off the mark. The only government grant referred to is the original grant of the Sea Islands after the Civil War. It's not implied that this said anything about land tenure or individual acquisition of land. Choice (B) links heir's land, which operates *within* families, to marriage agreements *between* families. But it is never suggested that heir's land has anything to do with marriage. The fact that heir's land is defined as an unwritten contract eliminates choice (D).

87. (D)

This is an Application question. You must choose the social experience that most resembles one a Sea Islander might have. The second sentence of the paragraph states the importance of family ties and illustrates this by discussing how family members can acquire land through these ties. This is similar to acquiring a job or any other benefit through family connections, making choice (D) correct. Note that you needn't find evidence that the Sea Islanders get jobs this way; the point is that choice (D) is similar *logically* to an experience of the Sea Islanders, not that they might have this exact experience. Choice (A) is off primarily because of the reference to court supervision. The only reference to property, in sentences 3 and 4 of paragraph 2, emphasizes exchanges within the family with no such supervision. More generally, courts and other government institutions are not mentioned anywhere in the passage. Choice (B) is certainly not like anything in traditional Gullah life. It might be like and experience of the Gullah since the encroachments of tourism and commercialization, except that we are never told what these encroachments have been. Choice (C) relates to the importance of family units, but it is the extended family that is important to the Gullah, whereas choice (C) involves unrelated adults.

88. (A)

The question asks for the author's attitude towards the Gullah. The author is relatively objective but still favorable to the Gullah culture, calling it "unique" and

"vital" and its heritage "strong." This makes the positive but restrained terms in choice (A) accurate. Choice (B) describes a hesitant, wavering approach, one that would be characterized by mixed feelings or conflicting ideas. This simply does not fit the author's approach. Given the relative objectivity just mentioned, detached in choice (C) is not too far off, but quizzical, puzzled or bemused is totally inappropriate. As for choice (D), the author is *not* outraged, morally or any other way.

89. (D)

To answer this question, you have to remember that Jones-Jackson's views on the African influences on Gullah religious services appear in quotes in the final paragraph. The classical, Ciceronian rhetorical style and Sophistic ornaments—elements of the Gullah services, inspire the congregation to make raucous and joyous replies. Choice (D) focuses on this latter aspect and is thus correct. Choice (A) seemingly misinterprets the meaning of classical style, which refers to stylistic elements of the prayers and sermons, not to any type of music, which is never mentioned. Choice (B) mistakes Africa as an influence on Gullah services for Africa as a topic of the sermons—sermon topics are never mentioned. (C) refers to a detail mentioned in paragraph 2—it is not clear what, if anything, this has to do with religious services.

90. (C)

You have to identify the question that the passage *does* answer. The third and fourth sentences of paragraph 3 specify at least one element of Gullah religious beliefs that mirror African beliefs and inferably reflect and African influence—the belief in a body spirit. Hence the question in choice (C) can be answered. It's the only one that can be answered. The ways in which African traditions have been passed down, choice (A), are never specified. We simply know that they *have* been. Social ranking, choice (B), is never mentioned at all. Finally, choice (D) brings up something totally outside the passage. Mainland black culture is mentioned only glancingly in paragraph 1, referring to the period before the Civil War. And mainland Black culture today is never mentioned at all. You may have your *own* information or assumptions about this question, but remember, you can't bring them into the passage. You have to answer the question based on what the *author* says.

BIOLOGICAL SCIENCES EXPLANATIONS

Passage I (Questions 91–95)

91. (B)

You are asked to choose the answer that most accurately describes the cells of the medullary thick ascending limb of the loop of Henle. Now, if you know histology, this question probably isn't so difficult; but chances are histology is not your thing. However, the correct answer can most definitely be derived from the information in the passage and your outside knowledge. Looking at the answer choices, we see that they work around two cellular characteristics: the permeability of the plasma membrane, and the quantity of mitochondria. Well, the membrane of any cell in the nephron must be selectively permeable because the function of the nephron is to maintain an osmolarity gradient. This, by definition, can only be achieved with a selectively permeable membrane, which means that only certain ions and small solutes are able to freely cross the membrane. Based on this, choices (C) and (D) must be incorrect. Now you must decide between choices (A) and (B), and this requires you to decide whether mTALH cells have few or numerous mitochondria. This is the kind of detail that you *would* know from histology. But if you read the passage carefully, you'll find all you need to come up with the right answer. You're told that the cells of the mTALH are rich in Na⁺-K⁺ ATPase. An ATPase is an enzyme that degrades ATP into either ADP or AMP. The only reason for a cell to have a lot of ATPase is if the cell has a lot of ATP. And a cell would have a lot of ATP only if it had a lot of mitochondria, which are the organelles responsible for the majority of ATP synthesis in eukaryotic cells. Therefore, mTALH cells would be expected to have numerous mitochondria, in addition to having selectively permeable membrane. Thus choice (B) is the correct answer.

92. (A)

The first bit of useful information given to you in the question stem is that the role of Na⁺-K⁺ ATPase in renal cells is similar to its role in the neuron. So, let's talk a bit about what goes on inside a neuron. The interior of the neuron has a resting potential that is negative relative to its exterior; that is, the interior of the neuron is polarized. Depolarization of the neuron

results from the influx of positive sodium ions from the extracellular space into the intracellular space of the neuron. Once the potential reaches a threshold level, an action potential is triggered, followed by a repolarization period characterized by the movement of potassium ions out of the neuron. By the end of an action potential, the negative resting potential is re-established, but sodium is now inside the neuron, and potassium is now outside the neuron. The job of Na⁺-K⁺ ATPase is to transport three sodium ions out of the neuron for two potassium ions it transports into the neuron, thereby returning ion concentrations to resting levels.

OK, getting back to the question. . . . You're asked what would happen to the renal cells of a lab rat that was continually receiving ouabain. So even though there was key information in the question stem, and even though you needed outside knowledge regarding neurons, you still needed to import a piece of information from the passage—namely, that ouabain is an ATPase inhibitor. If the function of Na⁺-K⁺ ATPase is to pump sodium from inside the cell to the outside, then the continuous administration of ouabain would result in an increase in intracellular sodium concentration in renal cells. Therefore, choice (A) is correct and choice (B) is wrong. Choices (C) and (D) are wrong because ouabain would result in a *decrease*, not an *increase*, or no change, in intracellular K⁺ concentration. We would, however, expect a buildup of *extracellular* K⁺, but that's not one of the answer choices.

93. (B)

Experiment 1 is essentially designed to test the effect of arachidonic acid and its metabolites on isolated mTALH cells. According to the information given in the passage, cytochrome-dependent metabolic products of arachidonic acid affect Na⁺-K⁺ ATPase activity. Experiment 1 will clue us in as to how arachidonic acid metabolites affect Na⁺-K⁺ ATPase activity. In the first step of the experiment, arachidonic acid is added to isolated mTALH cells containing cytochrome. Since the metabolism of arachidonic acid is dependent on the cytochrome pathway, and these cells do contain cytochrome, AA is degraded to its metabolites. The effect of these metabolites is the inhibition of Cl⁻ uptake. The second step of the experiment is a simple control, in which cytochrome-depleted cells are used. In other words, we want to see what happens to Cl⁻ uptake when AA *cannot* be degraded into its

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metabolites. The result is that Cl^- uptake was *not* inhibited, which is what you would expect if the AA metabolites were the substances responsible for regulating the ATPase activity. In the third step, AA metabolites are added to isolated cells containing cytochrome and depleted of cytochrome. As expected, the metabolites inhibit uptake in both instances: the fact cytochrome is absent in some of the cells is irrelevant, since we're adding the AA metabolites directly to the cells. We don't have to rely on the cytochrome to metabolize the AA. To sum up, the first steps of Experiment 1 confirm that the production of AA metabolites is dependent on the cytochrome pathway. The third step of the experiment confirms that it is the metabolites of AA, not AA itself, that effect on $\text{Na}^+\text{-K}^+$ ATPase activity. Therefore, choice **(B)** is the correct answer, as it summarizes what was just said. Now let's examine the other answer choices. Choice **(A)** is incorrect because, as just discussed, it is not the cytochrome-dependent pathway itself that directly regulates $\text{Na}^+\text{-K}^+$ ATPase activity, but rather the end products it produces via the metabolism of AA. Choice **(C)** is incorrect, since Experiment 1 showed us that for AA to exert its normal effect on Cl^- uptake, cytochrome must be *present*, not absent, in the cell, since it is the AA metabolites, not arachidonic acid itself, that inhibits Cl^- uptake. Choice **(D)** is wrong, because the results of Experiment 1 show that AA metabolites inhibit Cl^- uptake in both cytochrome-containing and cytochrome-depleted mTALH cells.

94. (D)

In Experiment 2, we are told that ETYA is a competitive inhibitor of all AA metabolic pathways. As soon as you hear the term competitive inhibitor, you should already be thinking of an agent that inhibits a pathway by competing with the normal reactant molecules for binding sites in that pathway. ETYA molecules compete with AA molecules and their intermediates for binding sites in the cytochrome pathway. This means that less AA will be metabolized, if any AA is metabolized at all, which depends on how strong a competitor ETYA actually is. This also means that the uptake of Cl^- will most likely be *less* inhibited than when AA alone is added to the isolated mTALH cells. Choice **(D)** is the only one that mentions the occupation of binding sites in the cytochrome pathway as the reason for the effect on Cl^- uptake produced by the addition of ETYA. Choice **(D)**, therefore, is the correct answer. Choice **(A)** is incorrect, since there is no indication that ETYA inhibits $\text{Na}^+\text{-K}^+$

ATPase. Even though uptake of Cl^- was inhibited when ETYA was added in Experiment 2, this is not because ETYA inhibited the $\text{Na}^+\text{-K}^+$ ATPase. As said before, if anything, the addition of ETYA resulted in a situation where the uptake of Cl^- was less inhibited. Choice **(B)** is like choice **(A)** in that there is no reason or indication for you to conclude that ETYA brings about the degradation of arachidonic acid. Finally, choice **(C)** is incorrect because according to the design of Experiment 2, ETYA is a competitive inhibitor of arachidonic acid metabolic pathways, meaning that it occupies binding sites in these pathways; it does *not* occupy ouabain binding sites.

95. (B)

The question asks you to identify which of the answer choices does *not* suggest that AA must be metabolized to inhibit Cl^- uptake. Choice **(A)** reads "the effect of cytochrome depletion in Experiment 1." Well, the results of Experiment 1 indicate that cytochrome is necessary for AA to be degraded to its metabolites, and that it's the metabolites, and not AA itself, that inhibit Cl^- uptake. Therefore, choice **(A)** is wrong, since the effects of Experiment 1 *do* suggest that AA must be metabolized. Choice **(B)** talks of the effect of the addition of AA in the presence of ouabain only in Experiment 2. Well, the effect of this was a greater degree of the inhibition of Cl^- uptake, but all this suggests is that AA is somehow responsible for this effect, it does *not* suggest that the AA must first be metabolized. And although we know from the results of Experiment 1 that AA metabolites, the results of this step of Experiment 2 *alone* do not indicate this. Choice **(B)**, therefore, does *not* suggest that AA must be metabolized to inhibit Cl^- uptake, and is therefore the correct answer. Let's take a look at the remaining choices. Choice **(C)** is the effect of ETYA addition in Experiment 2. Well, the results of this step of Experiment 2 actually do suggest that AA must be metabolized to inhibit Cl^- uptake. Let's take a quick run through of the three steps of the experiment. In step 1, the addition of ouabain alone inhibits $\text{Na}^+\text{-K}^+$ ATPase. In step 2, the addition of AA plus ouabain increases the degree of inhibition of Cl^- uptake, because the ouabain inhibits ATPase activity itself. In step 3, we add ETYA. Well, we're told that ETYA is a competitive inhibitor of AA metabolic pathways. Since adding ETYA resulted in less inhibition than when it was only AA plus ouabain, we can deduce that this was because fewer AA metabolites were produced, if any at all. However, Cl^- uptake was still inhibited by the ouabain. So, the effect

of ETYA in Experiment 2 supports also suggests that AA must be metabolized to inhibit Cl^- uptake. Therefore, choice **(C)** is incorrect. Finally, choice **(D)** is really the same as choice **(C)**, since ETYA is essentially an inhibitor of the cytochrome pathway. Since the addition of a cytochrome pathway inhibitor blocks the inhibition of Cl^- uptake normally caused by AA suggests that AA must be metabolized by the cytochrome-dependent pathway to inhibit Cl^- uptake. So choice **(D)** is also out.

Passage II (Questions 96–101)

96. (C)

If you look at the nitrogen mustard molecule, you can see that the two chloride functional groups are both attached to primary carbon atoms. Since primary carbons have a strong tendency to undergo bimolecular rather than unimolecular reactions, the most likely mechanism for the reaction in question, the displacement of the chloride group, followed by cyclization is $\text{S}_{\text{N}}2$. If you think about it, the tertiary nitrogen atom's lone electron pair, which is concentrated in a small region and augmented by the electron-donating effect of the methyl group, is much more nucleophilic than the three electron pairs scattered all over the surface of the chlorine atom. Therefore, that nitrogen can displace the chloride group via $\text{S}_{\text{N}}2$, forming an ethylenimmonium ion. Thus choice **(C)** is correct. Let's go through the remaining choices. Choices **(A)** and **(B)** are wrong since unbranched carbon chains are not very susceptible to $\text{S}_{\text{N}}1$ and $\text{E}_{1\text{c}}$ reactions, because of the instability of primary carbocations. Another reason to reject choice **(B)** is that an elimination reaction will always involve the loss of two ions, and in this reaction only one is lost. Finally, choice **(D)** is also wrong because in an addition reaction, no ions or other particles will be lost at all.

97. (B)

This question simply requires you to realize that the ethylenimmonium derivative shown is a quaternary ammonium compound. When heated with strong aqueous base, any quaternary ammonium compound will decompose through an $\text{E}_{2\text{c}}$ mechanism. The strong aqueous base abstracts a proton from one of the alkyl side chains on the quaternary ammonium compound. The electrons on the side chain rearrange to form a double bond and release a tertiary amine with a lone

pair of electrons. Tertiary amines make great leaving groups because they readily stabilize the electrons that are passed to them when the proton is abstracted. The end result is the production of a tertiary amine, a straight-chain alkene from the alkyl side chain, and water from the base and the abstracted proton. This reaction is called a Hofmann elimination. Anyway, choice **(B)** correctly identifies the products.

98. (A)

When a question asks you what a passage implies, it is best to stick to the information given in the passage. If you go back to the passage, you see that we were told that the ethylenimmonium ion attacks unshared electron pairs in the functional groups of molecules, thereby driving the alkylation reaction. Well, of all the answer choices, only choice **(A)** lacks unshared electron pairs. The tetraethylammonium ion in tetraethylammonium chloride consists of a nitrogen atom covalently bound to four ethyl groups. All five of the nitrogen's valence electrons are involved in covalent bonds, so all electrons are shared. So, from the information in the passage, we would not expect nitrogen mustard to be able to alkylate this compound. Pyridine has a lone pair of electrons on the nitrogen in the aromatic ring, so we could expect choice **(B)** to react. *N*-methylethanamide has a lone pair on the amide nitrogen, so we may expect choice **(C)** to react, just as we may expect for choice **(D)**, ethanenitrile, with a lone pair on the nitrile nitrogen.

99. (D)

The passage and the way the experimental data are presented clearly imply that treatment with nitrogen mustard produces certain changes in the structure of guanine that result in noncomplementary cross-linkages between parallel nucleotides. As shown in Figure 2, the so-called "complementary" cross-linkages, adenine–thymine and guanine–cytosine, contain two and three hydrogen bonds, respectively. Normally, these are the only base pairs observed in DNA because these four bases differ in the number and alignment of the atoms that are able to hydrogen bond. However, the alkylation of guanine by nitrogen mustard alters its shape, making the enol form of guanine predominate rather than the keto form. Let's think about this structural change. In the unalkylated—that is, keto—form of guanine, shown in Figure 2, positions 6, 1, and 2 are occupied by carbonyl, NH , and NH_2 functionalities, respectively. In contrast, in the

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alkylated—that is, enol—form of guanine, the hydrogen is shifted from position 1 to the oxygen bonded at position 6, so that in the alkylated guanine, positions 1 and 2 will contain a nitrogen atom and an amino group, respectively, and position 6 will be bonded to a hydroxyl group. This is essentially identical to positions 1 and 6 in the adenine molecule. Since the complementary base for adenine is thymine, such a structure permits the formation of noncomplementary guanine–thymine linkages. The amino group at guanine’s second position is also able to participate in this hydrogen bonding.

Another thing that can happen to the alkylated guanine is that its second chloroethyl side-chain of the ethylenimonium can also react, and in so doing, it can alkylate another guanine residue in the parallel DNA strand. This will produce a noncomplementary guanine–guanine cross-linkage held in place by a covalent bond. Therefore, the possible noncomplementary cross-linkages caused by alkylation are guanine–thymine and guanine–guanine, choice **(D)**.

100. (A)

To answer this question, you have to understand the mechanism of the alkylation reaction. The actual alkylating species shown in Figure 1 is not nitrogen mustard but ethylenimonium. However, it is clear from Figure 1 that the release of chloride ion is the key step in the cyclization reaction. Therefore, for the ethylenimonium to be formed, the original molecule must have at least one chlorosubstituted side chain. Thus, with a nitrogen mustard derivative in which the chlorides in both side chains are replaced by methyl groups, no cyclization is possible. Hence, such a compound will not form ethylenimonium and, therefore, will not act as an alkylating agent. So in this case, you would not expect to find any noncomplementary cross-linkages in the DNA segment; thus choice **(A)** is correct.

101. (D)

This question focuses your attention on the sequence of experiments. Let’s consider the three experiments in light of what we learned from question 100. In Experiment 1, Culture I is treated with nitrogen mustard, so you can expect some noncomplementary guanine–thymine and guanine–guanine linkages to form. In Experiment 2, the nitrogen mustard treatment is preceded by enrichment of the culture with thymine. This should logically make noncomplementary guanine–thymine linkages more likely to form than in Experiment 1. On the other hand, this treatment should not significantly alter the likelihood that guanine–guanine linkages will form. Therefore, it must be the thymine that is responsible for the greater number of noncomplementary linkages in Culture II compared to Culture I. Now consider Experiment 3, which utilizes a nitrogen mustard derivative in which the chloride of one side-chain has been replaced by a methyl group. The side-chain containing the chloride will be able to cyclize and form ethylenimonium; the ethylenimonium compound may then alkylate guanine molecules and the alkylated guanines can form noncomplementary guanine–thymine linkages. However, such a structure will prevent the formation of guanine–guanine linkages because, as we described earlier, such a reaction would require a second chloroethyl side chain. Since guanine–guanine linkages should be totally absent, the total number of noncomplementary linkages in Culture III is likely to be much lower than that in Culture II; this correlates with the data in the table. Thus it is thymine and the nitrogen mustard derivative used in Experiment 3 that are responsible for the fact that the number of noncomplementary linkages in Culture II is considerably higher than those in cultures I and III; so, choice **(D)** is the correct answer.

Passage III (Questions 102–105)**102. (D)**

This is a thought question that requires you to combine your outside knowledge of the kidney function with the information given to you in the passage. The third paragraph of the passage tells you that the paraventricular nucleus contains large neurons called magnocellular neurons, which produce the peptide hormone vasopressin. Vasopressin, which is also known as ADH, or antidiuretic hormone, promotes water reabsorption in the collecting duct of the nephron. Thus it is clear that it is the paraventricular nucleus that is most closely tied with kidney function. That whole bit in the passage about the hypothalamo–hypophyseal tract was just a smokescreen. Now, suppose you did not know that vasopressin promotes water reabsorption at the collecting tubules. You still should have been able to make the connection between the paraventricular nucleus and the kidney because the first sentence of the third paragraph tells you that the paraventricular nucleus is involved in osmoregulation, which you know is the primary function of the kidney. Looking at the other answer choices: according to the passage, the suprachiasmatic nucleus is involved in the maintenance of circadian rhythms and sleep-wake cycles. These have nothing to do with water regulation and vasopressin; so, choice **(A)** is wrong. Choices **(B)** and **(C)** are wrong because the AH–POA and the PH–POA are involved in the responses elicited by the stimulation of the autonomic division of the nervous system—a.k.a., the parasympathetic and sympathetic divisions.

103. (B)

This is another question that requires you to take information in the passage one step further. According to the passage, stimulation of the PH–POA elicits sympathetic responses. Although the word “sympathetic” often means compassionate, understanding, and congenial, in biology the word sympathetic connotes something entirely different. The autonomic nervous system is one of two divisions of the motor division of the peripheral nervous system. The autonomic nervous system regulates the internal environment via involuntary actions and processes. Autonomic innervation regulates the heart, smooth muscle, and the endocrine, excretory, reproductive, and respiratory systems. The autonomic nervous system is further divided into two divisions, the sympathetic and

parasympathetic divisions, which generally innervate antagonistic pathways. Sympathetic innervation elicits the “fight-or-flight” responses that ready the body for action. These responses include increased heart rate, decreased gut motility, vasoconstriction of blood vessels in the skin, vasodilation of blood vessels in skeletal muscle, pupil dilation, and adrenaline secretion by the adrenal medullas. Adrenaline increases blood glucose, providing the muscle cells with the energy they need for rapid action. On the other hand, parasympathetic innervation elicits physiological responses that restore the body to normal conditions following sympathetic responses, such as decreasing heart rate, increasing digestive activity, and so on. Therefore, choice **(B)**, decreased heart rate, would be the *least* likely response to PH–POA stimulation; so, the correct answer choice is **(B)**.

104. (C)

You’re told in the passage that PH–POA stimulation due to the activity of cold receptors initiates shivering mechanisms and the secretion of TRH. If cold receptors are stimulated, it must be because internal body temperature has decreased; the goal is to raise body temperature back to normal. Shivering, which is involuntary skeletal muscle contraction, is one mechanism that increases internal heat production, thereby increasing body temperature. TRH secretion, which stimulates the pituitary to secrete TSH is another mechanism. TSH stimulates the thyroid gland to secrete the thyroid hormones, and one of the functions of these hormones is to increase basal metabolic rate. Increasing metabolic rate increases heat production, thereby warming the body. Thus choice **(C)** is the correct answer. Choice **(A)** is wrong, because although fever does raise internal body temperature, it does not raise it because of TSH secretion. Fever is the result of the actions of bacterial toxins acting on the preoptic area of the hypothalamus—the POA. Choice **(B)** is wrong, for the same reason. Although vasoconstriction of subcutaneous blood vessels diverts blood flow away from the skin’s surface, thereby decreasing heat loss to the environment via radiation, vasoconstriction is not the result of TSH secretion. Choice **(D)** is wrong because internal body temperature cannot be raised by increasing heat loss; it can be raised by *decreasing* heat loss.

MCAT Practice Test 1**105. (C)**

When plasma volume is low, one of the ways in which the body tries to raise plasma volume is by increasing water reabsorption in the kidneys. Water reabsorption can be increased by increasing the synthesis and secretion of the peptide hormone vasopressin, also known as ADH. According to the passage, it is the cells of the paraventricular and supraoptic nuclei that are responsible for synthesizing vasopressin. Since vasopressin is a peptide, an increase in vasopressin synthesis would mean an increase in the activity of the cell structures involved in peptide synthesis. Well, peptide synthesis involves transcription, which occurs in the nucleus, and translation, which occurs in the cytoplasm at the ribosomes. You are asked to determine which of the organelles listed in the answer choices would be *most* active in paraventricular neurons. Well, if you quickly scan the choices, the clear standout is choice **(C)**, ribosomes. But let's just take a look at the other choices to make sure that we can definitely eliminate them. Choice **(A)**, the plasma membrane, would not be expected to be more active than usual do to increased vasopressin synthesis, so choice **(A)** is wrong. Peptide synthesis is an energy-requiring process, and this implies that ATP synthesis and therefore mitochondria activity would increase during periods of peptide synthesis. However, the mitochondria would not be expected to be the *most* active organelles, especially with respect to the ribosome activity going on. Therefore, choice **(B)** is wrong. As for choice **(D)**, lysosomes are the vesicles involved in intracellular digestion, not protein synthesis. Therefore, choice **(D)**, can clearly be ruled out. So, our initial hunch panned out; choice **(C)** is the correct answer.

Discrete Questions**106. (B)**

This question requires you to be familiar with neural regulation of the heart and the autonomic division of the nervous system. Heart rate is regulated by the autonomic nervous system, as well as by the hormone epinephrine, or adrenaline, which is produced by the adrenal medulla. The autonomic nervous system is involved in the control of most involuntary functions, such as smooth muscle contraction and a variety of endocrine and exocrine secretions. In contrast, the somatic nervous system is responsible for the voluntary

contractions of striated skeletal muscle. Although heart muscle is also striated, its contraction is regulated by the autonomic nervous system, though not initiated by it. Cardiac muscle is myogenic; that is, it contracts without nervous stimulation. But the rate at which it contracts can be modified by the autonomic nervous system. Therefore, choice **(C)**—innervation by the somatic motor neurons of the spinal cord—can be rejected right off the bat. Choice **(D)** is wrong because even though there are chemoreceptors in the heart that detect changes in the concentrations of carbon dioxide and hydrogen ions in the blood, these receptors signal the brain to modify the breathing rate—not the heart rate. So, now you are down to two choices; but to distinguish between the two, you've got to be familiar with the different functions of the two divisions of the autonomic nervous system. Parasympathetic innervation decreases heart rate, while sympathetic innervation increases it. Since you are told that the oculo-cardial reflex causes a decrease in heart rate, this reflex must be transmitted via parasympathetic innervation. Therefore, choice **(A)** is wrong and choice **(B)** is the right answer.

107. (B)

Extraction is a way of separating a dissolved compound from a complex solution. For the extraction to be successful, two conditions must be met. First, the extracting solvent and the original solution must be immiscible and the desired compound should be able to pass from one layer to the other. Second, the component which is to be extracted must be more soluble in the extracting solvent than in the original solution. Here, we do not know the composition of the solution; the only hint we're given is what components are supposed to be extracted. Chloroethanoic acid, being an alpha-halogenated carboxylic acid, is highly polar, and will be best at extracting highly polar compounds. Choice **(A)**, para-diethylbenzene, contains two electron-donating ethyl groups attached at positions 1 and 4 of the benzene ring; thus, the two equal dipoles are oriented in exactly opposite directions, and the overall dipole moment is zero. Thus choice **(A)** is wrong. Choice **(C)**—with two benzyl groups attached to the oxygen atom—and choice **(D)**—with two phenyl groups attached to the benzene ring at positions 1 and 4—are also wrong for the same reason. Finally, choice **(B)** contains a deprotonated carboxyl group, which has an electron-withdrawing effect, at position 1, and an electron-donating amino group at position 4. Since these dipoles have opposite charges and are

opposite each other on the benzene ring, the molecule has a relatively large dipole moment, and is polar. Thus choice **(B)** can be extracted by chloroethanoic acid; so this choice is the correct answer.

108. (C)

To answer this question, you must recall the basic physiology of microcirculation and filtration. Let's start with basic terminology. The hydrostatic pressure of blood is the pressure exerted by the blood against the vessel wall. It is directly proportional to blood volume, blood viscosity, and heart rate; on the other hand, it is inversely proportional to the vessel's cross-sectional area. In general, hydrostatic pressure tends to force fluid out of the capillaries. In contrast, the osmotic pressure, which is directly proportional to the concentration of blood solutes, tends to pull water out of the tissues and into the capillaries. At the arterial end of a capillary, the hydrostatic pressure is higher than osmotic pressure, which means that there's a net movement of fluid out of the capillaries. At the venous end of a capillary, hydrostatic pressure of blood is lower than osmotic pressure, which means that there's a net movement of fluid into the capillaries. Globular proteins, such as albumin, are responsible for maintaining the osmotic pressure of blood. The higher the plasma concentration of these proteins, the less fluid that will leave the capillary at its arterial end and the more fluid that will enter the capillary at its venous end.

Although a good deal of the total osmotic pressure is created by inorganic ions, these ions are less reliable in terms of continuous maintenance of the osmotic pressure, because they are easily filtered through the capillary walls. On the contrary, large plasma proteins, which are unable to pass through the capillary walls, are essentially the only permanent osmotic factors in the blood. Now, being aware of the osmotic properties of globular proteins, let's imagine what would happen to capillary circulation if the lymphatic system of some bodily tissue were destroyed, and as a result the tissue contained an excess of globular proteins. Well, there would be a greatly increased osmotic pressure in the tissue, surrounding the capillary, tending to draw fluid into the tissue. Therefore, at the venous end of the capillary, where the osmotic pressure of the blood would normally draw fluid back into the capillary, there is an even higher osmotic pressure in the tissues, such that the tissue would retain more fluid than it normally does. This would eventually lead to hyperhydration; and

excessive hyperhydration would eventually lead to the elephantiasis. Thus choice **(C)**—high osmotic pressure of the tissue—is correct, and choice **(D)** is wrong. Choices **(A)** and **(B)** are irrelevant, since the hydrostatic pressure of blood depends on factors such as the blood volume, heart rate, and is independent of the osmotic pressure of either the blood or tissues.

109. (A)

This question deals with the chemistry of carbonyl compounds and alcohols. Hydrogen atoms alpha to an aldehyde or ketone group are fairly acidic, since the electron-withdrawing effect of the carbonyl group will stabilize the corresponding alpha carbanion. Thus hydroxyl, which is a strong base, will readily abstract a hydrogen atom. The resulting carbanion will be nucleophilic and will therefore add to the carbonyl group of its parent compound to form a beta-hydroxy carbonyl compound. In this case, this is the compound listed as Compound I in choices **(A)** and **(D)**, so one of these must be the correct answer and **(B)** and **(C)** must be incorrect. To distinguish between **(A)** and **(D)**, you have to go through the rest of the reaction sequence. Heating an alcohol in the presence of an acid catalyst (usually sulfuric acid) will cause elimination of a molecule of water and formation of a carbon-carbon double bond. The beta-hydroxy carbonyl compound here will undergo this reaction just like any other alcohol; the double bond will form between the beta and alpha carbons, producing the structure shown in choice **(A)** as compound II. Thus choice **(A)** is correct and choice **(D)** is wrong. Just to finish off the reaction sequence, the last reaction shown a heterocatalytic reduction between the double bond and the carbonyl group of the alpha-unsaturated aldehyde, which produces butanol as the final product.

110. (A)

The oil refinery and its pollution made the white-winged butterflies more visible against a background of polluted leaves and grass, and therefore more susceptible to the predations of natural enemies such as birds. When these birds killed the most visible butterflies, the less conspicuous remaining butterflies, such as those with grey-white wings, reproduced within a smaller population, thereby increasing the frequency of those genes controlling darker wing colors in future generations. Since the butterflies with light-colored wings were less camouflaged than those with darker wing colors, the

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dark-colored butterflies were better adapted to their environment and more likely to survive and mate with each other, producing more dark-colored descendants. This pattern of genotypic change, which favors individuals with an extreme phenotype, such as black-winged butterflies, is called directional selection; so, choice **(A)** is correct. Now, let's go through the other choices. Stabilizing selection favors the middle-of-the-road phenotypes at the expense of the more extreme phenotypes. Stabilizing selection narrows the bell curve of phenotypic frequency; so, choice **(B)** is wrong. Disruptive selection favors several extreme phenotypic forms within a population; so, choice **(C)** is also incorrect. Finally, gene flow is associated with migrations of individuals between different populations of the same species; however, as the question doesn't mention any migrations, choice **(D)** is also wrong.

Passage IV (Questions 111–116)

111. (C)

This is a fairly straightforward Graphical Analysis question. From the graph you can see that the amount of active anti-PC present in circulation decreases as the amount of anti-Id the rabbits are pre-treated with increases. In other words, these two variables are inversely proportional. Therefore, **(B)** is wrong and choice **(C)** is the right answer. Now let's go over the remaining wrong answers. Choice **(A)** is incorrect because, not only can't this be concluded from the bar graph, but the passage states that animals do produce antibodies against their own antibodies. Choice **(D)** is incorrect because we've just illustrated that a conclusion can be drawn about the relationship between the amount of anti-Id a rabbit is pre-treated with and the amount of active anti-PC the rabbit has in circulation.

112. (D)

This question looks really intimidating at first glance—at second glance, too. However, that stuff about a second experiment involving two rabbits, phosphorylcholine and a blood exchange is all just a smokescreen. All you need to do to answer this question is just figure out which of the four organs is lymphoid tissue, since that's where you're told the phosphorylcholine fixed. Choices **(A)**, **(B)**, and **(C)** are incorrect because the heart, liver, and stomach are *not* lymphoid organs. The spleen, on the other hand, as well

as the lymph nodes, bone marrow, thymus, tonsils, and adenoids, are all lymphoid organs. Therefore, choice **(D)** is the correct answer.

113. (C)

The only reason immune complexes wouldn't be detected in the test tube is if the antigen didn't bind to the Ig molecule. In other words, there weren't any immune complexes to be detected. An antibody won't bind with an antigen unless its antigen binding sites are specific for the antigen in question. Thus choice **(C)** is the right answer. Choice **(A)** is incorrect because immune complexes can be formed *in vitro*, as well as *in vivo*. In fact, the presence of immune complexes is used as an immunological technique to detect the presence of a particular antigen or antibody in the serum. Choice **(B)** is incorrect, because once an immune complex is formed it is highly unlikely that this complex will dissociate unless other factors, such as an extremely high concentration of antibody, are present. Since this is not the case here, choice **(B)** can be eliminated. Choice **(D)** is incorrect because immune complexes are large enough to be detected. In some instances, an antigen is too small to elicit antibody production, but that's a whole separate issue from the detectability of an antigen-antibody complex that has already formed.

114. (B)

To answer this question, you have to look at the bar graph. Specifically, you need to compare the results of the rabbits that were given 1 microgram of anti-Id with the results of the control group. The concentration of active anti-PC present in the control group after 6 weeks was approximately 80 micrograms per milliliter. The concentration of active anti-PC present in the group that was pretreated with one microgram of anti-Id was twice the amount present in the control group, which is about 160 micrograms per milliliter. The rabbits had more active anti-PC present when they were treated with 1 microgram of anti-Id than when they were not exposed to the anti-Id at all. And although this may seem counterintuitive, it can be concluded that the concentration of active anti-PC is increased when the rabbits are pretreated with 1 microgram of anti-Id. Thus statement II is correct and statement I is incorrect. This means that choices **(A)** and **(C)** must be wrong. It does seem kind of odd that the control group would have *less* active anti-PC than the group treated with 1 microgram of anti-Id. If anything, you would expect the control

group to have the *highest* concentration of active anti-PC. However, this is clearly not the case, nor are you being asked to account for this bizarre data. As for statement III, it's incorrect because you know that the anti-Id will bind with the anti-PC. There is no information in the passage or the graph to suggest that pretreatment with anti-Id would affect the binding of the two antibodies. Therefore, choice **(D)** must be wrong and the correct answer is choice **(B)**.

115. (A)

The question stem claims that idiotypic regulation is controlled by a positive feedback mechanism. So, to answer this question you need to know how a positive feedback mechanism works. A positive feedback mechanism is one in which the production of one compound stimulates the production of another compound. In idiotypic regulation, this would mean that the presence of one antibody would stimulate the production of its own antibody—its anti-Id. The only choice that fits this definition of a positive feedback mechanism for idiotypic regulation is choice **(A)**. Choice **(B)** is incorrect because this would mean that a *negative* feedback mechanism is responsible for idiotypic regulation. A negative feedback mechanism is one in which the production of one compound suppresses the production of another compound. Choice **(C)** is incorrect because even though this answer choice follows the definition of a positive feedback mechanism, phosphorylcholine is not the compound that would stimulate the production of anti-Id. Phosphorylcholine would stimulate the production of the anti-PC antibody, which in turn would stimulate the production of the anti-Id antibody. If you didn't read the question carefully you might have chosen choice **(D)** as the correct answer, since the results in the bar graph indicate that the concentration of anti-PC was either increased or decreased relative to the control group depending on the amount of anti-Id the rabbit was given as a pretreatment. However, choice **(D)** is not the correct answer to this question, because it does not conform to the definition of a positive feedback mechanism.

116. (B)

An anti-anti-Id is the antibody to an anti-Id. Anti-anti-Id specificity works according to the same rules as antibody-antigen specificity. The anti-Id is the antigen for which the anti-anti-Id is specific. The anti-anti-Id binds to the anti-Id and renders it effectively inactive. Choice **(A)** is incorrect because the anti-anti-Id is not

specific for the antibody to phosphorylcholine and would, therefore, not bind to it and thereby decrease the concentration of active anti-PC. Rather, the anti-anti-Id is specific for the anti-Id specific for the antibody to phosphorylcholine. Choice **(C)** is incorrect, because, just as the anti-anti-Id cannot bind to anti-PC—the antibody for phosphorylcholine, nor can it bind to phosphorylcholine itself, which is the original antigen. Choice **(D)** is incorrect because the specificity of an antibody cannot be altered.

Passage V (Questions 117–122)**117. (C)**

This question asks you to look at the active site shown in step one and estimate the pH. The only information we're given, however, is the pK_a 's of side chains of certain residues. The passage states that the important amino acid residues are the glutamate at residue 165, with a pK_a of 4.32, lysine 13, with a pK_a of 10.80, and histidine 95, with a pK_a of 6.00. In step 1, the glutamate is negatively charged, the lysine is positively charged, and the histidine is not charged. This is all the information you need to estimate the pH. You should remember from your studies that glutamate has an acidic amino acid side chain while lysine and histidine have basic amino acid side chains. Well, remember that when the pH of a solution is greater than the pK_a of an acidic side chain, the side chain will lose a proton and become negatively charged. This is simply due to the fact that the concentration of protons in the solution is low and so the acid dissociates, trying to raise said concentration. Therefore, since the glutamate is charged, we know that the pH is greater than 4.3. That eliminates choice **(A)**. By similar reasoning, you should see that when the pH of the solution is less than the pK_a of a basic side chain, it will be positively charged. That's because the proton concentration is too high and the base tries to decrease it by becoming protonated. Therefore, since lysine is charged and histidine is not, you know the pH must be less than 10.8 and greater than 6.00. The only choice that fits that description is choice **(C)**; a pH of 8 is the most likely pH for the active site.

118. (C)

For this question, you have to compare the glutamate residue in the diagrams of Steps 1 and 2. You can see that in Step 1, the amine group does not have a proton.

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If you look at the next step, you can see that the carboxyl group *does* have a proton. A species that receives protons or donates electrons is known as a base—therefore, the glutamate residue is acting as a base in this step, and so choice **(C)** is correct. Let's look quickly at the other choices. Glutamate is not acting as a nucleophile because it does not become covalently attached to the substrate in step two, so choice **(A)** is incorrect. Glutamate is not acting as an acid, because an acid is defined as a species that donates protons or receives electrons, so choice **(B)** is incorrect. Finally, glutamate is not a zwitterion, because a zwitterion is a species that can have both a positive and negative charge, so in this situation, glutamate is not a zwitterion, and choice **(D)** is incorrect. Only free amino acids can be zwitterions because their amino and carboxyl ends, which are the groups that can be charged, are free, rather than being part of peptide bonds.

119. (C)

This question is just like question 118, because it also asks you to compare diagrams to figure out the behavior of one of the amino acid residues. It asks you to look at the lysine residue in the diagrams of Steps 2 and 3. You can see that in Step 2, the amine group has only two protons, while in Step 3, it has gained a third proton. As we said in the previous question, a species that receives protons or donates electrons is known as a base. Therefore, in Step 2, the lysine residue is acting as a base; so, choice **(C)** is correct. Lysine is not acting as a nucleophile, because it does not become covalently attached to the substrate; so, choice **(A)** is incorrect. Lysine is not acting as an acid, because it is neither donating protons or receiving electrons; so, choice **(B)** is incorrect. Finally, lysine is not a zwitterion since it is part of a polypeptide chain and, therefore, it does not have both a positive and negative charge, so choice **(D)** is wrong.

120. (B)

This question requires you to use some of the information presented in the passage. The question mentions free energy, so you should look back at the passage to see what it says about free energy. It says that the reaction rate is controlled more by the free energy of the intermediate transition states than the free energy of substrate binding or product release. Now, if glutamate-165, which you are told is one of the catalytic residues, is replaced by aspartate, that should

change the energy profile. Since aspartate also has a carboxyl group and is only one carbon shorter than glutamate, the chemical properties of the two are fairly similar. In order for the mutant enzyme to have a reaction rate that is 1,000 times slower than the wild type, the free energy of the two transition states should be greater than those of the wild-type enzyme. In other words, it should take more energy to get from the enzyme-DHAP complex to the enzyme-enediol intermediate and from the enzyme-enediol intermediate to the enzyme-G3P complex; therefore, the corresponding peaks on the profile should be higher. If you compare the four answer choices to the wild-type profile, you can eliminate both choices **(A)** and **(D)**, because the two center peaks which correspond to the free energy of transition from enzyme-DHAP complex to the enzyme-enediol intermediate and from the enzyme-enediol intermediate to the enzyme-G3P complex, are lower than those of the wild-type enzyme. Choice **(C)** is also incorrect, because the two center peaks are the same, while the peaks on either side, which correspond to the free energy of binding the substrate and releasing the product, are greater than for the wild type. Since binding and release of substrate and product do not have a strong effect on the reaction rate, their corresponding peaks on the profile should not change. Thus choice **(B)** shows the correct energy profile: the two center peaks are greater than for the wild type and the two side peaks are the same as for the wild type.

121. (B)

To answer this question, you have to realize that the amino acids in the active site are all similar in character, so that the sort of amino acid that is most likely to be found there would be another one of the same type. The broadest classification of amino acids is whether they are hydrophilic or hydrophobic. Since DHAP has a phosphate group and is therefore polar and hydrophilic, it makes sense that it would fit into a binding pocket with hydrophilic residues. In a protein, hydrophobic residues tend to aggregate together at the inside of the molecule so as to minimize contact with water, and hydrophilic residues tend to be on the surface of the protein so as to increase contact with the aqueous environment. Since a hydrophilic pocket in a protein would tend to be more polar than a hydrophobic one, a polar molecule such as G3DP would tend to aggregate at that hydrophilic pocket. This idea corresponds to the solubility rule of “like dissolves like.” So, of the choices, **(B)** is the correct answer,

because phenylalanine is hydrophobic and would be the least likely to be found in the binding pocket of this enzyme. Choices **(A)**, **(C)**, and **(D)** are incorrect because they are all hydrophilic amino acids and *could* logically be found in the binding pocket.

122. (C)

This question involves a labeling experiment using deuterated water. Because the enediol reaction intermediate contains a double bond, it has a planar shape. In general, a planar molecule can be attacked from both faces of the molecule, so that both possible stereoisomers will be produced. In this experiment, however, only one stereoisomer is formed; therefore, choice **(D)** is incorrect. This also means that choice **(C)** is the correct answer, since one particular stereoisomeric form of the starting material reacts in such a way that it gives a specific stereoisomeric form of the product. As for the other two choices, **(A)**, which describes how hydrogen bonds hold the substrate's configuration in the active site, is actually true; however, the experiment described does not give you evidence to prove this, so this choice is incorrect. Choice **(B)** is also incorrect: there is no leaving group, and the deuterium is not a nucleophile, so this is obviously not a nucleophilic substitution, and, therefore, cannot be an inversion or configuration.

Passage VI (Questions 123–130)**123. (C)**

This question is one of pure outside knowledge. It relates to the content of the passage as far as it deals with virology, but nothing is said in the passage about viral structure. You should know that a virus essentially consists of a nucleic acid enclosed by a protein coat. The nucleic acid can be either linear or circular, and can be either single- or double-stranded DNA or RNA. The protein coat is called a capsid and is composed of many protein subunits. Choice **(A)** is wrong, because a virus does not have a lipid bilayer such as the plasma membrane. Choice **(B)** is incorrect because a plasmid is a piece of autonomous, self-replicating, extrachromosomal DNA, found mostly in bacteria and yeast. Finally, choice **(D)** is incorrect because the term virion refers to a fully formed virus particle. That leaves choice **(C)**.

124. (D)

This question requires you to make an inference from information presented in the passage. You're told that DT exerts its toxic effect on cells by inhibiting protein synthesis. Since protein synthesis occurs at the ribosomes, DT must in some way disrupt ribosome activity. Thus choice **(D)** is the right answer. Choice **(A)** is wrong because although the plasma membrane has many functions, including maintenance of cell asymmetry, chemical and electrical gradients, shape, protection and so on, protein synthesis is not one of them. True, the toxin binds to receptors expressed on the plasma membrane surface, but these receptors, (which are proteins) are synthesized by ribosomes and shuttled to the membrane. Choice **(B)** is wrong because the Golgi apparatus is the organelle responsible for the final modification and packaging of protein products, not in protein synthesis. Finally, choice **(C)**, mitochondria, is wrong, because the mitochondria is the organelle responsible for ATP synthesis. And, even though ATP is required for protein synthesis, you're told that DT inhibits protein synthesis, not ATP synthesis.

125. (A)

This question is one that truly requires outside knowledge. In fact, you don't even have to read the passage to answer this one. However, you do have to be familiar with the chemical characteristics of cell structures found on exterior surfaces of the plasma membrane, as opposed to characteristics of structures found on the interior surfaces of the membrane. Structures located on the exterior membrane surfaces, such as receptors, are in aqueous surroundings and must therefore be hydrophilic, or "water-loving." Structures that are embedded within the lipid membrane are not exposed to the intracellular or extracellular fluids, and are said to be hydrophobic or "water-fearing." Therefore, choice **(A)** is correct. Choice **(B)**, nonpolar, is incorrect because, in general, hydrophilic molecules are polar; that is, chemically or electrically asymmetrical. A nonpolar molecule would *not* be stable in a watery environment. Finally, choice **(D)**, lipophilic, is incorrect because this describes a molecule that is stable within a lipid environment, and unstable in an aqueous environment. Therefore, the IL-2 receptors expressed on the surface of a CD4+ T-cell would not be lipophilic, nonpolar, or hydrophobic, but they would be hydrophilic.

MCAT Practice Test 1**126. (D)**

This is also a fairly simple question that requires outside knowledge of enzyme types. Since you know that IL-2R is a protein, you just need to know that in order to degrade a protein into its monomeric units—amino acids—you need a protease. A protease is the kind of enzyme that would be capable of degrading IL-2R into its amino acid building blocks, thereby allowing scientists to determine IL-2R structure. Proteases hydrolyze the peptide bonds between amino acids. Therefore, choice **(D)** is the right answer. Choice **(A)** is wrong because a kinase is an enzyme that phosphorylates organic molecules. Choice **(B)** is incorrect because reverse transcriptase is the enzyme used by retroviruses, including HIV, to synthesize DNA from an RNA template. Choice **(C)** is incorrect because a restriction endonuclease is an enzyme that breaks long strands of nucleic acid into specific fragments.

127. (C)

All the information required to answer this question is in the passage. According to the first paragraph, the infection of a CD4+ T-cell begins with the binding of HIV to the CD4 receptors on the CD4+ T-cell surface. HIV then enters the cell. Once inside the CD4+ T-cell, HIV replication can only occur *after* the T-cell has been activated, resulting in the expression of the receptors for interleukin-2. These receptors are referred to as IL-2R. Therefore, choice **(D)** is wrong and choice **(C)** is the right answer. Choice **(A)** is clearly incorrect, since you're told that IL-2R expression is a result of HIV infection, not a cause of it. Choice **(B)** is wrong because it's just plain old nonsense. IL-2R expression is independent of exposure to DTIL-2, which is a man-made cytotoxin used to attack HIV-positive cells.

128. (A)

This question relies strictly on your outside knowledge, since no additional information is given in the passage regarding retroviruses and their mode of replication. Reverse transcriptase is the retroviral enzyme that synthesizes DNA from an RNA template. For a more detailed discussion of retroviral replication, please refer to the Molecular Genetics chapter of your Biology Review Notes.

129. (C)

The question asks you which of the three factors can be held accountable for the values plotted for HIV-positive

CD4+ T-cells treated with DTIL-2. Looking at the lower graph, we see that for the treated culture, viral protein synthesis was totally inhibited. So, basically, you're being asked to account for DTIL-2's toxicity to HIV-positive cells. Well, we know from the passage that DTIL-2 is a cytotoxin composed of the amino acid sequence of IL-2 that binds to IL-2R combined with the amino acid sequence of diphtheria toxin that inhibits protein synthesis. These are the essential qualities that make this cytotoxin effective. Now let's take a look at the factors. Statement I is the specificity of IL-2 for IL-2R. Well, this has just been mentioned as one of the essential characteristics in the effectiveness of DTIL-2; it is the IL-2 amino acid sequence and its specificity for the IL-2R expressed on HIV-positive cells that allows DTIL-2 to bind to the cells and inhibit viral protein synthesis. So, yes, this is an important factor as to why there was total inhibition of HIV protein synthesis. This means that choice **(B)** can be ruled out. Statement II is the presence of DT polypeptides in DTIL-2. Again, this was just mentioned as one of the essential characteristics of DTIL-2 effectiveness; it is the amino acid sequence of DT that inhibits viral protein synthesis in the HIV-positive cells. So this certainly is important in accounting for the activity of DTIL-2 and must also be included in our answer. And this means that choice **(A)** is also incorrect. Finally, let's look at statement III, which is the binding of the DT amino-acid sequence to IL-2R. Well, this is clearly not a factor, since IL-2R is specific only for IL-2, not for the DT amino acid sequence. So, there is no chance that the DT amino-acid sequence would ever bind to IL-2R. So, statement III can be eliminated, and we are left with statement I and II only, or choice **(C)**.

130. (D)

An increase in the viability of HIV-positive cells means that the cells are continuing to live and synthesize viral proteins, despite their exposure to DTIL-2, which was shown to be a very effective inhibitor of viral protein synthesis in the passage experiment. So let's look at this a little bit more closely. We know from the passage that DTIL-2 has the amino acid sequence of IL-2 that binds to IL-2R, and that this attribute is essential to the mechanism by which DTIL-2 selectively inhibits protein synthesis. We also know from the passage that IL-2 binds to IL-2R. What this means is that IL-2 competes with DTIL-2 for IL-2R binding sites on HIV-positive cells, and thereby decreases the frequency with which DTIL-2 will bind to IL-2R. This means that fewer cells will be affected by the presence of DTIL-2, especially if the concentration of DTIL-2 is very low relative to the

concentration of IL-2. Choice **(D)**, then, is the correct answer. Now let's look at the other answer choices. Choice **(A)** is incorrect, because we know from the passage that IL-2 binds to IL-2R, not to the DT amino acid sequence of DTIL-2. Choice **(B)** is wrong because it is pure nonsense. There is no reason for you to conclude that IL-2 somehow confers some sort of immunity on T-cells. Even if this were somehow possible, what would it matter, since these cells are already HIV-positive? Choice **(C)** sounds like a good explanation, but again, there is nothing in the passage to indicate that IL-2 inhibits DTIL-2 activity. Furthermore, what is this DT receptor that they're talking about? Choice **(C)**, therefore, is also incorrect.

Discrete Questions

131. (D)

The only reliable indication of pregnancy is the presence of HCG (human chorionic gonadotropin) in a blood sample, since no organ besides the placenta is capable of producing this hormone. Therefore, the logical explanation for why a uterine tumor would be misdiagnosed as pregnancy would be if this tumor produced HCG. Hence, choice **(D)** is correct. Now, let's go through the other choices. Choice **(A)** is wrong, since a high blood level of estrogens would be found in a variety of situations not necessarily related to a pregnancy. Normally, estrogens rise sharply in the day immediately preceding ovulation (the so-called ovulatory surge). Estrogen levels can also rise in patients with certain types of ovarian or adrenal tumors. FSH, follicle-stimulating hormone, and LH, luteinizing hormone, are responsible for the development of a follicle in the first half of the ovarian cycle and are also, along with estrogens, participants of the ovulatory surge. LH also stimulates the development of the corpus luteum, the atrophied mass of yellow-colored ovarian follicle tissue that produces progesterone and estrogen. The main function of progesterone is to prepare the uterine lining, known as the endometrium, for a possible implantation. These preparations include extensive vascularization and the development of a powerful secretory apparatus. In the event that implantation does *not* occur, the highly vascularized endometrial layer sloughs off by the end of the ovarian cycle. However, if a woman does get pregnant, the corpus luteum will continue producing progesterone to safeguard the developing placenta, until

the placenta is capable of producing progesterone itself. Therefore, since high blood levels of progesterone can be found in both the second half of the ovarian cycle and pregnancy, this cannot serve as a reliable indicator of pregnancy, and so choice **(B)** is wrong. Finally, throughout pregnancy, the increase in progesterone and estrogen secretion by the placenta suppresses the production of FSH and LH to prevent the development of other ovarian follicles; therefore, high levels of these hormones would indicate an *absence* of pregnancy. Therefore, choice **(C)** must be wrong since high levels of FSH and LH would not be the cause of the tumor's misdiagnosis.

132. (D)

The dipole moments of di-substituted benzenes depend on two main factors: The nature of the substituents, and their positions. In general, 1,4 or para-disubstituted benzenes in which one substituent is electron-donating and the other one is electron-withdrawing will have the highest dipole moments. For example, choice **(D)**, *para*-aminonitrobenzene, contains an electron-donating amino group and an electron-withdrawing nitro group that are attached to the ring in para orientation—in other words, so that one is opposite the other. Therefore, the electron-donating effect of the amino group and the electron-withdrawing effect of the nitro group have an additive effect, shifting electron density strongly in the direction of the nitro group. This creates a strong negative charge on the “nitro” end of the molecule, and a strong positive charge on the “amino” end. So this molecule has a very high dipole moment, and choice **(D)** is correct. Let's go through the remaining choices. Meta- and ortho-disubstituted benzenes generally have lower dipole moments than para-disubstituted benzenes, because the orientation of the substituents is such that their dipoles cannot be completely additive. Thus choices **(A)** and **(B)** are wrong. Finally, choice **(C)**, *para*-dihydroxybenzene, contains identical electron-donating para-substituents; their effects are equal in magnitude but oriented in opposite direction, so that they cancel out and the molecule has an overall dipole moment of zero. Therefore, choice **(B)** is also wrong.

133. (A)

To answer this question, you must realize that when a patient loses 20–30 liters of watery feces daily his blood volume will drop to a critical level in a matter of one or two days. As a result, the cardiac output—that

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is, the total blood volume the left ventricle pumps out of the heart per minute—will drop to the extent that it fails to provide tissues with sufficient oxygen and nutrients. Heart failure was actually the main reason for the heavy death tolls exacted by the cholera epidemics in medieval Europe. However, the point of this particular question is that when blood volume and cardiac output decrease, the hydrostatic pressure of the blood will considerably drop as well. Since the rate of glomerular filtration in the kidneys is directly proportional to the difference between the capillary hydrostatic pressure and the pressure inside the glomerular lumen, such a critical drop in blood pressure will essentially result in complete suppression of glomerular filtration. Hence, choice **(A)** is correct. Now, let's go through the other choices. Choice **(D)** is wrong because the decrease in blood volume due to the diarrhea will cause the juxtaglomerular apparatus of the kidney to increase its production of renin, an enzyme which converts the protein angiotensinogen, synthesized in the liver, to angiotensin I, which is subsequently converted to angiotensin II. Angiotensin II raises blood pressure by causing the smooth muscles of arterial walls to contract, and also enhances the production of aldosterone in the adrenals. Aldosterone, in turn, stimulates the kidneys to increase their reabsorption of sodium. As sodium leaves the kidneys, water passively follows, thereby raising blood volume. Therefore, sodium and water reabsorption will be enhanced, not suppressed, by a decrease in cardiac output; so, choices **(B)** and **(D)** are wrong.

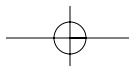
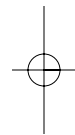
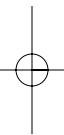
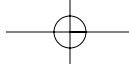
134. (D)

Since thymine is not found in RNA—single-stranded or double-stranded—choices **(A)** and **(B)** can be immediately eliminated. RNA has uracil in place of thymine. So you know that this must be a DNA virus. If it were double-stranded DNA, the amount of adenine would have to equal the amount of thymine, and the amount of cytosine would have to equal the amount of guanine, since adenine pairs with thymine and cytosine pairs with guanine. Since this is clearly not the case, the genetic material in question must be single-stranded DNA. Therefore, choice **(C)** is wrong and choice **(D)** is the right answer.

135. (A)

The pedigree in the question illustrates the inheritance pattern of the genetic disease ataxia-telangiectasia. We hope you weren't scared off by this difficult-to-pronounce disease, because you don't have to know anything about it to answer the question. Remember, do not be fooled by the perceived level of difficulty of a question topic. This is just a bluff; this question is really a simple matter of understanding basic Mendelian inheritance patterns. So let's talk about some of those basics. First, a dominant trait is one that is expressed when an individual has either one *or* two copies of the allele. A recessive trait is one that is expressed *only* when an individual has *two* copies of the allele. An X-linked trait is one that is found on the X chromosome, and can therefore be passed on from father to daughter, and from mother to daughter and son. A male cannot transmit an X-linked trait to a son because the son inherits his X allele from his mother, not his father.

OK, looking at the pedigree, you'll see that the trait *cannot* be a recessive trait, because if it were, *all* of the children in the third generation would express the trait. Why? Because this would mean that both of the second-generation parents would have the homozygous recessive genotype, which means that both parents could only produce gametes that containing this recessive allele. And this, in turn, means that all of their children would express the trait, which is clearly not the case. This line of reasoning holds true for both an autosomal recessive trait and an X-linked recessive trait. Therefore, choices **(B)** and **(D)** must be wrong. Now, knowing that the trait must be dominant, you should realize that if the trait were X-linked dominant, then all second-generation daughters would have to express the trait, since they inherited one of their X chromosome from their father, who expressed the trait himself. However, this is also clearly not the case. Therefore, choice **(C)** must be wrong, and choice **(A)** must be the correct answer. The first-generation mom must have the recessive phenotype and her mate must be heterozygous dominant—that would explain the second-generation daughter who doesn't express the trait. Likewise, the shaded couple in the second generation must both be heterozygous dominant, which would explain their son who doesn't express the trait.





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