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Topic Break Down

Topic	No. of Questions
Topic 1, Verbal Reasoning	194
Topic 2, Biological Sciences	249
Topic 3, Physical Sciences	340
Topic 4, Psychology and Sociology	28
Total	811

QUESTION NO: 1

Hemophilia is a genetically inherited disease that causes the synthesis of an abnormal clotting factor. As a result, hemophiliacs bleed excessively from the slightest injury. The figure below is a partial pedigree for the hemophilia trait in Queen Victoria's descendants. The pedigree indicates no history of hemophilia for either parent prior to the F1 generation.

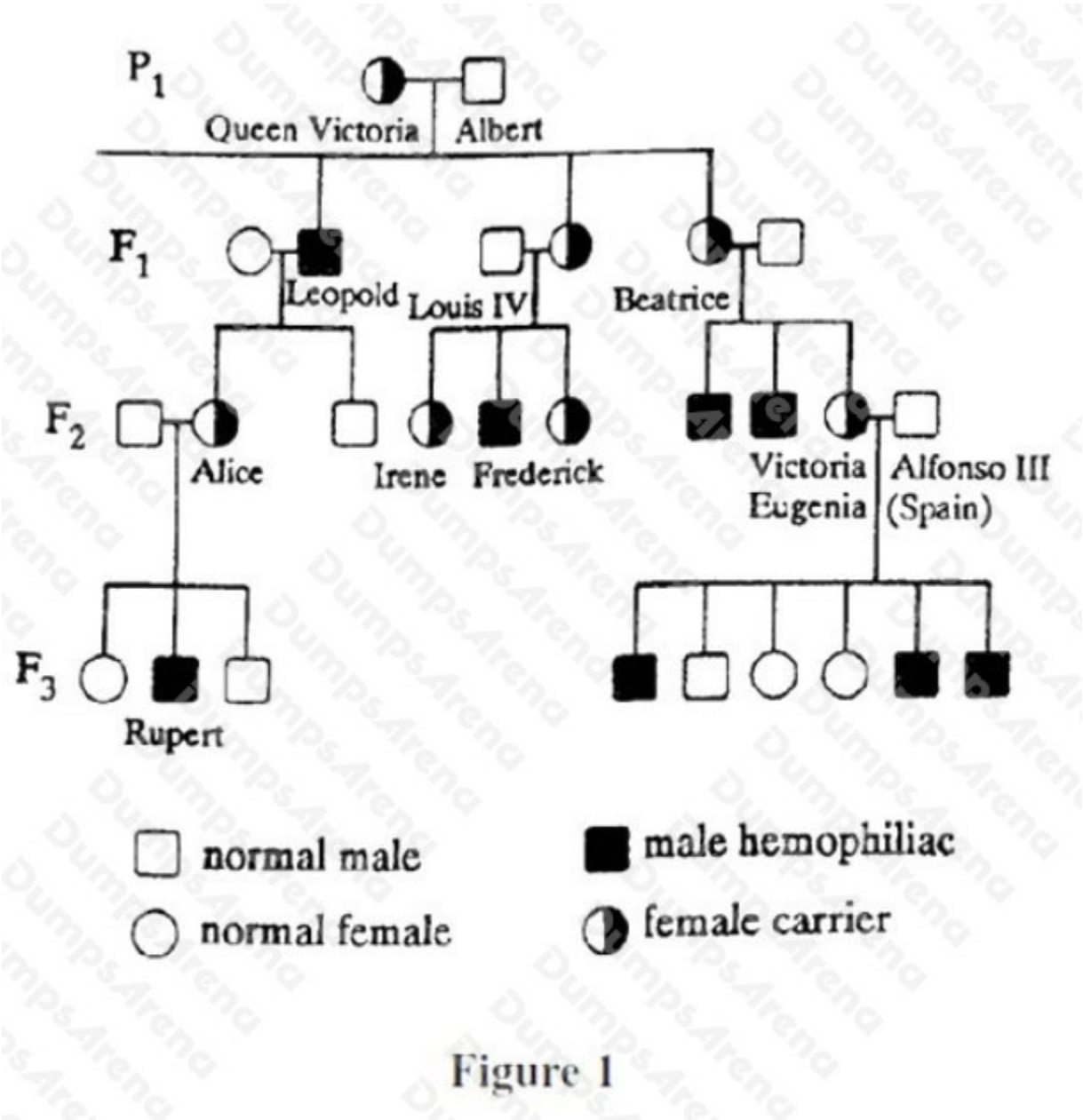

Figure 1

Which of the following best explains why Louis IV was NOT a hemophiliac?

A. His son Frederick was a hemophiliac.

B. He did not inherit the gene for hemophilia from his mother.

C. His father-in-law, Albert, was not a hemophiliac.

D. Only females can be carriers of the gene for hemophilia.

ANSWER: B

Explanation:

A male can inherit an X-linked trait only from his mother, since he inherits his one X chromosome from her. Thus, Louis IV, who was normal, did not inherit the gene for hemophilia from his mother, who is not shown on the pedigree. Remember, Louis IV was not a blood relative of the Queen, he was her son-in-law. Choice A is incorrect, since Louis IV's son, Frederick, has hemophilia because he inherited the gene from his mother, who was a carrier (although we don't know her name). Besides, whether Louis IV's children were hemophiliacs, carriers, or normal, is irrelevant to the discussion of why Louis himself was normal. Choice C is incorrect because Albert was not a blood relative of Louis IV, so Albert's genotype is independent of Louis' genotype. As for choice D, while it is true that only females can be carriers of the hemophilia gene, or of any X-linked gene for that matter, this does not answer the question.

QUESTION NO: 2

A student conducts a chemical analysis of the components of a popular soft drink. The beverage label shows that the drink contains carbonated water, phosphoric acid, caffeine, and caramel color, but does not indicate the concentrations of these chemicals.

	Carbonic Acid	Phosphoric Acid
MW	62.03	98.00
mp (°C)	n/a	42.35
K_a	(1) 4.3×10^{-7} (2) 5.61×10^{-11}	(1) 7.52×10^{-4} (2) 6.23×10^{-8} (3) 2.2×10^{-13}
Formula	H_2CO_3	H_3PO_4

Table 1

Dissolved carbon dioxide will react reversibly with water to form carbonic acid. In an attempt to analyze the beverage composition, the student conducts the following experiments on a one liter sample of the beverage.

Experiment 1

The sample is placed in a sealed beaker cooled to 10° C and a vacuum is created in the space above the beverage. The gas pumped from this space is passed through a solution of BaCl2, producing a white precipitate. The process continues until no more precipitate forms. The precipitate is dried and found to have a mass of 9.5 grams.

Experiment 2

The remaining solution left in the sealed beaker is then titrated with 0.01 M NaOH to give the titration curve shown in Figure 1.

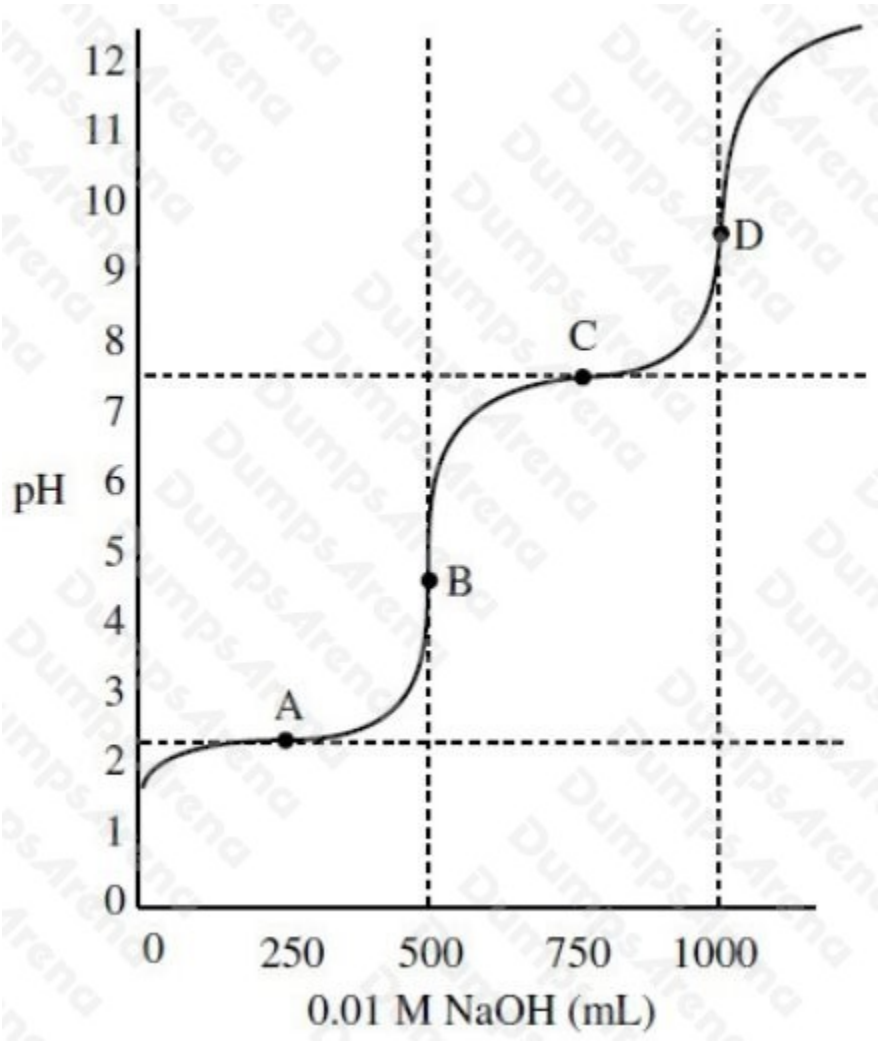

Figure 1

The student uses the data from Experiment 1 and Experiment 2 to calculate the initial pH of the beverage. If a significant quantity of precipitate was lost in the drying process of Experiment 1, the calculated pH:

A. would be less than the actual pH.

B. would be greater than the actual pH.

C. would be the same as the actual pH.

D. would differ from the actual pH in a random manner.

ANSWER: B

Explanation:

If a significant quantity of precipitate were lost, the student would conclude that there was less carbonic acid than was actually present. This would lead to the calculation of a less acidic, higher pH, than the actual pH.

QUESTION NO: 3

The polymerase chain reaction (PCR) is a powerful biological tool that allows the rapid amplification of any fragment of DNA without purification. In PCR, DNA primers are made to flank the specific DNA sequence to be amplified. These primers are then extended to the end of the DNA molecule with the use of a heat-resistant DNA polymerase. The newly synthesized DNA strand is then used as the template to undergo another round of replication.

The 1st step in PCR is the melting of the target DNA into 2 single strands by heating the reaction mixture to approximately 94° C, and then rapidly cooling the mixture to allow annealing of the DNA primers to their specific locations. Once the primer has annealed, the temperature is elevated to 72° C to allow optimal activity of the DNA polymerase. The polymerase will continue to add nucleotides until the entire complimentary strand of the template is completed at which point the cycle is repeated (Figure 1)

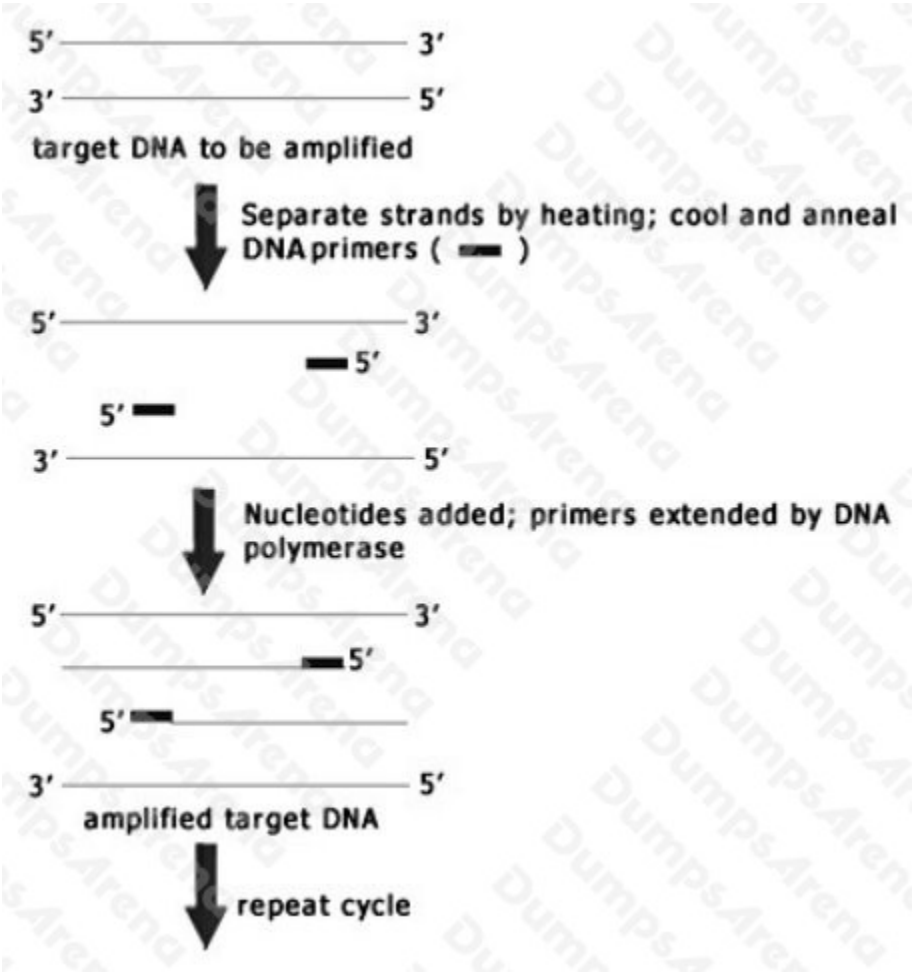

Figure 1

One of the uses of PCR is sex determination, which requires amplification of intron 1 of the amelogenin gene. This gene found on the X-Y homologous chromosomes has a 184 base pair deletion on the Y homologue. Therefore, by amplifying intron 1 females can be distinguished from males by the fact that males will have 2 different sizes of the amplified DNA while females will only have 1 unique fragment size.

Why is a heat resistant DNA polymerase required for successive replication in the polymerase chain reaction, rather than simply a human DNA polymerase?

A. The high temperatures required to melt the DNA double strand may denature a normal human cellular DNA polymerase.

B. The high temperatures required to melt the DNA would cause human DNA polymerase to remain bound to the DNA strand.

C. Heat resistant DNA polymerase increases the rate of the polymerase chain reaction at high temperatures whereas human DNA polymerase lowers the rate.

D. Heat resistant DNA polymerase recognizes RNA primers whereas human DNA polymerase does not.

ANSWER: A

Explanation:

Since mammalian cells function at 37° C, this is also the optimal temperature for enzyme activity. The temperatures used in PCR, which are well above 70° C, would easily denature human DNA polymerase which is why a heat resistant DNA polymerase is required. Using human DNA polymerase would require new enzyme after each cycle, and therefore would not be very efficient.

QUESTION NO: 4

Several techniques have been developed to determine the order of a reaction. The rate of a reaction cannot be predicted on the basis of the overall equation, but can be predicted on the basis of the rate-determining step. For instance, the following reaction can be broken down into three steps. A + D → F + G

Step 1

A → B + C(slow)

Step 2

B + D → E + F(fast)

Step 3

E + C → G (fast)

Reaction 1

In this case, the first step in the reaction pathway is the rate-determining step. Therefore, the overall rate of the reaction must equal the rate of the first step, k1 [A] where k1 is the rate constant for the first step. (Rate constants of the different steps are denoted by kx, where x is the step number.)

In some cases, it is desirable to measure the rate of a reaction in relation to only one species. In a second-order reaction, for instance, a large excess of one species is included in the reaction vessel. Since a relatively small amount of this large concentration is reacted, we assume that the concentration essentially remains unchanged. Such a reaction is called a pseudo first-order reaction. A new rate constant, k', is established, equal to the product of the rate constant of the original reaction, k, and the concentration of the species in excess. This approach is often used to analyze enzyme activity.

In some cases, the reaction rate may be dependent on the concentration of a short-lived intermediate. This can happen if the rate-determining step is not the first step. In this case, the concentration of the intermediate must be derived from the

equilibrium constant of the preceding step. For redox reactions, the equilibrium can be correlated with the voltage produced by two half-cells by means of the Nernst equation. This equation states that at any given moment:

$$E = E^0 - \left(\frac{RT}{nF}\right) \ln \left([C]^c[D]^d/[A]^a[B]^b\right)$$

Equation 1

When

a A + b B → c C + d D

Reaction 2

Note: R = 8.314 J/K·mol; F = 9.6485 × 104 C/mol.)

What is the effect of increasing the concentration of reactants in a voltaic cell?

A. The voltage increases, while the spontaneity of the reaction remains the same.

B. The spontaneity of the reaction increases, but the voltage remains the same.

C. Both the voltage and the spontaneity of the reaction increase.

D. The reaction rate increases, but the voltage and spontaneity of the reaction are unchanged.

ANSWER: C

Explanation:

To answer this question, you need to understand the relationship between the concentration of reactants and the spontaneity and voltage of the reaction. First let's review what is meant by voltage. When a reaction takes place in a voltaic cell, the oxidation reaction at the anode produces excess electrons. Meanwhile, reduction at the cathode uses up electrons. For the reaction to continue, the cathode needs an additional supply of electrons. As a result of the two half-reactions, there is a movement of electrons through the wire from the anode to the cathode. The faster the reaction takes place, the greater the electrical force pushing electrons away from the anode and pulling them toward the cathode will be. This pressure on the electrons is called the electromotive force, or EMF. The electromotive force is measured in volts, and so is also known as the voltage. Don't confuse the voltage with the current – the voltage is the pressure on the electrons, while the current is the actual movement of electrons through the wire. The current depends not only on the pressure exerted by the EMF, but also on the amount of resistance of the wire. The voltage or electromotive force created by a redox reaction depends on the number of electrons exchanged in the reaction and the rate at which the reaction takes place. If the rate of the reaction changes, then the voltage or potential also changes. If the concentration of reactants is increased, then the reaction will move more quickly to the right, producing more electrons at the anode and using more at the cathode. This increases the voltage. So an increase in the concentration of reactants will increase the voltage. The spontaneity of a reaction is determined by Gibb's free energy, ΔG. If ΔG is negative, the reaction is spontaneous; if ΔG is positive, the reaction is not spontaneous. There is a direct relationship between the potential of a reaction and its free energy, given by the equation: $\Delta G = – nFE$, where n is the number of moles of electrons transferred in the reaction, F is Faraday's constant and E is the cell voltage. So what will happen to the value of ΔG if we increase the concentration of the reactants? The reaction will proceed more quickly, increasing the flow of electrons, and therefore increasing the voltage, which in turn will make the value of ΔG more negative. As the value of ΔG becomes more negative, the reaction becomes more spontaneous. So choice C is correct; the increased concentration of reactants increases both the voltage and the spontaneity of the reaction.

QUESTION NO: 5

The sexual reproduction in Rhizopus is:

A. anisogamous.

B. conjugation.

C. oogamous.

D. ogamous and anisogamous.

ANSWER: B

QUESTION NO: 6

If a person having Rh-negative blood is given Rh-positive blood by mistake, it will stimulate formation of:

A. Rh-antigens.

B. blood clots.

C. Rh-antibodies.

D. None of them.

ANSWER: C

QUESTION NO: 7

The rich analyses of Fernand Braudel and his fellow Annales historians have made significant contributions to historical theory and research. In a departure from traditional historical approaches, the Annales historians, assume (as do Marxists) that history cannot be limited to a simple recounting of conscious human actions, but must be understood in the context of forces and material conditions that underlie human behavior. Braudel was the first Annales historian to gain widespread support of the idea that history should synthesize data from various social sciences, especially economics, in order to provide a broader view of human societies over time (although Febvre and Bloch, founders of the Annales school, had originated this approach).

Braudel conceived of history as the dynamic interaction of three temporalities. The first of these, the evenementielle, involved short-lived dramatic “events,” such as battles, revolutions and the actions of great men, which had preoccupied traditional historians like Carlyle. Conjonctures was Braudel’s term for larger cyclical processes that might last up to half a century. The longue duree, a historical wave of great length, was for Braudel the most fascinating of the three temporalities. Here he focused on those aspects of everyday life that might remain relatively unchanged for centuries. What people ate, what they wore, their means and routes of travel – for Braudel these things create “structures” which define the limits of potential social change for hundreds of years at a time.

Braudel’s concept of the longue duree extended the perspective of historical space as well as time. Until the Annales school, historians had taken the juridical political unit the nation-state, duchy, or whatever as their starting point. Yet, when such enormous timespans are considered, geographical features may well have more significance for human populations than national borders. In his doctoral thesis, a seminal work on the Mediterranean during the reign of Philip II, Braudel treated the

geohistory of the entire region as a “structure” that had exerted myriad influences on human lifeways since the first settlements on the shores of the Mediterranean Sea. And so the reader is given such arcane information as the list of products that came to Spanish shores from North Africa, the seasonal routes followed by Mediterranean sheep and their shepherds, and the cities where the best ship timber could be bought.

Braudel has been faulted for the imprecision of his approach. With his Rabelaisian delight in concrete detail, Braudel vastly extended the realm of relevant phenomena; but this very achievement made it difficult to delimit the boundaries of observation, a task necessary to beginning any social investigation. Further, Braudel and other Annales historians minimize the differences among the social sciences. Nevertheless, the many similarly-designed studies aimed at both professional and popular audiences indicate that Braudel asked significant questions which traditional historians had overlooked.

Some historians are critical of Braudel’s perspective for which of the following reasons?

A. It seeks structures that underlie all forms of social activity.

B. It assumes a greater similarity among the social sciences than actually exists.

C. It fails to consider the relationship between short-term events and long-term social activity.

D. It rigidly defines boundaries for social analysis.

ANSWER: B

Explanation:

The author voices the possible criticisms of Braudel in the last paragraph. One of them is that he minimized the differences among the social sciences, so Choice B looks like the correct answer here.

The author is never critical of Braudel’s “structures,” so A is out. The relationship between short-term events and long-term social activity is not mentioned by the author at all, so C is wrong, and Choice D can be eliminated because Braudel is criticized for having no boundaries for social analysis, not for having rigid boundaries.

QUESTION NO: 8

A ski jump is an inclined track from which a ski jumper takes off through the air. After traveling down the track, the skier takes off from a ramp at the bottom of the track. The skier lands farther down on the slope.

Figure 1 shows a ski jump, in which the ramp at the lower end of the track makes an angle of 30° to the horizontal. The track is inclined at an angle of to the horizontal and the slope is inclined at an angle of 45° to the horizontal. A ski jumper is stationary at the top of the track. Once the skier pushes off, she accelerates down the track, and then takes off from the ramp. The vertical height difference between the top of the track and its lowest point is 50 m, and the vertical height difference between the top of the ramp and its lowest point is 10 m.

Figure 1

The distance traveled by the skier between leaving the ski jump ramp and making contact with the slope is called the jump distance. In some cases, in order to increase the jump distance a skier will jump slightly upon leaving the ramp, thereby increasing the vertical velocity. Unless otherwise stated, assume that friction between the skis and the slope is negligible, and ignore the effects of air resistance.

If a skier uses skis of greater surface area, which of the following would occur?

A. The normal force of the slope on the skier would increase.

B. The normal force of the slope on the skier would decrease.

C. The pressure exerted on the slope by the skis would increase.

D. The pressure exerted on the slope by the skis would decrease.

ANSWER: D

Explanation:

The only condition that changes in this question is the surface area of the skis. The normal force of the slope on the skier depends only on the mass of the skier, the acceleration due to gravity, and the angle of the slope. Therefore, changing the surface area of the skis would not affect the normal force, and choices A and B are incorrect. Therefore, the pressure exerted on the slope by the skis must depend on the surface area of the skis. The exact relationship is P = F/A, where P is the pressure on the slope due to the skis, F is the force exerted by the skis on the slope, and A is the surface area over which the force acts, which in this case is the surface area of the skis. The force exerted by the skis is just the component of the weight of the skier normal to the slope, or the normal force, which is constant. Therefore, the pressure is inversely proportional to the surface area of the skis. So the pressure decreases as the surface area increases, choice D.

QUESTION NO: 9

Noncompetitive inhibition differs from uncompetitive inhibition in that a noncompetitive inhibitor binds to an allosteric site on the enzyme and prevents it from catalyzing a reaction, whereas uncompetitive inhibitors bind to the enzyme-substrate complex and prevent catalysis. Increasing the substrate concentration would have which of the following effects?

A. Increasing impact of uncompetitive inhibitor and decreasing concentration of noncompetitive inhibitor

B. Decreasing impact of uncompetitive inhibitor and increasing impact of noncompetitive inhibitor.

C. Increasing impact of uncompetitive inhibitor

D. No effect

ANSWER: C

Explanation:

As substrate concentration increases, there will be more binding between the substrate and the enzyme. More enzyme-substrate complex in solution means more opportunity for an uncompetitive inhibitor to bind. Thus, as substrate concentration increases, the impact of an uncompetitive inhibitor would be expected to increase.

A: The concentration of a noncompetitive inhibitor isn’t changed by changing the substrate concentration. B, D: As discussed above, the impact of an uncompetitive inhibitor would be increased.

QUESTION NO: 10

If the noise level is increased by 30 decibels, what is the ratio of the new intensity to the original intensity?

A. 10

B. 30

C. 100

D. 1000

ANSWER: D

Explanation:

The sound level β is given by 10 log(I/I0), where I is the intensity of the sound and I0 is a reference intensity. Let's call the original intensity I1, and the final intensity I2. Let's start with the original sound level. Substituting into the equation, we get the β1 = 10 log(I1/I0). Next, we can express the new intensity level as β2 = 10 log(I2/I0). To find the difference in the two intensity levels, we subtract β1 from β2, and we get 10 log(I2/I0) − 10 log(I1/I0). To simplify all that, remember that the log of a quotient is equivalent to the log of the numerator minus the log of the denominator. So β2 − β1 = 10(logI2 – logI0 − logI1 + logI0) which equals 10(logI2 − logI1). Now, we know that β2 − β1= 30, so we can say that 30 = 10 log(I2/I1). Simplifying, we get that the log (I2/I1) = 3. Taking the antilog, the ratio of I2 to I1, which is the ratio of the new intensity to the original intensity, equals 103 or 1000, which is answer choice D.

QUESTION NO: 11

Four major blood types exist in the human ABO blood system: types A, B, AB, and O; and there are three alleles that code for them. The A and B alleles are codominant, and the O allele is recessive. Blood types are derived from the presence of specific polysaccharide antigens that lie on the outer surface of the red blood cell membrane. The A allele codes for the production of the A antigen; the B allele codes for the production of the B antigen; the O allele does not code for any antigen.

While there are many other antigens found on red blood cell membranes, the second most important antigen is the Rh antigen. Rh is an autosomally dominant trait coded for by 2 alleles. If this antigen is present, an individual is Rh+; if it is absent, an individual is Rh−. For example, a person with type AB blood with the Rh antigen is said to be AB+.

These antigens become most important when an individual comes into contact with foreign blood. Because of the presence of naturally occurring substances that closely mimic the A and B antigens, individuals who do not have these antigens on their red blood cells will form antibodies against them. This is inconsequential until situations such as blood transfusion, organ transplant, or pregnancy occur.

Erythroblastosis fetalis is a condition in which the red blood cells of an Rh+ fetus are attached by antibodies produced by its Rh− mother. Unlike ABO incompatibility, in which there are naturally occurring antibodies to foreign antigens, the Rh system requires prior sensitization to the Rh antigen before antibodies are produced. This sensitization usually occurs during the delivery of an Rh + baby. So while the first baby will not be harmed, any further Rh+ fetuses are at risk.

The Coombs tests provide a method for determining whether a mother has mounted an immune response again her baby's blood. The tests are based on whether or not agglutination occurs when Coombs reagent is added to a sample. Coombs reagent contains antibodies against the anti-Rh antibodies produced by the mother. The indirect Coombs test takes the mother's serum, which contains her antibodies but no red blood cells, and mixes it with Rh+ red blood cells. Coombs reagent is then added. If agglutination occurs, the test is positive, and the mother must be producing anti-Rh antibodies. The direct Coombs test mixes the baby's red blood cells with Coombs reagent. If agglutination occurs, the test is positive, and the baby's red blood cells must have been attacked by its mother's anti-Rh antibodies.

A couple decide to have a child. If the father's genotype is AO and the mother has type B blood of unknown genotype, which of the following are possible blood types for their child?

I. A

II. B

III. A, B

IV. O

A. I and II only
This means that statement I is also correct; but this doesn't help you decide between choices B and D because they both contain statement I. In fact, you should have known that I was correct because it appears in both of these remaining choices. So what it comes down to is whether or not this child could have type O blood. Well, if the father donates an O allele, the child's genotype will be OO and the phenotype could have type O. This means that statement IV is also correct; all four blood types are possibilities.

B. I, II, and III only
Therefore, statements II and III are correct. Well, since III is correct, you can rule out choices A and C because they don't contain it. Now let's assume the mother's genotype to be BO. This means that she can donate an O allele to the child. In this case, if the father donates an A allele, the child's genotype will be AO and the phenotype will be

C. I, II, and IV only

D. I, II, III, and IV

E. A
II. B
III. A, B
IV. O

ANSWER: D

Explanation:

This is one of those questions requiring an understanding of simple genetics and the ABO system. If you didn't already know it, you're told in the passage that the A and B alleles are codominant to each other, and that the O allele is recessive. Codominance means that both the alleles are phenotypically expressed. So, when a person has both the A and the B alleles, a person is said to have type AB blood and expresses the properties ascribed to BOTH alleles – that is, their red blood cells have both the A and B antigens on their surface. During sexual reproduction, the mother and father each donate one allele to their offspring. In this case we know the father's genotype is AO. This means that he can donate either an A allele or an O allele to his child. We don't, HOWEVER, know the mother's genotype; we only know that her phenotype is type B blood. Well, this means that her genotype is either BO or BB – we simply don't know which one it actually is.

Let's first assume the mother to have the genotype BB and must therefore donate a B allele to the child. In this situation, if the father donates an A, the child's genotype and phenotype will b ABk. If the father donates an O allele, the child's genotype will be BO and the phenotype will be type

B. Therefore, statements II and III are correct. Well, since III is correct, you can rule out choices A and C because they don't contain it. Now let's assume the mother's genotype to be BO. This means that she can donate an O allele to the child. In this case, if the father donates an A allele, the child's genotype will be AO and the phenotype will be

A. This means that statement I is also correct; but this doesn't help you decide between choices B and D because they both contain statement I. In fact, you should have known that I was correct because it appears in both of these remaining choices. So what it comes down to is whether or not this child could have type O blood. Well, if the father donates an O allele, the child's genotype will be OO and the phenotype could have type O. This means that statement IV is also correct; all four blood types are possibilities.

QUESTION NO: 12

Destroying the cerebellum of a cat would cause significant impairment of normal:

A. urine formation.

B. sense of smell.

C. coordinated movement.

D. thermoregulation.

ANSWER: C

Explanation:

To answer this question, you have to be familiar with the functions under the control of the cerebellum. The cerebellum is part of the hindbrain, which is the posterior part of the brain and consists of the pons and the medulla oblongata, in addition to the cerebellum. The cerebellum receives sensory information from the visual and auditory systems, as well as information about the orientation of joints and muscles. In fact, one of the cerebellum's main functions is hand-eye coordination. It also receives information about the motor signals being initiated by the cerebrum. The cerebellum takes all of this information and integrates it to produce balance and unconscious coordinated movement. Damage to the cerebellum could damage any one of these functions. Total destruction of the cerebellum would eliminate all of them. Therefore, choice C is correct because destruction of a cat's cerebellum would seriously impair coordinated movement in the cat. Let's take a look at the other choices. Urine formation, choice A, is the primary function of the kidneys, with a little bit of hormonal regulation to help things out. Choice B, sense of smell, or olfaction, is a function of the cerebrum not the cerebellum. Thermoregulation, choice D, is a function of the hypothalamus, which is a part of the cerebrum.

QUESTION NO: 13

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

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

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

C. In the lamp shown, the phosphor coating is calcium metasilicate, which emits orange to yellow light.

In the phosphor coating, an electron falls from an excited state to a lower energy state, emitting a photon with an energy of 2.07 eV. What is the wavelength of the light emitted by the fluorescent tube? (Note: Planck's constant h = 4.14 × 10−15 eV·s, and c = 3 × 108 m/s.)

A. 300 nm

B. 600 nm

C. In the lamp shown, the phosphor coating is calcium metasilicate, which emits orange to yellow light.

In the phosphor coating, an electron falls from an excited state to a lower energy state, emitting a photon with an energy of 2.07 eV. What is the wavelength of the light emitted by the fluorescent tube? (Note: Planck's constant h = 4.14 × 10−15 eV·s, and c = 3 × 108 m/s.)

900 nm

D. 1242 nm

ANSWER: B

Explanation:

This question is a straightforward application of the equation energy equals hc/λ as given in the answer to question 92. Here, the energy is given in electron-volts instead of joules, but that should not bother you since Planck's constant, h, is given as 4.14 × 10−15 electron-volt seconds. The wavelength therefore equals (4.14 × 10−15)(3 × 108) / 2.07. Rounding everything to the nearest integer gives λ equals (12 × 10−7) / 2, or 6 × 10−7 meters, choice B.

QUESTION NO: 14

Which gas is formed when ammonium chloride is heated with aqueous sodium hydroxide?

A. Ammonia

B. Chlorine

C. Hydrogen

D. Nitrogen

ANSWER: C

QUESTION NO: 15

Graphite is used in the nuclear reactors for specific purpose that is:

A. to absorb neutrons.

B. to slow down neutrons.

C. to absorb alpha particles.

D. to slow down high speed electron.

ANSWER: B

QUESTION NO: 16

Every atomic orbital contains plus and minus regions, defined by the value of the quantum mechanical function for electron density. When orbitals from different atoms overlap to form bonds, an equal number of new molecular orbitals results. These are of two types: σ or π bonding orbitals, formed by overlap between orbital regions with the same sign, and antibonding σ* or π* orbitals, formed by overlap between regions with opposite signs. Bonding orbitals have lower energy than their component atomic orbitals, and antibonding orbitals have higher energy. The electron pairs reside in the lower-energy bonding orbitals; the higher-energy, less stable orbitals remain empty when the molecule is in its ground state.

A benzene ring has six unhybridized pz orbitals (one from each carbon atom), which together from six molecular π orbitals, each one delocalized over the entire ring. Of the possible π orbital structures for benzene, the one with the lowest energy has the plus region of all six p orbital functions on one side of the ring. The six electrons occupying the orbitals fill the three most stable molecular orbitals, leaving the other three empty.

Molecular orbitals are filled from the lowest to the highest energy level. The number of bonds between atoms is determined by the number of filled bonding orbitals minus the number of filled antibonding orbitals; each antibonding orbital cancels out a filled bonding orbital. For a diatomic molecule, orbitals in the n = 2 energy level are filled as follows: σ2s, σ*2s, σ2pz, π2px and π2py (equal in energy), π*2px and π*2py (equal in energy), σ*2pz. (The designation of the three p orbitals as px, py, and pz are interchangeable.)

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

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

A. azimuthal quantum number.

B. magnetic quantum number.

C. principal quantum number.

D. spin quantum number.

ANSWER: B

Explanation:

This is straightforward question relying on your knowledge of quantum numbers. The first quantum number, n, is called the principal quantum number and determines which principal energy level the electron is in, n = 1, n = 2 etc. This does not help specify between the px and py orbital, thus it is not the answer we are looking for. The second quantum number is the azimuthal number designated by l. This determines the subshell s, p, d or f. The azimuthal quantum number can also be

referred to as the angular momentum quantum number. Choice A is the azimuthal quantum number, and it does not help us distinguish the px orbital from the py orbital, so we can rule choice A out. The third quantum number, the magnetic quantum number specifies the particular orbitals within a subshell and is given by ml. Each of these orbitals can hold two electrons. There's only one orbital in an s subshell, in a p subshell there are three, in a d subshell there are five, and in an f subshell there are seven. The three p orbitals are known as px, py, and pz. The magnetic quantum number allows you to differentiate between the px and the py orbital, so choice B is the correct answer. The fourth quantum number, known as ms, tells us whether the electron has a plus or minus spin. Each orbital when filled contains two electrons of opposite spins. Thus it is choice B, the magnetic quantum number, ml, that distinguishes the x, y, and z orbitals of the p subshell.

QUESTION NO: 17

Although we know more about so-called Neanderthal men than about any other early population, their exact relation to present-day human beings remains unclear. Long considered sub-human, Neanderthals are now known to have been fully human. They walked erect, used fire, and made a variety of tools. They lived partly in the open and partly in caves. The Neanderthals are even thought to have been the first humans to bury their dead, a practice which has been interpreted as demonstrating the capacity for religious and abstract thought.

The first monograph on Neanderthal anatomy, published by Marcelling Boule in 1913, presented a somewhat misleading picture. Boule took the Neanderthals' lowvaulted cranium and prominent brow ridges, their heavy musculature, and the apparent overdevelopment of certain joints as evidence of a prehuman physical appearance. In postulating for the Neanderthal such "primitive" characteristics as a stooping, bent-kneed posture, a rolling gait, and a forward-hanging head, Boule was a victim of the rudimentary state of anatomical science. Modern anthropologists recognize the Neanderthal bone structure as that of a creature whose bodily orientation and capacities were very similar to those of present-day human beings. The differences in the size and shape of the limbs, shoulder blades, and other body parts are simply adaptations which were necessary to handle the Neanderthal's far more massive musculature. Current taxonomy considers the Neanderthals to have been fully human and thus designates them not as a separate species, Homo neanderthalensis, but as a subspecies of Homo sapiens: Homo sapiens neanderthalensis.

The rise of the Neanderthals occurred over some 100,000 years – a sufficient period to account for evolution of the specifically Neanderthal characteristics through free interbreeding over a broad geographical range. Fossil evidence suggests that the Neanderthals inhabited a vast area from Europe through the Middle East and into Central Asia from approximately 100,000 years ago until 35,000 years ago. Then, within a brief period of five to ten thousand years, they disappeared. Modern human, not found in Europe prior to about 33,000 years ago, thenceforth became the sole inhabitants of the region. Anthropologists do not believe that the Neanderthals evolved into modern human beings. Despite the similarities between Neanderthal and modern human anatomy, the differences are great enough that, among a population as broad-ranging as the Neanderthals, such an evolution could not have taken place in a period of only ten thousand years. Furthermore, no fossils of types intermediate between Neanderthals and moderns have been found.

A major alternative hypothesis, advanced by

E. Trinkaus and W.W. Howells, is that of localized evolution. Within a geographically concentrated population, free interbreeding could have produced far more pronounced genetic effects within a shorter time. Thus modern human could have evolved relatively quickly, either from Neanderthals or from some other ancestral type, in isolation from the main Neanderthal population. These humans may have migrated throughout the Neanderthal areas, where they displaced or absorbed the original inhabitants. One hypothesis suggests that these "modern" humans immigrated to Europe from the Middle East.

No satisfactory explanation of why modern human beings replaced the Neanderthals has yet been found. Some have speculated that the modern humans wiped out the Neanderthals in warfare; however, there exists no archeological evidence of a hostile encounter. It has also been suggested that the Neanderthals failed to adapt to the onset of the last Ice Age; yet their thick bodies should have been heat-conserving and thus well-adapted to extreme cold. Finally, it is possible that the improved tools and hunting implements of the late Neanderthal period made the powerful Neanderthal physique less of an advantage than it had been previously. At the same time, the Neanderthals' need for a heavy diet to sustain this physique put them at a disadvantage compared to the less massive moderns. If this was the case, then it was improvements in human culture – including some introduced by the Neanderthals themselves – that made the Neanderthal obsolete.

It can be inferred from the passage that the rate of evolution is directly related to the:

A. concentration of the species population.

B. anatomical features of the species.

C. rate of environmental change.

D. adaptive capabilities of the species.

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It can be inferred from the passage that the rate of evolution is directly related to the:

ANSWER: A

Explanation:

According to the fourth paragraph, interbreeding in a concentrated population can produce more pronounced genetic effects in a shorter period of time than interbreeding in a sparser population would. From this it can be inferred that the rate of evolution is directly related to the concentration of the species population (Choice A).

Changes in the anatomical features of a species (Choice B) may be a way to measure the rate of evolution, but anatomical features do not directly affect the rate of evolution. The rate of environmental change (Choice C) and the adaptive capabilities of a species (Choice D) may both affect a species’ survival, but they too do not speed evolution up in the way that concentrating the population can.

QUESTION NO: 18

What is the identity of the reducing agent and oxidizing agent, respectively, in the reaction shown below?

$2Cr(OH)3 + 3H2O2 + 4NaOH \rightarrow 2Na2CrO4 + 8H2O$

A. Cr(OH)+ and NaOH

B. Cr(OH)3 and H2O2

C. H2O2 and Cr(OH)3

D. H2O2 and NaOH

ANSWER: B

Explanation:

To answer this question, you must identify the atom that is reduced and the atom that is oxidized. In the reaction above, chromium is oxidized from +3 to +6, which makes chromium hydroxide the reducing agent. Alternatively, oxygen in hydrogen peroxide is reduced from −1 to −2, which makes it the oxidizing agent. Thus, the correct answer is B.

QUESTION NO: 19

The periodic beating of the heart is controlled by electrical impulses that originate within the cardiac muscle itself. These pulses travel to the sinoatrial node and from there to the atria and the ventricles, causing the cardiac muscles to contract. If a current of a few hundred milliamperes passes through the heart, it will interfere with this natural system, and may cause the heart to beat erratically. This condition is known as ventricular fibrillation, and is life-threatening. If, however, a larger current of about 5 to 6 amps is passed through the heart, a sustained ventricular contraction will occur. The cardiac muscle cannot relax, and the heart stops beating. If at this point the muscle is allowed to relax, a regular heartbeat will usually resume.

The large current required to stop the heart is supplied by a device known as a defibrillator. A schematic diagram of a defibrillator is shown below. This device is essentially a “heavy-duty” capacitor capable of storing large amounts of energy. To charge the capacitor quickly (in 1 to 3 seconds), a large DC voltage must be applied to the plates of the capacitor. This is achieved using a step-up transformer, which creates an output voltage that is much larger than the input voltage. The transformer used in this defibrillator has a step-up ratio of 1:50.

The AC voltage that is obtained from the transformer must then be converted to DC voltage in order to charge the capacitor. This is accomplished using a diode, which allows current flow in one direction only. Once the capacitor is fully charged, the charge remains stored until the switch is moved to position B and the plates are placed on the patient’s chest. To cut down the resistance between the patient’s body and the defibrillator, the electrodes are covered with a wetting gel before use. Care must be taken to insure that the patient is not in electrical contact with the ground while the defibrillator is in use.

The resistance between the two electrodes when placed apart on the patient’s chest is 1,000 Ω when wetting gel is used. What is the initial current through the patient’s heart, assuming that all the current takes this path?

A. 0.16 A

B. 4 A

C. 6.25 A

D. 8 A

ANSWER: D

Explanation:

This question asks you to calculate the initial current through the patient, and this can be done by using Ohm’s law which states that the current is equal to the voltage divided by the resistance. We know that the resistance across the two electrodes is 1000 ohms when a wetting gel is applied, but as in the previous question we do not have a value for the initial voltage. This be calculated as well. We know that the transformer increases the input voltage by a factor of 50, and since the input voltage is 160 volts, the output voltage will be 8000 volts. This voltage charges the capacitor only, so the voltage across the capacitor when fully charged will be 8000 volts. By substituting the values for the resistance and the voltage into Ohm’s law, we find that the initial current flowing through the patient is 8000 divided by 1000, or 8 amps which is choice D.

QUESTION NO: 20

An individual is born with a mutation causing her to partially retain a form of fetal hemoglobin into adulthood. Compared to a normal individual, this person would exhibit:

A. no differences from a normal adult.

B. significantly reduced oxygen binding in the lungs.

C. no symptoms, since retention of fetal hemoglobin would be fatal.

D. increased oxygen binding to hemoglobin in the tissues.

ANSWER: D

Explanation:

Fetal hemoglobin has a higher affinity for oxygen than does adult hemoglobin. Thus, it binds and holds oxygen more tightly. An individual with fetal hemoglobin would show increased oxygen binding to hemoglobin as a result.

A – false, because fetal and adult hemoglobin are different.

B – false, because fetal hemoglobin binds more to oxygen, not less.

C – false. In fact, reactivating fetal hemoglobin can be used as a treatment for sickle-cell.