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QUESTION 1

Tetrodotoxin, the extremely potent poison produced by the puffer (fugu) fish, binds tightly to Na+ channels and blocks the flow of Na+ ions but does not affect K+ or Cl- channels. Tetrodotoxin directly blocks which phase of action potential propagation?

A. Depolarization

B. Repolarization

C. Hyperpolarization

D. Saltatory conduction

Correct Answer: A

An action potential begins with the opening of voltage gated sodium channels that allow sodium to flow into the axon, depolarizing the cell. This is followed by opening of potassium channels that allow potassium to flow out of the cell,

repolarizing it. Blocking the sodium channels would block depolarization. Choice B is incorrect because repolarization is achieved primarily by opening potassium channels. Choice C is incorrect because hyperpolarization is also due primarily

to the flux of potassium ions out of the axon.

Choice D is incorrect because saltatory conduction refers to conduction between nodes of Ranvier in myelinated fibers.

QUESTION 2

The Russian wheat aphid, Diuraphis noxia, is a small green insect discovered in southern Russia around the turn of the century. Agricultural researchers are not quite sure, but they believe the Russian aphid adapted itself to wheat about ten thousand years ago, when the crop was first domesticated by man. What is not in doubt is the insect\\'s destructiveness. Spread by both wind and human transport, the Russian aphid has destroyed wheat fields throughout Asia, Africa, and Latin America. Until a few years ago, the United States had been free of this pest. But in the spring of 1986, a swarm of Russian aphids crossed the Mexican border and settled a few hundred miles north, in central Texas. From there, it quickly spread to other Western states, destroying wheat fields all along its path. In fact, the level of destruction has been so great over the past five years that entomologists are calling the Russian aphid the greatest threat to American agriculture since the Hessian fly, Phytophaga destructor, was inadvertently brought to the colonies on ships by German mercenary troops during the Revolutionary War. A combination of several factors have made it particularly difficult to deal with the threat posed by this aphid. First, Russian aphids reproduce asexually at a phenomenal rate. This process, known as parthenogenesis, often results in as many as twenty generations of insects in a single year. Although most generations remain in a limited geographic area because they have no wings, a few generations are born with wings, allowing the insect to spread to new areas. Second, because wheat is a crop with a very low profit margin, most American farmers do not spray it with pesticides; it simply is not economical to do so. And since the Russian aphid has only recently entered the United States, it has no natural enemies among North American insects or animals. As a result, there have been no man-made or natural obstacles to the spread of the Russian aphid in the United States.

Agricultural researchers seeking to control the Russian aphid have looked to its place of origin for answers. In the Soviet Union, the Russian aphid has been kept in check by predators which have evolved alongside it over many thousands of years. One species of wasp seems to be particularly efficient at destroying the aphid. The pregnant females of the species search the Russian aphid\\'s home, the interior of a wheat stalk, sting the aphid into paralysis, and then inject an egg into its body. When the egg hatches the wasp larva feeds off of the aphid, killing it in the process.

The introduction of predators like the wasp, coupled with the breeding of new strains of insect-resistant wheat, may substantially curb the destructiveness of the Russian aphid in the future. For the time being, however, American farmers are left to their own devices when it comes to protecting their wheat crops

It can reasonably be inferred that the author of the passage is:

A. a botanist with an interest in wheat production.

B. an agriculturist with an interest in pest control.

C. a pest exterminator with an interest in agriculture.

D. an entomologist with an interest in asexual reproduction.

Correct Answer: B

This is an application question about the passage\\'s authorship. In order to answer a question about authorship, it is necessary to consider the passage as a whole, particularly its content and level of complexity. Two major themes are reflected in this passage: (1) Russian aphids have spread far and wide, causing serious damage to wheat fields in America and other countries and (2) methods for controlling the aphid\\'s destructiveness are currently being investigated by agricultural researchers. Given that the focus is on an agricultural crop being plagued by a destructive pest, an agriculturist with an interest in pest control, choice (B), is most likely to have written this passage. A botanist with an interest in wheat production, choice (A), is not likely to have written this passage because, although the passage deals with wheat and briefly mentions the possibility of producing insect-resistant strains of wheat (in the last paragraph), the passage certainly doesn\\'t focus on the botany of wheat production. As for choice (C), if a pest exterminator with an interest in agriculture had written this passage we would expect a much more technical and detailed discussion about the ridding of this pest and the use of pesticides (and perhaps other chemicals) as possible means of controlling the aphid. And, this passage is unlikely to have been written by an entomologist with an interest in asexual reproduction, choice (D). Although an entomologist, or someone who studies insects, may be a likely author, the aphid\\'s method of reproduction is a minor issue in this passage, confined to a couple of sentences in the first half of the third paragraph.

QUESTION 3

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.

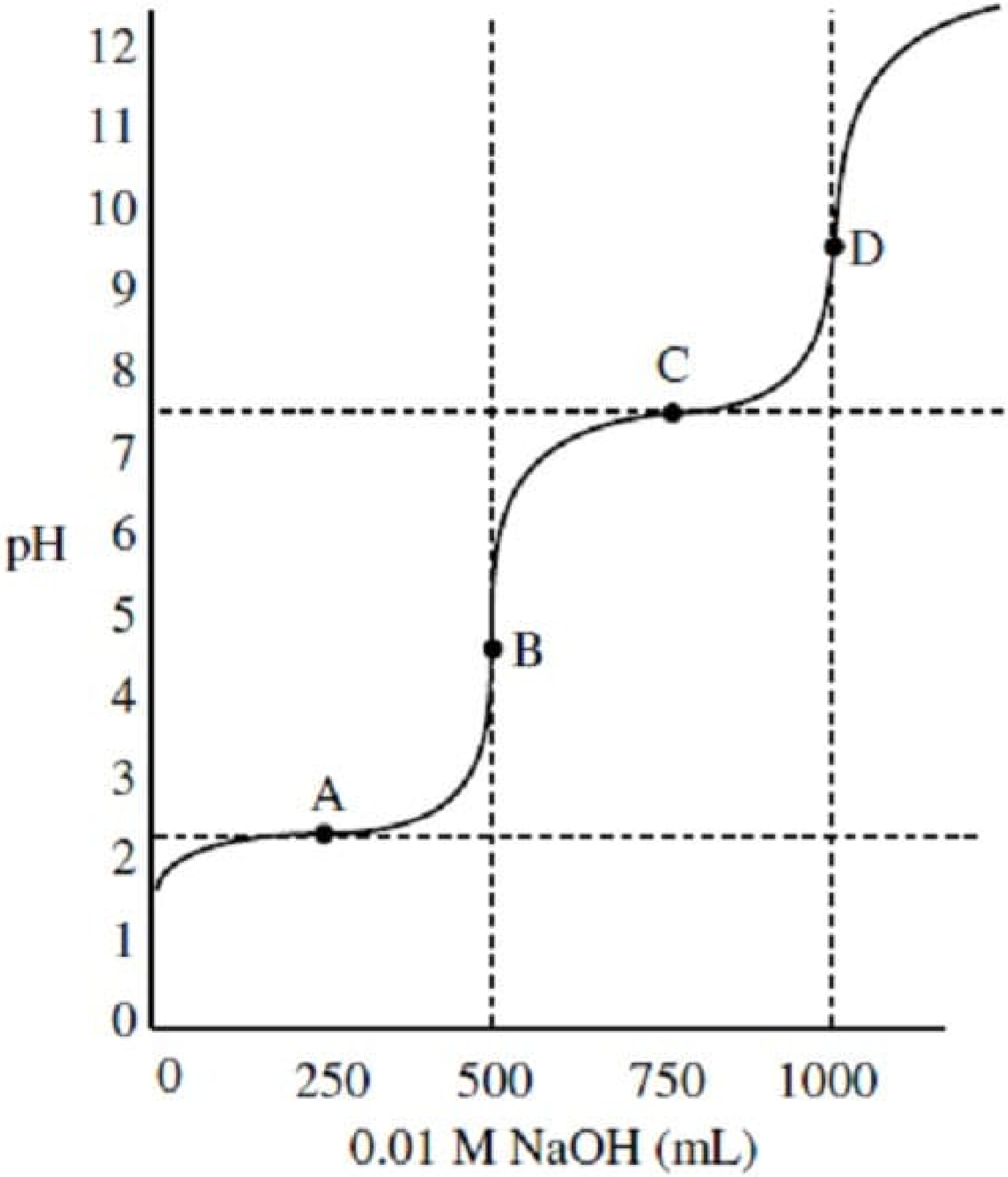

Figure 1

Which region of the graph in Figure 1 provides the best buffering around neutral pH?

A. A

B. B

C. C

D. D

Correct Answer: C

The best buffering occurs in the flat regions of the titration curve where the concentrations of acid and conjugate base are equal. Points A and C are good buffering regions, but point C is the best buffering region around neutral (7) pH.

QUESTION 4

A researcher in a molecular biology lab planned to carry out an extraction procedure known as an alkaline plasmid prep, which is designed to purify plasmids, small pieces of the hereditary material DNA, from bacterial cells. The bacteria are first placed into a test tube containing liquid nutrient medium and allowed to grow until they reach a high population density. The culture, which consists of solid cells suspended in the medium, is then centrifuged; a solid pellet is formed. The supernatant is poured out, leaving the pellet behind, and the cells are resuspended in a mL of lysis buffer solution (50 mM glucose, 25 mM Tris buffer and 10 mM ethylenediaminetetraacetic acid (EDTA), with 5 mg of the enzyme lysozyme added). They are then incubated for 30 minutes at 0°C, during which time the bacterial cell walls break down and the cell contents are released into the solution. After incubation, 1 mL of 0.4 N sodium hydroxide and 1 mL of 2% sodium dodecyl sulfate (SDS) are added, and the solution is again incubated on ice for 10 minutes. 2 mL of 3 M sodium acetate are added and the mixture is incubated for 30 minutes at 0°C. The test tube is centrifuged once more and the supernatant is decanted into a clean tube, leaving behind the protein and most other cell components in the pellet. Finally, 10 mL of pure ethanol are added to the supernatant from the previous step to precipitate out the DNA, and the test tube is incubated at –20°C for 60 minutes, during which the mixture remains liquid. The mixture is centrifuged a final time and the supernatant removed. The translucent precipitate that results is washed with 70% ethanol (70% ethanol and 30% water by volume), allowed to dry, and resuspended in 1 mL of TE buffer (10 mM Tris, 1 mM EDTA). In preparation for this experiment, the researcher prepared stock solutions of the various chemicals that she will need in the experiment. Stock solutions are highly concentrated solutions of commonly used chemicals in water from which dilute solutions are prepared for daily use. Table 1 shows the chemicals, their molecular formulas and weights, and the composition of commonly used stock solutions.

Table 1

Compound	Formula	MW	Stock
Tris	$(CH_2OH)_3CNH_2$	121	1*M* (pH 8)
EDTA	$(HOOCCH_2)_4(CNH_2)_2$	292	0.5 *M* (pH 8)
Sodium hydroxide	NaOH	40	5 *N*
SDS	$C_{11}H_{23}CH_2OSO_3^-Na^+$	288	10%
Sodium acetate	$CH_3COO^-Na^+$	82	3 *M* (pH 5.2)
Ethanol	CH_3CH_2OH	46	95%

Pure ethanol (CH3CH2OH) is difficult to prepare and therefore expensive; 95% ethanol is much cheaper. Consequently, 95% ethanol is generally used in the preparation of dilute ethanol solutions. How much 95% ethanol would be needed to produce a 500 mL solution of 70% ethanol by volume in water?

A. 333 mL

B. 350 mL

C. 368 mL

D. 475 mL

Correct Answer: C

The easiest way to do it is to figure out how much ethanol is in the solution at the end of the dilution, and work backwards from the end. Now, notice that the meaning of the percentage sign in this question and in the preceding question is different -- there we were talking about percentage by mass, whereas this question tells you clearly that it\\'s dealing with percentage by volume. Also, you\\'re told in the passage that a 70% ethanol solution contains 70% ethanol and 30% water by volume. In practice, this is how researchers do usually measure solutions, just for convenience-- it\\'s easiest to measure liquids by their volume and measure solids by their mass. Anyway, 500 milliliters of a 70% ethanol solution will contain 350 milliliters of ethanol and 150 milliliters of water. So we need an amount of 95% ethanol that contains 350 milliliters of ethanol. If we call this amount X, then 0.95X equals 350 milliliters. So we want a choice that\\'s just a little more than 350, and the only one that fits is C. Sure enough, if we solve the equation, we find that X equals 368 milliliters, choice C.

QUESTION 5

Musical instruments generate vibrations in the air that are perceived as musical tones. In many kinds of drums, these vibrations are created by a standing waves in a vibrating membrane. In a timpani drum, membrane vibration is coupled to the vibration of an enclosed volume of air. There may also be a second membrane whose vibration is coupled to that of the first by the enclosed air space, as in a snare drum. An idealized circular membrane will vibrate at normal mode frequencies given by Equation 1 where T is the membrane tension, r is the membrane radius, is the mass per unit area of the membrane, and frel is the relative frequency shown under each mode in Figure 1. The pitch of drums can be tuned by adjusting the membrane tension.

$$f_{mm} = \frac{2.40 \times f_{rel}}{2\pi r}\sqrt{\frac{T}{\sigma}}$$

Equation 1

The modes are designated by two numbers, m and n. m indicates the number of diameter nodes, and n indicates the number of circular nodes. Several modes of vibration are shown in Figure 1.

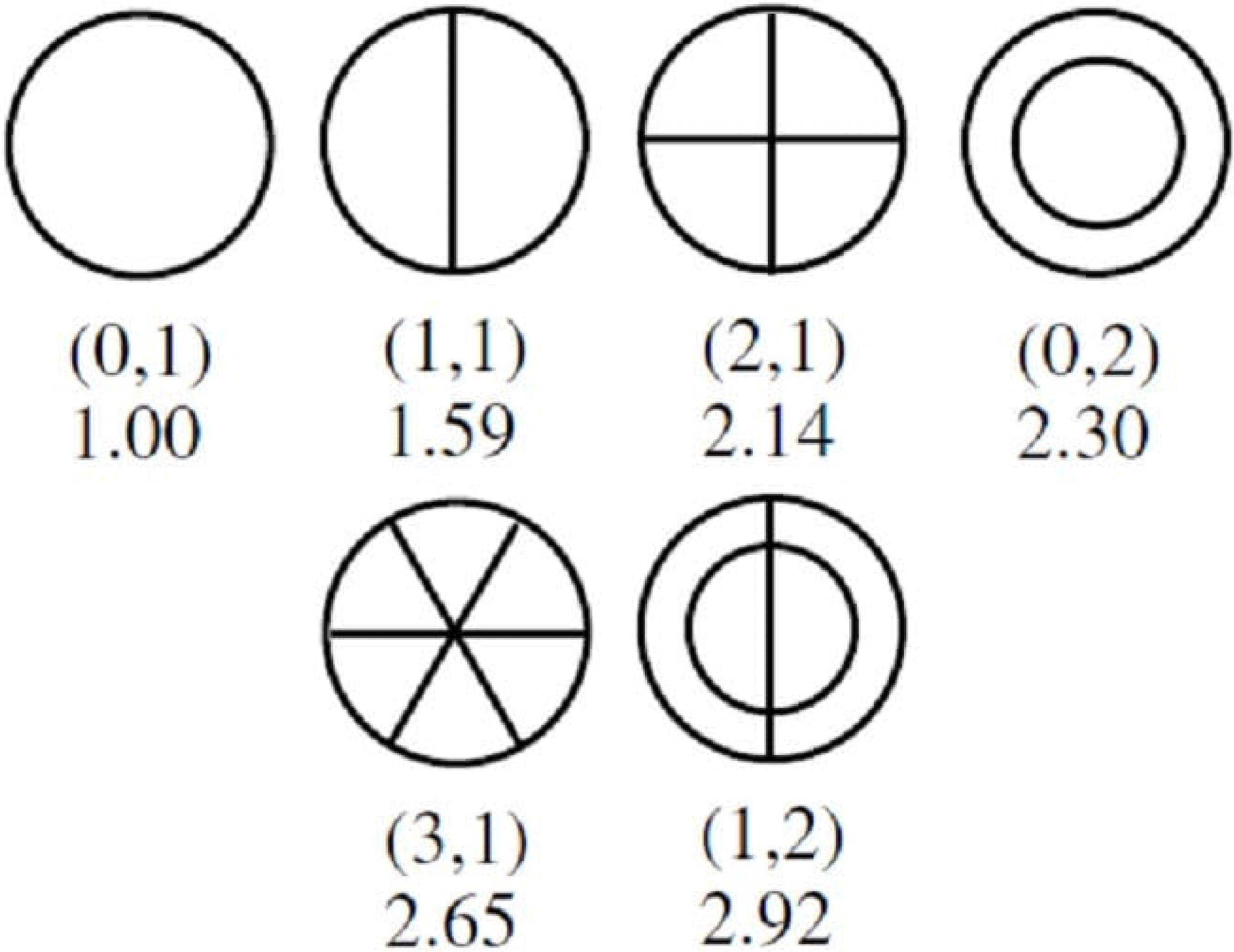

Figure 1

If the tension of a drum membrane is increased by a factor of four and the radius is increased by a factor of two, then the (1,1) modal frequency would:

A. not change.

B. increase by a factor of 1.59.

C. increase by a factor of 2.

D. increase by a factor of 4.

Correct Answer: A

Looking at Equation 1, we see that the frequency is inversely proportional to the membrane radius and directly proportional to the square root of the tension.

$$\frac{2.40 \times f_{rel}}{2\pi a}$$

$$\sqrt{T/\sigma}$$

inversely proportional to membrane radius directly proportional to square root of membrane tension

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