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QUESTION 1

The simple harmonic motion of a mass suspended from vertical springs is investigated in two experiments. The springs used in both experiments have a spring constant k and a natural length L0. The material used to make the springs has a

Young\\'s modulus of 2 x 1011 Pa.

In the first experiment a mass m is suspended from a spring. The mass stretches the spring to a new length L, called the equilibrium length.

In the second experiment the mass m is suspended from two identical springs as shown in Figure 2 below. When the mass m is in equilibrium, each spring is stretched from its natural length by the same amount xe.

In both experiments the masses of the springs are negligible, and the elastic limits of the springs are never exceeded.

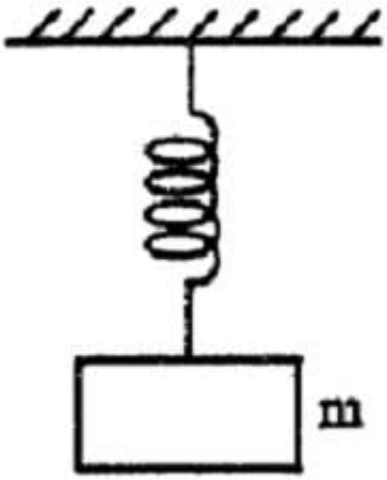

Figure 1

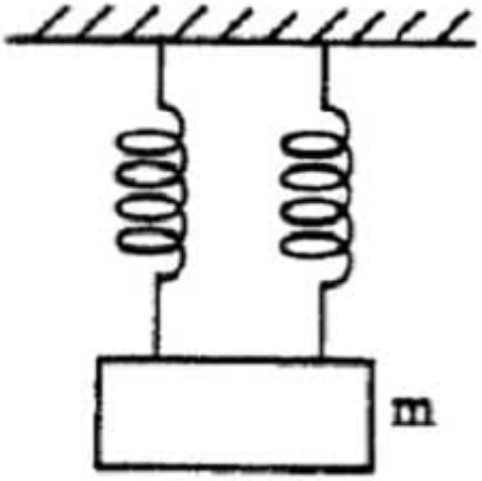

Figure 2

In the first experiment, when a 5-kg mass is oscillating, the frequency of oscillation is 2 Hz. What is the value of the spring constant?

A. 5/2 N/m

B. 20 N/m

C. 402 N/m

D. 802 N/m

Correct Answer: D

QUESTION 2

At a recent meeting of the American Public Transit Association, the Environmental Protection Agency unveiled stringent new standards for pollution control. The transit authorities were particularly concerned about the implementation of a proposed "Clean Air Act." They believed the provisions of the Clean Air Act could severely affect basic services to their local communities. Many transit agencies were concerned that it would be difficult to comply with the pollution and emissions control standards while continuing to operate within realistic budgets. The aim of the Clean Air Act is to assure that by the year 2000, there will be a reduction of at least 10 million tons of sulfur dioxide from 1980 levels. The bill also calls for a reduction in pollutants that contribute to the depletion of ozone. Strict regulations of toxic air emissions would have to be established and enforced. Additionally, the Clean Air Act would establish specific acid-rain reduction quotas and enforce severe penalties for transgressors of any of the new clean air regulations. There is little doubt that mass-transit suppliers will be considerably affected by this new legislation, just as the chemical and petroleum industries have already been affected by similar legislation. Transit authorities are challenged to strike a difficult balance between complying with the government\\'s new standards and developing an official concern for the environment, while continuing to fulfill the transportation needs of the general population. Among the areas addressed by the Clean Air Act, the topic of mobile resources is of particular interest to mass transit authorities. Provisions contained in the Act under this title are aimed at encouraging the development and practical use of alternative fuel sources, like solar energy and methane fuel. The goal of this section of the Act is to eradicate toxic fuel emissions in order to provide cleaner air and a more favorable environment. The Act even goes so far as to declare that in cities like New York, Los Angeles and Houston -- where air quality is particularly noxious and toxins exceed the limits of federal regulations -- forms of mass transit should run on so-called "clean-burning fuels" by the year 2000. Such fuels include reformulated gasoline, propane, electricity, natural gas, ethanol, methanol, or any similar type of low-emission fuel. In addition, the Act proposes that, by 1994, all new urban buses in cities with populations exceeding one million must operate solely on clean-burning fuels. The topics of alternative fuels and alternative fuel vehicles represent, by far, the most controversial issue in the Clean Air Act. President Bush has called alternative fuels "bold and innovative" means to control pollution, but according to many transportation experts, the Act\\'s proposals on alternative fuel usage are unrealistic. The transit authorities recognize that concern for the environment and health hazards like pollution are global issues. However, most transit officials concur that inventing and developing new ways to fuel mass transit will take at least 50 years to realize. They point out that the Act does not mention the political and social ramifications of usurping the role of the petroleum industries. The Act does not mention if or how the thousands of people employed by the oil industry will get retrained to produce and implement the use of "clean" fuel. No one disputes the fact that people need some form of transportation to get from place to place. Preserving the environment should be a priority, yet we need to remember that even if toxic emissions are completely eliminated sometime in the future, the challenge of moving mass numbers of people where they want to go will still exist and must remain a priority. Transit authorities contend that unless the Clean Air Act also acknowledges this, and develops a way to encourage mass transit over personal transportation, the problems of pollution might not be significantly altered. They suggest that there are many areas in this country that have little or no mass transit and that, if the Clean Air Act\\'s goal is to reduce pollution, perhaps the most practical and realistic means to achieve that goal is to encourage the development and maintenance of mass transit systems.

According to the passage, the main goal of the Clear Air Act was to:

A. make sure that pollution was completely eradicated by the year 2000.

B. reduce the amount of sulfur dioxide levels in the air by at least 10 million tons from 1980s levels.

C. eliminate all pollution.

D. enforce harsh penalties for transgressors of any of the new clean air regulations.

Correct Answer: B

The answer to this Detail question can be found in the first sentence of Paragraph 2: the aim of the Clean Air Act is to reduce the level of sulfur dioxide by at least 10 million tons (Choice B). Choices A and B are incorrect because they\\'re too extreme; the second paragraph doesn\\'t say anything about "completely eradicating" pollution or "eliminating" toxic

air emissions (the latter will just be "strictly regulated"). Finally, although penalties for transgressors of the regulations would be enforced by the Act, the main goal of the Act is not to punish people for polluting but to reduce the level of pollution, so Choice D is wrong.

QUESTION 3

Spiders can be distinguished from insects because they have:

A. two antennae.

B. eight legs.

C. jointed legs.

D. separated head, thorax and abdomen.

Correct Answer: B

QUESTION 4

It is critical for the human body blood to maintain its pH at approximately 7.4. Decreased or increased blood pH are called acidosis and alkalosis respectively; both are serious metabolic problems that can cause death. The table below lists the major buffers found in the blood and/or kidneys. Table 1 Buffer pKa of a typical conjugate acid:*

$HCO_3^- \rightleftharpoons CO_2$

+ Histidine side chains

HPO_4^{2-}

$\rightleftharpoons H_2PO_4^-$

Organic phosphates N-terminal amino groups

$\rightleftharpoons NH_4^+$

NH_3

7.0

8.0

9.2

pK_a

*For buffers in many of these categories, there is a range of actual values.

pK_a

The relationship between blood pH and the of any buffer can be described by the Henderson-Hasselbalch equation:

pK_a

pH = + log([conjugate base]/[conjugate acid]) Equation 1

CO_2

Bicarbonate, the most important buffer in the plasma, enters the blood in the form of carbon dioxide, a byproduct of metabolism, and leaves in two forms: exhaled and excreted bicarbonate. Blood pH can be adjusted rapidly by changes

CO_2

in the rate of exhalation. The reaction given below, which is catalyzed by carbonic anhydrase in the erythrocytes, describes how bicarbonate and interact in the blood.

CO_2

+ + Reaction 1

What would be the nature of the compensatory change that would take place in the respiratory system response to acidosis caused by organic acids?

A. Breathing rate would increase and total blood CO_2 / HCO_3^- concentration would increase

B. Breathing rate would increase and total blood CO_2 / HCO_3^- concentration would decrease

C. Breathing rate would decrease and total blood CO_2 / HCO_3^- concentration would increase

D. Breathing rate would decrease and total blood CO_2 / HCO_3^- concentration would decrease

A. Option A

B. Option B

C. Option C

D. Option D

Correct Answer: B

As the passage states, the immediate buffering effect of bicarbonate is controlled by changes in the breathing rate. When acidosis occurs, the concentration of H+ is too high. As discussed earlier, Le Chatelier\\'s principle applies: In order to decrease the concentration of H+, the concentration of carbon dioxide must decrease. If the breathing rate

increases, more carbon dioxide is exhaled and its concentration in the blood decreases. Since the effect of this rapid breathing is to remove carbon dioxide from the body, the ultimate effect is to decrease the total CO2/ HCO3?concentration in the blood. Therefore, choice B is correct. Choice A is wrong because the ratio of CO2/ HCO3?would decrease, not increase. Choice C and choice D are wrong because the breathing rate would increase, not decrease.

QUESTION 5

Artificial kidneys have been used for almost 50 years to treat patients with different forms of renal failure. The artificial kidney (dialysis machine) removes unwanted substances from the blood by diffusion. A patient\\'s blood is passed through channels bounded by a porous, semi-permeable membrane that allows the free diffusion in both directions of all plasma constituents except the plasma proteins. Erythrocytes and other cellular components of blood cannot pass through the membrane. The other side of the membrane is exposed to the dialyzing fluid which carries away the unwanted materials. If the concentration of a material in the blood is greater than in the dialyzing fluid, there will be a net flow of the material from the plasma to the dialyzing fluid. If the concentration of a material in the blood is less than in the dialyzing fluid, there will be a net flow of the material from the dialyzing fluid into the blood. The composition of normal plasma, plasma in an individual suffering renal failure, and dialyzing fluid are shown in Table 1.

Constituent	Normal Plasma (mEq/L)	Plasma w/ renal failure (mEq/L)	Dialyzing Fluid (mEq/L)
Na^+	142	142	133
K^+	5	7	1.0
Cl^-	107	107	105
HCO_3^-	27	14	35.7
Urate	0.3	2	0
Constituent	**Normal Plasma (mg/dl)**	**Plasma w/ renal failure (mg/dl)**	**Dialyzing Fluid (mg/dl)**
Glucose	100	100	125
Urea	26	200	0
Creatinine	1	6	0

Table 1

Dialysis replaces some functions of the kidneys and attempts to correct the effects of renal failure. For example, patients with renal failure develop acidosis due to a buildup of metabolically produced acids in the circulation. Without dialysis,

the pH of the blood will drop and coma may occur. Dialyzing fluid contains a relatively high concentration of bicarbonate which diffuses into the circulation and neutralizes the acid.

In order to prevent the net movement of water between the blood and the dialyzing fluid, the dialyzing fluid:

A. is hypoosmotic to blood.

B. is isoosmotic to blood.

C. contains a higher concentration of solutes than blood.

D. contains hydrophilic proteins.

Correct Answer: B

If the dialyzing fluid is isoosmotic, it has the same concentration of particles and thus, the same osmotic pressure exists on either side of the membrane. There will be no net flow of water by osmosis between the blood and the dialyzing fluid. Choice A is incorrect because a hypoosmotic dialyzing fluid would lead to flow of water into the circulation from the dialyzing fluid. Choice C is incorrect because a solution with a higher concentration of solutes is hyperosmotic. A hyperosmotic dialyzing fluid would lead to flow of water out of the circulation from the dialyzing fluid. Choice D is incorrect because hydrophilicity has nothing to do with the net flow of water. A hydrophilic protein is "water-loving" because it contains polar amino acids.