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**Passage I (Data Representation)**

The decay of uranium-238 (238U) to lead-206 (206Pb) is often used for radiometric dating of rocks. 238U is a radioactive substance that decays at a unique rate until it becomes stable in the form of 206Pb. The concentration of 206Pb in the rock can be used to determine the age of the rocks. The half-life (t1/2) of 238U is 4468 million years; thus, it takes 4468 million years for the concentration of 238Uin the sample to decrease by half (and for 206Pb to increase by the same amount). Figure 1 shows the half-life of the radioactive 238U decay. Samples were collected from two different regions in both the Rocky Mountains in Colorado and the Appalachian Mountains in Georgia and the percent of 238U was determined at different depths. The regional 238U % values in the Rocky Mountains and Appalachian Mountains are shown in Figure 2. The average 238U % values in the Rocky Mountains and Appalachian Mountains are shown in Figure 3.

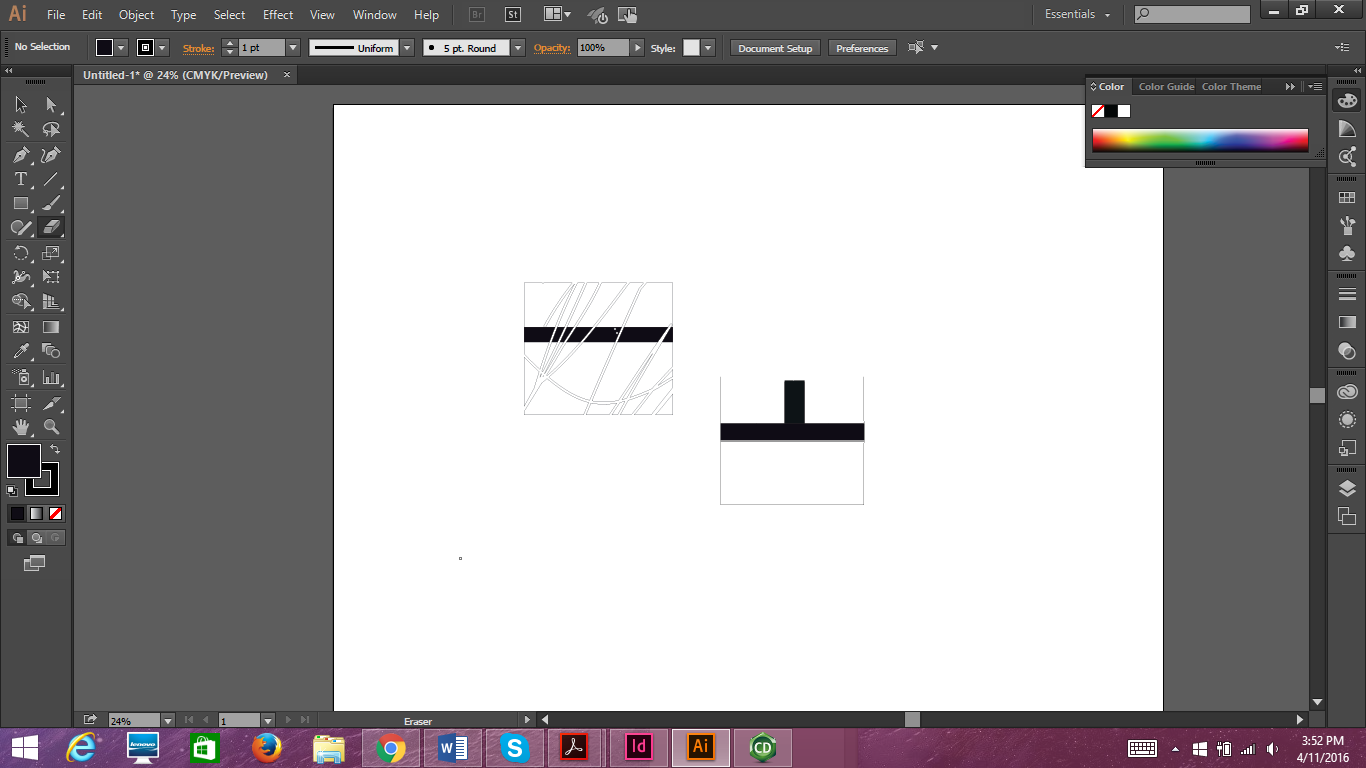
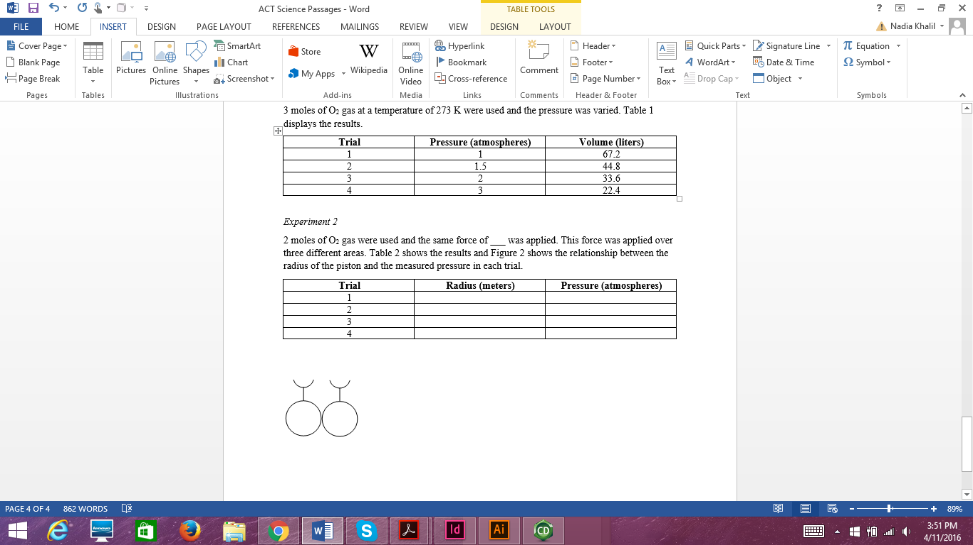
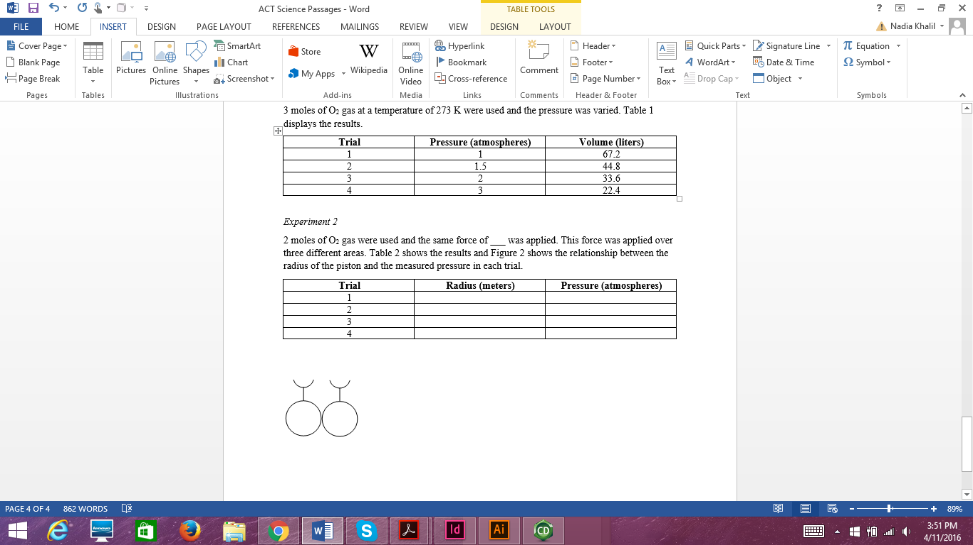
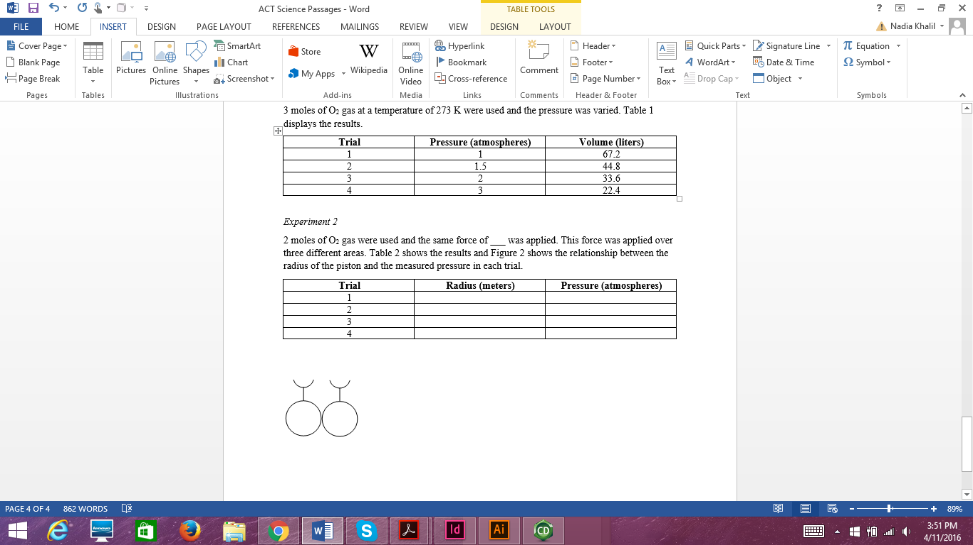
1. According to Figure 1, what is the percent of 238U in the sample after two half-lives?
   1. 50%
   2. 25%
   3. 75%
   4. 12.5%
2. According to Figure 1, how old is a rock with 50% 238U concentration?
   1. 4468 million years old
   2. 8936 million years old
   3. 17,872 million years old
   4. 35,744 million years old
3. According to Figure 2, which rock contains the least amount of lead-206 (206Pb)?
   1. Region 2 Rocky Mountains at 0 inches
   2. Region 1 Rocky Mountains at 350 inches
   3. Region 2 Appalachian Mountains at 350 inches
   4. Region 1 Appalachian Mountains at 0 inches
4. According to Figure 2, the % of 238U in the sample was greater in Region 1 of the Rocky Mountains compared to Region 2 of the Rocky Mountains at which of the following depths?
   1. 100 in, 200 in, and 300 in
   2. 0 in, 200 in, and 350 in
   3. 0 in , 100 in, and 200 in
   4. 50 in, 150 in, and 250 in
5. Based on the information provided in Figure 3, which rock was the oldest?
   1. 0 inches in the Rocky Mountains
   2. 0 inches in the Appalachian Mountains
   3. 350 inches in the Rocky Mountains
   4. 350 inches in the Appalachian Mountains
6. According to the passage, which of the following is the most stable?
   1. 238-uranium
   2. 234-uranium
   3. 207-lead
   4. 206-lead

**Answers and Explanations to Passage I Questions**

1. **B**. Half-life was defined in the passage as the amount of time it takes for the concentration in the sample to decrease by half. Therefore, after one half-life, the sample will have 50% of what it previously had. After two half-lives, the sample will have half of what it had at one half-life, so half of 50% is 25%.
2. **A**. The half-life, which was defined as the amount of time it takes for the concentration in the sample to decrease by half, is 4468 million years old. Therefore, after 4468 million years old, the concentration of 238U in the sample will be 50%.
3. **D**. The rock with the least amount of lead-206 is the rock with the most amount of uranium-238, since uranium-238 turns into lead-206. The correct answer, according to Figure 2, is D, since the bar graph at the rock at 0 inches in the Appalachian Mountains is the highest in the graph.
4. **C**. The only depths at which Region 1 is greater than Region 2 for the Rocky Mountains are 0 in, 100 in, and 200 in, according to Figure 2. Check at which depths the blue bar graph is taller than the orange bar graph, since these pertain to Regions 1 and 2 of the Rocky Mountains, respectively.
5. **C**. The rock is older as there is less 238U in the sample. The rock at 350 inches in the Rocky Mountains had the lowest 238U %, as indicated in Figure 3.
6. **D**. Only 238 uranium and 206-lead were mentioned in the passage. Of the two, 206-lead is more stable. The passage indicates that 238-uranium is *radioactive* and it *decays* to form the more *stable* 206-lead.

**Passage II (Experiments/ Research Summary)**

The ideal gas law states the PV=nRT where P= pressure, V=volume, n= number of moles, R= the ideal gas constant, and T= temperature. The equation for pressure is P=F/A where F= force and A= area, and A= πr2, where π=3.14 and r=radius of the circle. Using the piston pictured in Figure 1, a student performed two experiments.



**Figure 1**

*Experiment 1*

3 moles of O2 gas at a temperature of 273 K were used and the pressure was varied. Table 1 displays the results.

**Table 1**

|  |  |  |
| --- | --- | --- |
| **Trial** | **Pressure (atmospheres)** | **Volume (liters)** |
| 1 | 1 | 67.2 |
| 2 | 1.5 | 44.8 |
| 3 | 2 | 33.6 |
| 4 | 3 | 22.4 |

*Experiment 2*

2 moles of O2 gas were used and the same force of 5 N was applied. This force was applied over three different areas. Table 2 shows the results and Figure 2 shows the relationship between the radius of the piston and the measured pressure in each trial.

**Table 2**

|  |  |  |
| --- | --- | --- |
| **Trial** | **Radius (meters)** | **Pressure (atmospheres)** |
| 1 | 0.35 m | 12.99 |
| 2 | 0.45 m | 7.86 |
| 3 | 0.75 m | 2.83 |
| 4 | 1 m | 1.59 |

**Figure 2**

1. In Table 1, what is true about the relationship between pressure and volume?
   1. As pressure is increased, volume is increased.
   2. As pressure is increased, volume was unchanged.
   3. As pressure increased, volume decreased.
   4. There is no relationship between pressure and volume.
2. Based on Table 2 and Figure 1 it could be determined that a piston with a radius of 0.6 m would have a pressure close to:
   1. 10 atm
   2. 4 atm
   3. 2 atm
   4. 0.5 atm
3. In Experiment 2, which of the following factors was varied?
   1. The area of the piston
   2. The force applied to the piston
   3. The number of moles of oxygen in the piston
   4. The identity of the gas in the piston
4. The following hypothesis was put forth prior to the experiments: Pressure is inversely related to volume. An inverse relationship implies that when one quantity increases, the other decreases. Do Tables 1 and 2 support this hypothesis?
   1. No. Experiment 1 contradicts the hypothesis and shows a direct relationship between pressure and volume. The pressure increases with volume.
   2. No. Experiment 2 contradicts the hypothesis and shows a direct relationship between pressure and volume. The pressure increases with volume.
   3. Yes. The results of both experiments show an inverse relationship between pressure and volume. When the pressure increases, volume decreases.
   4. No. Neither experiment shows any relationship between volume and pressure.
5. Using the piston in Figure 1 and the results of both experiments, which of the following conditions would result in the largest pressure?
   1. 3 moles of O2 gas, 2 L volume
   2. 3 moles of O2 gas, 3 L volume
   3. 2 moles of O2 gas, 1 L volume
   4. 2 moles of O2 gas, 3 L volume
6. Based on the information in the passage, figures, and tables, which of the following sets of conditions would most likely produce a pressure of 20 atmospheres (assume the number of moles used is the same as in Experiment 2)?
   1. Force of 5 N; volume of 0.25L
   2. Force of 10 N; volume of 2 L
   3. Force of 8 N; volume of 12 L
   4. Force of 4 N; volume of 6 L

**Answers and Explanations to Passage II Questions**

1. **C.** Table 1 clearly shows that as the pressure is increased, the volume is decreased.
2. **B**. A radius of 0.6 m falls in between the radius sizes in Trial 2 and Trial 3. The pressure, therefore, should be somewhere in between the pressures in Trial 2 and 3, so it should be between 2.83 and 7.86 atm. The only option that fits this criteria is B. 4 atm.
3. **A**. The radius was changed in Experiment 2, and changing the radius also changes the area, which was given in the paragraph A= πr2.
4. **C**. In Experiment 1, the relationship is clear between pressure and volume: when one increases the other decreases. In Experiment 2, as the radius increases, so too does the volume of the piston. When the volume increases (radius increases), Table 2 and Figure 2 indicate that pressure decreases. Therefore, the results in Experiment 2 also demonstrate the same inverse relationship between pressure and volume.
5. **C**. Using the relationship relating number of moles and volume provided in the paragraph, PV=nRT, the answer can be determined. Because we are looking for the effect on pressure and only moles (n) and volume (V) come into play, we can rearrange this equation to: P=n/V. This allows us to clearly see the relationship between moles, volume, and pressure, and it allows us to make quick calculations to determine our answer. For A, P=3/2=1.5. For B, P=3/3=1. For C, P=2/1=2. For D, P=2/3=0.66. The largest of these is 2, which corresponds to option C.
6. **A.** The relationship between force, area, and pressure is P=F/A. The only option where F/A = 20 is option A, where the pressure is 5/0.25 = 20.

**Passage III (Data Representation)**

Gastroesophageal Reflux Disease, commonly referred to as “GERD” or “acid reflux” negatively impacts the quality of life of over 60% of people within a twelve-month period. This disease is characterized by a malfunctioning sphincter, called the “lower esophageal sphincter” or “cardiac sphincter” between the esophagus and the stomach, as shown in Figure 1.



**Figure 1**

The distribution of symptoms of GERD is depicted in Figure 2.

**Figure 2**

Treatment options for GERD include medications, lifestyle modifications, and surgical interventions. The prevalence of these treatments are compared in Figure 3 and the efficacy in Figure 4.

**Figure 3 Figure 4**

Figure 5 provides a comparison between the classes of medication used to treat GERD.

**Figure 5**

1. Which region of the body most accurately describes the site of pathology (the root cause of the disease) in GERD patients?
   1. The heart valves
   2. The region between the esophagus and the stomach
   3. The region between the esophagus and the small intestine
   4. The region between the stomach and the small intestine
2. According to Figure 2, which GERD symptom depends the least on age?
   1. Heart burn
   2. Wheezing
   3. Sore throat
   4. Dental Erosion
3. Figure 2 suggests that the least common GERD symptom in GERD patients of all ages is
   1. Heart burn
   2. Sore throat
   3. Dental Erosion
   4. Dysphagia
4. What can be concluded about surgical interventions according to Figures 3 & 4?
   1. Surgical interventions are the most effective but least prevalent treatment option
   2. Surgical interventions are the most dangerous and least prevalent treatment option
   3. Surgical interventions are the most effective and most prevalent treatment option
   4. Surgical interventions are moderately effective and the most prevalent treatment option
5. What type of treatment do most GERD patients opt for?
   1. Medications
   2. Surgical interventions
   3. Lifestyle modifications
   4. Physical therapy
6. According to Figure 5, which class of medication would be most useful for someone experiencing symptoms of GERD and requiring immediate relief?
   1. Pro-kinetic agents
   2. Proton Pump Inhibitors
   3. H2 Blockers
   4. Antacids
7. An 85-year-old GERD patient likely exhibits all of the following symptoms except
   1. Heart burn
   2. Stomach and chest pain
   3. Wheezing
   4. Regurgitation

**Answers and Explanations to Passage III Questions**

1. **B**. The region between the esophagus and the stomach. The passage states that the damaged site in GERD patients it the lower esophageal sphincter. Figure 1 indicates that this sphincter is in between the esophagus and the stomach.
2. **C**. Sore throat. Figure 2 shows that sore throat in GERD patients fluctuates the most compared to other symptoms, as indicated by the jagged, up-and-down nature of the plot for sore throat.
3. **C**. Dental erosion. Figure 2 shows a relatively straight, horizontal line indicating presence of dental erosion at less than 10% across all ages.
4. **A**. Surgical interventions are the most effective but least prevalent treatment option. Figure 3 shows that the most prevalent treatment is lifestyle modifications and the least prevalent is surgical interventions. Figure 4 shows that medications are the least effective form of treatment and surgical interventions are the most.
5. **C.** Lifestyle modifications. This can be deduced directly from Figure 3.
6. **D**. The question asks which medication would be the most useful immediately or which one has the greatest short-term effectiveness. Figure 5 shows that antacids have the highest short-term effectiveness.
7. **C**. Of all the symptoms listed, wheezing is the least common amongst GERD patients, as indicated by Figure 2.

**Passage IV (Experiments/ Research Summary)**

Friction describes a force that resists movement. Static friction is a type of friction that describes the force on an object that keeps it from moving. Thus, in order to move an object, the force applied (by a human or some other source) must exceed the force of static friction; otherwise, the object, despite applied force, will remain stationary.

The force of static friction exerted by an object is calculated as follows:

*f*s,max = µsn

where *f*s,max is the force that must be overcome by an external source in order to cause movement of the object, µs is the coefficient of static friction that characterizes the type of material the object and the surface are made from, and n is equal to the weight of the object on a horizontal surface.

To learn more about static friction, a student performed the following experiments.

*Experiment 1*

In each trial, a box was pushed on a horizontal surface with just enough force to move the box. The material of the box and the floor was changed in this experiment. The force required to just move the box was measured. Surface area of the interface between the box and the floor was constant. The weight of the box in each trial was also constant. Table 1 displays the results.

**Table 1**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Material of Box | Material of Floor | Force Measured |
| Trial 1 | Rubber | Concrete | 45 N |
| Trial 2 | Steel | Steel (dry) | 36 N |
| Trial 3 | Wood | Wood | 22.5 N |
| Trial 4 | Ice | Ice | * 1. N |

*Experiment 2*

In each trial, a force of 30 N was applied to a box made out of rubber on a horizontal, concrete surface. The area of the interface between the box and the floor was not changed. The results are displayed in Table 2.

**Table 2**

|  |  |  |
| --- | --- | --- |
|  | Weight of Box | Was movement of the box observed? |
| Trial 1 | 28 N | Yes |
| Trial 2 | 31 N | No |
| Trial 3 | 33 N | No |
| Trial 4 | 37 N | No |

1. What is the independent variable in Experiment 1?
   1. *f*s,max
   2. µs
   3. n
   4. There is an independent variable, but it is not listed here.
2. Based off of the information in Experiment 1, which box/floor combination has the greatest coefficient of static friction?
   1. Rubber/ Concrete
   2. Steel/ Steel (dry)
   3. Wood/ wood
   4. Ice/ ice
3. It can be concluded from the results of Experiment 2 that the coefficient of static friction (µs) between a rubber object and a concrete surface is closest to
   1. 0.35
   2. 0.8
   3. 1.0
   4. 1.25
4. Which of the following most accurately explains why movement was observed for the 28 N rubber box in Experiment 2?
   1. The static friction decreased because µs was decreased in this trial.
   2. The static friction increased because µs was increased in this trial.
   3. The applied force was increased to so that it was greater than the opposing frictional force.
   4. The frictional force exerted by the box was less than the applied force.
5. What change to Trial 3 of Experiment 2 would NOT allow the box to move?
   1. Increase the force applied to a magnitude greater than 33 N.
   2. Change the material in order to increase the µs.
   3. Change the material in order to decrease the µs.
   4. Both A and C.
6. After conducting these experiments, the student concludes that it is easiest (requires the least amount of force) to move light objects made of ice on surfaces made on ice compared to the other materials used in the experiment. Is this conclusion supported by the results of Experiments 1 and 2?
   1. Yes. Ice/Ice had the lowest coefficient of static friction, which agrees with the results of Experiment 1, and lighter objects reduced the frictional force exerted by the object, which agrees with Experiment 2.
   2. Yes. Ice/Ice had the greatest coefficient of static friction, which agrees with the results of Experiment 1, and lighter objects increased the frictional force exerted by the object, which agrees with Experiment 2.
   3. No. Ice/Ice had the lowest coefficient of static friction, which agrees with the results of Experiment 1, and lighter objects reduced the frictional force exerted by the object, which agrees with Experiment 2.
   4. No. Ice/Ice had the greatest coefficient of static friction, which agrees with the results of Experiment 1, and lighter objects increased the frictional force exerted by the object, which agrees with Experiment 2.

**Answers and Explanations to Passage IV Questions**

20. **B**. µs. The variable that is altered between trials is the type of material of the box and the surface. The passage indicates that µs quantifies this variation in material.

21. **A**. Rubber/Concrete. Table 1 shows that the greatest amount of force needed to move the box was in Trial 1. Since this force is *f*s,max, and µs is directly proportional to *f*s,max, then µs is also the greatest. This makes sense if we think about it in logical terms too. If it took a really large amount of force to push an object, then the material of that object/ surface is probably the one that gives the most trouble when trying to push it, so the µs is the greatest. Remember: weight of the box and surface area were kept constant in Experiment 1!

22. **C**. 1.0. The information provided for the experiment indicates that the force applied remains constant at 30 N. In order for the box to move *f*s,max cannot be greater than 30 N. If the 28 N box moved but the 31 N box did not, then it is safe to assume that the *f*s,max is at least 28N (but could be greater) and less than 31 N. To isolate for the coefficient of static friction, the equation should be rearranged to: µs = *f*s,max/ n. Remember, n = the weight of the object on a horizontal surface. To determine µs, we can use any number between 28 N and 31 N for n and we use 30 N for *f*s,max. Thus, µs = 30N/30N = 1.0.

23. **D**. The frictional force exerted by the box was less than the applied force. In this experiment, the weight of the box is changed. As weight increases, so too does *f*s,max (as µs is constant). If *f*s,max exceeds our applied force of 30 N, the box will not move because the frictional force of the box is greater than the force with which we are pushing it.

24. **B**. Change the material in order to increase the µs. This option would not allow the box to move; in fact, it would make it more difficult to move the box. If µs is increased, then the frictional force exerted by the box is also increased, which means that the applied force would have to be greater in an attempt to be greater than the frictional force.

25. **A.** Yes. Ice/Ice had the lowest coefficient of static friction, which agrees with the results of Experiment 1, and lighter objects reduced the frictional force exerted by the object, which agrees with Experiment 2. The Ice/Ice trial in Experiment 1 required the least amount of force in order to be moved, and the only variable was the type of material, so the type of material is what made the Ice/Ice trial the one with the least amount of applied force necessary to move the object. The quantification of the type of material (the Ice/Ice) is determined by the Ice/Ice µs. Experiment 2 showed that reduction in weight of the object made the object easier to move (thus reducing the frictional force exerted by the object).

**Passage V (Data Representation)**

Enzymatic activity is a crucial aspect of chemical digestion. The enzymes break down specific types of molecules in a way that makes the nutrients and other components readily absorbed by the digestive organs of the body. One such example is trypsin. Trypsin is produced by the pancreas, and it digests proteins.

Trypsin’s range of activity depends on temperature; below a certain temperature, the kinetic energy is too low for significant reactivity, and above a certain temperature, the enzyme is denatured and can no longer function. This relationship is depicted in Figure 1

**Figure 1**

pH is another factor that effects the activity of trypsin and enzymes in general. The relationship between pH and enzyme reactivity for trypsin and another digestive enzyme called pepsin is shown in Figure 2.

Basicity

Acidity

**Figure 2**

In the lab, BAPNA, a synthetic protein substrate that consists of a dye bound to an amino acid (building block of proteins), trypsin, and water can be used in experimentation to simulate protein in the human digestive system. Upon digestion by trypsin, BAPNA is broken into its parts; the release of the dye causes the solution to yellow. Each of the following test tubes were incubated for an hour at 37⁰C, the average core temperature of a human being. The results are shown in Table 1

**Table 1**

|  |  |  |
| --- | --- | --- |
|  | Components | Color |
| Test Tube 1 | 3 mL water + 3 mL trypsin | Clear |
| Test Tube 2 | 3 mL water + 3 mL BAPNA | Clear |
| Test Tube 3 | 3 mL trypsin + 3 mL BAPNA | Yellow |

1. According to Figure 1, at which temperature would you expect trypsin’s activity to be the lowest?
   1. 45⁰C
   2. 15⁰C
   3. 90⁰C
   4. 37⁰C
2. Which enzyme works in a more acidic environment according to Figure 2?
   1. Trypsin; its optimal activity occurs at a pH greater than 7
   2. Pepsin; its optimal activity occurs at a pH greater than 7
   3. Trypsin; its optimal activity occurs at a pH less than 7
   4. Pepsin; its optimal activity occurs at a pH less than 7
3. What does the experiment mentioned in the passage test for?
   1. The digestive activity of BAPNA
   2. The digestive activity of trypsin
   3. The solubility of BAPNA in water
   4. The solubility of trypsin in water
4. What is responsible for the color change observed in Test Tube 3 in Experiment 1?
   1. The presence of trypsin
   2. The presence of BAPNA
   3. The cleavage of BAPNA
   4. The incubation temperature of 37⁰C
5. If a test tube containing 3 mL of BAPNA and 3 mL of trypsin was boiled for 4 minutes and then incubated at 37⁰C for 1 hour, what would be the expected color of the solution?
   1. Clear
   2. Pale yellow
   3. Yellow
   4. Not enough information given.
6. Based on the information presented in the passage, what is the pH of the pancreas closest to?
   1. 2
   2. 6
   3. 8
   4. 14

**Answers and Explanations to Questions in Passage V**

26. **C.** 90⁰C. Figure 1 shows the reactivity of trypsin at various temperatures. It shows that trypsin’s reactivity is highest at around 37⁰C and is decreased as the temperature deviates from this number. The graph shows that the reactivity towards the left end of the graph (at colder temperatures) is not as low as the reactivity at the right end of the graph (at higher temperatures), so 90⁰C, being on the far right, would be expected to have the lowest reactivity. Additionally, the difference between 37⁰C and 15⁰C is 25 while the difference between 37⁰C and 90⁰C is 53.

27. **D**. Pepsin; its optimal activity occurs at a pH less than 7. The graph shows that pepsin’s highest level of activity occurs around a pH of 2 while trypsin’s highest level of activity occurs around a pH of 8. pH less than 7 is acidic and pH greater than 7 is basic.

28. **B**. The digestive activity of trypsin. The passage states that trypsin is the enzyme with digestive ability and BAPNA is the protein-dye complex being digested. The color change in the experiment occurs only when trypsin successfully digests BAPNA.

29. **C.** The cleavage of BAPNA. When the enzyme trypsin successfully digests the protein-dye complex BAPNA, the dye is released and changes the color of the solution from clear to yellow.

30. **A**. Clear. This question requires some integration. Figure 1 shows that trypsin has little to no activity at extremely high temperatures (boiling). If trypsin does not react, then BAPNA will not be digested and the dye would not be free to change the solution from clear to yellow, so the solution will remain clear.

31. **C**. 8. The passage indicates that the pancreas produces trypsin. Figure 2 shows that the optimal pH for trypsin activity is 8. One would thus expect the pancreas to have a pH close to that.

**Passage VI (Experiment/ Research Summary)**

Photosynthesis is the chemical process by which plants obtain nutrients for growth and development from light sources, namely the sun. The equation for photosynthesis is

6CO2 + 6H2O 🡪 C6H12O6 + O2

carbon dioxide + water 🡪 sugar + oxygen

A student performed two experiments to assess the relationship between light and photosynthesis. Because oxygen is a by-product of the reaction, it was used to quantify photosynthesis in both experiments.

*Experiment 1*

The student placed the plant species *Cabomba* in a beaker filled with a solution of 1% sodium hydrogen carbonate and placed a funnel on top of the plant to funnel the oxygen molecules as shown in Figure 1. The distance between the light sources and the plant-apparatus was variegated. The results are shown in Figure 2.



**Figure 1**

**Figure 2**

*Experiment 2*

The student placed the plant species *Cabomba* in test tubes and wrapped each test tube in red, blue, or green acetate paper. The student then placed the light source at a distance of 5 cm from the test tube and tabulated the number of oxygen bubbles observed in a one minute period for each test tube. The results are shown in Figure 3.

**Figure 3**

1. How would the relationship between the distance of the light source and the number of oxygen bubbles observed be characterized according to the results of Experiment 1?
   1. Linear and negatively correlated
   2. Linear and positively correlated
   3. Exponential and negatively correlated
   4. Exponential and positively correlated
2. What was the dependent variable in Experiment 1?
   1. The *Cabomba*plant
   2. The distance of the light source
   3. The number of oxygen bubbles observed
   4. The 1% sodium hydrogen carbonate solution
3. What is being measured in Experiment 1 by tabulating oxygen bubbles?
   1. The wavelengths of light
   2. The amount of carbonate present in solution
   3. The rate of photosynthesis
   4. The age of the *Cabomba* plant used
4. Which of the following experimental errors most significantly affects the respective experiment?
   1. The student did not give the plant enough time to adjust to the difference in lighting before tabulating the oxygen bubbles observed in Experiment 1
   2. In Trial 2 of Experiment 1, the distance from the light source was actually 3.8 cm instead of 4 cm.
   3. The light source used was also a heat source.
   4. The student used different samples of *Cabomba* in each of the test tubes in Experiment 2.
5. The *Cabomba* plant was able to utilize which type of light most efficiently?
   1. White light (clear)
   2. Red light
   3. Blue light
   4. Green light
6. If a sample of *Cabomba* was placed at a distance of 11 cm from a light source, how many oxygen bubbles would you expect according to the results of Experiment 1?
   1. 100
   2. 0
   3. 60
   4. 50
7. The student learned from his teacher that white light encompasses all colors of light and that plants reflect most of the green light directed towards them, which is why plants appear green. Do the results of this student’s experimentation support these facts?
   1. Yes. In Experiment 1, white light resulted in the most photosynthesis while green light resulted in the least.
   2. Yes. In Experiment 2, white light resulted in the most photosynthesis while green light resulted in the least.
   3. No. In Experiment 1, white light resulted in the most photosynthesis while green light resulted in the least.
   4. No. In Experiment 2, white light resulted in the most photosynthesis while green light resulted in the least.

**Answers and Explanations to Passage VI Questions**

32. **A**. Linear and negatively correlated. As the distance increases, the number of oxygen bubbles produced decrease (negative correlation), and this occurs at a steady rate, as seen by the relatively straight line/ constant slope (linear).

33. **C**. The number of oxygen bubbles observed. The dependent variable is the variable that is changed by (*or dependent on*) another variable that is controlled by the experimenter (the independent variable). The number of oxygen bubbles observed *depends* on how close the light source is to the plant.

34. **C**. The rate of photosynthesis. This was stated in the passage. Since the equation shown for photosynthesis produces oxygen, oxygen was measured to assess the rate of photosynthesis.

35. **C**. The light source used was also a heat source. This experimental error most seriously compromises the experiment because it introduces a new, uncontrolled variable: heat. The relationship between light and distance is no longer isolated, so the experimenter would not be able to draw any conclusions regarding the cause of changes in number of oxygen bubbles observed as distance is altered. Heat is what we call a ‘confounding variable.’

36. **A**. Figure 3 shows that the greatest number of oxygen bubbles observed occurred in the trial with white light, or the test tube without an acetate covering around it.

37. **D**. 50. This can be determined by extending the line of the graph in Figure 2. The slope should remain constant, so the line should be extended in a relatively straight fashion. The only option that suits this criteria is 50.

38. **B**. First, the experiment differentiating between the colors of light was Experiment 2, so A and C can be ruled out. Second, white light did in fact result in the greatest number of oxygen bubbles observed while green resulted in the fewest, ruling out D.

**Passage VII (Conflicting Scientists)**

Solubility describes the ability of solute particles to dissolve in a solvent, or medium of much larger quantity. It is well established that solubility of a solute increases with increasing temperature. Two scientists present their hypotheses on the reason for this phenomenon.

*Scientist I*

Increasing the temperature of a solution increases the average kinetic energy of the molecules within that solution. This happens because heat is itself a form of energy, and once the molecules absorb the energy from the added heat, they convert that energy to kinetic energy. This increase in kinetic energy causes the molecules in solution to speed up and collide at much greater rates and more vigorously. These faster molecules are more effective at breaking apart intact solutes, which explains why increased temperature increases solubility.

*Scientist II*

Le Chatelier’s principle states that a system will always try to maintain equilibrium. If a stressor is added to the system, other factors will adapt in order to compensate for that initial change imposed by the stressor. When temperature of a solution is increased, the added heat is a stressor to the equilibrium of the solution. In order to compensate for this stressor, the solution will attempt to reduce the heat in the solution by trying to cool down. It does this by allowing the solutes present in solution to dissolve; this reduces temperature because the solute particles absorb heat until their bonds are broken. Thus, the increase in solubility results when temperature is increased in order to reinstate equilibrium.

1. How would Scientist II explain why pressure added to a system decreases the volume of that system if all other variables are held constant?
   1. The average kinetic energy of the molecules is increased, so in order to maintain that, volume is decreased.
   2. The increase in pressure is an added stressor that is compensated for by a decrease in volume.
   3. Increasing pressure increases heat which also decreases volume.
   4. The system decreases its volume in response to an increase in pressure to shift the system further away from equilibrium.
2. Which of the following, if true, would weaken the hypothesis of Scientist 1?
   1. Increasing temperature slows molecules down.
   2. The increase in kinetic energy of the molecules of the solvent is sufficient for breaking the bonds of the solute particles.
   3. In order to break, the bonds of solute particles release energy, thereby increasing the temperature of the system.
   4. Equilibrium is a driving force for the progression of chemical reactions.
3. One similarity between the two hypotheses is that:
   1. both rely on Le Chatelier’s principle
   2. both describe kinetic energy in some form relating to an increase in solubility
   3. both neglect the importance of determining how heat increases solubility
   4. both relate heat to some property of the molecules
4. Which of the following is explained by Scientist I but not Scientist II?
   1. Why the solubility of gases decreases with increasing temperature
   2. How systems respond to deviations from equilibrium
   3. How the increase in temperature is an increase in energy in the form of heat
   4. Why dissolution is favored as temperature is increased
5. Scientist II’s description of the increase in solubility is best illustrated by which of the following graphs?
6. Increasing temperature also speeds up the rate of a given chemical reaction. Which of the following would Scientist 1 suggest as the cause of this increase in the rate?
   1. The molecules move rapidly to expend the added energy that heat provided, which increases their rate of collision and thus reaction.
   2. The molecules’ added energy in the form of heat is converted to kinetic energy of the molecules, which speeds up the molecules and increases their rate of collision and thus the reaction.
   3. An increase in the reaction rate compensates for the increase in temperature.
   4. Increasing temperature gives the molecules enough energy to orient themselves for collisions that result in reactions.

**Answers and Explanations to Passage VII Questions**

39. **B.** The increase in pressure is an added stressor that is compensated for by a decrease in volume. Scientist II’s argument relied primarily on discussion of Le Chatelier’s principle, which in turn uses progression towards equilibrium as the driving force of a reaction.

40. **A**. Increasing temperature slows molecules down. Scientist I’s argument relies on the assumption that energy in the form of heat is transferred to molecules in solution and converted into kinetic energy. This increase in kinetic energy speeds up the movement of molecules. If this does not occur, then Scientist I’s conclusion regarding increased kinetic energy and solubility would be weakened.

41. **D**. Both relate heat to some property of the molecules. Scientist I relates heat to the average kinetic energy of the molecules while Scientist II relates heat to the breaking of molecular bonds.

42. **C**. How the increase in temperature is an increase in energy in the form of heat. Scientist I describes how an increase in temperature is a transfer of heat energy to the molecules, which convert that energy into kinetic energy for movement. Scientist II describes heat energy in relation to dissolution of solutes absorbing heat energy.

43. **A.** Time increases along the x-axis and temperature increase along the y-axis. Scientist II argues that the increase in temperature is a stressor that displaces the system from equilibrium and says that dissolution is a mechanism by which this stress is mitigated. The graph in A shows temperature spiking at one point (deviation from equilibrium), after which the system gradually returns to the original temperature (return to equilibrium). This is parallel to the argument of Scientist II.

44. **B**. The molecules’ added energy in the form of heat is converted to kinetic energy of the molecules, which speeds up the molecules and increases their rate of collision and thus the reaction. This answer choice discusses how increase in temperature is a transfer of energy in the form of heat, which is then converted into kinetic energy, which then increases collisions of molecules, just as Scientist I postulates the increase in collisions and speed is the reason solute particle dissolution increases with increasing temperature.