ACT Test 1 Section 4

Instructions for Science Reasoning Questions

Read the passage. For each question, fill in the letter on your answer sheet that corresponds to the best answer.

You are not permitted to use a calculator.

Humidity is the term used to describe the amount of moisture content in the air. There aer several methods of expressing humidity. Absolute humidity (g/m^3) (the density of water in the atmosphere) is defined as the mass of water vapor per volume of air. However, relative humidity (%) is the most common method of expressing moisture in the atmosphere. It is the ratio of water vapor in the air compared to the amount the air can hold at a specific temperature (°F) and pressure.

Experiment 1

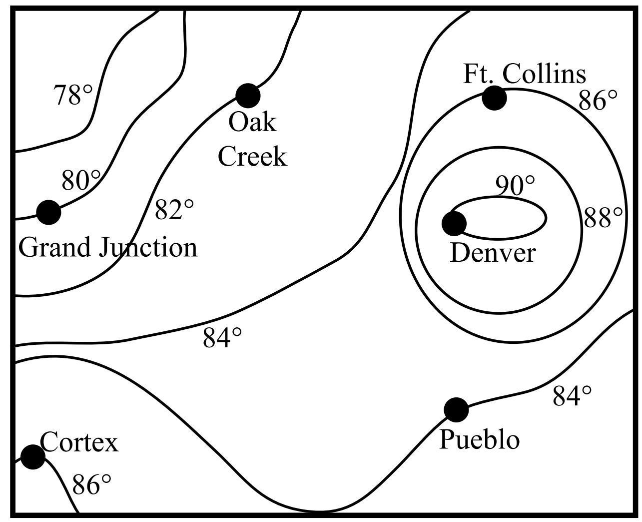
Weather observations were taken in five areas across the country (Table 1). The temperature, relative humidity, and absolute humidity were measured.

Table 1

Location	Temp. °F	Relative Humidity	Absolute Humidity
Phoenix, AZ	110	22	17
Newark, NJ	65	85	7
Orlando, FL	76	94	16
Nome, AK	24	90	2
San Diego, CA	45	54	4

Experiment 2

At higher temperatures, the atmosphere can hold larger amounts of water, making it feel warmer than the actual temperature. The Humiture Index (Table 2) combines the temperature and humidity to determine an apparent temperature. Actual temperatures were measured across Colorado and are plotted as isotherms (equal lines of temperature) on the map in Figure 1.



Colorado —— isotherms F°

Figure 1

Table 2

Temp. °F	Relative Humidty % 10	20	30	40	50	60	70	80	90	100
104	90	98	106	112	120					
102	87	95	102	108	115	123				
100	85	92	99	105	111	118				
98	82	90	96	101	107	114				
96	79	87	93	98	103	110	116			
94	77	84	90	95	100	105	111			
92	75	82	87	91	96	101	106	112		
90	73	79	84	88	93	97	102	108		
88	70	76	81	85	98	93	98	102	108	
86	68	73	78	82	86	90	94	98	103	
84	66	71	76	79	83	86	90	94	98	103
82	63	68	73	76	80	83	86	90	93	97
80	62	66	70	73	77	80	83	86	90	93
78		63	67	70	74	76	79	82	85	89
76		60	63	67	70	73	76	79	82	85

1 Which location in Table 1 has the greatest amount of water vapor in the atmosphere?

- (A) Phoenix, AZ
- (B) San Diego, CA
- (C) Orlando, FL
- (D) Nome, AK

2 At which two locations would the poorest rate of evaporation occur?

- (F) Phoenix and Orlando
- (G) Nome and San Diego
- (H) Nome and Orlando
- (J) Newark and San Diego

3 Determine the Humiture index for Denver, Colorado and Cortez, Colorado using the following humidity data:

Location	Relative Humidity
Denver, Colorado	40
Cortez, Colorado	80

- (A) 40 and 80
- (B) 90 and 86
- (C) 88 and 98
- (D) 108 and 82

4 Based on the passage, what conclusion could be made about the effect of temperature on the humidity?

- (F) The temperature does not affect the humidity.
- (G) The temperature affects only the relative humidity.
- (H) The temperature affects only the absolute humidity.
- (J) The temperature affects both the absolute and relative humidity.

5 Based on the passage, what would happen to the relative humidity if the temperature increased and the amount of water vapor in the air remained constant?

- (A) The relative humidity would decrease and the absolute humidity would remain constant.
- (B) The absolute humidity would decrease and the relative humidity would remain constant.
- (C) Both would remain constant.
- (D) Both would increase.

6 At which place would the highest amount of water vapor most likely be located?

- (F) On a cool beach in autumn
- (G) In a blizzard
- (H) In an office building
- (J) On a hot, humid lakeshore in the summer

The HIV virus contains RNA inside of a protein coat (or shell). The protein coat is used to carry the virus from cell to cell and to infect cells. Part of the protein coat, the docking region, functions solely to recognize the appropriate receptor, bind to the receptor, and then inject the RNA into the cell. The RNA then incorporates itself into the cell's replication process and alters the process to make multiple copies of itself. The viral RNA also programs the cell to produce multiple copies of the protein coat. The new viruses then infect other cells. This virus is also known to change its protein coat, thus several strains of the virus can exist.

A chemist is purifying a new protein which may prevent the binding of the AIDS virus to its receptor, the CD3 receptor on T cells. This new molecule is thought to be released by the cell into the extracellular fluid. The molecule must then pass through the cell membrane before it is excreted. Once in the extracellular fluid, the molecule is hypothesized to bind to the protein coat of the HIV virus such that the virus cannot bind to the CD3 receptor. Thus the virus cannot infect the T cell.

This new molecule was purified and evaluated in the following series of experiments.

Experiment 1

Since the molecule was believed to be excreted, cell media was collected and concentrated. Then, cultured T cells were grown with the HIV virus and different amounts, 50, 100, 500, and 1,000 ul, of the concentrated media. From this it was determined that the HIV infection was prevented when 500 ul and 1,000 ul of concentrated media was added.

Experiment 2

Cell media was then separated by column chromatography and the fractions were assayed. Five fractions containing large amounts of protein and two fractions containing no protein were used. Two of the protein fractions prevented HIV infection. The two non-protein fractions had no effect on the HIV virus. Gel electrophoresis showed the protein fractions to have molecular weights of 23 and 46 kiloDaltons (kD).

Experiment 3

The two fractions were further purified and binding assay was performed. It was determined that the 46 kD protein binds in a 1:1 ratio with the HIV virus and the 23 kD protein binds in a 2:1 ratio.

7 Why was the protein initially purified from the cell media?

- (A) It was membrane bound and portions of the membrane were left in the media.
- (B) The cell excreted the protein into the media.
- (C) The protein was inactive inside the cell but became activated after excretion into the media.
- (D) The media was the easiest fraction to purify.

8 What was the motivation for experiment 1?

- (F) To determine if HIV virus was in the media
- (G) To determine if T cells could be infected with rhinovirus
- (H) To determine if the protein excreted in the media could prevent HIV infection
- (J) To determine the concentration of the protein in the media

9 Why were different volumes of concentrated media used in Experiment 1?

- (A) To approximate the effectiveness of the concentrate.
- (B) To determine the amount of HIV virus.
- (C) To determine the number of cells needed for HIV infection.
- (D) To determine the protein concentration of the media.

10 Why did the scientist separate the cell media into different fractions and assay the fractions individually?

- (F) Small amounts of cell media were needed to prevent HIV infection.
- (G) Chromatography increased the effectiveness of the molecule.
- (H) Only molecules of specific molecular weights could be assayed.
- (J) Isolation of the exact molecule for the cell media allowed it to be identified and studied individually.

11 Which conclusion can be drawn from Experiment 3?

- (A) The 46 kD molecules may contain two sub-unit molecules of 23 kD each which bind to HIV.
- (B) Non-protein molecules are as effective as the 46kD molecules in preventing HIV infection.
- (C) Binding assays are not effective in determining the ratios of proteins needed to prevent HIV infection.
- (D) Gel electrophoresis can be used to separate protein fractions.

12 The motivation for Experiment 2 was

- (F) to determine whether column chromatography had any effect on the HIV virus.
- (G) to determine whether fractionalizing the virus was effective in killing it.
- (H) to isolate and separate protein fractions based on size in order to characterize them.
- (J) to compare the effectiveness of gel electrophoresis with column chromatography.

A chemist is investigating the possible use of catalysts to increase the rate of a reaction. A polymerization reaction is used to make a polyacetal compound which is used in medical prosthetics. Currently, the reaction is done in a solution with an acid solvent. But the reaction is very slow and the product output is low. About 1 mg of polyacetal is produced from every 25 mg of acetal monomer. The remaining 24 mg contain unreacted monomers, dimers (two acetal monomers linked together, and trimers. The desired chain length for the polyacetal is at least 7 monomers linked together. A chain length of 10 is most desired. The current reaction produces 10% of the 10 length, 15% of 8 length, and 60% of 7 units.

Experiment 1

The reaction is performed in the presence of a solid nickel catalyst. The polymer is then separated from the nickel beads, and the distribution of chain lengths of monomers is tested. For every 25 mg of monomer used, 2.5 mg of polyacetal, with chain lengths greater than 7, is produced. The chain distribution is 20% greater than 10, 25% of 9 lengths, 20% of 8 lengths, and 3% of 7 lengths. The remaining 20 mg of monomers have either been converted to dimmers, trimers, or unreacted monomers.

Experiment 2

The solvent in which the reaction is performed was changed. Now the reaction was done in a combination of acetic acid and acetone with the nickel catalyst. The yield increased to 7.5 mg of polyacetal for every 25 mg of monomer. The distribution of polymer sizes was the same as with the nickel catalyst and the acid solvent.

Experiment 3

The catalyst was then changed to a cadmium sheet. The reaction was still in the acetic acid and acetone solvent. The results were 5.0 mg of product for every 25 mg of monomer used. However of the 5.0 mg, 80% had lengths of 10 or greater, and the remaining 20% had lengths of 8 or more. The remaining 20 mg contained mostly trimers.

13 What is the order of experimental conditions of solvent and catalyst which gives the highest to lowest yields of product?

- (A) Acid > acid solvent + nickel > acid/acetone solvent + nickel > acid/acetone + cadmium
- (B) Acid solvent + nickel > acetone/acid solvent + nickel > acid solvent > acid/acetone solvent + cadmium
- (C) Acid/acetone solvent + cadmium > acid/acetone solvent + nickel > acid solvent + nickel > acid solvent
- (D) Acid/acetone solvent + nickel > acid/ acetone solvent + cadmium > acid solvent + nickel > acid solvent

14 Which conditions produced the highest number of polymers of length 10 or greater?

- (F) Acid solvent
- (G) Acid solvent + nickel
- (H) Acid/acetone solvent + nickel
- (J) Acid/acetone solvent + cadmium

15 In comparison to the other yields, what yield would you predict under the condition of acid solvent + cadmium?

- (A) Between 2.5 mg and 5.0 mg
- (B) Between 1 mg and 2.5 mg
- (C) Between 5.0 mg and 7.5 mg
- (D) Greater than 7.5 mg

16 The surface area of the nickel beads was 10 times greater than the surface area of the cadmium sheet. If the surface area of the catalyst was found to be important in determining the reaction rate and product outcome, then what statement is most likely to be true?

- (F) Using cadmium beads would increase the productions of polyacetal.
- (G) Using a nickel sheet would increase the production of polyacetal.
- (H) Using cadmium beads would decrease the production of polyacetal.
- (J) Using a zinc sheet would decrease the production of polyacetal.

17 Compare the effects of the overall use of the catalyst and solvent changes on the production of polyacetal polymers.

- (A) The solvent change increased production, but the catalyst decreased it.
- (B) The solvent change decreased production, but the catalyst increased it.
- (C) The solvent change increased production, and so did the catalyst.
- (D) The solvent change and catalyst both decreased production.

18 The largest polymer chain lengths for the polyacetal were produced by

- (F) using the acid solvent alone.
- (G) using a combination of acetic acid and acetone with the nickel catalyst.
- (H) using a combination of acetic acid and acetone with the cadmium sheet catalyst.
- (J) using a combination of the acid solvent and the nickel catalyst.

Cosmology is the study of the structure of the universe as the whole system of matter and energy in existence everywhere. There are two main theories in modern cosmology:

Theory 1: The Big Bang

Based on the observation that galaxies are receding away from each other, this theory states that there was a time when all of matter in the universe was close together. At the beginning, the universe was extremely hot and very dense, from which it began to rapidly expand. Expansion from this configuration is known as the Big Bang and seeks to explain the universe as we now see it. Recent evidence suggests that this event occurred around 14 ± 6 billion years ago. This theory predicts a certain abundance of light chemical elements such as deuterium (heavy hydrogen) and helium. It also predicts the existence of the microwave background radiation observed in 1965, which is a relic of the initial expansion. Most astronomers accept the Big Bang theory as the best available cosmological model of the universe.

Theory 2: The Steady State

In this theory, the large scale structure of the universe looks the same not only in each region of space, but also in different eras of time. Thus, in the Steady State cosmology there is no Big Bang, no beginning, and the universe has looked about the same forever. According to this theory, new galaxies must constantly be forming in spaces vacated as older galaxies recede, and this necessities continuous creation of matter. Some scientists see this theory as a violation of the concept of conservation of mass, but defenders of the theory argue that it is hardly more outrageous than imagining all the mass of the whole universe appearing at once, as in the Big Bang theory. A major argument against the Steady State theory, however, is it fails to predict the observed microwave background radiations.

19 It can be inferred from the passage that cosmology is

- (A) the study of the universe's origin.
- (B) a study of the structure of the universe as a single, orderly system.
- (C) the Big Bang theory.
- (D) the Steady State theory.

20 The Big Bang cosmology can be distinguished from the Steady State cosmology by the phrase:

- Ⓕ "a static, non-evolving universe"
- Ⓖ "continuous creation of matter"
- Ⓗ "the galaxies receding from each other"
- Ⓙ "the universe expanding from an extremely hot and very dense state"

21 The Steady State cosmology essentially says

- Ⓐ the universe is the same at all times.
- Ⓑ there should be microwave background radiation.
- Ⓒ galaxies are receding away from each other.
- Ⓓ the universe began with a rapid expansion.

22 It is reported that quasars (distant bright galaxies known as quasi-stellar objects) are more numerous at great distances (hence, earlier times). This observation

- Ⓕ supports the Steady State theory.
- Ⓖ supports the idea of an initial explosion 14 billion years ago.
- Ⓗ supports the observation of the cosmic microwave background radiation.
- Ⓙ contradicts the predictions of the Steady State theory.

23 According to the Big Bang theory, the age of the Universe is at least

- Ⓐ 14 billion years.
- Ⓑ 8 billion years.
- Ⓒ 20 billion years.
- Ⓓ 6 billion years.

24 It can be inferred from the passage that most astronomers would

- Ⓕ support both theories.
- Ⓖ disapprove of the Big Bang theory.
- Ⓗ approve of the Steady State theory.
- Ⓙ agree with the Big Bang theory and disagree with the Steady State theory.

25 According to the Steady State theory, the universe

- Ⓐ began in a non-violent manner.
- Ⓑ has existed forever.
- Ⓒ will end in a Big Bang.
- Ⓓ None of the above

We are investigating the pressure vs temperature behavior of new materials for underwater applications. Below is a phase diagram obtained through measurements of the pressure vs. the temperature.

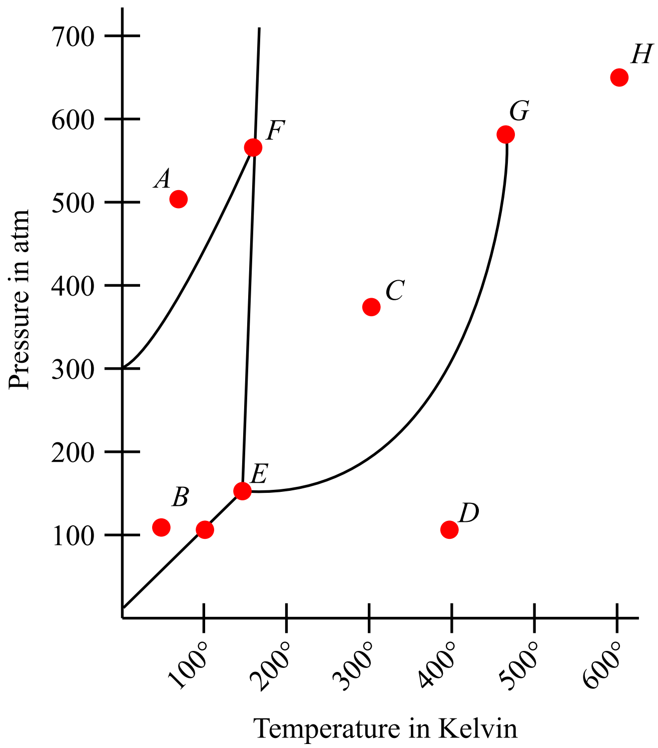


Figure 1

To assist in interpreting the phase diagram, the densities of certain points are recorded in Table 1. This material was shown to exist in two solid phases, one which was more stable than the other. The solid present at 100 K and 100 atm was soft and ductile; the other solid phase was hard and brittle.

Table 1

Point	Density, g/L
A	10.00
C	2.00
H	0.05
E	1.00

26 Which letter on the phase diagram indicates the pressure and temperature where the material exists in all three phases simultaneously?

- (F) Point F
- (G) Point G
- (H) Point E
- (J) Point H

27 Based on Table 1 and the phase diagram, which sequence shows the relationship of the densities among solids, liquids, and gases?

- (A) Solids > liquids > gases
- (B) Liquids > solids > gases
- (C) Gases > liquids > solids
- (D) Depends on the pressure and temperature of the phase

28 How would a chemist adjust the temperature and pressure in order to liquefy the material at point D?

- (F) At constant pressure, decrease the temperature
- (G) Increase the pressure while increasing the temperature
- (H) Decrease the pressure while decreasing the temperature
- (J) Increase the pressure at constant temperature

29 At which combination of temperature and pressure will the material being studied exist in two phases at the same time?

- (A) T = 50 K, P = 100 atm
- (B) T = 600 K, P > 600 atm
- (C) T = 200 K, P = 550 atm
- (D) T = 150 K, P = 150 atm

30 At which point, A or B, is the material in a more stable phase?

- (F) Point A is more stable because it is a solid.
- (G) Point B is more stable because it is soft.
- (H) Point A is more stable because it exists at a higher pressure.
- (J) The stabilities cannot be compared based on the information given.

Cell membranes regulate materials passing into and out of the cell. They consist of a lipid bilayer containing associated integral peripheral proteins.

Lipid-soluble substances can pass through the membrane by dissolving in the membrane lipids. Although the inner portion of the lipid bilayer is hydrophobic, water and water-soluble materials are able to cross the membrane and enter the cell.

One mechanism by which such hydrophillic substances cross the membrane is though aqueous pores within the membrane. For a given group of homologus compounds, rates of membrane penetration are inversely related to molecular size, suggesting that the size of a pore must be at least as large as the molecule passing through it.

Table 1

Permeant	**ΔH (kcal/mole)**	**Nuumber of Hydrogen Bonds**
Glycerol	24	6
Ethylene glycol	18.5	4
Diethylene glycol	18.5	4
Triethylene glycol	20.5	4
1,2, - Propandiol	19.5	4
1,3, - Propandiol	19	4
Propanol	4.5	2
Thiourea	13.5	4

Movement of molecules across cell membranes occuring n response to a concentration gradient is termed "passive transport" and implies that the membrane does not expend any energy. "Passive transport" is misleading. A molecule with high lipid solubility easily enters a cell membrane from the aqueous extracellular space. However, transport of the molecule from the membrane into the aqueous cytoplasm is more difficult because the cohesive bonds formed between the lipid molecules of the membrane must be broken before the molecule can leave the membrane. The passage of lipophillic molecules from one aqueous phase occurs only if the molecules have appropriate energy activation to overcome the lipid barrier.

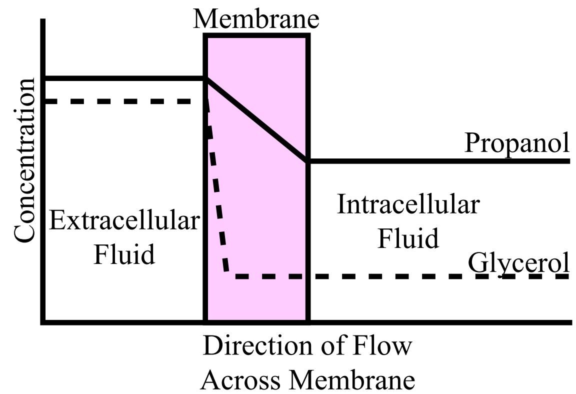


Figure 1

31 From the data given in Table 1, the energy of activation (ΔH) of the substances

- (A) increases as the number of hydrogen bonds increases.
- (B) decreases as the number of hydrogen bonds increases.
- (C) is independent of the number of hydrogen bonds.
- (D) cannot be determined from this data.

32 Refer to Figure 1, which illustrates the concentration of substances on either side of a lipid membrane separating two aqueous compartments. Which of the following statements explains why propanol has a higher concentration than glycerol across the cell membrane?

- (F) Propanol is lipid-insoluble and crosses the membrane via aqueous channels.
- (G) Glycerol is lipid-soluble and remains solubilized within the membrane rather than entering the aqueous phase.
- (H) Choices F and G are both true.
- (J) Neither choice F nor choice G is true.

33 Refer to Table 1 and Figure 1. Assume that the concentrations of propanol and 1, 3-propandiol are equal in the left compartment (extracellular fluid). Compared to propanol, the concentration of 1, 3-propandiol in the right compartment (intracellular fluid) would be

- (A) higher.
- (B) lower.
- (C) the same.
- (D) cannot be determined

34 Compared to water-soluble substances, such as glycerol and ethylene glycol, penetration of ethers, ketones, and aldehydes across lipid membranes

- (F) is faster.
- (G) is slower.
- (H) is at the same rate.
- (J) cannot be determined

35 For lipophilic substances that cross lipid membranes passively, the amount of energy needed to break cohesive bonds is _________ that of hydrophilic substances.

- (A) greater than
- (B) less than
- (C) equal to
- (D) cannot be determined

A man pulls a crate at a constant speed of 2 m/s up a hill using a rope inclined at 25° with respect to the 30° incline. The force of friction between the crate and the slope varies with the roughness of the surface over the 20 m long slope. The rope is assumed not to stretch as it is pulled. However, the tension may vary. Table 1 shows the tension in the rope and the roughness of various portions of the surface.

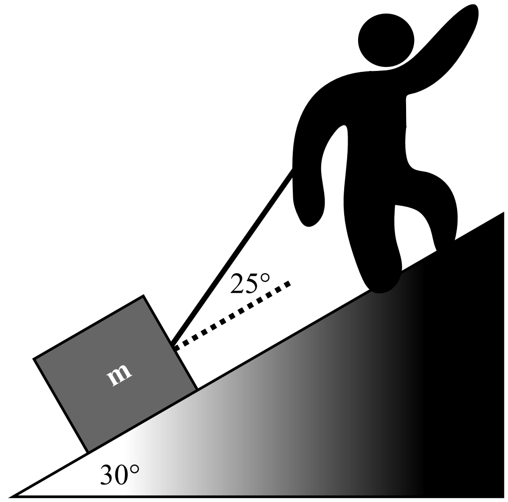


Figure 1

Table 1

Mass of block (kg)	Distance (m)	Roughness Factor	Tension (N)
10	5	0.001	2.5
	10	0.203	17.3
	12	0.013	3.7
	17	0.001	2.5
	20	0.072	9.2
25	5	0.001	6.6
	10	0.203	35.5
	12	0.013	9.3
	17	0.001	6.3
	20	0.072	2.3
50	5	0.001	12.5
	10	0.203	rope broke
	12	0.013	18.5
	17	0.001	12.5
	20	0.072	46

36 According to the experimental data, if the distance along the slope is constant, the tension in the rope is proportional to

- (F) the tension of the man.
- (G) the mass of the block.
- (H) the roughness of the slope.
- (J) the angle of the slope.

37 According to Table 1, if the mass of the block is held constant, the tension in the rope is proportional to

- (A) the distance of the slope.
- (B) the angle of the slope.
- (C) the strength of the man.
- (D) the roughness factor.

38 Assuming a constant mass and roughness factor, if the distance along the slope is increased, which of the following would be expected to occur?

- (F) The tension of the rope would increase.
- (G) The tension of the rope would decrease.
- (H) The tension of the rope stays the same.
- (J) The rope breaks.

39 Which of the following was assumed in the designing of the experiment?

- (A) The length of the rope will influence the tension in the rope.
- (B) The length of the rope will not influence the tension in the rope.
- (C) The mass of the block will not influence the tension in the rope.
- (D) The tension depends on how hard the man pulls.

40 Which of the following statements summarizes the results of the experiment?

- (F) On a surface which is uniformly rough, tension is proportional to mass.
- (G) Roughness is proportional to distance.
- (H) Mass is proportional to distance.
- (J) Tension is proportional to distance.