**Multiple Choice**

*Identify the letter of the choice that best completes the statement or answers the question and place your selection ON THE ANSWER SHEET.*

**Use the following information for #1-3**

Given a small 4.00 kg mass attached to the right hand end of a horizontal "massless spring" on a frictionless horizontal surface. The left end of the spring is attached to a rigid support. The force constant of the spring is k. (k, in N/m , is the ratio of the force on the mass to the stretch of the spring (displacement of the mass) from equilibrium produced by the force). The mass is initially in equilibrium and at rest. Then, the mass is displaced from rest a distance of 0.04 m to the right and released with an initial speed v0 to the right away from the rigid support. The mass oscillates executing simple harmonic motion. At release the kinetic energy of the mass was 1.6 J, and its potential energy relative to its equilibrium point was 1.8 J .

**1**. At the 0.03 m mark, the acceleration of the mass is ___ $m/s^2$ .

A) 16.9 B) 10.6 C) 8.4 D) 5.3 E) 0.4

**2.** The speed of the mass when at the equilibrium point (x = 0 m) is ___m/s .

A) 2.8 B) 2.2 C) 1.8 D) 1.3 E) less than 0.25

**3.** If the attached mass was 8.00 kg, the frequency of the simple harmonic motion would have been ___ the frequency of the 4.0 kg mass.

A) double B) 1.41 times C) the same as D) 0.707 times E) half

**Use the following information for #4-6**

A 0.2 kg object is projected at 50 m/s in a vertical plane at an angle of 30 degrees above the horizontal. It follows a parabolic path with a maximum vertical height of $Y_{max}$. On its way back down it strikes a target located at one-fourth of $Y_{max}$ off the original launch elevation (descended 0.75 $Y_{max}$)

**4**. While in the air, the magnitude of its minimum speed was ___ m/s .

A) 0 B) 25 C) 30 D) 43 E) 47

**5**. The acceleration of the object from after launch until just before it hits the target

A) decreases on the way up but constant on the way down
B) is constant on the way up, but decreases on the way down
C) decreases on the way up and increases on the way down
D) increases on the way up and decreases on the way down
E) is constant while in the air

**6**. When the object strikes the target, its horizontal position is ___ m .

A) 242 B) 206 C) 163 D) 125 E) 72

**Use the following information for #7-8**
Given two light bulbs, a 100 W and a 50 W, connected in series.

**7**. The current in the 100 W bulb is ____ the current in the 50 W bulb.
A) twice as great as B) greater than, although not double, C) the same as
D) half as great as E) smaller than, although not half,

**8.** If the 50 W bulb burns out, the current in the 100 W bulb __
A) doubles B) increases, although not doubling C) remains the same
D) is halved E) decreases

**Use the following information for #9-10**.
Given a horizontal uniform electric field created by two vertical, parallel metal capacitor plates located in a vacuum. The electric field between the plates is 1,500 Newtons/Coulomb . The separation between the plates is 0.02 m . The positive charge is on the left, the negative on the right.

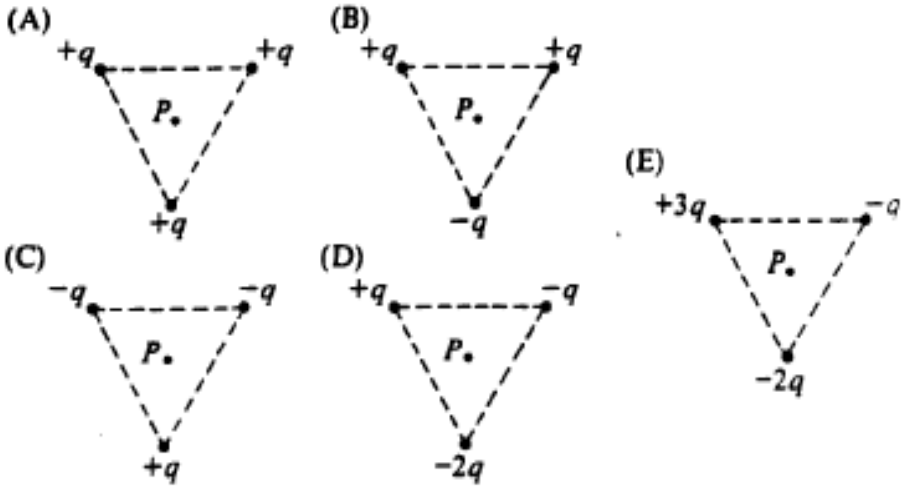
**9.** The work done in moving an electron horizontally from left to right in the field from 0.005 to 0.015m is ____ the work done in moving a proton horizontally from right to left from 0.015 to 0.005 m
A) approx. 1/2000 as much as
B) approx. 1/45 as much as
C) the same as
D) approx. 45 times as much as
E) approx. 2,000 times as much as

**10**. The potential difference required to produce the electric field is ___ volts.
A) 75,000 B) 750 C) 300 D) 75 E) 30

**Use the following information for #11-12**.
Given 5 equilateral triangular arrangements of charges. Each charge is located at the vertex of a triangle. The sides of the triangles are all equal in length. The point P is equidistant from each vertex of the triangle. (It is the intersection of the lines bisecting the angles of the triangle.) The charges used are combinations of +q, -q, -2q, and +3q.

**11.** For which triangle is the magnitude of the electric potential at point P the largest?_
A) A B) B C) C D) D E) E

**12.** For which triangle is the electric field strength, E, at point P equal to zero? ___



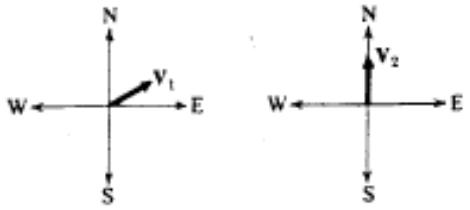

A) A B) B C) C D) D E) E

**13**. A 300 N object is accelerated at 2 m/s/s up a 45 degree incline for a distance of 5 m starting from a speed of 2.0 m/s up the incline. The force of sliding friction on the object is 24.5 Newtons. The net force on the object is ___ N .

A) 232 B) 212 C) 139 D) 85.7 E) 61.2

**Use the following information for #14-15.**

A 2.0 kg point mass is traveling at a speed , v, of 100 m/s at an angle of 30 degrees north of east, in a horizontal plane at time equals zero. When time is 10.0 s, the mass is traveling due north at 100 m/s.




**14**. The change in the kinetic energy of the mass from its value when the time was 0 second, to its value when time was 10 seconds was

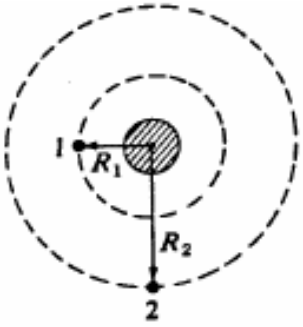
A) a decrease of 2500 J
B) an increase of 2500 J
C) a decrease of 7,000 J
D) an increase of 7,000 J
E) zero

**15**. Assuming the direction change took place at a constant acceleration, the magnitude of the force required to make the change was___ N .

A) zero B) 7.3 C)17.3 D)20 E)23.3

**Use the following information for #16-17**

Given a small point mass object in circular orbit about planet P. When this object was on the surface of planet P its weight was 100 Newtons. The radius of planet P is R. The planet is a homogeneous sphere. The radius of the orbit, R1, is twice the radius of the planet, that is, 2R.




**16**. The centripetal force on the orbiting object is ___ N.

A) 125 B) 100 C) 71 D) 50 E) 25

**17.** A second point mass is in circular orbit $R_2$ which is 4R. On the planet's surface this object weighed 200 Newtons. The kinetic energy of this mass at a radius of $R_2$ is ____ the kinetic energy of the first mass in orbit of radius $R_1$.

A) double B) 1.4 times C) equal to D) 0.71 times E) half

**Use the following information for #18-19**
Given a 893 kg solid copper sphere that is heated and placed into 1000 kg of water. The water covers the sphere. Assume no heat is lost to, nor gained from the container, nor the air. Just the water and the sphere are involved. The water was originally at 20°C and is heated to 25°C in cooling the sphere. The sphere cools to the 25°C temperature.

The density of copper is 8.93 times the density of water.
The specific heat of copper is 387 J/ kg ·°C, (about 9% that of water, which is 4,186 J/kg·°C).
The heat of fusion of copper is $1.34 \times 10^{+5}$ Joules/ kilogram

**18**. The sphere's radius is __ m .

A) 0.6 B) 0.44 C) 0.29 D) 0.25 E) 0.15

**19**. The original temperature of the sphere when it started its cooling in the water was about ___ degrees Celsius.

A) over 300 B) 85 C) 60 D) 42 E) 30

**20**. Given four cylinders (I, II, III, and IV) standing vertically, all with the same height. The cylinders are closed at the bottom, open at the top, and filled with liquid. Cylinders I and II have a cross-sectional area ***A***. Cylinders III and IV have a cross-sectional area of half ***A*** , that is, ***A/2*** . Cylinders I and III are filled with a liquid with density ***d*** . Cylinders II and IV are filled with a liquid with a density twice ***d***, that is, ***2d.*** Rank the order of the cylinders on the basis of the pressure on the bottom of the cylinder from the liquid in the cylinder, placing them in descending order, the largest first. Indicate a tie with an equals sign.

A) I, II, III, IV
B) IV, II, II, I
C) I=II, III=IV
D) II=IV, I=III
E) II, I=IV, III

**21.** A sound wave travels through water, arrives at an interface with air, and passes into the air. When it passes into the air, its ____ always remains the same as it was when the sound was in water.

A) velocity B) amplitude C) frequency D) wavelength E) direction

**Use the following information for #22-23**
A sound producing device, a whistle or siren, produces a continuous sound of frequency 800 Hz. The sound source moves to the right at 30 m/s toward a stationary observer. The speed of sound in air is 343 m/s.

**22.** The frequency of the sound heard by the observer is __ Hz .

A) 926 B) 877 C) 823 D) 746 E) 691

**23**. The temperature of the air is ___ degrees Celsius.

A) 20 B) 26 C) 31 D) 36 E) 42

**Use the following information for #24-26**
A square piece of glass is inserted in the vertical side of a large water filled tank to form a viewing port. The port is a square with a 0.10 m side. The tank is filled 15 meters deep with fresh water. The center of the glass viewing port is 6.5 meters below the water surface.

**24**. The force on the viewing port from the water is ___ N .

A) 3392 B) 1470 C) 964 D) 637 E) 0.7

**25.** If the tank had been filled with sea water, the force on the glass from the water would have been

A) double B) a few percent higher C) the same D) a few percent lower E) half

**26.** A thin square metal plate is placed in the tank. It is oriented vertically in the middle of the tank away from the tank's sides. The plate is 0.10 m on a side. The plate's center is at a depth of 6.5 m. The pressure at the center of the plate due to the water is ***P*** . If the plate were rotated so that it was in a horizontal plane, its center still at a depth of 6.5 m, the water pressure at the center of the plate would be __ times ***P*** .

A) 0 B) 0.5 C) 0.71 D) 1 E) 1.4

**27.** Given one liter of an ideal gas in a closed container. The gas is at a temperature of 200 °C and pressure of 2 atmospheres. The volume of the gas if it were at a temperature of 300°C and a pressure of 4 atmospheres would have been ___ liter(s).

A) 0.61 B) 0.75 C) 1.26 D) 2.12 E) 2.42

**28.** Given a flat metal washer made of copper. Its outer radius, $R_2$, is 0.02 m. The radius of the hole in the center, $R_1$, is 0.01 m. The metal washer is heated uniformly. Which of the following takes place?

A) Both the outer radius $R_2$ and hole radius $R_1$ increase.
B) Both the outer radius $R_2$ and hole radius $R_1$ decrease.
C) The outer radius $R_2$ increases but the radius of the hole $R_1$ decreases.
D) The outer radius $R_2$ decreases but the radius of the hole $R_1$ increases.
E) Copper is a metal and does not expand.

**Use the following information for #29-30**
Given a rectangular tank filled with water to a level ***h.*** A rectangular boat of cross-sectional area **A**, floats in the water. In the boat are a person and a solid copper block. The person very slowly places the metal block in the water and it sinks to the bottom of the tank.

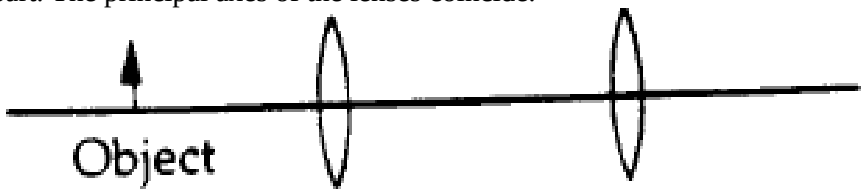
**29**. As a result,

A) more of the boat floats out of the water
B) less of the boat floats out of the water
C) the boat floats with the same amount out of the water.

**30.** The water level in the tank

A) rises (more of the tank is filled)
B) lowers
C) remains the same

**Use the following information for #31-33**
Given a small object arrow placed to the left of two thin spherical lenses. The object is 0.01 m tall with the pointed end pointing upward and is 0.20 m from lens 1. The lenses each have a focal length of 0.30 m, the lens closer to the object being lens 1, $L_1$, and the right most lens being lens 2, $L_2$. The lenses are 0.30 m apart. The principal axes of the lenses coincide.




**31**. The image formed by lens 1 is

A) real and larger than the object
B) real and smaller than the object
C) virtual and larger than the object
D) virtual and smaller than the object

**32**. The final image of the object formed by this combination of lenses is ___ m tall.

A) 0.045 B) 0.03 C) 0.025 D) 0.20 E) 0.015

**33.** If the two lenses are placed back-to-back touching so as to form an approximate single lens, the approximate focal length of that lens would be ___ m .

A) 0.60 B) 0.45 C) 0.30 D) 0.15 E) 0.10

**Use the following information for #34-37**
A beam consisting of light of two frequencies is incident upon a transmission diffraction grating producing Fraunhofer diffraction. The wavelengths in a vacuum of the two light components are $6 \times 10^{-7}$ m and $5.5 \times 10^{-7}$ m. The first order diffraction maximum of the $6 \times 10^{-7}$ m light is slightly less than 30 degrees.

**34**. The second order maximum for the $6 \times 10^{-7}$ m light will be at approximately ____ degrees.

A) 90 B) 75 C) 60 D) 45 E) 15

**35**. The first order maximum for the $5.5 \times 10^{-7}$ m light will be at an angle _____ the angle for the first order maximum of the $6 \times 10^{-7}$ m light.

A) 1/4 B) slightly less than C) equal to D) slightly greater than E) double

**36.** When these two wavelengths meet in space, they combine (interfere) to form a wavelength of __. M
A) $0.5 \times 10^{-7}$
B) $5.75 \times 10^{-7}$
C) $11.5 \times 10^{-7}$
D) $32.5 \times 10^{-7}$
E) none-they do not interfere

**37**. The frequency of the $6 \times 10^{-7}$ m light is _____ Hz .

A) 60 B) $2 \times 10^{6}$ C) $5 \times 10^{-14}$ D) $5 \times 10^{14}$ E) $5 \times 10^{15}$

**Use the following information for #38 - 39**
Given a vertical glass tube filled entirely with water. The upper end of the tube is open to the air. The water level can be adjusted. A tuning fork is struck and held above the open end of the glass tube. The water level is lowered from the top. The first sound resonance point for the sound from the tuning fork is heard when the water level is at the 0.17 m mark. The next resonances occur when the water level is at the 0.55 and 0.93 m mark.

**38** If the next resonance point were determined, it would be at the __ m mark.

A) 0.98 B) 1.12 C) 1.27 D) 1.31 E) 1.44

**39**. If a tuning fork with a lower frequency were used, the separation between resonance points would

A) decrease (be closer) B) remain the same C) increase (be further apart).

**Use the following information for #40-42**
A long very light horizontal string is attached at one end to a small vibrator. The other end passes over a pulley and has a mass attached to it, producing a tension in the string of 20 N. Two meters of the string are in vibration. A driving frequency of 100 HZ produces a standing wave of five loops, that is, 0.40 m between nodes.

**40**. The speed of the transverse wave on the string is ____ m/s .

A) 200 B) 80 C) 60 D) 40 E) 20

**41**. The frequency of the sound produced in the room by the vibrating string is ___ Hz .

A) 200 B) 100 C) 80 D) 60 E) 40

**42**. The frequency required to have the string vibrate as two loops is __ Hz

A) 32 B) 40 C) 100 D) 250 E) 500

**43**. A bullet is fired from a rifle resting on a horizontal frictionless surface. As the bullet emerges from the rifle, the rifle and bullet have ____ . (p, the amount of "momentum" refers to the magnitude of the momentum)

A) the same amount of kinetic energy (KE) and same amount of momentum
B) the same amount of K.E. but the bullet has more p
C) different amounts of K.E. but the same p
D) different amounts of K.E. but the bullet has more p
E) different amounts of K.E. but the rifle has more p

**Use the following information for #44-45.**
Given a 50 picofarad ($50 \times 10^{-12}$ Farad) parallel plate capacitor with square plates one centimeter apart and air or vacuum between the plates. The capacitor is fully charged to 20 volts.

44. The charge on the capacitor is approximately ____ Coulomb.

A) $10^{-9}$ B) $10^{-5}$ C) 0.10 D) 1.0 E) 10

45. If the plate separation had been double its original value, the potential difference required to get the same amount of charge on the capacitor would be ___ volts .

A) 10 B) 14 C) 20 D) 28.2 E) 40

**Use the following information for #46-48**
A solid cylinder rolls from rest without slipping down an inclined plane a distance of 10.0 m. The top of the plane is 6.0 m above the ground. The cylinder has a radius of 0.15 m and a mass of 10 kg.

**46.** If an identical cylinder were dropped and fell the 6.0 m, then the total kinetic energy of the cylinder when it hits the ground after falling 6.0 m from rest would be ___ the total kinetic energy of the rolling cylinder after rolling from rest the 10 m without slipping.

A) greater than B) the same as C) less than

**47.** If the radius of the cylinder were 0.20 m instead of 0.15 m, (mass remains the same) then its acceleration down the plane when rolling without slipping would be ____ its acceleration when the radius was 0.15 m and it rolled without slipping.

A) 0.15/ 0.20 times
B) $(0.15/0.20)^2$ times
C) the same as
D) 0.20/0.15 times
E) $(0.20/0.14)^2$ times

**48**. Given a second cylinder with a radius 0.15 m, but with a 0.075 m meter hole drilled in its center (now shaped like a thick washer with inner radius 0.075 m and outer radius 0.15 m) . Cylinder has a constant density. The two cylinders are released from the top of the ramp and roll without slipping down the plane, the solid cylinder reaches the bottom ___ the cylinder with the center drilled out.

A) at the same time as B) ahead of C) later than

**Use the following information for #49-51**
Given two "point masses" moving along a straight line on a horizontal frictionless surface. One has a mass 2.0 kg and is moving to the right at 4.0 m/s. The second has a mass 4.0 kg and is moving to the left at 2.0 m/s

**49.** The total kinetic energy in this system of two particles before they collide is __ J.

A) 0 B) 8.0 C) 16.0 D) 24.0 E) 32.0

**50.** If the two particles have a perfectly elastic collision, the velocity of the 2.0 kg particle would be
A) 4.0 m/s to the right
B) 4.0 m/s to the left
C) 1.4 m/s to the left
D) 2 m/s to the right
E) 2 m/s to the left

**51.** If the two particles had a perfectly inelastic collision (stuck together), the velocity of the center of mass before the collision would be ____ the velocity of the center of mass after the collision.

A) double
B) half
C) greater than, but not double
D) the same as
E) less than, but not half

**Use the following information for #52-53**
Given a uniform plank inclined against a vertical "smooth" wall. The weight of the plank is 150.0 N. Its length is 3.0 m. The coefficient of static friction between the plank and the floor on which it rests is 0.40 . The plank is inclined at an angle of 60 degrees with the horizontal.

**52**. The force on the plank at its lower end due to friction is ___ N .

A) 150.0 B) 129.9 C) 60.0 D) 43.3 E) 0.02

**53**. If the plank had the same mass but it had a density that decreased at a constant lineal rate from a value at the floor to half this value at the top of the plank, then the vertical force from the floor on the bottom of the plank would be ____ N .

A) over 300
B) between 200 and 300
C) 150
D) between 120 and 90
E) zero, the plank would slip.

**Use the following information for #54-56.**
Electrons are accelerated from rest to a speed of 107 m/s (should be $10^7$ m/s). Then, they enter a constant magnetic field perpendicular to the field, where they travel in circular paths of radius 0.10 m.

**54.** Protons are also singly charged. The potential difference required to accelerated a proton from rest to 107 m/s would be approximately ___ the potential difference required for the electron.

A) the same as B) 1/2000 C) 1/45 D) 45 times E) 2000 times

**55. Eliminated** ~~The magnitude of the magnetic field required for the elecron to travel in the circle was approximately __ T.~~

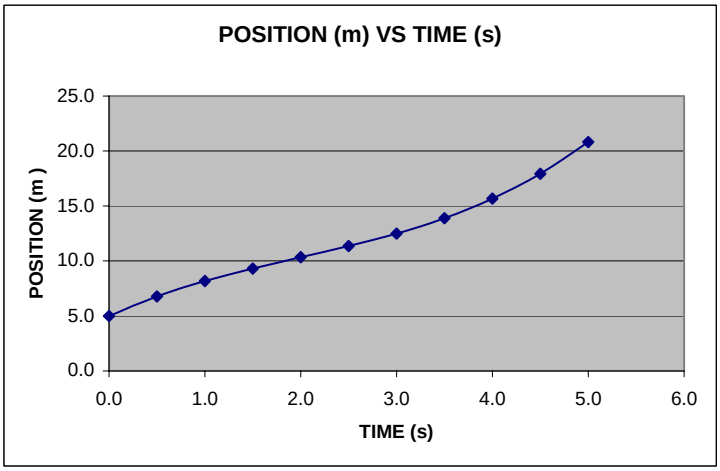
~~A)$10^{-7}$ B) $10^{-3}$ C) 0.1 D) 10 E) 100~~

**56.** After completing one circle the increase in the electron's kinetic energy was approximately ____ J.

A) 10 B) 1 C) 0.1 D) 0.01 E) zero

**Use the following information for #57-58**
Given a record of position in meters as a function of time in seconds for a rectilinear motion of a 0.5 kg "point mass".

| TIME S | POS. m |
|---|---|
| 0.0 | 5.0 |
| 0.5 | 6.8 |
| 1.0 | 8.2 |
| 1.5 | 9.3 |
| 2.0 | 10.3 |
| 2.5 | 11.4 |
| 3.0 | 12.5 |
| 3.5 | 13.9 |
| 4.0 | 15.7 |
| 4.5 | 17.9 |
| 5.0 | 20.8 |




**57.** The acceleration of the point mass was ___ .

A) always positive
B) always negative
C) negative and then positive
D) positive and then negative
E) negative, then positive, then negative

**58.** To the correct number of significant figures, the average velocity of the point mass during the time interval 0 to 5.0 seconds was ___ m/s .

A) 4.2 B) 4.16 C) 4 D) 3.2 E) 3.16

**Use the following information for #59-61**
Given an incline that forms a 3, 4, 5 triangle, one end of the hypotenuse of the incline being 3.0 m above the lower end. A 100 N block, initially moving at 2.0 m/s down the incline, is pushed down the hypotenuse of the incline for a distance of 5.0 m by a constant force of 50 N downward parallel to the incline. The force of friction on the sliding block is 40 N.

**59.** The work done by the 50 N force in moving the block the 5.0 m distance was ___ J.

A) 200 B) 250 C) 350 D) 400 E) 450

**60.** The coefficient of sliding friction for this block and incline is approximately

A) 0.20 B) 0.30 C) 0.40 D) 0.50 E) 0.60

**61**. The speed of the block at the end of the 5.0 m travel is ___ m/s .

A) 5.5 B) 8.5 C) 10.2 D) 11.0 E) 16

**Continue on to the next page**

**Read the following selection and answer questions 62-66 on the answer sheet.**

**Air Pollution**

Air pollution and air quality were not considered a global concern until the second half of the twentieth century. The topic was traditionally a problem only for heavily industrialized areas. The effects of air pollution and poor air quality manifest far downwind from the sources of the pollution. The cumulative effects of air pollution are historically linked to our dependence on the combustion of fossil fuels to satisfy domestic, industrial and automotive energy demands. Developed nations have implemented costly technologies and pollution regulations to decrease the units of air pollution emitted. However, problems still exist in these nations because of their large populations. Developing nations typically do not have adequate pollution regulations and cannot afford to implement the costly technology to minimize air pollutants. Air pollution and air quality problems extend far beyond urban and industrialized areas.

**62.** Air pollution contributes to the following environmental problems:
- **A)** acid rain
- **B)** ozone depletion
- **C)** global warming
- **D)** all of the above
- **E)** none of the above

**63.** Sulfur emissions from coal-fired power plants are one of the sources of air pollution and poor air quality because it

I. Contributes to the acid rain problem
II. Damages the lungs of living organisms
III. Smells like rotten eggs

- **A)** I & II
- **B)** I & III
- **C)** II & III
- **D)** I, II & III

**64.** The human effect of poor air quality are being seen through an increase in everything but
- **A)** Asthma and emphysema
- **B)** Birth defects and cancer
- **C)** Allergies and diabetes
- **D)** Bronchitis and pneumonia

**65.** Which of the following do air pollutants affect the least?
- **A)** the hydrologic cycle
- **B)** the biochemical cycles
- **C)** the biosphere
- **D)** the atmosphere
- **E)** the rock cycle

**66.** Particulate matter degrades air quality. Which of the following does not contribute to the release of particulates into the air?
- **A)** Revegetation
- **B)** Deforestation
- **C)** Urban sprawl
- **D)** Volcanic eruptions
- **E)** Automobile exhaust

**Read the following selection and answer questions 67-71 on the answer sheet.**

**Water Pollution**

The majority of the water on this planet is located in the oceans or is frozen. The amount of water on which all plants, animals and people sustain themselves, totals less than one percent. As the human population increases so does their need for water. Presently the majority of the drinking water consumed comes from surface water or groundwater. Restoring polluted surface water and/or groundwater is a time consuming and expensive process. Presently, the primary water pollution problem in the world is the lack of clean, disease-free drinking water. In the United States it is sediment pollution.

**67.** What tests would you perform on a water sample to help determine if the water sample is disease free?

**A)** Nitrogen and phosphorus
**B)** Pesticides and fertilizers
**C)** Heavy metals and sediment
**D)** Fecal coliform and cryptosporidium
**E)** Dissolved oxygen and biological oxygen demand

**68.** Following a heavy rainfall, a sample of water is taken from a shallow lake. Successive pH readings over several months show the average pH of all the rainfall measurements is 5.0 You should

**A)** not worry, it is normal
**B)** test the water for sulfates
**C)** test the water for phosphates
**D)** look at the aquatic insects along the shore

**69.** If a water body has a mat of green algae growing over its surface it is termed eutrophic. Eutrophication can be caused naturally or by man. If the algae mat gets too thick the water body will

**A)** Have an high dissolved oxygen and low biological oxygen demand
**B)** Have a low dissolved oxygen and a high biological oxygen demand
**C)** Have a low dissolved oxygen and a low biological oxygen demand
**D)** Have a high dissolved oxygen and a high biological oxygen demand

**70.** An increase in sediment in surface water can be caused by

**A)** Cultivating crop land
**B)** Construction of buildings
**C)** Grazing or Feeding lots
**D)** All of the above
**E)** None of the above

**71. Eliminated** ~~Aquifers are underground zones from which groundwater can be extracted. Groundwater flows very slowly and if polluted is extremely difficult to remediate. Aquifers are not presently~~

~~**A)** being contaminated by underground storage tanks~~
~~**B)** being stressed because of an increase in usage~~
~~**C)** drying up because of lack of recharge~~
~~**D)** an issue of environmental concern~~
~~**E)** experiencing salt water intrusion~~

**The End**