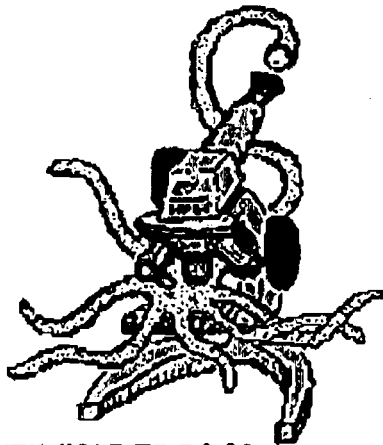


UIL SCIENCE

DISTRICT 1 • 2007



GENERAL DIRECTIONS:

- DO NOT OPEN EXAM UNTIL TOLD TO DO SO.
- Ninety minutes should be ample time to complete this contest, but since it is not a race, contestants may take up to two hours. If you are in the process of actually writing an answer when the signal to stop is given, you may finish writing that answer.
- Papers may not be turned in until 30 minutes have elapsed. If you finish the test in less than 30 minutes, remain at your seat and retain your paper until told to do otherwise. You may use this time to check your answers.
- All answers must be written on the answer sheet provided. Indicate your answers in the appropriate blanks provided on the answer sheet.
- You may place as many notations as you desire anywhere on the test paper except on the answer sheet, which is reserved for answers only.
- You may use additional scratch paper provided by the contest director.
- All questions have ONE and only ONE correct (BEST) answer. There is a penalty for all incorrect answers.
- If a question is omitted, no points are given or subtracted.
- On the back of this page is printed a copy of the periodic table of the elements. You may wish to refer to this table in answering the questions, and if needed, you may use the atomic weights and atomic numbers from the table. Other scientific relationships are listed also.
- Silent hand-held calculators that do not need external wall plugs may be used. Graphing calculators that do not have built-in or stored functionality that provides additional scientific information are allowed. Small hand-held computers are not permitted. Calculators that accept memory cards or memory sticks are not permitted. Each contestant may bring one spare calculator. All memory must be cleared.
- Answers within 5% of the exact answer will be considered correct.

SCORING:

All questions will receive 6 points if answered correctly; no points will be given or subtracted if unanswered; 2 points will be deducted for an incorrect answer.

UNIVERSITY INTERSCHOLASTIC LEAGUE

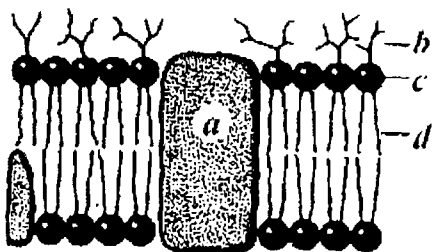
Making a World of Difference

Biology Questions (1 – 20)

1. Which of the following subcellular structures does **NOT** have any membranes?

- A) lysosome
- B) Golgi apparatus
- C) chloroplast
- D) ribosome
- E) endoplasmic reticulum

2. Which of the labeled parts in the diagram below illustrates the hydrophilic portion of a phospholipid molecule?



- A) a
- B) b
- C) c
- D) d
- E) none of the above

3. The DNA of a certain organism has guanine as 30 percent of its nucleotide bases. What percentage of its bases would be adenine?

- A) 10
- B) 20
- C) 30
- D) 40
- E) 50

4. Which of the following occurs during meiosis but does **NOT** occur during mitosis?

- A) Double-chromatid chromosomes move to the poles.
- B) Single-chromatid chromosomes move to the poles.
- C) Chromosomes shorten and thicken and are double-stranded.
- D) Nuclear membrane and nucleolus disappear.
- E) Centromeres divide.

5. Which of the following is an intron?

- A) a foreign RNA sequence inserted in the normal mRNA that codes for a protein
- B) a DNA sequence that is not transcribed
- C) a DNA sequence that is used to link a plasmid with a foreign DNA
- D) a DNA sequence that codes for the protein product of the gene
- E) an mRNA sequence that is edited from a transcript before translation

6. The process by which a virus transfers genes from one bacterial cell to another is called _____.

- A) transformation
- B) translation
- C) transduction
- D) translocation
- E) transcription

7. Which of the following is **NOT** true of viruses?

- A) The nucleic acid in viruses may be DNA or RNA, either single-stranded or double-stranded.
- B) Some viruses reproduce in the cytoplasm, others in the nucleus.
- C) When a virus attacks a bacterial cell, only the nucleic acid usually enters the cell.
- D) The nucleic acid in the virus codes for the proteins that make up the coat of the virus and for some enzymes.
- E) Viruses are sensitive to most antibiotics, particularly penicillin.

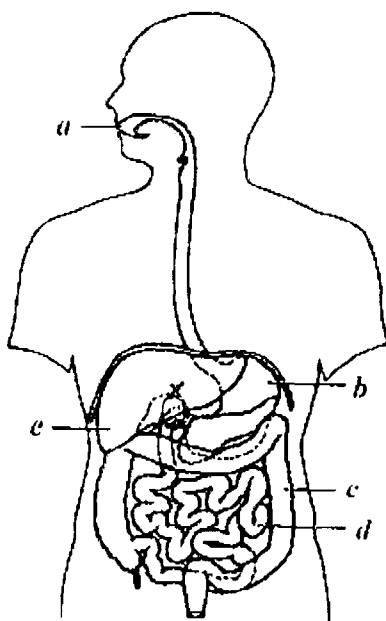
8. Malaria, which – after AIDS and tuberculosis – is the third largest infectious cause of death worldwide, is caused by a(n) _____.

- A) bacterium
- B) virus
- C) protist
- D) fungus
- E) invertebrate

9. Which of the following characteristics of arthropods was probably the most important adaptation for living on land?

- A) segmentation
- B) complete digestive tract
- C) exoskeleton
- D) circulatory system
- E) coelom

10. The region of tissue at the growing tips of roots and stems is ____.
- apical meristem
 - lateral meristem
 - parenchyma
 - periderm
 - pericycle
11. Which of the following parts of the trunk of a tree is the most important in the transport of sugars from the leaves to the roots?
- heartwood
 - sapwood
 - cambium
 - outer bark
 - inner bark
12. In plants, the gametophyte generation is produced by ____.
- fertilization of an egg cell by a sperm cell
 - the formation of four gametes by meiosis
 - haploid spores that divide by mitosis
 - fusion of male and female sporophyte cells
 - mitosis of sporophyte cells
13. Which organ or other structure shown in the diagram below is the location where carbohydrate digestion begins?

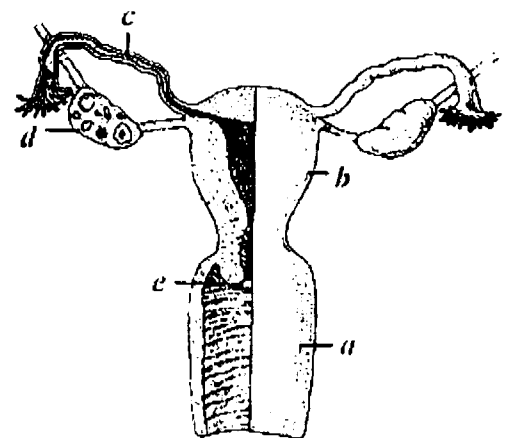


- a
- b
- c
- d
- e

14. Which of the following is NOT true of human lungs?
- Gas exchange always takes place across moist membranes.
 - The gases move across the exchange membranes by diffusion.
 - The concentration of CO_2 is higher in the air in the lungs than in the blood in the alveolar capillaries.
 - The walls of the alveoli are only one cell thick.
 - The total exchange surface area is very large.
15. Which of the following is NOT a function of the mammalian kidney?
- removal of excess sodium ions from the blood
 - reabsorption of salts and sugar from blood filtrate
 - synthesis of urea
 - concentration of urine
 - filtration of the blood
16. Which of the following hormones regulates the rate of cellular respiration?
- insulin
 - thyroid hormone
 - parathyroid hormone
 - adrenocortical hormones
 - vasopressin

17. The diagram below depicts the human female reproductive system. In which labeled structure does fertilization occur?

- a
- b
- c
- d
- e



18. Flowers pollinated by hummingbirds are often red and usually odorless. Hummingbirds see red easily but have a poor sense of smell. This is an example of ____.
- mimicry
 - polymorphism
 - stabilizing selection
 - convergence
 - coevolution
19. Which of the following occurred first on Earth?
- evolution of eukaryotes
 - accumulation of oxygen in the atmosphere
 - evolution of photosynthetic flowering plants
 - evolution of prokaryotes
 - evolution of *Homo sapiens*
20. Which of the following is NOT a density-dependent factor that limits population growth?
- intraspecific competition
 - interspecific competition
 - disease
 - fire
 - mutualism
23. How many electrons are in the ground state of one calcium ion?
- 18
 - 21
 - 20
 - 22
 - 19
24. Isotopes result because atoms of a specific kind may have ____.
- different numbers of protons
 - none of the other choices describe isotopes
 - the same number of electrons and protons
 - different numbers of electrons
 - different numbers of neutrons
25. If an orbital has a shape which is designated by having $l=1$, there are ____ possible spatial orientations of that orbital.
- 2
 - 1
 - 4
 - 3
 - 5

Chemistry Questions (21 – 40)

21. The oxidation number for nitrogen in NCl_3 is ____.
- 1
 - 3
 - 1
 - 0
 - 3
22. Which reactants will NOT generate significant amount of a gas-phase product in aqueous solution?
- $\text{NaOH} + \text{NH}_4\text{Cl}$
 - $\text{Na} + \text{H}_2\text{O}$
 - $\text{Zn} + \text{HCl}$
 - $\text{CaCO}_3 + \text{HCl}$
 - $\text{Na}_2\text{CO}_3 + \text{CaCl}_2$
26. An element (call it X) in Group IA of the periodic table forms a compound with an element (call it Y) of Group VIA. The compound would most likely have the formula ____ and would have ____ bonding.
- XY_2 , covalent
 - XY_6 , covalent
 - XY_2 , ionic
 - X_2Y , ionic
 - X_2Y , covalent
27. Choose the species that is incorrectly matched with the electronic geometry about the central atom.
- BeBr_2 , linear
 - PF_3 , pyramidal
 - CF_4 , tetrahedral
 - NH_3 , tetrahedral
 - H_2O , tetrahedral

HS Science • District 1 • 2007

28. The conjugate acid of $\text{NH}_3(\text{aq})$ is _____.
- H_3O^+
 - NH_2^-
 - Cl^-
 - NH_4^+
 - H_2O
29. What is the molarity of chloride ion in the solution after mixing 100 mL of 0.0500 M calcium hydroxide with 200 mL of 0.0500 M hydrochloric acid?
- 0.0167 M
 - 0.0500 M
 - 0.0250 M
 - 0.00833 M
 - 0.0333 M
30. Which of the following statements does **NOT** describe the general properties of liquids?
- Liquids diffuse only very slowly compared to solids.
 - Volatile liquids have high vapor pressures at room temperature.
 - The liquid state is highly disordered compared to the solid state.
 - Liquids have characteristic densities that do not change greatly with temperature, as long as the liquid is not vaporized.
 - Liquids have characteristic densities that do not change greatly with pressure, as long as the liquid is not vaporized.
31. A reversible reaction is at equilibrium at constant pressure and temperature if the free energy of the system _____.
- decreases
 - is a maximum
 - is a minimum
 - increases
 - is zero
32. For a multistep reaction, the observed order of the reaction is generally determined by the _____.
- activation energy
 - time at which the concentrations of all species are measured
 - ratio of reactant and product concentrations
 - slowest reaction of the sequence
 - stoichiometric coefficients of the net reaction
33. Equal volumes of an HCl solution ($\text{pH} = 3.00$) and a NaOH solution ($\text{pH} = 10.00$) are mixed. The final solution would have a pH of _____.
- 7.0
 - 3.3
 - 6.5
 - 3.1
 - 8.5
34. K_{sp} for zinc sulfide is 1.1×10^{-21} . At what sulfide concentration will zinc sulfide precipitate from a 0.2 M solution of zinc nitrate?
- 3.3×10^{-11} M
 - 5.5×10^{-20} M
 - 5.5×10^{-21} M
 - 2.4×10^{-10} M
 - 2.2×10^{-20} M
35. The electrolysis of molten lithium hydride using inert electrodes produces metallic lithium and gaseous hydrogen. Hydrogen gas is produced at the _____ which is the _____ electrode. Electrons flow through the wire from the _____ to the other electrode.
- anode, positive, anode
 - cathode, positive, anode
 - anode, positive, cathode
 - cathode, positive, cathode
 - cathode, negative, anode
36. For the reaction $? \text{Fe} + ? \text{H}_2\text{O} \rightarrow ? \text{Fe}_3\text{O}_4 + ? \text{H}_2$, a maximum of _____ grams of Fe_3O_4 could be formed from 9.93 grams of Fe and 6.77 grams of H_2O .
- 13.7
 - 9.6
 - 5.5
 - 24.7
 - 30.2
37. What volume is occupied by 64.0 grams of CH_4 at 127°C under a pressure of 2610 torr?
- 38.2 liter
 - 53.6 liter
 - 68.9 liter
 - 15.3 liter
 - 26.8 liter

38. A solution is made from 323. mL of CH_3OH (density 0.800 g/mL) and 90.4 mL of water (density 1.000 g/mL). The mole fraction of methanol in this solution is _____.

- A) 0.863
- B) 0.247
- C) 1.110
- D) 1.356
- E) 0.617

39. At $T = 546^\circ\text{C}$, $K_c = 5.930 \times 10^2$ for the gas-phase reaction $\text{A} + \text{B} \leftrightarrow \text{C} + \text{D}$. Starting with 1.00 mole each of A and B in a 5.00 liter container, what will be the equilibrium concentration of C at $T = 546^\circ\text{C}$?

- A) 0.134 M
- B) 0.269 M
- C) 0.077 M
- D) 0.192 M
- E) 0.423 M

40. What is the pH of a 1.46×10^{-3} M aqueous solution of calcium hydroxide at 25°C ? K_w for H_2O at 25°C is 1.0×10^{-14} .

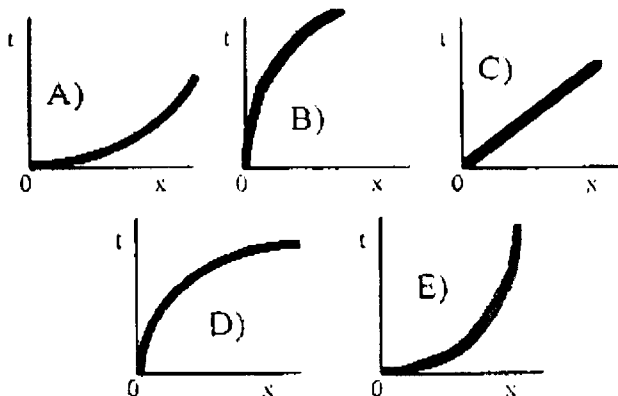
- A) 12.2
- B) 11.5
- C) 10.8
- D) 10.1
- E) 9.4

Physics Questions (41 – 60)

41. At what speed is an object's apparent mass 5.00% greater than its rest mass?

- A) 1.5×10^7 m/sc
- B) 4.3×10^7 m/sc
- C) 5.5×10^7 m/sc
- D) 7.2×10^7 m/sc
- E) 9.1×10^7 m/sc

42. George is a sky-diver. He steps out of a stationary hot-air balloon gondola, falls freely for a while, and then opens his parachute. Which spacetime diagram shows the free-fall position of his descent? Be careful: Time t is the vertical axis. Distance is the horizontal axis, with $x = 0$ the balloon's position, and x increases as George falls.

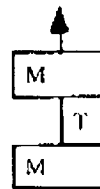


43. John has become bald, so he wears a hat when he stands outside in the blazing sun when the sun is directly overhead (John lives right on the equator). The hat has an emissivity $e = 0.60$ and a cross sectional area of 450 cm^2 . The solar constant is $1.00 \times 10^3 \text{ W/m}^2$. How much energy does John's hat absorb in 2 minutes?

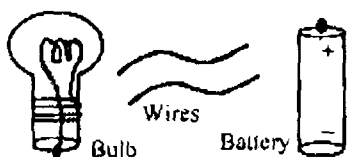
- A) 932 J
- B) 2541 J
- C) 2973 J
- D) 3240 J
- E) 4160 J

44. A brick of mass 2.50 kg is hanging from a massless rope. Attached to the brick is another massless rope, with another identical brick suspended from it. The top rope is being pulled up, so that the bricks are uniformly accelerated at 4.38 m/s^2 . What is the tension in the rope joining the bricks?

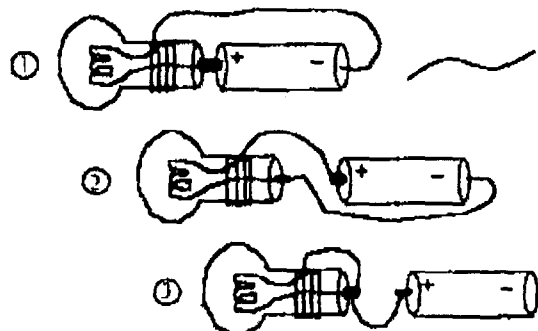
- A) 30.2 N
- B) 35.5 N
- C) 45.9 N
- D) 49.1 N
- E) 52.6 N



45. A light bulb, two wires, and a battery are shown. When properly arranged, the light bulb will glow.



Shown below are three arrangements. In which will the light bulb NOT glow?



- A) ① and ②
 B) ② and ③
 C) ① only
 D) ② only
 E) ③ only
46. A wooden cube with sides equal to 4.80×10^{-2} m is floating in water, but it just barely sinks when a metal disc of mass 5.28×10^{-2} kg and volume 1.30×10^{-5} m³ is attached. What is the cube's density?
- A) 640 kg/m³
 B) 692 kg/m³
 C) 747 kg/m³
 D) 870 kg/m³
 E) 931 kg/m³
47. A circular hoop of radius $R = 0.500$ m and mass $M = 2.70$ kg is rotating in its own plane with an angular speed of $\omega = 6.66$ radians/s. It is brought to a stop in $t = 13.22$ s by a constant torque T . What is the magnitude of this torque?
- A) $T = 0.14$ N•m
 B) $T = 0.21$ N•m
 C) $T = 0.34$ N•m
 D) $T = 1.03$ N•m
 E) $T = 1.92$ N•m

48. A highway is built using concrete slabs of length $L = 10.00$ m, with spaces (expansion cracks) between them to prevent buckling. The concrete is laid when the ambient temperature is 20°C , but the expected temperature range is -40°C to $+50^\circ\text{C}$. How large should the expansion cracks be at 20°C ? The coefficient of linear expansion of concrete is $\alpha = 12 \times 10^{-6} \text{ K}^{-1}$, and its coefficient of volume expansion is $\beta = 36 \times 10^{-6} \text{ K}^{-1}$.

- A) 0.4 cm
 B) 1.0 cm
 C) 1.6 cm
 D) 2.2 cm
 E) 2.8 cm
49. Julia is a scientist and so is very careful about using significant figures correctly. Recently she was given the following sum to evaluate: $1.1 \times 10^{-3} + 3.05 \times 10^{-2} + 2.611 \times 10^2 + 4.026 \times 10^3$. What was her result?
- A) 4.2871316×10^3
 B) 4.287132×10^3
 C) 4.28713×10^3
 D) 4.2871×10^3
 E) 4.287×10^3
50. A simple pendulum oscillates at a frequency of exactly 1.0000 Hz. At $t = 0$ it is released from rest at an initial angle of $\theta = 0.5000^\circ$. What is the first time after zero when the angle of the pendulum will be zero? Neglect friction.
- A) 0.2500 s
 B) 0.5000 s
 C) 1.0000 s
 D) 3.1416 s
 E) 6.2832 s

51. In a physics text book, one of the problems at the end of a chapter asks for the probability of obtaining an 11 when throwing two dice. The subject of the chapter is _____.
- A) relativity
 B) linear momentum
 C) angular momentum
 D) thermodynamics
 E) waves

52. Here is the Mayan glyph meaning *black hole*:



In astrophysics, a black hole having a mass equal to the mass of our Sun would have a diameter of what?

(Note: the mass of the Sun is

$$M_{\odot} = 2.0 \times 10^{30} \text{ kg};$$

the Newtonian gravitational constant is

$$G = 6.67 \times 10^{-11} \text{ m}^3 \cdot \text{s}^{-2} \cdot \text{kg}^{-1};$$

the speed of light is $c = 3.0 \times 10^8 \text{ m} \cdot \text{s}^{-1}$.

- A) 6 km
 B) 12 km
 C) 24 km
 D) 48 km
 E) 96 km
53. Up, Down, Top, and Bottom are names given to _____.
- A) pions
 B) muons
 C) neutrinos
 D) quarks
 E) bosons
54. John the stunt man drives his car off a cliff 37.6 feet high. His speed as he leaves the cliff moving horizontally is 42.6 miles/hour. His son Jim calculates John's speed when he strikes the ground by working in units of miles (mi) and hours (hr) rather than meters and seconds, where $1 \text{ mi} = 1609.344 \text{ m} = 5280 \text{ feet}$. What is Jim's correct answer?
- A) 88.2 mi/hr
 B) 76.1 mi/hr
 C) 68.1 mi/hr
 D) 59.8 mi/hr
 E) 54.2 mi/hr

55. Planet A has exactly half the radius of planet B. Planet A also has exactly half the surface gravity of planet B. Both planets are spherical and non-rotating; each has constant density. How does the density ρ_a of planet A compare to the density ρ_b of planet B?
- A) $\rho_a = 4\rho_b$
 B) $\rho_a = 2\rho_b$
 C) $\rho_a = \rho_b$
 D) $\rho_a = \rho_b/2$
 E) $\rho_a = \rho_b/4$
56. One sound wave has exactly four times the amplitude of another. What is the ratio of the intensity of the first sound wave to the second?
- A) 16:1
 B) 4:1
 C) 2:1
 D) $\sqrt{2}:1$
 E) Can't tell from the data given
57. It is a dark and stormy night. Sam is driving his car at a careful 50 km/hour when without warning he hits a brick wall head on. The air bag inflates and the front of his car compresses so that his deceleration is quite uniform, and he travels 0.50 m as he comes to rest. What is the magnitude of Sam's average acceleration during this crash? Express the answer as a multiple of the acceleration of gravity g .
- A) 5 g
 B) 10 g
 C) 15 g
 D) 20 g
 E) 25 g
58. A toy rocket sled slides on a horizontal track. It starts moving by expelling CO_2 gas at a rate of $2.55 \times 10^{-3} \text{ kg/s}$ with a speed of 65.2 m/s. What is the force on the sled at the starting moment?
- A) 0.466 N
 B) 0.366 N
 C) 0.266 N
 D) 0.166 N
 E) 0.066 N

59. A cannon at ground level fires a cannon ball a distance of $R = 1.500$ km when aimed upward at 45° . If the same cannon were on the brink of a vertical cliff $H = 200$ m high, how far from the base of the cliff would the cannon ball land when the cannon is aimed horizontally? Oh yes, this experiment is being conducted on the Moon, where gravity is $1/6$ that of Earth's.

- A) 366 m
- B) 491 m
- C) 603 m
- D) 775 m
- E) 1293 m

60. A block of wood with mass $m = 2.6$ kg is sliding down a plane slanted downwards at $\theta = 17.6^\circ$ below the horizontal. It starts with a speed of $v = 3.78$ m/s and travels a distance $d = 2.52$ m along the plane before coming to rest. What is the coefficient of kinetic friction μ ?

- A) $\mu = 0.36$
- B) $\mu = 0.42$
- C) $\mu = 0.50$
- D) $\mu = 0.57$
- E) $\mu = 0.62$

**UIL HIGH SCHOOL SCIENCE CONTEST
ANSWER KEY**

DISTRICT 1 • 2007

- | | | | | | |
|-----|---|-----|---|-----|---|
| 1. | D | 21. | E | 41. | E |
| 2. | C | 22. | E | 42. | B |
| 3. | B | 23. | A | 43. | D |
| 4. | A | 24. | E | 44. | B |
| 5. | E | 25. | D | 45. | E |
| 6. | C | 26. | D | 46. | A |
| 7. | E | 27. | B | 47. | C |
| 8. | C | 28. | D | 48. | A |
| 9. | C | 29. | E | 49. | E |
| 10. | A | 30. | A | 50. | A |
| 11. | E | 31. | C | 51. | D |
| 12. | C | 32. | D | 52. | A |
| 13. | A | 33. | B | 53. | D |
| 14. | C | 34. | C | 54. | E |
| 15. | C | 35. | A | 55. | C |
| 16. | B | 36. | A | 56. | E |
| 17. | C | 37. | A | 57. | D |
| 18. | E | 38. | E | 58. | D |
| 19. | D | 39. | D | 59. | D |
| 20. | D | 40. | B | 60. | E |

PHYSICS KEY for Science Contest • District 1 • 2007

41. (E) An object's apparent mass is given by $m = m_0(1 - v^2/c^2)^{-1/2}$, where m_0 is the rest mass.
42. (B) In free-fall, the distance of fall increases as a quadratic function of time and doesn't level off.
43. (D) The energy is the solar constant, times e , times the elapsed time, times the area of the hat.
44. (B) The net force on the bottom brick is $T - Mg$, so that $T - Mg = Ma$.
45. (E) For the bulb to glow, a circuit must be completed, and ③ is the only non-circuit arrangement.
46. (A) The volume of the cube, $1.106 \times 10^{-4} \text{ m}^3$, plus the volume of the disc, displaces a mass of water equal to $1.236 \times 10^{-1} \text{ kg}$, and this equals the mass of the cube plus the mass of the disc. Divide the mass of the cube by the cube's volume to get its density.
47. (C) The initial angular momentum of the hoop, its moment of inertia MR^2 times its angular speed in radians/s, is equal to the torque times the time, Tt .
48. (A) The coefficient of volume expansion is irrelevant; the amount a slab will expand in a temperature range of ΔT (one K is 1°C) is $\alpha L \Delta T$. The range from 20°C to 50°C is $\Delta T = 30 \text{ K}$ (of course the slab will only contract if it gets colder).
49. (E) The 4.026×10^3 term is 4026, and so any term less than 0.1 doesn't matter.
50. (A) The pendulum will first be at angle zero after $1/4$ of an oscillation.
51. (D) Laws of thermodynamics are based on probability, as used in kinetic theory for example.
52. (A) The diameter of a black hole of mass M is given by $D = 4GM/c^2$.
53. (D) Two other quark names in use are Strange and Charm.
54. (E) The acceleration of gravity is $g = 9.81 \text{ m/s}^2 = 7.900 \times 10^4 \text{ mi/hr}^2$. The distance of fall is $s = 37.6 \text{ feet} = 7.1212 \times 10^{-3} \text{ mi}$. The vertical velocity of John's car at impact is $v = (2gs)^{1/2} = 33.54 \text{ mi/hr}$. John's speed is found with this as vertical component and 42.6 mi/hr as horizontal.
55. (C) The surface gravity scales directly as the mass and inversely as the square of the radius. The mass scales as the density times the cube of the radius, so the surface gravity scales directly as the density times the radius.
56. (E) Other factors are involved, in particular the frequencies of the waves.
57. (D) With constant acceleration a , initial speed v (be sure to use m/s), and distance traveled d , the relation is $a = v^2/2d$.
58. (D) By conservation of momentum, the expelled gas gives the sled a momentum of $(2.55 \times 10^{-3}) \times 65.2$ per second just at starting out. This is the force.
59. (D) Let the speed of the cannon ball when first fired be v_0 . If the cannon is aimed upward at 45° , the vertical initial speed is $v_0 \sin 45^\circ$, so that the ball spends a total time of $T = 2(v_0/g_m) \sin 45^\circ$ in flight with g_m being the Moon's gravity). It travels a distance $R = v_0 T \cos 45^\circ = v_0^2/g_m$. In the second shot, the time to fall H is $t = (2H/g_m)^{1/2}$, and the distance the ball moves is $D = v_0 t$. Hence $D = (2RH)^{1/2}$. Note that value of g_m is irrelevant.
60. (E) The wood gains $mgd \sin \theta$ in gravitational energy and starts with kinetic energy equal to $mv^2/2$. The total energy is dissipated in the frictional work of Fd , where the frictional force is $\mu mg \cos \theta$. Note that m doesn't matter.