



SCIENCE

Invitational A • 2010



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

OTHER USEFUL INFORMATION

Avogadro's Number, $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$

Absolute zero = 0 K = -273.15°C

Atmospheric pressure, 1 atm = $1.013 \times 10^5 \text{ N/m}^2 = 101.3 \text{ kPa} = 760.0 \text{ Torr} = 760.0 \text{ mmHg}$

Standard temperature and pressure (STP) is 0°C and 1 atm

Gram molecular volume at STP = 22.4 L

Mechanical equivalence of heat, 1 kcal = 1 Cal = 1,000 cal = 4,186 J

Gas constant, $R = 1.987 \text{ cal/mol}\cdot\text{K} = 0.08206 \text{ atm}\cdot\text{L/mol}\cdot\text{K} = 8.314 \text{ J/mol}\cdot\text{K}$

Dulong and Petit's constant = 6.0 amu \cdot cal/gram \cdot K

Faraday's constant, 1 F = 96,485 C/mol

Acceleration of gravity at Earth's surface, $g = 9.80 \text{ m/s}^2$

Gravitational constant, $G = 6.67 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$

Horsepower, 1 hp = 746 W = 550 ft \cdot lbs/s

Boltzmann's constant, $k_B = 1.38 \times 10^{-23} \text{ J/K}$

Stefan-Boltzmann constant, $\sigma = 5.67 \times 10^{-8} \text{ W/m}^2\cdot\text{K}^4$

Elementary charge, $e = 1.602 \times 10^{-19} \text{ C}$

Coulomb's law constant, $k = 1/4\pi\epsilon_0 = 8.988 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$

Permittivity of free space, $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{N}\cdot\text{m}^2$

Permeability of free space, $\mu_0 = 4\pi \times 10^{-7} \text{ T}\cdot\text{m/A}$

Electron volt, 1 eV = $1.602 \times 10^{-19} \text{ J}$

Vacuum speed of light, $c = 3.00 \times 10^8 \text{ m/s}$

Planck's constant, $h = 6.626 \times 10^{-34} \text{ J}\cdot\text{s} = 4.136 \times 10^{-15} \text{ eV}\cdot\text{s}$

Planck's reduced constant, $\hbar = h/2\pi = 1.054 \times 10^{-34} \text{ J}\cdot\text{s} = 6.582 \times 10^{-16} \text{ eV}\cdot\text{s}$

Atomic mass unit, 1 amu = 1 u = $1.66 \times 10^{-27} \text{ kg} = 931.5 \text{ MeV}/c^2$

Electron rest mass, $m_e = 9.11 \times 10^{-31} \text{ kg} = 0.000549 \text{ u} = 0.511 \text{ MeV}/c^2$

Proton Mass = $1.6726 \times 10^{-27} \text{ kg} = 1.00728 \text{ u} = 938.3 \text{ MeV}/c^2$

Neutron Mass = $1.6749 \times 10^{-27} \text{ kg} = 1.008665 \text{ u} = 939.6 \text{ MeV}/c^2$

Some standard values for water:

Mass density, $\rho = 1.00 \text{ g/cm}^3 = 1,000 \text{ kg/m}^3$

Heat capacity or Specific heat, $c = 1.00 \text{ cal/gram}\cdot\text{C}^\circ = 1.00 \text{ kcal/kg}\cdot\text{C}^\circ = 4186 \text{ J/kg}\cdot\text{C}^\circ$

Latent heats, $L_F = 79.7 \text{ kcal/kg} = 3.33 \times 10^5 \text{ J/kg}$ & $L_V = 539 \text{ kcal/kg} = 22.6 \times 10^5 \text{ J/kg}$

Index of refraction, $n = 1.33$

Biology Questions (1 – 20)

- Which of the following is distinctively associated with organic compounds?
 - carbon
 - hydrogen
 - nitrogen
 - oxygen
 - sulfur
- Which of the following structures is absent in bacterial cells?
 - plasma membrane
 - nucleoid
 - cytoplasm
 - nucleus
 - DNA
- Movement of a molecule against a concentration gradient is
 - simple diffusion.
 - facilitated diffusion.
 - osmosis.
 - active transport.
 - bulk flow.
- Organisms that derive their chemical energy from the process of chemosynthesis are also classified as
 - autotrophs.
 - parasites.
 - heterotrophs.
 - saprophytes.
 - mutualists.
- Which of the following is NOT associated with meiosis?
 - reduction of number of chromosomes.
 - somatic cells
 - sexual reproduction
 - sperm and egg
 - germ cells
- Various forms of a gene at a given locus are called
 - chiasmata.
 - alleles.
 - autosomes.
 - loci.
 - chromatids.
- When a virus takes over the machinery of a cell, it forces the cell to manufacture more
 - mitochondria for energy for the virus.
 - liposomes to isolate themselves from water.
 - food particles.
 - viral particles.
 - Golgi bodies so that the cell will secrete the excess viruses.
- The first organisms on Earth that did not require water for reproduction were the
 - ferns.
 - lycophytes.
 - cycads.
 - flowering plants.
 - gymnosperms.
- Which of the following does NOT include parasites?
 - arthropods
 - cnidarians
 - flatworms
 - nematodes
 - roundworms
- Which of the following cells of plants are alive when functioning?
 - tracheids
 - cork
 - scelereids
 - parenchyma
 - vessel elements
- Which of the following is a micronutrient for plants?
 - sulfur
 - calcium
 - phosphorus
 - manganese
 - magnesium

12. Alternation of generations in plants refers to
- A) expression of recessive traits.
 - B) presence of a diploid and a haploid generation in the life cycle of plants.
 - C) presence of the different sexes in two different plants.
 - D) occurrence of a sexually reproducing diploid stage followed by an asexually reproducing haploid stage during the life cycle of higher plants.
 - E) juvenile and adult forms of plants.
13. Which of the following substances is released by motor neurons to initiate a muscle contraction?
- A) acetylcholine
 - B) dopamine
 - C) serotonin
 - D) noradrenalin
 - E) adrenalin
14. Which of the following is NOT a function of the lymphatic system?
- A) fighting infection
 - B) transporting dissolved gases
 - C) reclaiming fluids
 - D) harboring white blood cells
 - E) transporting fats
15. Body cells have "self" markers located
- A) in their nuclei.
 - B) in the endoplasmic reticulum.
 - C) in the mitochondria.
 - D) on the plasma membrane.
 - E) inside the Golgi bodies.
16. Filtration of blood occurs in which section of the mammalian nephron?
- A) glomerulus
 - B) loop of Henle
 - C) proximal tubule
 - D) distal tubule
 - E) collecting duct
17. Which of the following events of development occurs last?
- A) cleavage
 - B) gamete formation
 - C) gastrulation
 - D) organ formation
 - E) tissue specialization
18. The forelimbs of early mammals were similar in all features except
- A) embryonic origin.
 - B) position on the body.
 - C) number.
 - D) function.
 - E) composition.
19. Which of the following is NOT a part of a community?
- A) bacteria
 - B) populations
 - C) animals
 - D) soil
 - E) plants
20. Which of the following is NOT dependent on the others as a food supply?
- A) carnivores
 - B) herbivores
 - C) detritivores
 - D) producers
 - E) decomposers
- Chemistry Questions (21 – 40)**
21. Which of the following changes is a chemical change?
- A) boiling water
 - B) leaves changing colors in the fall
 - C) cutting grass
 - D) crushing a leaf in your hand
 - E) dropping a ball
22. The number of calories needed to raise the temperature of 50 g of water from 20°C to 40°C is ____.
- A) 200
 - B) 100
 - C) 500
 - D) 1000
 - E) 800

23. The symbol for the element zinc is _____ .
- Zn
 - Zc
 - Znc
 - Zi
 - Z
24. The molecular weight of ethylchloride is _____ .
- 64.5 grams/mole
 - 48.5 grams/mole
 - 28.0 grams/mole
 - 34.0 grams/mole
 - 69.5 grams/mole
25. What is the empirical formula for a compound that is 87.5% nitrogen and 12.5% hydrogen by mass?
- N_2H_5
 - N_3H_2
 - NH_3
 - N_2H_3
 - NH_2
26. How many mL of a 0.320 molar solution of sucrose in water are needed to have 0.160 moles of sucrose?
- 557.3 mL
 - 500 mL
 - 219 mL
 - 438 mL
 - 598.5 mL
27. The combustion of hydrazine, N_2H_4 , produces NO and water. If the chemical reaction for this process is properly balanced, what is the sum of the coefficients for the PRODUCTS? Use the smallest set of integers to balance the equation.
- 8
 - 7
 - 4
 - 2
 - 10
28. When silver nitrate(aq) and calcium chloride(aq) are mixed, the precipitate that forms is:
- $CaNO_3$
 - $Ca(NO_3)_2$
 - AgCl
 - $AgNO_3$
 - $AgCl_2$
29. How many protons are present in one copper(II) ion ?
- 30
 - 27
 - 29
 - 28
 - 26
30. In the Aufbau order of occupancy of electronic energy levels, the level occupied just after 4p is _____ .
- 5s
 - 4d
 - 3f
 - 5p
 - 6p
31. In addition to the s type electrons, Gallium will have _____ electrons in the 4p energy sublevel.
- 3
 - 13
 - 1
 - 2
 - 4
32. Which of the following is a poor conductor of electricity?
- potassium
 - mercury
 - molten sodium chloride
 - copper
 - sulfur
33. Water molecules bind to each other mainly by
- breaking an O-H bond in neighboring water molecules.
 - oxygen lone pair interactions with hydrogen atoms of a neighboring molecule.
 - electrons being paired between them.
 - ejecting electrons from oxygen.
 - formation of hydronium and hydroxide ions.

34. Consider the following reaction:
- $$\text{H}_2(\text{g}) + \text{CO}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{g}) + \text{CO}(\text{g})$$
- ΔH_f for $\text{CO}_2(\text{g}) = -22.5 \text{ kJ/mole}$
 ΔH_f for $\text{CO}(\text{g}) = -6.3 \text{ kJ/mole}$
 ΔH_f for $\text{H}_2\text{O}(\text{g}) = -13.8 \text{ kJ/mole}$
- A) ΔH of the reaction is positive.
 B) ΔH of the reaction is negative.
 C) ΔH of the reaction is zero.
 D) The reaction is exergonic.
 E) Can't answer because ΔH_f for $\text{H}_2(\text{g})$ is not given.
35. A catalyst ____ .
- A) lowers ΔS for the process
 B) increases the amount of products present at equilibrium
 C) increases the rate at which equilibrium is reached but decreases the equilibrium constant
 D) increases the rate at which equilibrium is reached without changing the equilibrium constant
 E) increases ΔH for the process
36. Which solution has the greatest concentration of hydroxide ions?
- A) 1.0 M NaCl
 B) 1.0 M NaOH
 C) 0.1 M $\text{Ca}(\text{OH})_2$
 D) 1.0 M HCl
 E) 1.0 M $\text{Fe}(\text{OH})_3$
37. A sample of pure water is neutral because it contains ____ .
- A) some hydronium ions
 B) some hydroxide ions
 C) equal amounts of hydroxide and hydronium ions
 D) only H_2O molecules
 E) non-polar molecules
38. In the following reaction, which species is reduced?
- $$\text{Ni} + 2 \text{H}^+ + 2 \text{Cl}^- \rightarrow \text{NiCl}_2 + \text{H}_2$$
- A) Ni
 B) H_2
 C) NiCl_2
 D) H^+
 E) Cl^-
39. For the reaction
- $$? \text{Al} + ? \text{CuSO}_4 \rightarrow ? \text{Al}_2(\text{SO}_4)_3 + ? \text{Cu}$$
- a maximum of ____ grams of $\text{Al}_2(\text{SO}_4)_3$ could be formed from 8.167 grams of Al and 7.147 grams of CuSO_4 .
- A) 2.0
 B) 3.6
 C) 7.1
 D) 11.2
 E) 5.1
40. When 0.05956 moles of ammonium sulfate, are dissolved in enough water to make 116 milliliters of solution, how many ammonium ions are present?
- A) 7.2×10^{22}
 B) 2.9×10^{22}
 C) 1.1×10^{24}
 D) 5.7×10^{21}
 E) 1.1×10^{22}

Physics Questions (41 – 60)

41. According to Feynman which of the following statements contains the most information to be passed on if all of scientific knowledge was to be destroyed.
- A) Conservation of Energy
 B) Newton's Second Law of Motion
 C) The Atomic Hypothesis
 D) Ohm's Law
 E) Einstein's Equation

42. According to Feynman what happens to water when it evaporates?
- It cools because the faster moving molecules escape from the water surface.
 - It cools because the slower moving molecules escape from the water surface.
 - It stays the same temperature.
 - It warms because the faster moving molecules escape from the water surface.
 - It warms because the slower moving molecules escape from the water surface.
43. This Texas physicist is interested in structural phase transitions and the effects of entropy on these transformations. He/she received his/her Ph.D. from the University of Cincinnati.
- Tikhon Bykov
 - Margaret Cheung
 - David Hough
 - Mahdi Sanati
 - B. F. L. Ward
44. How much heat is required to bring 1.50 kg of water at 20°C to 1.50 kg of steam at 100°C?
- 1.00×10^6 J
 - 1.13×10^6 J
 - 3.39×10^6 J
 - 3.89×10^6 J
 - 4.02×10^6 J
45. What is the change in entropy of the system when 1.25×10^3 J of heat is added to the system that is maintained at a constant 75.0°C?
- + 290 J/K
 - + 16.7 J/K
 - + 3.59 J/K
 - 3.59 J/K
 - 16.7 J/K
46. A spelunker drops a stone from rest into a well. The speed of sound is 343 m/s in air, and the sound of the stone striking the bottom is heard 2.15 s after the stone is dropped. How deep is the well? You may neglect air resistance and assume that the speed of sound is constant.
- 10.1 m
 - 11.4 m
 - 20.2 m
 - 21.4 m
 - 22.7 m
47. A person drops from rest off a tall cliff. In falling a distance h , she attains a speed v . Assuming free-fall conditions, how much farther must she fall in order to attain a speed of $2v$?
- $1/4 h$
 - h
 - $2h$
 - $3h$
 - $4h$
48. A fire hose ejects a stream of water at an angle of 35.0° above the horizontal. The water leaves the nozzle with a speed of 25.0 m/s. How far from a building should the fire hose be to hit the highest possible fire? You may neglect any dissipative effects.
- 21.0 m
 - 30.0 m
 - 42.8 m
 - 59.9 m
 - 63.7 m
49. A 1380 kg car is moving due east with an initial speed of 27.0 m/s. After 8.00 s the car has slowed down to 17.0 m/s. Find the magnitude and direction of the net force that produces the deceleration.
- 1730 N, due east
 - 1730 N, due west
 - 4660 N, due west
 - 7590 N, due east
 - 7590 N, due west

50. A coin is placed on a horizontal turntable that is rotating at 33.3 rpm. If the coefficient of static friction between the coin and the turntable is 0.100, how far from the center of the turntable can the coin be placed without having it slip off?
- 0.0884 cm
 - 2.81 cm
 - 8.06 cm
 - 28.1 cm
 - 80.6 cm
51. For a force to be conservative, what is the condition upon the work done by the force as you go from point A to point B?
- The work done by the force is zero.
 - The work done by the force is positive.
 - The work done by the force is negative.
 - The work done by the force can have any value, but depends upon the path taken from A to B.
 - The work done by the force can have any value, but is independent of the path taken from A to B.
52. A boy shoots a 51 g pebble straight up with a slingshot whose spring constant is 320 N/m. The slingshot is initially stretched by 0.20 m. How high above the starting point does the pebble fly? You may neglect any dissipative effects.
- 1.3 m
 - 6.4 m
 - 13 m
 - 64 m
 - 130 m
53. An insect has a completely inelastic collision with the windshield of a truck that is traveling along a highway. Which of the following is true about the collision?
- The magnitudes of the force and change in momentum are smaller for the bug than the truck.
 - The magnitude of the force is smaller for the bug than the truck, but the magnitude of the change in momentum is the same for the bug and the truck.
 - The magnitude of the change in momentum is smaller for the bug than the truck, but the magnitude of the force is the same for the bug and the truck.
 - The magnitudes of the force and change in momentum are the same for the bug and the truck.
 - The magnitude of the force is larger for the bug than the truck, but the magnitude of the change in momentum is the same for the bug and the truck.
54. A skater is initially spinning at a rate of 10.0 rad/s with a rotational inertia of $2.50 \text{ kg}\cdot\text{m}^2$ when her arms are extended. What is her angular velocity after she pulls her arms in and reduces her rotational inertia to $1.60 \text{ kg}\cdot\text{m}^2$? You may neglect any frictional torques during the spin.
- 0.400 rad/s
 - 6.40 rad/s
 - 15.6 rad/s
 - 64.0 rad/s
 - 154 rad/s
55. A trapped ideal gas has an initial volume V_0 . If during a process both the temperature and the pressure are tripled, then what is the new volume of the gas?
- $\frac{1}{9} V_0$
 - $\frac{1}{3} V_0$
 - V_0
 - $3 V_0$
 - $9 V_0$

56. An insulator is charged and brought near an electrically isolated metal conductor that is initially uncharged. Which of the following is true about the electrical force between the two objects?
- They exert no electric force on one another.
 - They attract one another.
 - They repel one another.
 - If the insulator is positively charged then they attract, but if it is negatively charged then they repel.
 - If the insulator is positively charged then they repel, but if it is negatively charged then they attract.
57. What is the radius of a circular loop of wire such that the magnetic field at its center is 1.8×10^{-4} T when the loop carries a current of 12 A?
- 1.3 cm
 - 4.2 cm
 - 12 cm
 - 16 cm
 - 21 cm
58. Two parallel wires in a horizontal plane are oriented such that wire 1 is up from wire 2 in the plane. The two wires carry currents I_1 and I_2 to the right. The wires each have length L and are separated by a distance d . What is the magnitude and direction of the magnetic field due to wire 1 at the middle of wire 2? You may assume that $L \gg d$.
- $(\mu_0 I_1)/(2\pi d)$ into the horizontal plane
 - $(\mu_0 I_1)/(2\pi d)$ out of the horizontal plane
 - $(\mu_0 I_1 I_2)/(2\pi L)$ up in the horizontal plane
 - $(\mu_0 I_2)/(2\pi d)$ into the horizontal plane
 - $(\mu_0 I_2)/(2\pi d)$ out of the horizontal plane
59. A slide projector uses a slide of width 5.08 cm and produces a real image that is 2.00 m wide on a screen that is 3.50 m away. What is the focal length of the projector lens?
- 9.21 cm
 - 8.67 cm
 - + 8.67 cm
 - + 9.21 cm
 - + 3.41 m
60. For a radioactive decay, $N(t) = N_0 e^{-\lambda t}$, what are the appropriate S.I. units for the decay constant, λ ?
- Becquerel/s (Bq/s)
 - curie/s (Ci/s)
 - Gray (Gy)
 - sievert (Sv)
 - 1/s

**UIL HIGH SCHOOL SCIENCE CONTEST
ANSWER KEY**

INVITATIONAL A • 2010

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

PHYSICS KEY for Science Contest • Invitational A • 2010

41. (C) “If in some cataclysm, all of scientific knowledge were to be destroyed, and only one sentence passed on to the next generations of creatures, what statement would contain the most information in the fewest words? I believe that it is the *atomic hypothesis* (or the *atomic fact*, or whatever you wish to call it) that *all things are made of atoms – little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another.*”
42. (A) The water cools because the faster moving molecules escape from the water surface.
43. (D) Dr. Mahdi Sanati, Assistant Professor of Physics at Texas Tech University, is interested in structural phase transitions and the effects of entropy on these transformations.
44. (D) $Q = mc\Delta T + mL_v = 1.5(4186)(100-20) + 1.5(22.6 \times 10^5) = 3.89 \times 10^6 \text{ J}$
45. (C) $\Delta S = Q/T = +1.25 \times 10^3 / (75 + 273.15) = +3.59 \text{ J/K}$
46. (D) From $h = \frac{1}{2}gt^2$ & $h = v_{\text{sound}}t \Rightarrow t_{\text{total}} = (2h/g)^{1/2} + h/v_{\text{sound}}$ which can be solved to get $(1/v_{\text{sound}})^2 h^2 - (2t/v_{\text{sound}} + 2/g)h + t^2 = 0$ to get $h = 21.4 \text{ m}$
47. (D) using $v^2 = v_0^2 + 2a\Delta y$, $v^2 = 0^2 + 2gh$ & $(2v)^2 = v^2 + 2gd \Rightarrow d = 3v^2/2g = 3(2gh)/2g = 3h$. Note: the questions asks how much further and not how far from the top of the cliff.
48. (B) $t = (v_y - v_{oy})/a = (0 - 14.34)/9.8 = 1.463 \text{ s}$ & $x = v_{0xt} = 20.98(1.463) = 30.0 \text{ m}$
49. (B) $\Sigma F = ma = 1380(17 - 27)/8 = -1730 \text{ N}$ or 1730 N , due west.
50. (C) From the free-body diagram:
 $\Sigma F_{\text{centrip}} = ma_{\text{centrip}} \Rightarrow F_{\text{frs}} = \Sigma_s F_N = \Sigma_s mg = mR\omega^2 \Rightarrow R = \Sigma_s g/\omega^2 = 0.0806 \text{ m}$
51. (E) The work done by a conservative force is independent of the path taken from point A to point B.
52. (C) By conservation of energy: $mgh = \frac{1}{2}kx^2 \Rightarrow h = kx^2/(2mg) = 12.8 \text{ m}$
53. (D) The force on the bug by the truck and the force on the truck by the bug are third law pairs and thus are equal in magnitude and opposite in direction. Since the collision time is the same for both the bug and the truck then by the impulse-momentum theorem the magnitude of the change in momentum is the same for each, or equivalently since momentum is conserved in the collision.
54. (C) By conservation of angular momentum: $I_0\omega_0 = I\omega \Rightarrow \omega = (2.5/1.6)10 = 15.6 \text{ rad/s}$
55. (C) By the ideal gas law: $V = nRT/P = nR(3T_0)/(3P_0) = nRT_0/P_0 = V_0$
56. (B) No matter what the charge is on the insulator it will induce a separation of charge on the conductor and attract each other.
57. (B) From $B = (\mu_0 I)/(2R) \Rightarrow R = (\mu_0 I)/(2B) = 0.0419 \text{ m}$
58. (A) For a long straight wire: $B = (\mu_0 I)/(2\pi R) = (\mu_0 I_1)/(2\pi d)$ and by the right hand rule it goes into the horizontal plane.
59. (C) From the lateral magnification equation:
 $M = h_i/h_o = -d_i/d_o \Rightarrow d_o = -3.5 \text{ m}$ ($0.0508 \text{ m}/-2.00 \text{ m}$) = 0.0889 m and thus the focal length is: $f = (1/d_o + 1/d_i)^{-1} = 0.08669 \text{ m}$
60. (E) The S.I. units of the decay constant, λ , are $1/\text{s}$.