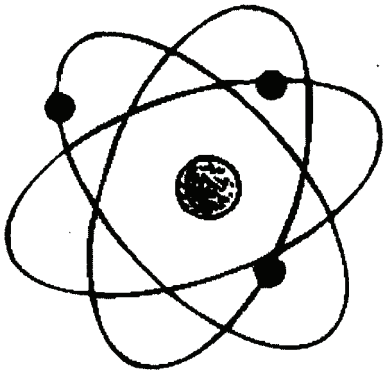
UIL

SCIENCE

District 2 • 2009



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.

Periodic Table of the Elements

1A												3A	4A	5A	6A	7A	8A
1 H 1.008	2A						8B			1B	2B						2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 23.00	12 Mg 24.31	3B	4B	5B	6B	7B				1B	2B	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.70	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.0	89 Ac 227.0	104 Rf (261)	105 Ha (262)	106 Unh (263)	107 Uns (262)		109 Une (267)									

Lanthanides	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
Actinides	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np 237.0	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)

See Reverse Page for Other Useful Information

OTHER USEFUL INFORMATION

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

Absolute zero = 0 K = -273.15°C

Atmospheric pressure, 1 atm = 1.013×10^5 N/m^2 = 101.3 kPa = 760.0 Torr = 760.0 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 cal/mol•K = 0.08206 atm•L/mol•K = 8.314 J/mol•K

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

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

Acceleration of gravity at Earth's surface, g = 9.80 m/s^2

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

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

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

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

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

Coulomb's law constant, $k = 1/4\pi\varepsilon_o = 8.988 \times 10^9$ N•m^2/C^2

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

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

Electron volt, 1 eV = 1.602×10^{-19} J

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

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

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

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

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

Proton Mass = 1.6726×10^{-27} kg = 1.00728 u = 938.3 MeV/c^2

Neutron Mass = 1.6749×10^{-27} kg = 1.008665 u = 939.6 MeV/c^2

Some standard values for water:

- Mass density, $\rho = 1.00$ g/cm^3 = 1,000 kg/m^3
- Heat capacity or Specific heat, c = 1.00 cal/gram•C° = 1.00 kcal/kg•C° = 4186 J/ kg•C°
- Latent heats, $L_F = 79.7$ kcal/kg = 3.33×10^5 J/kg & $L_V = 539$ kcal/kg = 22.6×10^5 J/kg
- Index of refraction, n = 1.33

Biology Questions (1 – 20)

1. If a new plant embryo had a mutation that rendered it unable to produce starch, which of the following functions would the new plant's cells not be able to perform?
   A) divide
   B) capture sunlight
   C) build cell walls
   D) store food
   E) absorb water and minerals from the soil

2. Which of the following is true of cellular membranes?
   A) they are impermeable to nonpolar molecules
   B) they are rigid
   C) they are composed of a protein bilayer
   D) they have lipids embedded in them
   E) they are permeable to small molecules

3. The quaternary structure of a protein is
   A) its three-dimensional shape
   B) the arrangement of its polypeptide subunits
   C) the form it takes on due to its cross-bridges
   D) its amino acid sequence
   E) the characteristics of its alpha-helices and beta-pleated sheets.

4. During aerobic respiration, H_2O is formed. Where do the oxygen atoms in the H_2O come from?
   A) carbon dioxide
   B) glucose
   C) molecular oxygen
   D) pyruvate
   E) lactate

5. Which of the following is found in nucleic acids?
   A) sulfur
   B) phosphorus
   C) potassium
   D) iron
   E) manganese

6. Which of the following is true?
   A) Viruses can reproduce on their own.
   B) Viruses can move by themselves.
   C) Viruses do not contain instructions to make more of themselves.
   D) Viruses are structurally organized.
   E) Viruses can carry out metabolic activities on their own.

7. Which of the following are NOT seed plants?
   A) conifers
   B) angiosperms
   C) cycads
   D) mosses
   E) grasses

8. Which annelid structure may resemble the ancestral structure from which the vertebrate kidney evolved?
   A) trachea
   B) nephridium
   C) mantle
   D) parapodia
   E) crop

9. Which of the following is NOT characteristic of the pericycle?
   A) outermost tissue in the vascular column
   B) origins of branch roots
   C) found in the root but not in the stem
   D) site for food storage
   E) located inside the endodermis

10. Most of the water moving into a leaf is lost through
    A) osmotic gradients.
    B) pressure flow forces.
    C) transpiration.
    D) translocation.
    E) active transport.

11. Which of the following do gametes, spores, and gametophytes have in common?
    A) All are diploid.
    B) All are haploid.
    C) All are found only in vascular plants.
    D) All are found only in seedless plants.
    E) None of them are photosynthetic in any plants.

12. Which of the following is NOT true?
    A) Tissues are composed of cells with similar structures but different functions.
    B) There are four major tissue types in animals.
    C) Tissues exhibit division of labor.
    D) Tissues are organized to form organs.
    E) A cell's nucleus is necessary for it to differentiate.

13. Movement of glucose through the membranes of the small intestine is primarily by
    A) osmosis.
    B) active transport.
    C) bulk flow.
    D) simple diffusion.
    E) facilitated diffusion.

14. Which of the following is NOT true?
    A) Carbon dioxide is more soluble in fluid than is oxygen.
    B) Carbon dioxide diffuses more rapidly across the respiratory surface than does oxygen.
    C) The major muscle involved in breathing is the diaphragm.
    D) Oxygen is carried primarily in blood plasma.
    E) Carbon dioxide is carried primarily in blood plasma.

15. Destruction of the motor areas in the left cerebral cortex results in
    A) the loss of sensation on the right side of the body.
    B) the loss of sensation on the left side of the body.
    C) the loss of voluntary movement on the left side of the body.
    D) the loss of voluntary movement on the right side of the body.
    E) no loss of function as the motor areas in the same area of the right cerebral cortex take over the functions of the destroyed areas.

16. The actions of insulin and glucagons could be described as
    A) synergistic.
    B) antagonistic.
    C) cooperative.
    D) permissive.
    E) mutualistic.

17. During which of the following stages of development are the germ layers formed?
    A) cleavage
    B) morula
    C) gastrula
    D) zygote
    E) blastula

18. Evolution occurs at what level of organization?
    A) organism
    B) molecule
    C) population
    D) organ
    E) ecosystem

19. Secondary succession occurs
    A) after a fire.
    B) on a new sand dune.
    C) on bare rock.
    D) immediately after the formation of a man-made lake.
    E) None of the above.

20. Humans, and other primates to some extent, differ from other animals in their ability to learn by
    A) conditioning.
    B) imprinting.
    C) habituation.
    D) insight.
    E) latent learning

Chemistry Questions (21 – 40)

21. Determine the oxidation number of manganese in $NaMnO_4$.
    A) +1
    B) +3
    C) +7
    D) +5
    E) +6

22. The number of valence electrons in the lowest valence state of one tin atom is _____ .
    A) 14
    B) 8
    C) 2
    D) 4
    E) 0

23. The energy of a photon is:
    A) $h c / \lambda$
    B) $c \lambda$
    C) $n \lambda$
    D) c / λ
    E) $\lambda / h c$

24. What is the maximum number of spatial orbitals there can be with n = 3 and l = 3?
    A) 5
    B) 2
    C) 1
    D) none
    E) 3

25. Which of the following is a representative element?
    A) vanadium
    B) all of the elements mentioned
    C) iron
    D) antimony
    E) none of the elements mentioned

26. In a 0.1 M solution of lithium sulfide, what fraction of the total number of ions is sulfide ions?
    A) 2/3
    B) none of the other answers is correct
    C) 1/4
    D) 1/3
    E) 1/2

27. What is the expected molecular geometry of SiF_4?
    A) pyramidal
    B) angular
    C) trigonal bipyramidal
    D) octahedral
    E) tetrahedral

28. Calculate the molarity of a potassium hydroxide solution if 25.0 mL of that solution reacted with .400 g of KHP (KHP contains one replaceable hydrogen and has a molecular weight of 204.2 g).
    A) .12 M
    B) .025 M
    C) .078 M
    D) .049 M
    E) .092 M

29. When zinc metal is oxidized according to the reaction $Zn + NO_3^- \rightarrow Zn^{2+} + N_2$, its equivalent weight is _____ . Note: the equation is incomplete and unbalanced.
    A) 32.7 g/mol
    B) 130.7 g/mol
    C) 65.38 g/mol
    D) 26.2 g/mol
    E) 163.4 g/mol

30. Which of the following processes is endothermic ?
    A) melting
    B) condensation at the triple point
    C) cooling
    D) condensation at the boiling point
    E) crystallization

31. The vapor pressure of a solvent in a solution _____ as its mole fraction decreases. This is known as _____ .
    A) decreases, Raoult's Law
    B) decreases, Bragg's Law
    C) increases, Raoult's Law
    D) increases, Bragg's Law
    E) increases, Henry's Law

32. A reversible reaction is at equilibrium at constant pressure and temperature if the free energy difference between the reactants and products _____ .
    A) is a minimum.
    B) decreases.
    C) is zero.
    D) is a maximum.
    E) increases.

33. Ozone provides protection from _____ light in sunlight.
    A) red
    B) infrared
    C) ultraviolet
    D) green
    E) blue

34. When the system A + B ⟷ C + D is at equilibrium _____ .
    A) the reverse reaction has stopped.
    B) neither the forward nor the reverse reactions have stopped.
    C) both the forward and reverse reaction have stopped.
    D) the sum of the concentrations of A and B equals the sum of the concentrations of C and D.
    E) the forward reaction has stopped.

35. Given the following acid ionization constants, K_a

HF	7.2×10^{-4}
HNO_2	4.5×10^{-4}
CH_3COOH	1.8×10^{-5}
HClO	3.5×10^{-8}
HCN	4.0×10^{-10}

    Which is the weakest acid?
    A) HClO
    B) HNO_2
    C) HF
    D) CH_3COOH
    E) HCN

36. Calculate the pH of the solution resulting from the addition of 10.0 mL of 0.100 M sodium hydroxide to 40.0 mL of 0.100 M hydrochloric acid.
    A) 1.57
    B) 3.11
    C) 1.22
    D) 2.30
    E) 2.67

37. Which of the following is NOT included in the net equation for the electrolysis of aqueous sodium sulfate ?
    A) $H_2(g)$
    B) Na(s)
    C) O_2 (g)
    D) $OH^-(aq)$
    E) $H_2O(l)$

38. For the reaction ? C_3H_8 + ? O_2 → ? CO_2 + ? H_2O, a maximum of ___ grams of CO_2 could be formed from 3.548 grams of C_3H_8 and 6.118 grams of O_2 .
    A) 5.05 g
    B) 2.02 g
    C) 9.09 g
    D) 7.07 g
    E) 11.11 g

39. At 160.2°C and 712.0 torr, 424. mL of a gaseous compound has a mass of 0.642 g. What is the molecular weight of the compound?
    A) 80.4 g/mol
    B) 103.3 g/mol
    C) 40.2 g/mol
    D) 126.3 g/mol
    E) 57.4 g/mol

40. 84.47 grams of an aqueous solution of silver nitrate contains 4.18 grams of silver nitrate. What is the percent by mass of silver nitrate in this solution? The density of the solution is 1.07 g/ml.
    A) 1.98 %
    B) 3.47 %
    C) 8.92 %
    D) 10.9 %
    E) 4.95 %

Physics Questions (41 – 60)

41. This UT theoretical physicist was awarded numerous prizes including the Dirac Prize and the American Physical Society's Einstein Prize. His/her research was predominantly on canonical quantum gravity, the wave function of the universe, the many-worlds interpretation of quantum mechanics and numerical relativity. He/she had taught at the Institute for Advanced Study & UNC Chapel Hill prior to coming to UT.
    A) Bryce DeWitt
    B) Cécile DeWitt-Morette
    C) Richard Matzner
    D) E.C.G. Sudarshan
    E) Jack Swift

42. According to the Born interpretation, the wave function of an electron indicates which of the following about the electron?
    A) The exact location of the electron.
    B) The probability of locating the electron.
    C) The future trajectory of the electron.
    D) The past trajectory of the electron.
    E) The trajectory of the electron.

43. One of the classic tests of general relativity proposed by Einstein was the measurement of the deflection of starlight by the sun. Under which of the following conditions was this test originally carried out (and repeated by our UT theoretical physicist) for starlight in the visible portion of the spectrum?
    A) When the earth is at aphelion.
    B) When the earth is at perihelion.
    C) During a total lunar eclipse.
    D) During a total solar eclipse.
    E) At anytime during the night.

44. Given that we are 2.6×10^4 light-years (ly) from the center of the Milky Way Galaxy and that it takes 1 galactic year (GY) or 250 megaannum (Ma) to complete a rotation about the center. What is our average speed about the center of the galaxy in light-years/megaannum? Recall that a light-year is defined as the distance that light travels in a vacuum in one year and that a megaannum is defined as the amount of time equal to one million years. You may assume that our motion about the center of the galaxy is circular and at a constant speed.
    A) 6.5×10^2 ly/Ma
    B) 1.6×10^5 ly/Ma
    C) 2.1×10^5 ly/Ma
    D) 8.5×10^6 ly/Ma
    E) 2.1×10^9 ly/Ma

45. A naughty child who is standing on a bridge that is 80.0 m above the surface of a river notices a raft moving at a constant speed towards the bridge. The child drops a rock off of the bridge in an attempt to hit the raft. If the rock is dropped when the raft is 6.5 m away from the bridge and the rock hits the water 2.0 m in front of the raft, then what is the speed of the raft? You may neglect air resistance for this calculation.
    A) 0.50 m/s
    B) 1.1 m/s
    C) 1.6 m/s
    D) 2.9 m/s
    E) 4.0 m/s

46. A projectile is fired from the surface of level ground at an angle of θ_0 above the horizontal. What is the formula for the ratio of the maximum height H to the range R? You may neglect air resistance for this calculation.
    A) $H/R = \frac{1}{4} \tan \theta_0$
    B) $H/R = \frac{1}{2} \tan \theta_0$
    C) $H/R = \tan \theta_0$
    D) $H/R = 2 \tan \theta_0$
    E) $H/R = 4 \tan \theta_0$

47. A 5.00 kg box is sliding across the horizontal floor of an elevator. The coefficient of kinetic friction between the box and the floor is 0.250. Determine the magnitude of the force of kinetic friction that acts upon the box when the elevator is accelerating downward at a constant 1.50 m/s^2.
    A) 1.06 N
    B) 1.44 N
    C) 10.4 N
    D) 12.3 N
    E) 14.1 N

48. A rescue helicopter lifts a 75 kg person straight up with a cable. The person has a constant upward acceleration of 0.75 m/s^2 and is lifted from rest through a distance of 12 m. What is the final speed of the person? You may neglect air resistance for this calculation.
    A) 1.2 m/s
    B) 2.1 m/s
    C) 4.2 m/s
    D) 16 m/s
    E) 43 m/s

49. You have a 2.0 hp motor and a 1.0 hp motor. Compared to the 2.0 hp motor, which of the following is TRUE for the 1.0 hp motor?
    A) Half of the amount of work in half the amount of time.
    B) Half of the amount of work in twice the amount of time.
    C) Twice of the amount of work in half the amount of time.
    D) Twice of the amount of work in twice the amount of time.
    E) None of the above.

50. A train is rounding a circular turn of radius 175 m. At one point during this motion the train has an angular acceleration 1.75×10^{-3} rad/s^2 and an angular speed of 5.25×10^{-2} rad/s. What is the angle of the total acceleration vector as measured relative to the radial direction?
    A) 5.76°
    B) 17.0°
    C) 25.8°
    D) 32.4°
    E) 57.6°

51. A stationary 3.5 kg block is hung from the end of a vertical spring that is attached to the ceiling. If the current elastic (spring) potential energy of the mass/spring system is 2.2 J, then what is the elastic potential energy of the system at rest when the 3.5 kg block is replaced with a 6.5 kg block?
    A) 0.64 J
    B) 1.2 J
    C) 2.1 J
    D) 4.1 J
    E) 7.6 J

52. Water is flowing at 2.5 m/s in a horizontal pipe under a pressure of 225 kPa. If the pipe narrows to half its original diameter, then what is the pressure in the narrow section? You may assume that the water is incompressible and that it undergoes laminar nonviscous flow.
    A) 102 kPa
    B) 151 kPa
    C) 178 kPa
    D) 202 kPa
    E) 215 kPa

53. A swimming pool contains 125 m^3 of water. If the sun heats the water from 15.0 °C to 24.0 °C, then what is the change in the volume of the water? You are given that the coefficient of volumetric thermal expansion for water is 207×10^{-6} $(C°)^{-1}$.
    A) 1.84×10^{-7} m^3
    B) 1.49×10^{-5} m^3
    C) 0.125 m^3
    D) 0.233 m^3
    E) 0.621 m^3

54. Oxygen has a molar mass of 32 g/mol and nitrogen has a molar mass of 28 g/mol. The oxygen and nitrogen molecules in the room have:
    A) the same average kinetic energy and the same average speed.
    B) the same average speed, but the oxygen molecules have a higher average kinetic energy.
    C) the same average speed, but the oxygen molecules have a higher average kinetic energy.
    D) the same average kinetic energy, but the oxygen molecules have a higher average speed.
    E) the same average kinetic energy, but the nitrogen molecules have a higher average speed.

55. Two point charges are placed on the x-axis. The first charge $q_1 = +7.5\ \mu C$ is at $x_1 = +2.0$ cm, while the second charge $q_2 = -18\ \mu C$ is at $x_2 = +5.0$ cm. What is the magnitude and direction of the net electric field at x= +4.0 cm?
    A) 1.79×10^9 N/C in the positive x direction
    B) 1.62×10^9 N/C in the positive x direction
    C) 1.45×10^9 N/C in the positive x direction
    D) 1.45×10^9 N/C in the negative x direction
    E) 1.79×10^9 N/C in the negative x direction

56. Two equal positive point charges +Q are on the x-axis. One is at x = −a, and the other one is at x = +a. What is the magnitude of the electric field and the electric potential at the origin? Assume that the potential goes to zero as you move infinitely far away from the point charge.
    A) E = 0 & V = 0
    B) E = 0 & V = 2kQ/a
    C) $E = 2kQ^2/a^2$ & V = 0
    D) $E = 2kQ^2/a^2$ & V = 2kQ/a
    E) None of the above.

57. A wire has a resistance of 22.0 Ω. It is melted down and reformed into a wire that is three times longer than the original wire, but still has the same volume as the original wire. What is the resistance of the newly formed wire?
    A) 2.44 Ω
    B) 7.33 Ω
    C) 22.0 Ω
    D) 66.0 Ω
    E) 198 Ω

58. A capacitor with capacitance C is charge to a voltage V and then connected across a resistor with resistance R. What is the equation for the energy stored in the capacitor as a function of time t in terms of the given quantities?
    A) $U(t) = (\frac{1}{2} CV^2)e^{-[2t/(RC)]}$
    B) $U(t) = (\frac{1}{2} CV^2)e^{-[t/(RC)]}$
    C) $U(t) = (\frac{1}{2} CV^2)e^{-[tRC]}$
    D) $U(t) = (\frac{1}{2} CV^2)[1 - e^{-[t/(RC)]}]$
    E) $U(t) = (\frac{1}{2} CV^2)[1 - e^{-[2t/(RC)]}]$

59. A 0.55 m length of wire is formed into a single square loop that carries 8.0 A of current. The loop is placed in a 0.25 T magnetic field that is oriented parallel to the plane of the loop. What is the magnitude of the maximum torque that the loop will experience?
    A) 7.1×10^{-4} m•N
    B) 1.8×10^{-3} m•N
    C) 3.8×10^{-2} m•N
    D) 6.1×10^{-1} m•N
    E) 1.1×10^{0} m•N

60. A transformer is constructed with 330 turns in the primary and 1250 turns in the secondary. If the rms input voltage is 120 V and the rms output current is 15.0 A, then what is the rms output voltage and rms input current? You may assume that the transformer is 100% efficient.
    A) $V_{rms} = 31.7$ V & $I_{rms} = 3.96$ A
    B) $V_{rms} = 31.7$ V & $I_{rms} = 56.8$ A
    C) $V_{rms} = 56.8$ V & $I_{rms} = 31.7$ A
    D) $V_{rms} = 455$ V & $I_{rms} = 3.96$ A
    E) $V_{rms} = 455$ V & $I_{rms} = 56.8$ A

UIL HIGH SCHOOL SCIENCE CONTEST
ANSWER KEY

DISTRICT 2 • 2009

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

41. (A) The citation for Bryce DeWitt's posthumous APS Einstein Prize reads as follows "*For a broad range of original contributions to gravitational physics, especially in quantum gravity, gauge field theories, radiation reaction in curved spacetime, and numerical relativity; and for inspiring a generation of students.*"

42. (B) According to Born's statistical interpretation, the spatial integral of the modulus squared of the wave function gives the probability of locating the particle in that interval (the one that was integrated over) as a function of time.

43. (D) The deflection of starlight in the visible portion of the spectrum by the sun can only be measured during a total solar eclipse.

44. (A) avg speed = $[2\pi(2.6\times10^4)]/250 = 6.5\times10^2$ ly/Ma

45. (B) With up as positive and the origin at the water, $0 = 80+0+\frac{1}{2}(-9.8)t^2 \Rightarrow t = 4.04$ s, and thus, speed = 4.5/4.04 = 1.1 m/s

46. (A) From the launch point to the maximum height, $0 = v_0 \sin\theta_0 - gt \Rightarrow t = (v_0 \sin\theta_0)/g$ thus we can find, the maximum height $H = 0 + v_0 \sin\theta_0 (v_0 \sin\theta_0/g) - \frac{1}{2} g(v_0 \sin\theta_0/g)^2 = \frac{1}{2} (v_0^2 \sin^2\theta_0)/g$ & the total time $t = 2(v_0 \sin\theta_0)/g$, so the range $R = 0 + v_0 \cos\theta_0 (2\, v_0 \sin\theta_0/g)$, therefore the ratio of $H/R = [\frac{1}{2} (v_0^2 \sin^2\theta_0)/g]/[(2\, v_0^2 \cos\theta_0 \sin\theta_0)/g] = \frac{1}{4} \tan\theta_0$

47. (C) From Newton's 2nd Law: $F_N - F_G = ma \Rightarrow F_N = 41.5$ N thus, $F_{frk} = \mu_k F_N = 10.4$ N

48. (C) $W_{NET} = \Delta KE \Rightarrow [75(0.75)]12 \cos0° = \frac{1}{2}(75) v^2 - 0 \Rightarrow v = 4.24$ m/s

49. (E) The 1.0 hp motor should be able to do half the work in the same time or the same amount of work in twice the time, none of the listed options gives the correct comparison ratio of work to time.

50. (D) $a_{tan} = 175(1.75\times10^{-3}) = 0.306$ m/s^2 & $a_c = 175(5.25\times10^{-2})^2 = 0.482$ m/s$^2 \Rightarrow$ $\theta = \tan^{-1}(a_{tan}/a_c) = \tan^{-1}(0.306/0.482) = 32.4°$

51. (E) $PE_s = \frac{1}{2} kx^2$ & at equilibrium $kx = mg \Rightarrow PE_s = \frac{1}{2} (mg)^2/k$, thus $PE_s = (6.5/3.5)^2 2.2 = 7.6$ J

52. (C) $A_1v_1 = A_2v_2$ & $A_2 = \frac{1}{4} A_1 \Rightarrow v_2 = 4(2.5) = 10$ m/s and from Bernoulli's equation: $225\times10^3 + \frac{1}{2}(1000)2.5^2 = P_2 + \frac{1}{2}(1000)10^2 \Rightarrow P_2 = 178$ kPa

53. (D) $\Delta V = 207\times10^{-6}(125)[24 - 15] = 0.233$ m^3

54. (E) Since they are at the same temperature then they will have the same average kinetic energy. However, since the nitrogen molecules are less massive then they will have a higher average speed.

55. (A) $\Sigma E = E_2 + E_1 = 9\times10^9[(18\times10^{-6})/(0.01)^2 + (7.5\times10^{-6})/(0.02)^2] = +1.79\times10^9$ N/C (in the +x direction)

56. (B) By symmetry $E = 0$ & $V = V_1 + V_2 = 2V = 2kQ/a$

57. (E) volume $= A_1L_1 = A_2L_2$ & $L_2 = 3\, L_1 \Rightarrow A_2 = 1/3\, A_1$, thus $R_2 = \rho\, L_2/A_2 = \rho\, 3L_1/(\frac{1}{3} A_1) = 9\, (\rho L_1/A_1) = 9\, R_1 = 198\ \Omega$

58. (A) $U(t) = \frac{1}{2} CV^2(t)$ for a discharging capacitor $V(t) = Ve^{-t/(RC)} \Rightarrow U(t) = (\frac{1}{2} CV^2)e^{-[2t/(RC)]}$

59. (C) For a square $P = 4L \Rightarrow L = 0.55/4 = 0.138$ m & $A = L^2 = 0.138^2 = 0.0189$ m^2, thus the maximum torque $\tau_{max} = NIAB = (1)(8)(0.0189)(0.25) = 3.8 \times 10^{-2}$ m•N

60. (E) $V_s = (N_s/N_p)V_p = (1250/330)120 = 455$ V & $I_p = (N_s/N_p)I_s = (1250/330)15 = 56.8$ A