SCIENCE

Invitational B • 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.

Periodic Table of the Elements

1A																	8A
1 H 1.008	2A											3A	4A	5A	6A	7A	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	8B			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, $\hbar \equiv h/2\pi = 1.054 \times 10^{-34}$ 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. A macromolecule is composed of smaller units called
   A) polymers.
   B) isomers.
   C) monomers.
   D) isotopes.
   E) dimmers.

2. An organelle found in the nucleus is a
   A) plastid.
   B) vacuole.
   C) microvillus.
   D) nucleolus.
   E) basal body.

3. The sodium-potassium pump is an example of
   A) simple diffusion.
   B) facilitated diffusion.
   C) osmosis.
   D) active transport.
   E) bulk flow.

4. Chlorophyll reflects, and does not absorb, which color of light?
   A) red
   B) yellow
   C) orange
   D) green
   E) blue

5. If a parent cell has 16 chromosomes and undergoes meiosis, the resulting cells will have how many chromosomes?
   A) 64
   B) 32
   C) 16
   D) 8
   E) 4

6. A locus is
   A) a recessive gene.
   B) an unmatched allele.
   C) a sex chromosome.
   D) the location of an allele on a chromosome.
   E) a dominant gene.

7. Flu pandemics are caused by the spread of
   A) pathogenic bacteria.
   B) RNA viruses.
   C) DNA viruses.
   D) parasitic protozoans.
   E) fungi.

8. The seed of a plant develops from the
   A) gametophyte.
   B) ovary.
   C) ovule.
   D) pollen grain.
   E) zygote.

9. The mollusks with the most complex nervous systems are
   A) chitons.
   B) cephalopods.
   C) gastropods.
   D) bivalves.
   E) univalves.

10. Plant growth designated as "primary"
    A) occurs along the sides of stems.
    B) is dependent upon the apical meristem.
    C) increases the diameter of older plants.
    D) is responsible for additions to woody parts.
    E) produces secondary tissues.

11. Most of the macronutrients and micronutrients for plants function as
    A) food for plants.
    B) structural components for cells.
    C) elements needed for the development of mycorrhizae.
    D) cell wall components.
    E) enzyme activators.

12. "Double fertilization" in plants refers to the union of
    A) two eggs and one sperm.
    B) two sperm and one egg.
    C) two sperm and two eggs.
    D) one sperm to one egg and one sperm to the endosperm.
    E) one sperm to the egg and one sperm to the egg nucleus.

13. Muscle fatigue is a result of
    A) accumulation of lactic acid.
    B) exhaustion of available ATP.
    C) reduction in lactic acid and oxygen debt.
    D) failure of calcium channels to open after prolonged use.
    E) accumulation of ADP.

14. In humans, which of the following types of blood cells does not have a nucleus at maturity?
    A) erythrocytes
    B) lymphocytes
    C) neutrophils
    D) eosinophils
    E) monocytes

15. The markers that identify "self" are actually
    A) genes.
    B) proteins.
    C) lipids.
    D) small surface bumps.
    E) triplet codons.

16. Excess salts of saltwater fish are excreted by
    A) relatively large kidneys.
    B) through the skin.
    C) through the eyes.
    D) through special salt glands located in the tail.
    E) through the gills.

17. Which of the following is a single-layered, hollow ball of cells?
    A) blastula
    B) cleavage
    C) gastrula
    D) morula
    E) zygote

18. Darwin's finches are examples of
    A) scavengers.
    B) morphological isolation.
    C) adaptive radiation.
    D) punctuated equilibrium.
    E) convergence.

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. Most of the carbon now present in the Earth's atmosphere will eventually end up in which of the following "holding stations"?
    A) plants and animals
    B) plants and decomposers
    C) plants and soil
    D) plants and oceans
    E) plants and fossil fuels

Chemistry Questions (21 – 40)

21. Which of the following does not represent a chemical change?
    A) burning
    B) vaporizing
    C) fermenting
    D) rusting
    E) dimerizing

22. The molar heat of fusion of water is 6.02 kJ/mol. The energy required to melt 46.8 g of water is ___ .
    A) 2.32 kJ
    B) 6.02 kJ
    C) 7.77 kJ
    D) 282 kJ
    E) 15.7 kJ

23. The symbol for the element copper is _____ .
    A) Cp
    B) Cr
    C) Co
    D) Cu
    E) Ce

24. What is the formula weight of ammonium fluoride?
    A) 37
    B) 18
    C) 23
    D) 32
    E) 42

25. An analysis of nicotine (FW=162 amu) is 74.0% carbon, 8.65% hydrogen and 17.3% nitrogen. What is the molecular formula for nicotine?
    A) $C_{12}H_4N$
    B) $C_8H_{10}N_4$
    C) $C_9H_{12}N_3$
    D) $C_{10}H_{14}N_2$
    E) $C_{11}H_{16}N$

26. How many moles of Cl^- are present in 40. mL of 0.035 M solution?
    A) 0.0060
    B) 0.0018
    C) 0.0014
    D) 0.012
    E) 0.0080

27. Balance the equation for the combustion of hydrogen sulfide to produce sulfur, denoted as S_8, using the smallest set of integers. The sum of the coefficients of the products and reactants is _____ .
    A) 4
    B) 6
    C) 8
    D) 10
    E) 21

28. The solid product that forms when aqueous solutions of cobalt(II) chloride and sodium sulfide are mixed is _____.
    A) cobalt(II) sulfide and sodium chloride
    B) cobalt(II) sulfide and (sodium chloride)$_2$
    C) sodium chloride
    D) cobalt(II) sulfide
    E) no solid products are formed

29. How many neutrons are there in one atom of boron whose mass number is 9 ?
    A) 3
    B) 4
    C) 1
    D) 2
    E) 5

30. In the normal order of occupancy of electron energy levels, the level occupied just after 4d is _____ .
    A) 4p
    B) 5d
    C) 5s
    D) 4f
    E) 5p

31. A neutral isolated atom has the ground state configuration:
    $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^7$. Identify the element.
    A) Cannot be answered unless the atomic weight is known.
    B) phosphorus
    C) argon
    D) vanadium
    E) cobalt

32. Which of the following is the best description of covalent bonding?
    A) Bonding that occurs between elements with similar electronegativities and with transfer of electrons.
    B) Bonding that occurs between ions and elements and with the sharing of electrons.
    C) Bonding that occurs between elements with very different electronegativities and with sharing of electrons.
    D) Bonding that occurs between elements with similar electronegativities and with sharing of electrons.
    E) Bonding that occurs between elements with very different electronegativities and with transfer of electrons.

33. Which is the weakest type of attractive force between atoms and/or ions?
    A) ionic bond
    B) van der Waals forces
    C) hydrogen bond
    D) covalent bond
    E) coordinate covalent bond

34. Consider the following reaction:

? $SO_2(g)$ + ? $O_2(g)$ → ? $SO_3(g)$

ΔH_f for $SO_2(g)$ = -16.9 kJ/mole

ΔH_f for $SO_3(g)$ = -21.9 kJ/mole

A) ΔH for the reaction is positive.
B) ΔH for the reaction is zero.
C) ΔH for the reaction is negative.
D) ΔS for the reaction is positive.
E) Can't answer because ΔH_f for $O_2(g)$ is not given.

35. A catalyst ____ .

A) increases the reaction rate but does nor alter the activation energy of the reactive state
B) alters the reaction mechanism
C) is always a solid
D) changes the value for the heat of reaction
E) increases the rate of the reaction until all of the catalyst is consumed.

36. Which of the following relations is false?

A) 11.7 g of NaCl in 0.2 L of solution = 1.0 M NaCl
B) 42.0 g of $NaHCO_3$ in 250 ml of solution = 2.0 M $NaHCO_3$
C) 0.3 moles of HCl in 3.0 L of solution = 0.3 M HCl
D) 5×10^{-2} moles of $Ba(OH)_2$ in 1.0 L of solution = 0.05 M $Ba(OH)_2$
E) 1.6 g of NaOH in 0.4 L of solution = 0.1 M NaOH

37. An aqueous solution has $[H_3O^+] = 1.5 \times 10^{-7}$ M. At room temperature, $[OH^-]$ in this solution is _____ .

A) 1.5×10^{-7} M
B) 6.7×10^{-6} M
C) 6.7×10^{-8} M
D) zero
E) 6.7×10^{-7} M

38. In the following reaction, how many electrons are involved in the conversion of $SnCl_4$ to Sn in the following reaction?

$2\ Mg + SnCl_4 \rightarrow 2\ MgCl_2 + Sn$

A) three
B) four
C) two
D) one
E) eight

39. For the reaction ? C_3H_8 + ? O_2 → ? CO_2 + ? H_2O, a maximum of ? grams of CO_2 could be formed from 5.205 grams of C_3H_8 and 7.240 grams of O_2 .

A) 2.39
B) 10.8
C) 8.36
D) 5.98
E) 13.1

40. How many milliliters of a 0.310 molar HCl solution are needed to react completely with 2.70 grams of zinc to form zinc chloride?

A) 480.
B) 580.
C) 370.
D) 270.
E) 190.

Physics Questions (41 – 60)

41. According to Feynman what is the basic problem in theoretical physics today?

A) To better understand entropy.
B) To workout a quantum description of gravity.
C) To find the laws behind experiment.
D) To end the need for experiment.
E) To experimentally verify string theory.

42. According to Feynman what is our greatest success so far in physics?

A) atomic physics
B) electromagnetism
C) gravitational physics
D) quantum electrodynamics
E) thermodynamics

43. This Texas physicist is interested in nuclear physics, characterization of materials & radio astronomy. He/she received his/her Ph.D. from Texas A&M University.
    A) Jodi Cooley
    B) Jose Cortez
    C) David Hough
    D) Jorge López
    E) Richard Olenick

44. The Arecibo radio telescope has a diameter of 305 m and can observe radio wavelengths from 3.00 cm to 6.00 m. For a binary star system that is 2.50×10^{18} km away from the Earth, what is the minimum separation distance perpendicular to our line of sight that can be resolved by this telescope?
    A) 2.46×10^{14} km
    B) 3.00×10^{14} km
    C) 6.00×10^{14} km
    D) 4.92×10^{16} km
    E) 6.00×10^{16} km

45. In the following reaction
    $^{200}_{80}\text{Hg} + {}^{1}_{1}\text{H} \rightarrow {}^{197}_{79}\text{Au} + {}^{A}_{Z}\text{X}$.
    What is ${}^{A}_{Z}\text{X}$?
    A) ${}^{0}_{-1}\text{e}$
    B) ${}^{0}_{+1}\text{e}$
    C) ${}^{1}_{0}\text{n}$
    D) ${}^{1}_{1}\text{H}$
    E) ${}^{4}_{2}\text{He}$

46. A dolphin leaps out of the water at an angle of 35° above the horizontal. The magnitude of the horizontal component of the dolphin's velocity is 7.7 m/s. Find the magnitude of the vertical component of the dolphin's velocity.
    A) 5.4 m/s
    B) 6.3 m/s
    C) 9.4 m/s
    D) 11 m/s
    E) 13 m/s

47. You plan to cross a river in a canoe. The current flows from north to south at 1.0 m/s. In what direction should he head to get across the river to the east bank in the least amount of time if you are capable of paddling your canoe at 1.5 m/s in still water? Note: θ in the answer options is an acute angle.
    A) θ° east of north
    B) θ° east of south
    C) due east
    D) θ° north of east
    E) θ° south of east

48. A 20.0 kg sled is being pulled across a horizontal surface at a constant velocity. The pulling force has a magnitude of 80.0 N and is directed at an angle of 30.0° above the horizontal. Determine the coefficient of kinetic friction.
    A) 0.316
    B) 0.353
    C) 0.444
    D) 2.25
    E) 2.83

49. Given that the projectiles are fired as follows from the top of a building, which one will hit the ground with the greatest speed, i.e., the largest magnitude of instantaneous velocity? You may neglect air resistance for this calculation.
    A) straight up
    B) straight down
    C) horizontally
    D) at an angle either above or below the horizontal
    E) all of the above are the same

50. A 0.025 kg bullet is fired horizontally 350 m/s into a 4.000 kg block of ballistics gel sitting at the edge of a table that is 1.5 m above the floor. If after the bullet lodges into the block they move horizontally off the tabletop, then how far from the table do they hit the floor? You may neglect any frictional losses between the table and the block and air resistance.
    A) 0.30 m
    B) 0.82 m
    C) 1.2 m
    D) 3.9 m
    E) 1.8 m

51. The shaft of a pump starts from rest and undergoes a constant angular acceleration of 3.00 rad/s^2 for 18.0 s. At the end of this time interval, what is the shaft's angular speed?
    A) 6.00 rad/s
    B) 54.0 rad/s
    C) 81.0 rad/s
    D) 162 rad/s
    E) 486 rad/s

52. Two satellites, A and B, are in orbit around the earth. Satellite A has an orbital speed three times that of satellite B. Find the ratio (T_A/T_B) of the periods of the satellites. You may assume that the deviation from circular orbits is negligible.
    A) 1/27
    B) 1/3
    C) 1
    D) 3
    E) 27

53. If your lungs can reduce the pressure at the top of a straw by 10 kPa, then how high up the straw will the water go? You may neglect any viscous and capillary effects.
    A) 1.0 m
    B) 9.3 m
    C) 10 m
    D) 98 m
    E) Depends upon the cross-sectional area of the straw.

54. A boat is using sonar to detect the bottom of a freshwater lake. If the echo from a sonar signal is heard 0.540 s after it is emitted how deep is the lake? Assume the speed of sound in air is 343 m/s, the speed of sound in freshwater is 1493 m/s and the speed of an electromagnetic wave in freshwater is 2.25×10^8 m/s.
    A) 92 m
    B) 403 m
    C) 806 m
    D) 6.09×10^7 m
    E) 1.22×10^8 m

55. A 0.500 kg slab of granite is heated so that its temperature increases by 7.40 C°. The amount of heat supplied to the granite is 2.93 kJ. What is the specific heat of the granite?
    A) 0.0209 J/(kg•K)
    B) 0.0434 J/(kg•K)
    C) 20.9 J/(kg•K)
    D) 43.4 J/(kg•K)
    E) 792 J/(kg•K)

56. At three corners of a rectangle (length = 2d and height = d), the following charges are located: $+q_1$(upper left corner), $+q_2$(lower right corner), and $-q$(lower left corner). The net electric field at the upper right hand corner is zero. Find the magnitudes of q_1 and q_2.
    A) $|q_1| = 0.00800\ q$, $|q_2| = 0.0640\ q$
    B) $|q_1| = 0.0640\ q$, $|q_2| = 0.00800\ q$
    C) $|q_1| = 0.447\ q$, $|q_2| = 0.894\ q$
    D) $|q_1| = 0.0894\ q$, $|q_2| = 0.716\ q\ q$
    E) $|q_1| = 0.716\ q$, $|q_2| = 0.0894\ q$

57. Find the magnetic force exerted on a proton moving east at a speed of 6.0×10^6 m/s by a horizontal magnetic field of 2.50 T directed north.
    A) 2.5×10^{-20} N, up
    B) 2.5×10^{-20} N, down
    C) 4.2×10^{-17} N, north
    D) 2.4×10^{-12} N, up
    E) 2.4×10^{-12} N, down

58. In an a.c. circuit if the peak voltage is V_0, then what is the root-mean-square (rms) voltage?
    A) $0.5\ V_0$
    B) $0.707\ V_0$
    C) V_0
    D) $1.41\ V_0$
    E) $2\ V_0$

59. For the additive primary colors, what is the complementary color to blue?
    A) Cyan
    B) Green
    C) Magenta
    D) Red
    E) Yellow

60. UV light with a frequency of 3.0×10^{15} Hz strikes a metal surface and ejects electrons that have a maximum kinetic energy of 6.1 eV. What is the work function of the metal?

A) – 12 eV
B) – 6.3 eV
C) + 6.3 eV
D) +12 eV
E) + 19 eV

41. (C) "However, the aim is to see *complete nature* as different aspects of *one set* of phenomena. That is the basic problem in theoretical physics, today – *to find the laws behind experiment*; to *amalgamate these classes*."

42. (D) "The new view of the interaction of electrons and protons that is electromagnetic theory, but with everything quantum-mechanically correct, is called *quantum electrodynamics*. This fundamental theory of interactions of light and matter, or electric fields and charges, is our greatest success so far in physics."

43. (D) Dr. Jorge López, Chair and Shumaker Professor at The University of Texas at El Paso, is interested in nuclear physics, characterization of materials & radio astronomy.

44. (B) Using a small angle approximation the minimum separation, s_{min}, is given by: $s_{min} = R\theta_{min}$ & by Rayleigh's criterion for a circular aperture $\theta_{min} = 1.22\,\lambda_{min}/D \Rightarrow s_{min} = R(1.22\,\lambda_{min}/D) = 3.00 \times 10^{14}$ km

45. (E) By conservation of nucleon number and conservation of charge (or proton number) the missing particle is ${}^{4}_{2}He$.

46. (A) From the component triangle: $\tan(35°) = v_y/v_x \Rightarrow v_y = 7.7\tan(35°) = 5.4$ m/s

47. (C) In order to minimize the time to cross the river you must head due east. Note: any other direction will give you a smaller across river component of your velocity and thus a longer time.

48. (C) From the free-body diagram: $F_{frk} = 80\cos(30°)$ & $F_N = 196 - 80\sin(30°) = 156 \Rightarrow \mu_k = F_{frk}/F_N = 0.444$

49. (E) By conservation of energy (since we can neglect air resistance), all of the projectiles will hit with the same speed.

50. (C) From conservation of momentum in the collision: $v' = 0.025(350)/4.025 = 2.174$ m/s, and for the projectile motion of the bullet & block $t = (2h/g)^{½} = 0.5533$ s & $x = 2.174(0.5533) = 1.2$ m

51. (B) From angular kinematics: $\omega = \omega_0 + \alpha t = 0 + 3(18) = 54.0$ rad/s

52. (A) By Newton's second law: $\Sigma F_{centrip} = ma_{centrip} \Rightarrow GM_{earth}m/r^2 = mv^2/r \Rightarrow r = GM_{earth}/v^2$ & $T = 2\pi r/v \Rightarrow T = 2\pi\, GM_{earth}/v^3 \Rightarrow T_A/T_B = v_B^3/v_A^3 = v_B^3/(3v_B^3) = 1/27$

53. (A) From $\Delta P = \rho gh \Rightarrow h = \Delta P/(\rho g) = 10\times10^3/[1000(9.8)] = 1.0$ m

54. (B) $d = v(t/2) = 1493(0.54/2) = 403$ m

55. (E) $Q = mc\Delta T \Rightarrow c = Q/(m\Delta T) = 2.93\times10^3/[0.5(7.4)] = 792$ J/(kg·K)

56. (E) By components the electric field is: horizontal $\Rightarrow kq_1/(2d)^2 - kq/(5d^2)\cos\theta = 0$, where $\cos\theta = 2/5^{½} \Rightarrow q_1 = 8/[5(5)^{½}]\,q$ & vertical $\Rightarrow kq_2/d^2 - kq/(5d^2)\sin\theta = 0$, where $\sin\theta = 1/5^{½} \Rightarrow q_2 = 1/[5(5)^{½}]\,q$

57. (D) $F_B = qvB\sin\theta = 1.602\times10^{-19}(6\times10^6)2.5\sin(90°) = 2.4\times10^{-12}$ N, and by the right hand rule the direction of the magnetic force is up.

58. (B) For a sinusoidal voltage source: $V_{rms} = [1/(2)^{½}]\,V_0$

59. (E) Yellow is the complementary color to Blue, since Blue + Yellow = White.

60. (C) $E_{photon} = hf = KE_{max} + \phi_0 \Rightarrow \phi_0 = hf - KE_{max} = 4.136\times10^{-15}(3\times10^{15}) - 6.1 = 6.3$ eV