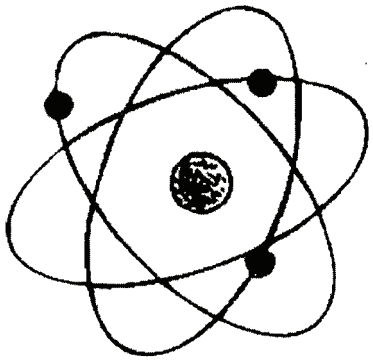
UIL

SCIENCE

Invitational B • 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.

UNIVERSITY INTERSCHOLASTIC LEAGUE

Making a World of Difference

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							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 = 3.00×10^8 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, ρ = 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. Which of the following is characteristic of ALL living cells?
   A) a nucleus
   B) a cell wall
   C) chloroplasts
   D) mitochondria
   E) a cell membrane

2. Which of the following is a lipid?
   A) an enzyme
   B) cholesterol
   C) starch
   D) DNA
   E) ATP

3. Which of the following sequences represents the hierarchical organization of genetic information?
   A) gene, nucleotide, DNA, chromosome, genome
   B) nucleotide, DNA, gene, chromosome, genome
   C) genome, DNA, chromosome, gene, nucleotide
   D) chromosome, gene, DNA, genome, nucleotide
   E) genome, gene, DNA, chromosome, nucleotide

4. The point where two sister chromatids are attached to each other is the
   A) kinetochore.
   B) centromere.
   C) chiasmata.
   D) centriole.
   E) aster.

5. The process of converting solar energy into chemical energy is
   A) anabolism.
   B) catabolism.
   C) chemosynthesis.
   D) metabolism.
   E) photosynthesis.

6. An organism with two different alleles for a given trait is
   A) homozygous.
   B) dominant.
   C) codominant.
   D) heterozygous.
   E) recessive.

7. Fossilized _____ organisms have been discovered in rocks that are at least 3.5 billion years old.
   A) eukaryotic
   B) prokaryotic
   C) fungal
   D) protistan
   E) algal

8. Flowers and fruits are produced by
   A) algae, mosses, ferns, gymnosperms, and angiosperms.
   B) mosses, ferns, gymnosperms, and angiosperms.
   C) ferns, gymnosperms, and angiosperms.
   D) gymnosperms and angiosperms.
   E) angiosperms.

9. Which of the following organisms is NOT an arthropod?
   A) crab
   B) spider
   C) butterfly
   D) starfish
   E) centipede

10. Plant tissue made up of cells that retain the ability to divide are
    A) vascular tissue.
    B) meristematic tissue.
    C) sclerenchyma tissue.
    D) reproductive tissue.
    E) parenchyma tissue.

11. Carbohydrates are stored in plants in the form of
    A) cellulose.
    B) sucrose.
    C) starch.
    D) fats.
    E) glucose.

12. The first leaves of a seed plant are the
    A) radicles.
    B) apical meristem.
    C) cotyledons.
    D) endosperm.
    E) epidermis.

13. Which of the following are the two primary functions of the mammalian digestive system?
    A) digestion and secretion
    B) digestion and absorption
    C) absorption and secretion
    D) digestion and detoxification
    D) absorption and detoxification

14. The mammalian vena cava carries blood towards which chamber(s) of the heart?
    A) left atrium
    B) right atrium
    C) left ventricle
    D) right ventricle
    E) left and right ventricles

15. What type of macromolecule are antibodies?
    A) carbohydrates
    B) lipids
    C) steroids
    D) nucleic acids
    E) proteins

16. Hormones in animals
    A) are produced in very large quantities.
    B) affect specific target cells and tissues.
    C) produce short-lived effects.
    D) are released from glands into ducts.
    E) affect the tissue in which they are produced.

17. Smooth muscle is
    A) involuntary and not striated.
    B) responsible for movement of the skeleton.
    C) involved in contraction of the heart.
    D) connected to bones by tendons.
    E) usually found to occur in bundles.

18. New genes arise from
    A) genetic drift.
    B) recombination.
    C) mutation.
    D) gene flow.
    E) independent assortment.

19. Which of the following is NOT a part of a community?
    A) bacteria
    B) fungi
    C) animals
    D) soil
    E) plants

20. The scientific process does NOT involve
    A) observations.
    B) data.
    C) proof.
    D) hypotheses.
    E) predictions.

Chemistry Questions (21 – 40)

21. In a chemical change _____ .
    A) the original material can never be regenerated.
    B) the products are different molecules than the starting materials.
    C) a phase change never occurs.
    D) a phase change must occur.
    E) the nuclei in products are different than the nuclei in the starting materials.

22. The number of calories needed to raise the temperature of 200 g of water from 20°C to 50°C is ____ .
    A) 4000 cal
    B) 14000 cal
    C) 10000 cal
    D) 6000 cal
    E) 2000 cal

23. Which of the following is an element?
    A) water
    B) salt
    C) earth
    D) brass
    E) oxygen

24. The formula weight of aluminum nitrate is _____ .
    A) 254 g/mol
    B) 238 g/mol
    C) 180 g/mol
    D) 213 g/mol
    E) 151 g/mol

25. Phenylpyruvic acid is composed of 65.85% C, 4.87% H, and 29.24% O. Its empirical formula is _____ .
    A) C_3H_2O
    B) $C_9H_8O_3$
    C) C_3H_3O
    D) $C_{66}H_5O_{29}$
    E) CHO_3

26. How many mL of a 0.150 M phosphoric acid solution do you need to get 1.47 g of phosphoric acid?
    A) 1.00 mL
    B) 1000 mL
    C) 100 mL
    D) 10.0 mL
    E) 250 mL

27. What volume of a 0.250 molar solution of silver nitrate is required to react with 18.1 g of potassium carbonate to produce silver carbonate?
    A) 0.55 L
    B) 2.85 L
    C) 0.95 L
    D) 0.35 L
    E) 1.05 L

28. What is the stoichiometric coefficient for O_2 in the balanced equation for the combustion of pentane? Use the smallest set of integer coefficients.
    A) 3
    B) 4
    C) 5
    D) 2
    E) 8

29. Which of the following is best described as an acid-base reaction?
    A) $Ca + 2\ H_2O \rightarrow Ca(OH)_2 + H_2$
    B) $2\ HgO \rightarrow 2\ Hg + O_2$
    C) $NH_3 + H_2O \rightarrow NH_4^+ + OH^-$
    D) $NaCl + AgNO_3 \rightarrow NaNO_3 + AgCl$
    E) $KCl + NH_4NO_3 \rightarrow KNO_3 + NH_4Cl$

30. How many protons are present in one potassium ion?
    A) 22
    B) 18
    C) 21
    D) 19
    E) 20

31. Maximum number of spatial orbitals possible in 4f is _____ .
    A) 10
    B) 5
    C) 7
    D) 14
    E) 32

32. Depict the electron configuration for silicon using rare gas notation.
    A) (Ne) $3p^2$
    B) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$
    C) (Ne) $3s^2\ 3p^4$
    D) (Ne) $3s^2\ 3p^2$
    E) (Ne) $3s^2\ 3p^3$

33. Which of the following has nonpolar bonds?
    A) H_2S
    B) HCl
    C) all are nonpolar
    D) OF_2
    E) Br_2

34. The primary interactions responsible for the unusual properties of water are
    A) none of these
    B) ionic bonding
    C) London forces
    D) metallic forces
    E) hydrogen bonding

35. Carbon monoxide reacts with oxygen to form carbon dioxide by the following reaction:
$2\ CO(g) + O_2(g) \rightarrow 2\ CO_2(g)$
ΔH for this reaction is –135.28 kcal/mol. How much heat would be released if 12.0 moles of carbon monoxide reacted with sufficient oxygen to produce carbon dioxide?
A) 811 kcal
B) 405 kcal
C) 270 kcal
D) 1623 kcal
E) Cannot answer without knowing the temperature.

36. A catalyst
A) does not enter into a reaction in any way.
B) increases the fraction of the molecules that collide with enough energy to react
C) increases the activation energy of the reaction.
D) provides energy to help the reactants achieve the required activation energy.
E) provides a different mechanism by which the reaction can occur.

37. Which solution has the highest concentration of hydroxide ion?
A) 2.0×10^{-2} moles of ammonia in 0.25 L of solution
B) 5.0×10^{-3} moles of hydrochloric acid in 500 ml solution
C) 0.18 grams of calcium hydroxide in 0.25 L of solution
D) 5.0×10^{-3} moles sulfuric acid in 0.5 L of solution
E) pure water

38. A Lewis acid is a substance which _____ in a reaction.
A) accepts hydrogen ions
B) donates electrons
C) donates hydrogen ions
D) accepts electron pairs
E) donates protons

39. The oxidation number of the Fe in FeO is _____.
A) +3
B) +2
C) –3
D) +1
E) –2

40. When a radioactive atom emits an α particle, its mass number
A) decreases by two
B) increases by two
C) decreases by four
D) increases by four
E) doesn't change

Physics Questions (41 – 60)

41. This UT theoretical physicist was a member of two departments at UT and was awarded numerous prizes including the Nobel Prize and was given the title of Viscount. His/her research was predominantly on non-equilibrium thermodynamics, dissipative systems and the nature of time. He/she was the director of the International Solvay Institute.
A) Bryce DeWitt
B) Cécile DeWitt-Morette
C) Ilya Prigogine
D) E.C.G. Sudarshan
E) Steven Weinberg

42. Which of the following is/are true about a process in a dissipative system?
I. The process is irreversible.
II. The mechanical energy is NOT conserved.
III. The total energy is NOT conserved.
A) I
B) II
C) III
D) I & II
E) I, II & III

43. For a macroscopic system which of the following law(s) of thermodynamics determines what we perceive as the direction of time?
    A) the zeroth law
    B) the first law
    C) the second law
    D) the third law
    E) all of the above

44. Which of the following is NOT a base unit in the International System of units (SI)?
    A) candela
    B) coulomb
    C) kelvin
    D) kilogram
    E) mole

45. How many significant digits are there in the following value: 25000?
    A) 2
    B) 3
    C) 4
    D) 5
    E) Indeterminate (can't tell)

46. In the humorous FFF system of units the base units of length, mass and time are the furlong, firkin and fortnight. What is the density of gold, $\rho = 19.3 \times 10^3$ kg/m^3, in this unusual system of units? Given that 1 furlong = 201.17 m, 1 firkin = 40.8233 kg and 1 fortnight = 1.2096×10^6 s.
    A) 9.68×10^{-2} firkin/furlong^3
    B) 2.35×10^{0} firkin/furlong^3
    C) 9.51×10^{4} firkin/furlong^3
    D) 3.85×10^{9} firkin/furlong^3
    E) 6.41×10^{12} firkin/furlong^3

47. A woman and her dog are out for a morning run to the river, which is located 4.0 km away. The woman runs at 2.5 m/s in a straight line. The dog is unleashed and runs back and forth at 4.5 m/s between his owner and the river, until she reaches the river. What is the total distance run by the dog?
    A) 2.8 km
    B) 4.5 km
    C) 7.2 km
    D) 8.1 km
    E) Not enough information.

48. A ball is dropped from rest from the top of a cliff that is 24 m high. From ground level, a second ball is thrown straight upward at the same instant the first ball is dropped. The initial speed of the second ball is the same as that with which the first ball eventually hits the ground. In the absence of air resistance, the motions of the balls are just the reverse of each other. Determine how far below the top of the cliff the balls cross paths.
    A) 2.3 m
    B) 6.0 m
    C) 12 m
    D) 18 m
    E) 22 m

49. A jogger travels a route that has two legs. The first leg is a displacement **A** of 2.50 km due south, and the second leg involves a displacement **B** that points due east. The vector difference **A** − **B** has a magnitude of 3.75 km. What is the magnitude of **B**, and what is the direction of **A** − **B** relative to due south?
    A) 2.80 km at 41.8° E of S
    B) 2.80 km at 48.2° E of S
    C) 2.80 km at 48.2° W of S
    D) 4.51 km at 41.8° E of S
    E) 4.51 km at 48.2° W of S

50. A plane is headed due south with a speed of 47.8 m/s with respect to still air. Then for 9.00×10^2 s a wind blows the plane so that it moves at 45.0° west of south, while the plane still continues to point due south. In this time the plane travels 81.0 km with respect to the ground. What is the magnitude and direction relative to due south of the velocity of the wind with respect to the ground?

A) 61.6 m/s at 14.0° W of S
B) 61.6 m/s at 76.0° W of S
C) 63.6 m/s at 90.0° W of S
D) 65.6 m/s at 14.0° W of S
E) 65.6 m/s at 76.0° W of S

51. You are holding an 88.9 N block against a vertical wall. The force that you apply to the block is at an angle of 40.0° with respect to the vertical. The coefficient of static friction between the block and the vertical wall is 0.560. What is the minimum magnitude of your applied force required to prevent the block from sliding down the wall?

A) 79.0 N
B) 82.9 N
C) 219 N
D) 415 N
E) 2150 N

52. A hovering helicopter of mass m_h is lowering a truck of mass m_t. If the truck's downward speed is increasing at a rate of 0.1g, then what is the tension in the supporting cable? You may neglect air resistance.

A) $1.1m_tg$
B) m_tg
C) $0.9m_tg$
D) $1.1(m_h + m_t)g$
E) $0.9(m_h + m_t)g$

53. A car goes from rest to 30 mph while traveling in a semi-circular arc of fixed radius. As described by a stationary observer on the ground, which of the following accelerations does the car experience?

I. A centripetal acceleration
II. A centrifugal acceleration
III. A tangential acceleration
IV. An angular acceleration

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

54. The motor of a ski boat generates an average power of 7.50×10^4 W when the boat is moving at a constant speed of 12.0 m/s. When the boat is pulling a skier at 12.0 m/s, the engine must generate an average power of 8.30×10^4 W. What is the tension in the towrope that is pulling the skier?

A) 0 N
B) 667 N
C) 6250 N
D) 6920 N
E) 13200 N

55. A 58 g tennis ball is released from rest at a height of 1.3 m above the floor. After striking the floor it rebounds to a height of 0.75 m above the floor. If the ball is in contact with the floor for 0.15 s then what is the magnitude of the average force exerted upon the ball by the floor?

A) 0.47 N
B) 1.0 N
C) 2.9 N
D) 3.4 N
E) 4.0 N

56. A thin uniform rod is initially positioned in the vertical direction, with its lower end attached to a frictionless axis that is mounted on the floor. The rod has a length of 2.00 m and is allowed to fall, starting from rest. Find the tangential speed of the free end of the rod, just before the rod hits the floor after rotating through 90.0°.
    A) 3.83 m/s
    B) 6.26 m/s
    C) 7.67 m/s
    D) 10.8 m/s
    E) 15.3 m/s

57. If a silver dollar acquires a net charge of −3.6 μC then what is the change in mass of the silver dollar due to the charging process and did the mass of the silver dollar increase or decrease?
    A) 2.0×10^{-17} kg increase
    B) 2.0×10^{-17} kg decrease
    C) 1.6×10^{-6} kg increase
    D) 1.6×10^{-6} kg decrease
    E) The mass does not change.

58. A spherical surface of radius 5.0 cm completely surrounds two charges $q_1 = +3.5$ μC and $q_2 = -2.3$ μC. What is the electrical flux through the surface of the sphere?
    A) 7.1×10^{1} N•m^2/C
    B) 4.2×10^{3} N•m^2/C
    C) 1.4×10^{5} N•m^2/C
    D) 4.3×10^{6} N•m^2/C
    E) 2.6×10^{8} N•m^2/C

59. Charges q_1=q and q_2=q are fixed in place, q_2 being located at a distance d to the right of q_1. A third charge q_3 is then fixed to the line joining q_1 and q_2 at a distance d to the right of q_2. The third charge is chosen so that the potential energy of the group is zero; that is the potential energy has the same value as that of the three charges when they are widely separated. Determine q_3 and express your answer in terms of q.
    A) −(2/3) q
    B) −(1/2) q
    C) +(1/2) q
    D) +(2/3) q
    E) There is no choice for q_3 that will make the potential energy of the group zero.

60. An airplane with a metal exterior is flying due east. The Earth's magnetic field has a downward vertical component and a horizontal component due north. Which point on the plane's exterior accumulates positive charge due to the motional emf?
    A) the nose (the point farthest east)
    B) the tail (the point farthest west)
    C) the tip of the left wing (the point farthest north)
    D) the tip of the right wing (the point farthest south)
    E) none of the above since it is an equipotential surface

UIL HIGH SCHOOL SCIENCE CONTEST
ANSWER KEY

INVITATIONAL B • 2009

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

41. (C) Ilya Prigogine was a member of both the Physics and Chemical Engineering Departments and was awarded the 1977 Noble Prize in Chemistry for his contributions to non-equilibrium thermodynamics, particularly the theory of dissipative structures.

42. (D) In a dissipative system, i.e., one with kinetic friction, air resistance, etc., any process is irreversible and the mechanical energy is not conserved. Total energy is always conserved.

43. (C) The second law of thermodynamics is used to determine that the following process will NOT naturally occur: a warmer than the ambient temperature box placed on a similarly warm surface will cool as it moves across the surface gaining speed.

44. (B) The coulomb is not a base SI unit, it is defined in terms of the ampere the base unit for electrical current.

45. (E) You can't tell if the ending zeros before the decimal just hold place or if they are significant, in order to tell this number should be written in scientific notation.

46. (D) 19.3×10^3 kg/m^3 × (1 firkin/40.8233 kg) × (201.17 m/1 furlong)^3 = 3.85×10^9 firkin/furlong^3

47. (C) t = 4,000/2.5 = 1600 s ⇒ d = 4.5(1600) = 7.2 km

48. (B) $v = (2gh)^{1/2} = 21.7$ m/s ⇒ $y_{cliff} = y_{ground}$ ⇒ $24 + 0 - 4.9t^2 = 0 + 21.7t - 4.9t^2$ ⇒ t = 1.11 s ⇒ y = 17.96 m above the ground therefore they meet at 6.0 m below the top of the cliff.

49. (C) $B = (3.75^2 - 2.50^2)^{1/2} = 2.80$ km & $\theta = \cos^{-1}(2.50/3.75) = 48.2°$ W of S

50. (E) ground speed: v = 81,000/900 = 90 m/s, S & W components = 63.64 m/s ⇒ wind speed components: 63.64 m/s W & (63.64 – 47.8) = 15.84 m/s S ⇒ $(63.64^2 + 15.84^2)^{1/2} = 65.6$ m/s at $\tan^{-1}(63.64/15.84) = 76.0°$ W of S

51. (A) From the free-body diagram (note: the static friction force will point up the wall) $F_N = F_A \sin 40°$ & $F_{frs} = 88.9\text{N} - F_A \cos 40° \Rightarrow F_{frs} = \mu_s F_N \Rightarrow F_A = 88.9/(\cos 40° + \mu_s \sin 40°) = 79.0\text{N}$

52. (C) From Newton's 2nd law for the system: $F_T - m_t g = m_t (-a) = m_t (-0.1g) \Rightarrow F_T = 0.9\, m_t g$

53. (D) Since the car is speeding up as it goes around the turn, then this implies it has both a tangential acceleration and an angular acceleration in addition to the centripetal acceleration as measured by the observer.

54. (B) $F = P/v \Rightarrow F_{boat} = 75{,}000/12 = 6250\text{N}$ & $F_{boat+skier} = 83{,}000/12 = 6917\text{N} \Rightarrow F_{skier} = 6917 - 6250 = 667\text{N}$

55. (E) $v_0 = (2 \cdot 9.80 \cdot 1.3)^{1/2} = 5.05$ m/s & $v = (2 \cdot 9.80 \cdot 0.75)^{1/2} = 3.83$ m/s ⇒ $\Delta p = (0.058) \cdot (+3.83) - (0.058) \cdot (-5.05) = 0.515$ kg•m/s ⇒ $(\Sigma F)_{avg} = 0.515/0.15 = 3.43$ N & from the free-body diagram: $(F_N)_{avg} = (\Sigma F)_{avg} + F_G = 3.43 + 0.568 = 4.0$ N

56. (C) From conservation of mechanical energy: $0 + 0 + mgh = 0 + \frac{1}{2} I\omega^2 + 0$, with h = L/2 & $I = (1/3)mL^2 \Rightarrow \omega = (3g/L)^{1/2} = 3.83$ rad/s and with $v = r\omega = 2(3.83) = 7.67$ m/s

57. (A) $\Delta\text{mass} = (\#\ e^-)(e^-\ \text{mass}) = (2.4\times10^{-6}/1.6\times10^{-19})\ 9.11\times10^{-31} = 2.0\times10^{-17}$ kg, since the electrons were added to the dollar then the mass of the dollar will increase

58. (C) $\Phi_E = Q_{enclosed}/\varepsilon_0 = (+3.5\times10^{-6} - 2.3\times10^{-6})/8.85\times10^{-12} = 1.4\times10^5\ \text{N}\cdot\text{m}^2/\text{C}$

59. (A) $U_E = k(q_1q_2)/d + k(q_1q_3)/(2d) + k(q_2q_3)/d = 0 \Rightarrow q^2 + \frac{1}{2} qq_3 + qq_3 = 0 \Rightarrow q_3 = -(2/3)q$

60. (C) The "free" charges in the conductive metal shell of the exterior of the plane will feel a force as they move through the Earth's magnetic field according to the right hand rule. The north component of the magnetic field causes the positive charges to move to the top surface of the plane, while the downward component of the magnetic field causes the positive charges to move north to the left wing.