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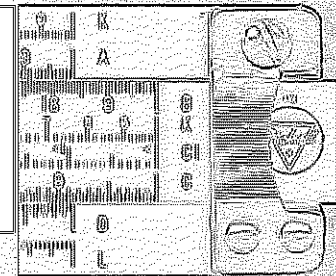
2008 UIL Science "B" Test
(11 pages)

UIL
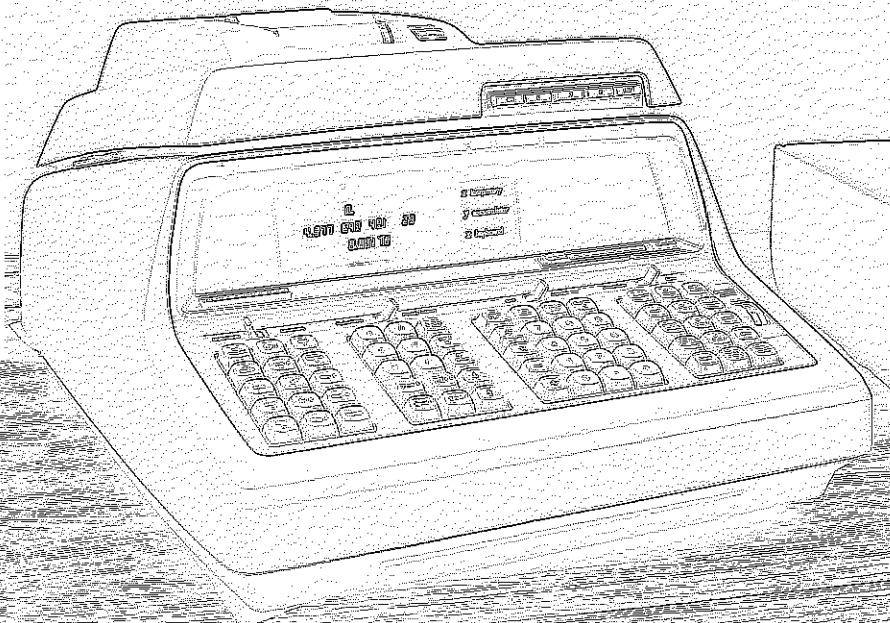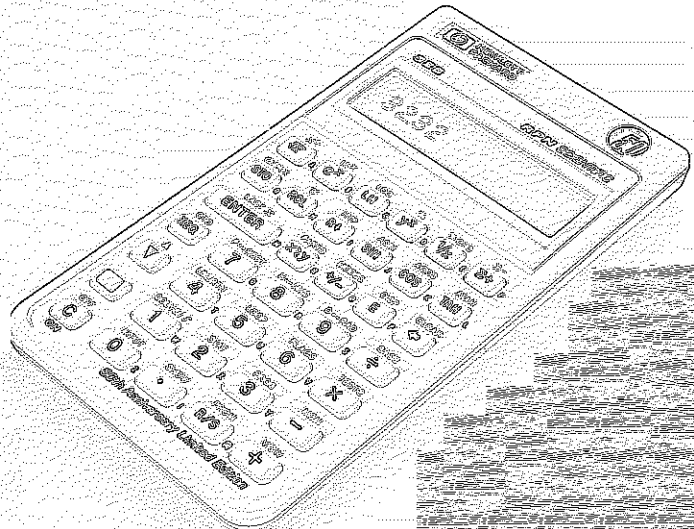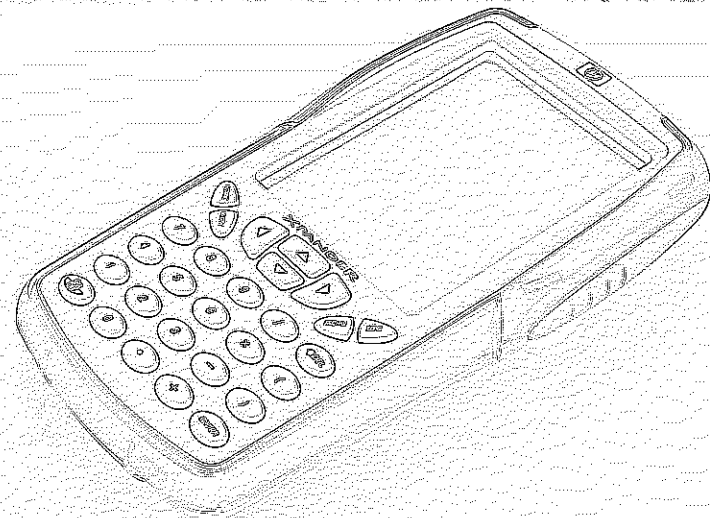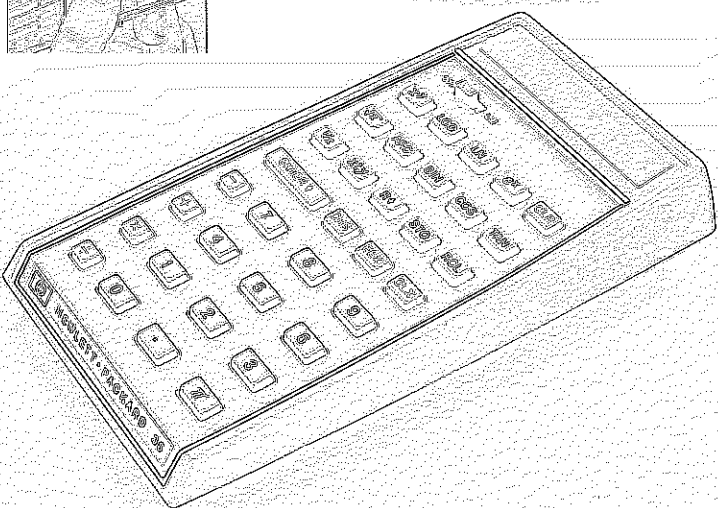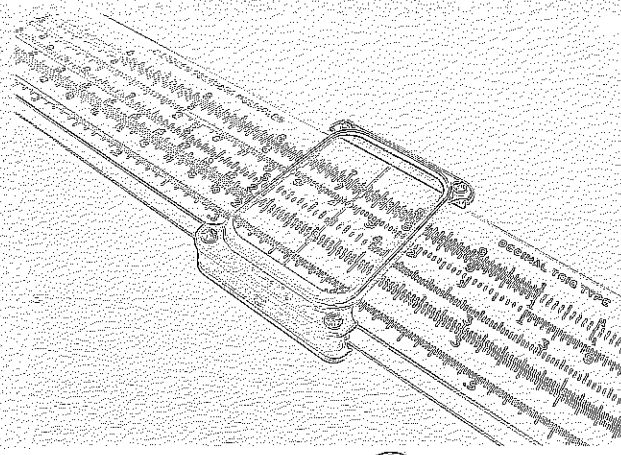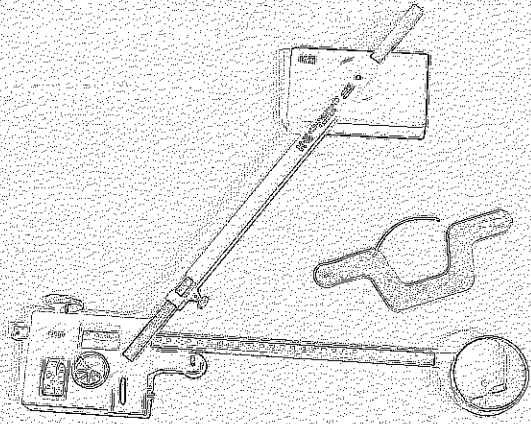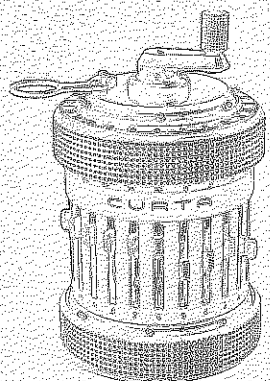
SCIENCE
Invitational B • 2008

GENERAL DIRECTIONS:

- DO NOT OPEN EXAM UNTIL TOLD TO DO SO.

- Ninety minutes should be ample time to complete this contest, but since it is not a race, contestants may take up to two hours. If you are in the process of actually writing an answer when the signal to stop is given, you may finish writing that answer.

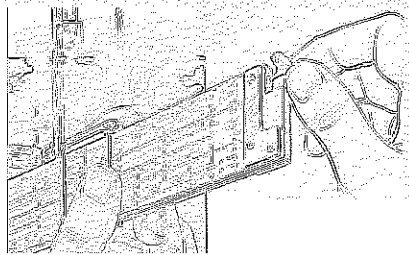- Papers may not be turned in until 30 minutes have elapsed. If you finish the test in less than 30 minutes, remain at your seat and retain your paper until told to do otherwise. You may use this time to check your answers.

- All answers must be written on the answer sheet provided. Indicate your answers in the appropriate blanks provided on the answer sheet.

- You may place as many notations as you desire anywhere on the test paper except on the answer sheet, which is reserved for answers only.

- You may use additional scratch paper provided by the contest director.

- All questions have ONE and only ONE correct (BEST) answer. There is a penalty for all incorrect answers.

- If a question is omitted, no points are given or subtracted.

- On the back of this page is printed a copy of the periodic table of the elements. You may wish to refer to this table in answering the questions, and if needed, you may use the atomic weights and atomic numbers from the table. Other scientific relationships are listed also.

- Silent hand-held calculators that do not need external wall plugs may be used. Graphing calculators that do not have built-in or stored functionality that provides additional scientific information are allowed. Small hand-held computers are not permitted. Calculators that accept memory cards or memory sticks are not permitted. Each contestant may bring one spare calculator. All memory must be cleared.

- Answers within 5% of the exact answer will be considered correct.

SCORING:

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

UNIVERSITY INTERSCHOLASTIC LEAGUE
Making a World of Difference

Biology Questions (1 – 20)

1. The breakdown of large molecules by the enzymatic addition of water is an example of a(n) _____ reaction.
   A) oxidation
   B) reduction
   C) condensation
   D) hydrolysis
   E) decarboxylation

2. Fluid-filled sacs that can store food, ions, or water in cells are _____.
   A) plastids
   B) vacuoles
   C) microvilli
   D) nucleoli
   E) Golgi bodies

3. The end-product of glycolysis is _____.
   A) acetyl-CoA
   B) oxaloacetate
   C) pyruvate
   D) citrate
   E) glucose

4. Meiosis usually results in the production of _____.
   A) two diploid cells
   B) four diploid cells
   C) two haploid cells
   D) four haploid cells
   E) eight haploid cells

5. According to Mendel, which of the following traits seem to disappear in the F1 generation?
   A) sex-linked
   B) dominant
   C) recessive
   D) codominant
   E) lethal

6. Which of the following could NOT be part of a molecule of RNA?
   A) AUGCGU
   B) ATGCGT
   C) UACGCA
   D) UAGCGU
   E) GCGUUU

7. When nutrients become scarce, some bacteria _____.
   A) form endospores
   B) engage in conjugation
   C) become pathogenic
   D) carry out photosynthesis
   E) lose their cell wall

8. Which of the following is true of fungi?
   A) Food is digested within vacuoles.
   B) Food is digested outside the body.
   C) Food is digested intracellularly.
   D) Food is digested within mitochondria.
   E) They take in nutrients that have been digested by other organisms.

9. Mosses are _____.
   A) algae
   B) bryophytes
   C) vascular plants
   D) gymnosperms
   E) seed plants

10. Air and water vapor cross the plant epidermis via _____.
    A) pits
    B) perforations
    C) osmosis
    D) stomata
    E) tracheids

11. Nodules found on the roots of leguminous plants are involved in supplying which element for a plant?
    A) nitrogen
    B) boron
    C) phosphorus
    D) magnesium
    E) sulfur

12. Which of the following is the female reproductive part of a flower?
    A) carpel
    B) sepal
    C) petal
    D) stamen
    E) receptacle

13. In humans and other animals, which germ layer produces the muscles and skeleton?
    A) ectoderm
    B) endoderm
    C) gastroderm
    D) mesoderm
    E) all of the germ layers

14. Which vitamin(s) is/are fat-soluble and can be stored in the body?
    A) vitamin A
    B) all of the B vitamins
    C) vitamin C
    D) vitamin B_1
    E) vitamin B_2

15. How long does a red blood cell typically live?
    A) 4 days
    B) 3 months
    C) 1 year
    D) 5 years
    E) all of a person's life

16. Which of the following is a junction between two neurons?
    A) Schwann cell
    B) node of Ranvier
    C) chemical synapse
    D) sodium gate
    E) myelin sheath

17. Which of the following is the proper sequence in the flow of air in mammals?
    A) nasal cavities, larynx, pharynx, bronchi, trachea
    B) nasal cavities, pharynx, bronchi, larynx, trachea
    C) nasal cavities, pharynx, larynx, trachea, bronchi
    D) nasal cavities, larynx, pharynx, trachea, bronchi
    E) nasal cavities, bronchi, larynx, trachea, pharynx

18. White blood cells are derived from stem cells in the ____.
    A) spleen
    B) thymus
    C) bone marrow
    D) blood
    E) liver

19. The most primitive living primate is the ____.
    A) Old World monkey
    B) lemur
    C) tree shrew
    D) tarsier
    E) New World monkey

20. The leading cause of human deaths is ____.
    A) heart disease
    B) malnutrition and starvation
    C) cancer
    D) war
    E) accidents

Chemistry Questions (21 – 40)

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

22. If 8000 calories of heat are added to 200 g of water at 20°C, what is the final temperature of the water? The heat capacity of water is 18 calories/(K-mole).
    A) 60°C
    B) 20°C
    C) 80°C
    D) 40°C
    E) 50°C

23. Which of the following lists gives the symbols for the elements: phosphorus, potassium, silver, chlorine, and sulfur, in that order?
    A) Ph, Po, Ag, Al, S
    B) K, Ag, Po, Cl, S
    C) P, K, Ag, Cl, S
    D) Ph, K, Ag, S, Cl
    E) P, Po, Ag, Cl, S

24. On a weight basis, a compound is 40.0% carbon, 53.3% oxygen and the rest is hydrogen. What is the empirical formula for this compound?

    A) CH_2O
    B) C_3H_4O
    C) $C_2H_4O_3$
    D) $C_3H_4H_4$
    E) $C_2H_6O_3$

25. Select the appropriate coefficient for O_2 when the equation is balanced using the smallest set of integers.

    ? O_2 (g) + ? C_5H_{12}(g) → ? CO_2 (g) + ? H_2O(g)

    A) 5
    B) 4
    C) 3
    D) 2
    E) 8

26. Complete and balance the equation for the precipitation reaction: $FeCl_3$(aq) + KOH(aq) →

    A) $FeCl_3$(aq) + 3 KOH(aq) →
    $FeK(OH)_3Cl$(s)
    B) $FeCl_3$(aq) + 3 KOH(aq) →
    $Fe(OH)_3$(aq) + KCl(s)
    C) $FeCl_3$(aq) + 3 KOH(aq) →
    $Fe(OH)_3$(s) + KCl(s)
    D) $FeCl_3$(aq) + 3 KOH(aq) →
    $Fe(OH)_3$(s) + KCl(aq)
    E) $FeCl_3$(aq) + 3 KOH(aq) →
    $Fe(OH)_3$(aq) + KCl(aq)

27. How many neutrons are there in one atom of $_{22}^{48}Ti$?

    A) 48
    B) 70
    C) 26
    D) 22
    E) none of these

28. In the normal order of occupancy of electron energy levels, the level occupied just after 4d is completely filled is _____ .

    A) 4f
    B) 5s
    C) 5p
    D) 4p
    E) 5d

29. 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) phosphorus
    B) cobalt
    C) vanadium
    D) Cannot be answered without more information.
    E) argon

30. Which of the following molecules contains both ionic and covalent bonding?

    A) N_2O_5
    B) H_2O_2
    C) CO_2
    D) RbCl
    E) KNO_3

31. Given that the distance between bases on a baseball diamond a perfect square) is 90. feet. Suppose the catcher can throw the baseball 85. miles per hour. If a runner on first base leaves first base just as the catcher throws the ball, how fast must the runner run to just beat the throw to second base by the catcher?

    A) 20 mph
    B) 40 mph
    C) 60 mph
    D) 80 mph
    E) 100 mph

32. The heat of fusion of a metal is 7.851 joules/gram at its freezing point of 432.7°F. How many grams of this metal can be melted by 5768. joules of energy?

    A) 514.
    B) 735.
    C) 1616.
    D) 1028.
    E) 294.

33. What pressure would a mixture of 3.2 grams of O_2, 6.4 grams of CH_4, and 6.4 grams of SO_2 exert if the gases were placed in a 3.69 liter container at 127°C?

    A) 7.5 atm
    B) 2.1 atm
    C) 5.3 atm
    D) 9.6 atm
    E) 3.7 atm

34. How many moles of chlorine nuclei are present in 7.79×10^{22} molecules of carbon tetrachloride?
    A) 1.14
    B) 0.932
    C) 0.725
    D) 0.518
    E) 0.362

35. How many moles of lithium phosphate are there in 72.4 grams of this substance?
    A) 0.250 mol
    B) 1.13 mol
    C) 0.875 mol
    D) 0.625 mol
    E) 1.38 mol

36. For the reaction
    $? \, Fe + ? \, H_2O \rightarrow ? \, Fe_3O_4 + ? \, H_2$,
    a maximum of ____ grams of Fe_3O_4 could be formed from 3.105 grams of Fe and 2.700 grams of H_2O.
    A) 7.7 gram
    B) 9.4 gram
    C) 6.0 gram
    D) 4.3 gram
    E) 3.1 gram

37. What is the molarity of Na^+ in a solution that has 0.0749 grams of NaCl dissolved in 8.70 liters of solution ?
    A) 0.00006 M
    B) 0.00010 M
    C) 0.00021 M
    D) 0.00027 M
    E) 0.00015 M

38. The freezing point depression constant of water is $-1.86°C/m$. What is the expected freezing point of a 0.455 molal aqueous solution of KBr?
    A) $-3.72°C$
    B) $-2.37°C$
    C) $-3.04°C$
    D) $-0.68°C$
    E) $-1.69°C$

39. Suppose you add 1.417×10^{-3} moles of NaOH to enough water to make 7330 milliliters of solution. What is the pH of the solution?
    A) 18.5
    B) 4.1
    C) 7.3
    D) 10.3
    E) 22.6

40. ^{239}Pu has a half-life of 2.4×10^4 years. If we have 32.0 g of ^{239}Pu now, how many grams will be left after 81600 years?
    A) 1.2 grams
    B) 6.6 grams
   C) 5.4 grams
    D) 3.0 grams
    E) 4.2 grams

Physics Questions (41 – 60)

41. In a particular carnival game the object is to pass a ball through a hole in a vertical wall, which can only be done if the ball's velocity is purely horizontal when it reaches the wall. If the player stands directly in front of the hole and the ball when released is 1.75 m away from the wall and is 0.750 m below the hole, with what speed does it pass through the hole?
    A) 1.25 m/s
    B) 1.92 m/s
    C) 2.24 m/s
    D) 4.47 m/s
    E) 11.4 m/s

42. Iodine-131 is a radioactive isotope of iodine that is used in various medical diagnostic procedures. If the half-life of Iodine-131 is 8.04 days then how long will it take for only 10.0 % of the initial dose to remain in the patient?
    A) 53.9 minutes
    B) 2.68 days
    C) 8.04 days
    D) 26.7 days
    E) This problem can't be solved with the given data.

43. At a point in space there is a magnetic field vector due to a first magnet that has a magnitude of 32.7 mT which points at 66.8° east of south and a second magnetic field vector due to another magnet that has a magnitude of 25.3 mT which points at 12.4° north of west. What is the magnitude and direction of the net magnetic field at this point?

    A) 9.17 mT at 35.7° east of south
    B) 9.17 mT at 54.3° east of south
    C) 27.3 mT at 25.7° west of south
    D) 27.3 mT at 64.3° west of south
    E) 41.3 mT at 54.3° east of south

44. Who formulated a matrix version of the quantum theory that was determined to be equivalent to the accepted wave formulation?

    A) Dirac
    B) Bohm
    C) Heisenberg
    D) de Broglie
    E) Pauli

45. If you double the amplitude of a sinusoidal wave then by what factor does the intensity of the wave change?

    A) 1/4
    B) 1/2
    C) 1
    D) 2
    E) 4

46. Taking the accepted Earth-Moon distance as 3.85×10^5 km, estimate the time delay for a radio signal sent to astronauts on the Moon.

    A) There is no time delay.
    B) 1.28 ms
    C) 128 ms
    D) 1.28 s
    E) 128 s

47. Three equal 10.0 kg masses are placed at the corners of an equilateral triangle with side length 5.00 cm. Only considering the gravitational interactions between the masses themselves, what is the magnitude of the net gravitational force acting on one of the masses due to the other two? Given that $G = 6.67 \times 10^{-11}$ Nm^2/kg^2.

    A) 2.57×10^{-7} N
    B) 4.62×10^{-6} N
    C) 5.34×10^{-6} N
    D) 5.15×10^{-4} N
    E) 1.41×10^{-3} N

48. A vertical spring with spring constant 208 N/m is used to launch a 1.25 kg projectile into the air. If the projectile has a velocity of 10.5 m/s at the equilibrium position of the spring when it separates from the spring, then by how much was the spring originally compressed? Neglect both friction and air resistance for this problem.

    A) 59.3 cm
    B) 65.1 cm
    C) 75.7 cm
    D) 81.4 cm
    E) 87.5 cm

49. In the Compton effect an incident photon is scattered off of a stationary electron, which of the following statements are true?

    A) The wavelength of the scattered photon is greater than the wavelength of the incident photon.
    B) The frequency of the scattered photon is greater than the frequency of the incident photon.
    C) The electron loses energy in the process.
    D) Momentum is conserved, but energy is not conserved.
    E) Energy is conserved, but momentum is not conserved.

50. A speaker radiates as an idealized point source of sound. When an observer is located 2.25 m away from the speaker the intensity level is 87.4 dB. What is the intensity level when the observer has moved to 225 m away from the speaker? Note: You may neglect reflections and absorption due to the intervening air.
    A) 0.00874 dB
    B) 0.0874 dB
    C) 47.4 dB
    D) 67.4 dB
    E) This problem can't be solved with the given data.

51. How many significant digits should be correctly reported in the solution to the following calculation?

    $$(14.2150/2.2744)^{1/2}$$

    A) 2
    B) 3
    C) 4
    D) 5
    E) 6

52. A 75.0 cm long steel wire that is 0.680 mm in diameter is tensioned to 18.0 N. If the elastic modulus of steel is 200 GPa then by how much did the string stretch when tensioned?
    A) 0.0632 μm
    B) 0.126 μm
    C) 46.5 μm
    D) 93.0 μm
    E) 186 μm

53. For a car traveling on a banked curve at a constant speed, what is the direction of the force of static friction between the tires and the surface of the banked curve?
    A) Down the incline.
    B) Up the incline.
    C) Opposite the direction of motion.
    D) No static friction force will be required.
    E) Can't tell from the information given.

54. A 1200 W water pump is 33.33% efficient. If turbulence and viscosity are neglected, what is the mass of water that can be pumped to a height of 6.45 m by this pump in 1.00 minute?
    A) 6.33 kg
    B) 380 kg
    C) 633 kg
    D) 3420 kg
    E) 3720 kg

55. The continuity equation in classical fluid dynamics is an expression of
    A) conservation of mass.
    B) conservation of energy.
    C) conservation of linear momentum.
    D) conservation of angular momentum.
    E) conservation of lepton number.

56. Two boxes, with masses 12.5 kg and 25.5 kg, are connected by a taut string on a surface that is inclined at 25° with respect to the horizontal. If the coefficients of kinetic friction between the boxes and the table are 0.100 and 0.150 respectively and the 25.5 kg box is placed below the 12.5 kg box on the incline, what is the magnitude of the acceleration of the 12.5 kg box just after they have begun to move down the incline?
    A) 2.81 m/s^2
    B) 2.96 m/s^2
    C) 3.25 m/s^2
    D) 4.14 m/s^2
    E) 8.33 m/s^2

57. Two bars are separated by a 1.55 mm gap when the temperature is 25.0°C. The ends of each bar opposite the gap are fixed in position. At 25.0°C the bar on the left is 24.8 cm long and is made of aluminum and the bar on the right is 15.8 cm long and is made of brass. Given that the coefficients of linear thermal expansion of brass and aluminum are $19.0 \times 10^{-6}\,(C°)^{-1}$ and $25.0 \times 10^{-6}\,(C°)^{-1}$ respectively, at what temperature will the gap between the bars close?
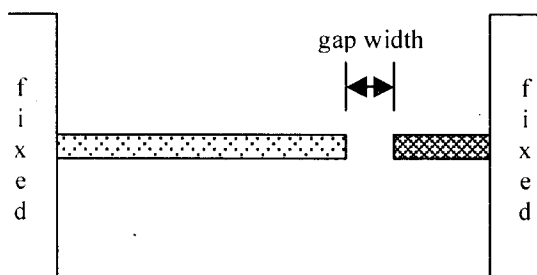
A) 26.7°C
B) 193°C
C) 205°C
D) 1710°C
E) 1820°C

58. A ball comes to rest in 1.45 minutes as it rolls a distance of 3.89 m without slipping in a straight line. If the acceleration was uniform and the radius of the ball is 12.0 cm then what was the initial angular speed of the ball?

A) 0.248 rad/s
B) 0.375 rad/s
C) 0.447 rad/s
D) 0.745 rad/s
E) 44.7 rad/s

59. A child while riding in the gondola of a hot air balloon that is rising upward at a constant speed of 8.25 m/s tosses a ball upward at an initial speed of 5.50 m/s *relative to the balloon* off of the side of the gondola. If the child threw the ball when he was 25.0 m above the ground below and neglecting air resistance, how long will it take the ball to hit the ground after it was thrown?

A) 1.77 s
B) 2.00 s
C) 2.56 s
D) 2.89 s
E) 4.06 s

60. For a non-relativistic inelastic collision, which of the following conservation principles apply:

   I. Conservation of Kinetic Energy

   II. Conservation of Linear Momentum

   III. Conservation of Angular Momentum

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

UIL HIGH SCHOOL SCIENCE CONTEST
ANSWER KEY

INVITATIONAL B • 2008

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

41. (D) Since the velocity is purely horizontal, it is at the top of the parabolic arc. The time to the top of the arc is given by $t = (0.75/4.9)^{1/2} = 0.391$ s, and the velocity is constant since it is the x-component, which is found to be $v_x = 1.75/.391 = 4.47$ m/s.

42. (D) For ten percent remaining we have (0.10)(initial amount) = (initial amount)$e^{-[(decay const)(time)]}$, thus solving for the time = $-\ln(0.10)/\{\ln(2)/(8.04)\} = 26.7$ days.

43. (A) By components: $\sum B_x = +32.7 \sin(66.8°) -25.3 \cos(12.4°) = +5.35$ and
$\sum B_y = -32.7 \cos(66.8°)+25.3 \sin(12.4°) = -7.45$ thus the magnitude is $[(5.35)^2+(-7.45)^2]^{1/2} = 9.17$ mT
and the angle is $\tan^{-1}(5.35/-7.45) = 35.7°$ east of south.

44. (C) Heisenberg's matrix formulation of quantum mechanics has been shown to be an equivalent description to the Schrödinger wave formulation of quantum mechanics.

45. (E) The intensity of a wave goes as the amplitude squared.

46. (D) The time for the signal is $(3.85×10^8)/(3.00×10^8) = 1.28$ s.

47. (B) The force along the sides is $2.67 ×10^{-6}$ N. Thus the magnitude of the net force is
$\{[2.67 ×10^{-6} \sin(60°)]^2 + [2.67 * 10^{-6} + 2.67 ×10^{-6} \cos(60°)]^2\}^{1/2} = 4.62 ×10^{-6}$ N.

48. (E) By conservation of mechanical energy you get: $\frac{1}{2}(1.25)(10.5)^2 = (1.25)(9.8)(-x) + \frac{1}{2}(208)x^2$, which
solves as $x = 0.875m = 87.5$ cm

49. (A) The scattered photon transfers energy to the electron, thus its frequency increases and its wavelength decreases and in the process both momentum and energy are conserved.

50. (C) The intensity goes as one over the distance from the source squared, so $I_1 = I_o 10^{8.74}$ then
$I_2 = I_o (2.25/225)^2 10^{8.74}$ and thus $\beta_2 = 10 \log\{[I_o (2.25/225)^2 10^{8.74}]/[I_o]\} = 47.4$ dB and I_o is not
needed for the calculation.

51. (D) The least number of s⸱ ⸱icant digits in the calculation is five so there are five significant digits in
the f⸱⸱ᵒ⸱

52. (⸱) ⸱⸱⸱⸱⸱⸱⸱ ial length)(tension)]/[(modulus)(area)] =
[(⸱⸱⸱⸱⸱ ⸱ᵒ)] 34×10^{-3}}^{2}] = 186 μm.

53. (E) On a banked ⸱ ⸱⸱⸱⸱⸱ f static friction may or may not be required and the direction of the centripetal component (up or down the incline) depends upon the speed of the vehicle.

54. (B) The average power is the work per time, thus we can find the mass by
$m = [(0.3333)(1200)(60)]/[(9.8)(6.45)] = 380$ kg.

55. (A) The continuity equation depending upon the setting is either an expression of conservation of mass or charge. So in this case it must be conservation of mass.

56. (D) Since the top block accelerates faster than the bottom block then the string will go slack and they will move/accelerate independently until they contact one another. So just after they begin to move the acceleration of the bottom block is $a = 9.8 [\sin(25°) - 0.10 \cos(25°)] = 3.25$ m/s^2.

57. (B) The gap distance is equal to the sum of the expansion of both of the bars. Thus the temperature difference = (gap)/[(Al coefficient)(Al original length) + (Br coefficient)(Br original length)] or
$T = (1.55×10^{-3})/[(25×10^{-6})(.248)+(19×10^{-6})(.158)] + 25 = 193$ °C.

58. (D) The angular acceleration is $\alpha = -\omega_o/87$ and thus $32.43 = 0 + \omega_o(87) + \frac{1}{2}(-\omega_o/87)(87)^2$ which gives
$\omega_o = 2(32.43)/87 = 0.745$ rad/s.

59. (E) The velocity of the ball relative to the ground is 13.75 m/s, up. Thus, the tin⸱ is found from
$0 = (+25) + (+13.75) t + \frac{1}{2}(-9.8) t^2$, which gives $t = 4.06$ s as the solution.

60. (D) In an inelastic collision both the linear and angular momenta are cons⸱⸱⸱ ⸱n, but the
kinetic energy is not conserved. What we write down depends upon ⸱.