SCIENCE
District 2 • 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.

Biology Questions (1 – 20)

1. Which of the following are organelles composed of a system of canals, tubes, and sacs that transport molecules inside the cytoplasm?
   A) Golgi bodies
   B) ribosomes
   C) mitochondria
   D) lysosomes
   E) endoplasmic reticula

2. A concentration gradient no longer exists when _____ .
   A) all the molecules have moved from high concentration to low
   B) the membrane pores close
   C) the temperatures is low
   D) there is no net movement
   E) bulk flow intervenes

3. According to Mendel, what kind of genes seem to disappear in F_1 pea plants?
   A) sex-linked
   B) dominant
   C) recessive
   D) codominant
   E) lethal

4. Aerobic organisms use _____ as the final electron acceptor in aerobic respiration.
   A) hydrogen
   B) carbon
   C) oxygen
   D) water
   E) NAD^+

5. Eukaryotic DNA molecules have which of the following?
   A) no proteins
   B) small amounts of protein at each end of the DNA molecules
   C) large amounts of protein at each end of the DNA molecules
   D) small amounts of protein dispersed among the DNA molecules
   E) large amounts of protein dispersed among the DNA molecules

6. Paired homologous chromosomes are found at the equator of a cell during _____ .
   A) metaphase I
   B) metaphase II
   C) prophase II
   D) anaphase I
   E) anaphase II

7. All fungi _____ .
   A) are unicellular
   B) are saprobes
   C) perform extracellular digestion
   D) are parasites
   E) are autotrophic

8. Which of the following invertebrate groups lacks tissues?
   A) nematodes
   B) sponges
   C) echinoderms
   D) flatworms
   E) cnidarians

9. Which of the following is NOT true?
   A) All vertebrates have a dorsal tubular nervous system.
   B) All vertebrates have a tail at some stage in their life cycle.
   C) All vertebrates have a notochord at some stage in their life cycle.
   D) All vertebrates have pharyngeal gill slits at some stage in their life cycle.
   E) All vertebrates have jaws.

10. The veins of leaves function in _____ .
    A) support
    B) identification
    C) transport of water and nutrients
    D) detachment in the autumn
    E) photosynthesis

11. What do gametes, spores, and the gametophyte generation have in common?
    A) They are all diploid.
    B) They are all haploid.
    C) They are limited to vascular plants.
    D) They are all unicellular.
    E) They are all multicellular.

12. Which of the following is the plant hormone that promotes cell division?
    A) auxin
    B) giberellin
    C) cytokinin
    D) abscisic acid
    E) ethylene

13. Which of the following bridges the gap between a neuron sending a message and the neuron receiving it?
    A) threshold value
    B) action potential
    C) transmitter substance
    D) neurohormone
    E) All of the above

14. Vertebrate hormones _____ .
    A) are all steroids
    B) are secreted by specialized exocrine glands
    C) are controlled by positive feedback mechanisms involving the pituitary gland
    D) produce effects only in cells with appropriate receptors
    E) exert their effects only on tissues located close to the gland where they are produced

15. Smooth muscle is _____ .
    A) involuntary and nonstriated
    B) responsible for movement of the skeleton
    C) involved in contraction of the heart
    D) connected to bones by tendons
    E) responsible for release of hormones from glands

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

17. Which of the following types of blood cells is NOT phagocytic?
    A) monocytes
    B) erythrocytes
    C) neutrophils
    D) eosinophils
    E) macrophages

18. The process of cleavage most commonly produces a _____ .
    A) zygote
    B) blastula
    C) gastrula
    D) third germ layer
    E) yolk sac

19. A species is composed of _____ .
    A) related organisms
    B) a group of reproductive females
    C) organisms located in the same habitat
    D) all males and females in the same geographical range with the same ecological requirements
    E) populations that have the potential to interbreed and produce fertile offspring

20. 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

Chemistry Questions (21 – 40)

21. List the oxidation numbers for each atom in the compound $NaBiO_3$.
    A) +2, +3, –2
    B) +1, +3, –1
    C) +1, +5, –6
    D) +1, +5, –2
    E) –1, +2, +2

22. The number of valence electrons in the lowest energy state of an antimony atom is ____ .
    A) 1
    B) 4
    C) 2
    D) 8
    E) 3

23. What is the frequency of photons with wavelength = 6580 A ?
    A) 4.6×10^{15} /s
    B) 8.0×10^{14} /s
    C) 3.0×10^{14} /s
    D) 4.6×10^{14} /s
    E) 8.7×10^{14} /s

24. The number of spatial orbitals with the quantum numbers n=6, l=2 and $m_l = -1$ is _____.
    A) 3
    B) 1
    C) 9
    D) 5
    E) 7

25. The Lanthanide series consists of elements filling what orbitals?
    A) g
    B) d
    C) p
    D) s
    E) f

26. The alkali metals have a low first and a high second ionization potential. The alkaline earth metals have low values for both first and second potentials. These observations suggest that _____.
    A) alkali metals should form stable +1 ions, while alkaline earth metals should form stable +2 ions
    B) both alkali metals and alkaline earth metals should form stable ions +1 ions
    C) alkali metals should form stable +1 ions, while alkaline earth metals should form stable –2 ions
    D) alkali metals should form stable -1 ions, while alkaline earth metals should form stable –2 ions
    E) both alkali metals and alkali earth metals should form very stable ions with –1 ions

27. Which of the following formulas is most likely to be incorrect?
    A) BF_3
    B) F_2O
    C) $LiBr_2$
    D) $CaCl_2$
    E) MgO

28. Which of the following molecules has sp^3d^2 hybrid orbitals?
    A) PF_5
    B) SF_6
    C) CH_4
    D) BF_3
    E) $BeCl_2$

29. What is the conjugate acid of CN^- ?
    A) none of the other responses is correct
    B) H^+
    C) HCN
    D) HF
    E) OH^-

30. What is the heat of fusion of chromium in kcal/mol if 10.0 grams of solid chromium absorb 673 calories of heat in melting at 2173 K ?
    A) 3.50 kcal/mole
    B) 0.321 kcal/mole
    C) 11.6 kcal/mole
    D) 1.64 kcal/mole
    E) 8.20 kcal/mole

31. For a certain process at 27 C, $\Delta G = +210.6$ kJ/mol and $\Delta H = -168.2$ kJ/mol. What is the entropy change for this process at this temperature ?
    A) 628.3 J/mol K
    B) 141.3 J/mol K
    C) –1.26 kJ/mol K
    D) –141.3 J/mol K
    E) 1.26 kJ/mol K

32. Consider the chemical reaction between compounds A and B that is first order in A and first order in B. From the information below, determine the missing concentrations of A and B. Answer in the order [A] then [B].

EXPERIMENT	INITIAL RATE(M/s)	[A]	[B]
1	0.10	0.20 M	0.050 M
2	0.40	_____ M	0.050 M
3	0.80	0.40 M	_____ M

    A) 0.80 M and 0.20 M
    B) 0.40 M and 0.10 M
    C) 1.60 M and 0.40 M
    D) 0.20 M and 0.80 M
    E) 0.10 M and 0.40 M

33. What is the pH of the solution obtained by mixing 10 mL of 1.0 M HCl with 75 mL of water and 15 mL of 1.0 M NaOH?
    A) 1.7
    B) 12.7
    C) 7.0
    D) 11.3
    E) 2.0

34. Aluminum metal is formed by the electrolysis of Al_2O_3. How many grams of Al are produced when 8.80×10^3 coulombs pass through the cell?
    A) 0.41 g
    B) 1.2 g
    C) 0.82 g
    D) 2.5 g
    E) 0.27 g

35. For the reaction ? Al + ? Cl_2 → ? $AlCl_3$, a maximum of ____ grams of $AlCl_3$ could be formed from 3.342 grams of Al and 6.059 grams of Cl_2.
    A) 7.6
    B) 11.
    C) 14.
    D) 17.
    E) 5.3

36. What volume of a 0.415 molar sulfuric acid solution would be required to neutralize completely 28.0 mL of a 0.160 molar sodium hydroxide solution?
    A) 11.9 mL
    B) 9.7 mL
    C) 7.6 mL
    D) 2.2 mL
    E) 5.4 mL

37. We observe that 8.30 grams of a gaseous compound occupies 1560 mL at 26.7°C and 1108 torr. What is the molecular weight of the compound?
    A) 162 g/mol
    B) 63 g/mol
    C) 36 g/mol
    D) 90 g/mol
    E) 198 g/mol

38. 1.652 grams of NaCl and 8.223 grams of KBr were dissolved in 47.8 mL of water. What is the mole fraction of Br^- in the solution?
    A) 0.055
    B) 0.027
    C) 0.035
    D) 0.024
    E) 0.010

39. $K_c = 1.506 \times 10^{-5}$ at T = 100 C for the reaction A(g) → 2 B(g) . What is K_c for the reaction: 2 B(g) → A(g) at T = 100 C ?
    A) 119500
    B) 93000
    C) 66400
    D) 26600
    E) 46500

40. What is the pOH of a 0.138 M barium hydroxide solution?
    A) 0.26
    B) 0.56
    C) 0.76
    D) 0.96
    E) 1.26

Physics Questions (41 – 60)

41. According to Feynman there are six types of conservation laws. Which of the following is NOT one of them?
    A) conservation of baryons
    B) conservation of charge
    C) conservation of energy
    D) conservation of leptons
    E) conservation of mass

42. Why does Feynman call the law of conservation of energy "a most abstract idea"?
    A) Because energy has many different forms.
    B) Because there are no know exceptions to this law.
    C) Because it is not a description of a mechanism.
    D) Because energy comes in little blobs of a definite amount.
    E) Because it is related to the fact that "*things do not depend on the absolute time*".

43. This Texas physicist is interested in nanostructures, quantum dots, carbon nanotubes, atomic force microscopy, non-linear dynamics and chaos. He/she received his/her Ph.D. from the University of California at Berkeley.
    A) Jose Cortez
    B) David Hough
    C) Gan Liang
    D) Jose Perez
    E) Patricia Reiff

44. According to Hewitt, "quantization is the idea that the natural world is granular rather than continuous." In quantum physics what is it that Hewitt says is quantized?
    A) charge
    B) energy
    C) mass
    D) space
    E) time

45. Different structural forms of an element in the same phase or state of matter and can exhibit very different physical properties and chemical behaviors. Carbon nanotubes are a member of the fullerene structural family that includes buckyballs (buckminsterfullerene), C_{60}, which are quite different from other structural forms of carbon such as diamond and graphite. What are the different structural forms of an element called?
    A) allotropes
    B) isomers
    C) isotopes
    D) isotropes
    E) stereoisomers

46. A balloonist, riding in the basket of a hot air balloon that is rising vertically with a constant velocity of 10.0 m/s, releases a sandbag when the balloon is 40.8 m above the ground. What is the bag's speed when it hits the ground? You may neglect air resistance.
    A) 18.3 m/s
    B) 26.4 m/s
    C) 28.3 m/s
    D) 30.0 m/s
    E) 40.0 m/s

47. While exploring a cave, a spelunker starting at the entrance moves through the following displacements. She goes 75.0 m north, 250 m east, 125 m at an angle 30.0° north of east and 150 m south. Find her resultant displacement from the cave entrance.
    A) 138 m at 0.415° N of E
    B) 314 m at 6.07° N of E
    C) 138 m at 0.415° S of E
    D) 335 m at 0.635° S of E
    E) 358 m at 2.00° S of E

48. A river has a steady speed of 0.500 m/s. A student swims upstream a distance of 1.00 km and swims back to the starting point. If the student can swim at a speed of 1.20 m/s in still water, how long does the trip take?
    A) 1.18×10^3 s
    B) 1.43×10^3 s
    C) 1.67×10^3 s
    D) 2.02×10^3 s
    E) 2.86×10^3 s

49. A bullet of mass m_1 is fired horizontally with a speed v_0 into the bob of a ballistic pendulum of mass m_2. The pendulum consists of a bob attached to one end of a very light rod of length L. The rod is free to rotate about a horizontal axis through its other end. The bullet is stopped in the bob. Find the minimum v_0 such that the bob will swing through a complete circle. You may neglect any dissipative losses in this problem.
    A) $[gL]^{1/2}$
    B) $2[gL]^{1/2}$
    C) $[5gL]^{1/2}$
    D) $(1 + m_2/m_1)\, 2[gL]^{1/2}$
    E) $(1 + m_2/m_1)\, [5gL]^{1/2}$

50. A car accelerates uniformly from rest and reaches a speed of 22.0 m/s in 9.00 s. If the diameter of a tire on this car is 58.0 cm, find the number of revolutions that the tire makes during this motion. You may assume that no slipping occurs during this motion.
    A) 27.2 rev
    B) 54.3 rev
    C) 268 rev
    D) 341 rev
    E) 536 rev

51. A 0.750 m long steel piano wire has a mass per unit length (or linear mass density) equal to 5.00×10^{-3} kg/m is under 1350 N of tension. Find the speed of a transverse wave traveling on this string. Given that steel has a mass density of 7.85 g/cm^3.
    A) 79.5 mm/s
    B) 415 mm/s
    C) 520 mm/s
    D) 415 m/s
    E) 520 m/s

52. The sound level at a distance of 3.00 m from a point source is 120 dB. At what distance will the sound level be 100 dB? You may neglect any dissipative losses and assume that the sound wave undergoes isotropic expansion in three-dimensions.
    A) 0.300 m
    B) 3.29 m
    C) 3.60 m
    D) 30.0 m
    E) 300 m

53. Which of the following waves is primarily longitudinal?
    A) gamma rays in free space
    B) seismic S-waves
    C) sound waves in air
    D) radio waves in free space
    E) visible light in free space

54. The surface of the Sun has a temperature of about 5800 K. The radius of the Sun is 6.96×10^8 m. Calculate the total energy radiated by the Sun each second. Assume that the emissivity of the Sun is 0.965.
    A) 3.77×10^{26} J/s
    B) 2.71×10^{30} J/s
    C) 6.65×10^{33} J/s
    D) 8.74×10^{34} J/s
    E) 1.54×10^{42} J/s

55. A charge of +9q is fixed to one corner of a square, while a charge of −8q is fixed to diagonally opposite corner. Expressed in terms of q, what charge should be fixed to the center of the square, so the potential is zero at each of the two empty corners?
    A) $-q/2$
    B) $-q/(2)^{1/2}$
    C) $-q$
    D) $-(2)^{1/2}q$
    E) $-2q$

56. A dielectric is inserted between the plates of a parallel plate capacitor, completely filling the region between the plates. If the capacitor was connected to a battery during the entire process, then which of the following statements is TRUE as the dielectric is inserted between the plates of the capacitor:
    A) The capacitance increases.
    B) The charge on (one of) the plates decreases.
    C) The magnitude of the net electric field between the plates does not change.
    D) The energy stored in the capacitor decreases.
    E) The voltage between the plates decreases.

57. In a dc circuit with a resistor and an inductor placed in series with an ideal battery and a switch. After the switch is closed the voltage drop across the inductor changes with time, with a characteristic time constant τ. By what factor does the time constant change if both the values of the resistance and inductance are doubled?
    A) 1/4
    B) 1/2
    C) 1
    D) 2
    E) 4

58. A 4.5 keV electron moves in a circular orbit that is perpendicular to a magnetic field of 0.325 T. Find the radius of the orbit.
    A) 7.87×10^{-8} m
    B) 6.96×10^{-6} m
    C) 7.87×10^{-6} m
    D) 6.96×10^{-4} m
    E) 7.87×10^{-2} m

59. If you wish to produce a virtual, upright, enlarged image with a single spherical mirror, then what type of mirror should you use and where should you place the object?

A) convex, $d_o > |f|$
B) convex, $d_o < |f|$
C) concave, $d_o > 2f$
D) concave, $d_o > f$
E) concave, $d_o < f$

60. Calculate the total binding energy of the ^{15}N nucleus. Given that the mass of the ^{15}N nucleus is 14.996269 u.

A) 7.699 MeV
B) 53.90 MeV
C) 61.60 MeV
D) 115.5 MeV
E) 132.0 MeV

UIL HIGH SCHOOL SCIENCE CONTEST
ANSWER KEY

DISTRICT 2 • 2010

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

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41. (E) Mass is not conserved, however according Einstein's formula $E=mc^2$ mass is related to energy and energy is conserved. "...associated with the relativity theory ... kinetic energy is combined with another thing called *mass energy*. An object has energy due to its sheer *existence*."

42. (C) "[Conservation of energy] is a most abstract idea, because it is a mathematical principle; it says that there is a numerical quantity which does not change when something happens. It is not a description of a mechanism, or anything concrete; it is just a strange fact...." " ... it does not tell us the mechanism or the *reasons* for the various formulas."

43. (D) Dr. Jose Perez, Professor of Physics at the University of North Texas, is interested in nanostructures, quantum dots, carbon nanotubes, atomic force microscopy, non-linear dynamics and chaos.

44. (B) According to Hewitt, "Quantum physics states that in the microscopic world of the atom, the amount of energy in any system is quantized — not all values of the energy are possible."

45. (A) An allotrope is an element whose atoms are bonded together in a different form, such as diamond and graphite (which are made up of only carbon). Note: an isomer is a chemical compound that shares the same molecular formula but has different structural formulae, such as for C_3H_8O which gives propan-1-ol, propan-2-ol & methoxyethane.

46. (D) With $v = [v_0^2 + 2a(y-y_0)]^{½} = [(+10)^2 + 2(-9.8)(0-40.8)]^{½} = 30.0$ m/s

47. (E) In the WE-direction: $0+250+125\cos30°+0 = 358.25$ & in the NS-direction: $75+0+125\sin30°-150 = -12.5 \Rightarrow [(358.25)^2 + (-12.5)^2]^{½} = 358$ m at $\tan^{-1}(-12.5/358.25) = -1.998°$ or 2.00° S of E

48. (D) $t_{total} = t_{up} + t_{down} = 1{,}000/(1.2-0.5) + 1{,}000/(1.2+0.5) = 2.02\times10^3$ s

49. (D) By conservation of energy: $0+(m_1+m_2)g(2L) = ½(m_1+m_2)v_{12}^2 \Rightarrow v_{12} = 2[gL]^{½}$ Thus, by conservation of momentum: $m_1v_0+0=+(m_1+m_2)v_{12} \Rightarrow v_0=(1+m_2/m_1)\,2[gL]^{½}$

50. (B) $\omega = v/r = 22/0.29 = 75.86$ rad/s & $\alpha = \Delta\omega/\Delta t = 75.86/9 = 8.429$ rad/s^2 $\Rightarrow$ $\theta = ½\alpha t^2 = ½(8.429)(9)^2 = 341.4$ rad (1 rev)/(2π rad) = 54.3 rev

51. (E) $v = [F_T/\mu]^{½} = [1350/(5\times10^{-3})]^{½} = 520$ m/s

52. (D) $I = 10^{(\beta/10)}10^{-12}$ W/m^2 $\Rightarrow I_1 = 10^0$ W/m^2 & $I_2 = 10^{-2}$ W/m^2 and from $I_1r_1^2 = I_2r_2^2 \Rightarrow r_2 = [10^0/10^{-2}]^{½}\,3 = 30.0$ m

53. (C) Electromagnetic waves in free space are transverse waves as are seismic S-waves, only sound waves in air are longitudinal waves.

54. (A) $P = \varepsilon\sigma AT^4 = 0.965(5.67\times10^{-8})\,[4\pi(6.96\times10^8)^2]\,5800^4 = 3.77\times10^{26}$ J/s

55. (B) $\Sigma V = k(+9q)/a + k(-8q)/a + kQ/[a/(2)^{½}] = 0 \Rightarrow Q = -q/(2)^{½}$

56. (A) A dielectric will always increase the capacitance by a factor of the dielectric constant κ.

57. (C) $\tau = L/R$, so when both L & R are doubled then τ does not change.

58. (D) $KE = ½mv^2 \Rightarrow v = [2(4.5\times10^3)(1.602\times10^{-19})/(9.11\times10^{-31})]^{½} = 3.9783\times10^7$ m/s & $\Sigma F_r = ma_r \Rightarrow$ $qvB\sin90° = mv^2/r \Rightarrow r = (mv)/(qB) = [(9.11\times10^{-31})(3.9783\times10^7)]/[(1.602\times10^{-19})(0.325)] = 6.96\times10^{-4}$ m

59. (E) Convex mirrors only produce reduced, virtual images. Thus, you will need a concave mirror and you will need to place the object inside the focal point of the mirror.

60. (D) Δm = (mass of Z protons + mass of N neutrons) – (mass of nucleus) = $7(1.00728u) + 8(1.008665u) - 14.996296u = 0.123984u$ & $E_B = (\Delta m)c^2 = [0.123984u\ (931.5\ MeV/c^2/u)]c^2 = 115.5$ MeV