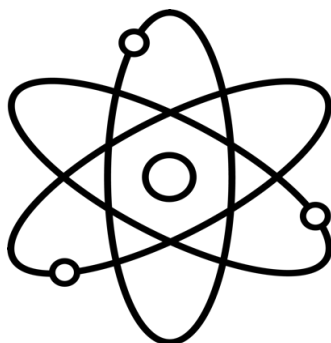




SCIENCE

District 1 • 2015



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.

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 1																8A 18				
1 H 1.008											3A 13		4A 14	5A 15	6A 16	7A 17	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 22.99	12 Mg 24.31	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8	8B 9	8B 10	1B 11	2B 12	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95			
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.41	31 Ga 69.72	32 Ge 72.64	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 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29			
55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.20	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)			
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (277)	109 Mt (268)	110 Ds (281)	111 Rg (272)	112 Cn (285)									

58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	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 (262)

Some Standard Properties of Water

property	symbol	value
density of water	ρ_{water}	1.000 g cm ⁻³
density of ice	ρ_{ice}	0.9167 g cm ⁻³
specific heats		
ice	C_{ice}	2.09 J g ⁻¹ K ⁻¹
water	C_{water}	4.184 J g ⁻¹ K ⁻¹
steam	C_{steam}	2.03 J g ⁻¹ K ⁻¹
heat of fusion	ΔH_{fus} or L_f	334 J g ⁻¹
heat of vaporization	ΔH_{vap} or L_v	2260 J g ⁻¹
index of refraction	n	1.33
autoionization	K_w	1.0×10^{-14}

Pressure
1 atm = 760 torr
= 101325 Pa
= 14.7 psi
1 bar = 10 ⁵ Pa
= 100 kPa

Energy
1 cal = 4.184 J
1 L atm = 101.325 J
1 Cal = 1 kcal
1 hp = 746 W
1 eV = 1.602 × 10 ⁻¹⁹ J

Various Physical Constants

property	symbol	value
universal gas constant	R	$8.314 \text{ J mol}^{-1} \text{ K}^{-1}$
		$62.36 \text{ L torr mol}^{-1} \text{ K}^{-1}$
		$0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1}$
		$1.987 \text{ cal mol}^{-1} \text{ K}^{-1}$
Planck's constant	h	$6.626 \times 10^{-34} \text{ J s}$
		$4.136 \times 10^{-15} \text{ eV s}$
Planck's reduced constant	$h/2\pi$	$1.054 \times 10^{-34} \text{ J s}$
		$6.582 \times 10^{-16} \text{ eV s}$
Boltzmann constant	k_B	$1.38 \times 10^{-23} \text{ J K}^{-1}$
Stefan-Boltzmann	σ	$5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
speed of light	c	$3.00 \times 10^8 \text{ m s}^{-1}$
speed of sound (at 20°C)	v_{air}	343 m s^{-1}
acceleration of gravity	g	9.80 m s^{-2}
gravitational constant	G	$6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Avogadro's number	N_A	$6.022 \times 10^{23} \text{ mol}^{-1}$
elementary charge	e	$1.602 \times 10^{-19} \text{ C}$
Faraday	F	96485 C mol^{-1}
Coulomb's law constant	k	$8.988 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$
Rydberg constant	R	$2.178 \times 10^{-18} \text{ J}$

Some Other Conversion Factors

1 in	=	2.54 cm
1 lb	=	453.6 g
1 mi	=	5280 ft = 1.609 km
1 gal	=	4 quarts = 231 in ³ = 3.785 L

property	symbol	value
electron rest mass	m_e	$9.11 \times 10^{-31} \text{ kg}$
		0.000549 u
		0.511 MeV c^{-2}
proton mass	m_p	$1.6726 \times 10^{-27} \text{ kg}$
		1.00728 u
		938.3 MeV c^{-2}
neutron mass	m_n	$1.6749 \times 10^{-27} \text{ kg}$
		1.008665 u
		939.6 MeV c^{-2}
atomic mass unit	u	$1.6605 \times 10^{-27} \text{ kg}$
		931.5 MeV c^{-2}
earth mass		$5.972 \times 10^{24} \text{ kg}$
earth radius		$6.371 \times 10^6 \text{ m}$
moon mass		$7.348 \times 10^{22} \text{ kg}$
sun mass		$1.989 \times 10^{30} \text{ kg}$
distance earth-moon		$3.844 \times 10^8 \text{ m}$
distance earth-sun		$1.496 \times 10^{11} \text{ m}$
permittivity of free space	ϵ_0	$8.85 \times 10^{-12} \text{ F m}^{-1}$
permeability of free space	μ_0	$4\pi \times 10^{-7} \text{ T m A}^{-1}$

Some Average Bond Energies (kJ/mol)

C-H	413	C-C	346	C-Cl	339	C-N	305
O-H	463	C=C	602	C-Br	285	N=N	418
N-H	391	C≡C	835	O=O	498	H-H	436
C-O	358	C=O	799	C≡O	1072	Br-Br	193
H-Cl	432	S-H	347	N≡N	945	Cl-Cl	242
H-Br	366	H-I	299	C≡N	887	I-I	151

Biology Questions (1 – 20)

- Catabolic pathways release energy by the _____ of organic molecules.
 - synthesis
 - reduction
 - anabolism
 - oxidation
 - generation
- DNA _____ is a process used in biotechnology that results in multiple copies of a gene.
 - cloning
 - replication
 - transcription
 - chain reactions
 - multiplication
- Animals and fungi are similar in that they are both _____.
 - multicellular
 - made of chitin
 - diploid for the majority of the life cycle
 - heterororphs
 - autotrophs
- Which of the following is NOT a function of a protein found in the plasma membrane?
 - Cellular joining
 - Catalyzing chemical reactions
 - Transport of ions
 - Peptide synthesis
 - Protein secretion
- The molecular connectors between DNA and polypeptides is/are _____.
 - histone proteins
 - RNA's
 - the nucleus
 - the rough endoplasmic reticulum
 - peptide bonds
- How many ester linkages between carboxylic acids and glycerol would be found in a phospholipid?
 - 0
 - 1
 - 2
 - 3
 - cannot be determined from the information provided.
- The chromosomal complement found in human male gamete contains
 - 23 autosomes and an X chromosome
 - 23 autosomes and a Y chromosome
 - 23 autosomes and either an X or a Y chromosome
 - 22 autosomes and both an X and Y chromosome
 - none of the above
- Bony fishes (Osteichthyes) are divided into two main clades: _____ and _____ fishes.
 - salt water, fresh water
 - ray finned, lobe finned
 - oviparous, viviparous
 - chordates, craniates
 - scaled, smooth
- How many different kinds of amino acids could be found in a protein?
 - 4 different kinds: A, T, G, C
 - 5 different kinds: A, T, G, C, U
 - 3 different kinds: phosphate, sugar and base
 - 20 different kinds: GAVLIMFWPSTCYNQDEKRH
 - 61 different kinds: 64 codons less the stop codons
- The process by which animals control solute concentrations and balance water gain and loss is called _____.
 - excretion
 - osmosis
 - osmolarity
 - osmoregulation
 - excregulation

11. Potential energy in biological systems can be found in
- Electrical bonds
 - Covalent bonds
 - Thermal bonds
 - A & B
 - A, B and C
12. Crossing over occurs during which phase of meiosis?
- prophase
 - prophase I
 - prophase II
 - metaphase I
 - metaphase
13. According to a phylogenetic tree, which of the following is NOT a reptile?
- eagle
 - snake
 - turtle
 - frog
 - crocodile
14. Terrestrial vertebrates all share which of the following in common?
- They are all tetrapods.
 - They are all amniotic.
 - They are all adapted to live on land.
 - They are all protostomes.
 - They all give birth to live young.
15. Homo sapiens migrated out of Africa about 100,000 years ago. Which one of the following species might the early H. sapiens have encountered?
- Australopithecus afarensis
 - Homo habilis
 - Homo neanderthalensis
 - Australopithecus africanus
 - Tyrannosaurus rex
16. The complete metamorphosis of arthropods includes which of the following stages?
- zygote, larva, cocoon, adult
 - Pupa, larva, cocoon, adult
 - Larva, pupa, adult
 - Larva, chrysalis, cocoon, adult
 - Pupa, cocoon, adult
17. Plants adapted to live on land have a waxy coating on their leaves called the cuticle. Which is the main function of the cuticle?
- to make the plant distasteful to herbivores
 - to allow germination to occur more quickly
 - to attract pollinators
 - to avoid desiccation
 - to allow leaves to float on water
18. Which of the following were primarily responsible for the accumulation of free oxygen on the early Earth?
- archaea
 - photosynthetic bacteria
 - photosynthetic eukaryote
 - chemosynthetic bacteria
 - chloroplasts
19. The two main divisions of the skeletal system are
- bone and bone marrow
 - cranial and subcranial
 - axial and appendicular
 - cranial and vertebral
 - axial and vertebral
20. The rate at which a substance diffuses is affected by the
- temperature of the solution.
 - concentration gradient in the system.
 - presence of ATP.
 - A and B
 - A, B and C

Chemistry Questions (21 – 40)

21. What is the name of the compound, $\text{Sn}(\text{C}_2\text{H}_3\text{O}_2)_2$?
- antimony(II) oxalate
 - tin carbonate
 - tin(II) diacetic acid
 - antimony acetate
 - tin(II) acetate
22. Balance the following reaction with whole numbers as coefficients.
- $$\text{PCl}_3(\text{s}) + \text{H}_2\text{O} \rightarrow \text{H}_3\text{PO}_3 + \text{HCl}$$
- What are the respective coefficients?
- 2 : 6 : 2 : 7
 - 1 : 2 : 2 : 5
 - 1 : 3 : 1 : 3
 - 3 : 6 : 3 : 9
 - 1 : 1 : 1 : 3
23. A laboratory bottle is labeled 15% KOH with a density of 1.122 g/mL. What is the molarity of the KOH?
- 3.00 M
 - 2.67 M
 - 2.55 M
 - 3.12 M
 - less than 2.20 M
24. When a metal reacts with a non-metal, the resulting compound is usually _____.
- a covalent compound
 - a polymer
 - a bimetallic compound
 - an ionic compound
 - a protein
25. What is the formal charge on the nitrogen in the ion, NH_4^+ ?
- +2
 - 2
 - 1
 - +1
 - 0
26. A sample of hydrogen gas has a volume of 725 mL at STP. What would be the volume of this sample of gas at 143°C and 280 torr?
- 3.00 L
 - 2.00 L
 - 3.50 L
 - 2.50 L
 - 4.00 L
27. A salt is known to have a negative value for $\Delta H_{\text{solution}}$. A sample of the salt is dissolved into some water but some of the salt remains undissolved. Which of the following procedures will help to dissolve the rest of the salt?
- heat the solution
 - cool the solution
 - add more water
 - add more salt
- I and III
 - I and IV
 - II and III
 - II and IV
 - only IV
28. A saturated solution of barium phosphate ($K_{\text{sp}} = 5.8 \times 10^{-39}$) has a barium concentration of 2.5×10^{-7} M. What is the concentration of phosphate in this solution?
- 1.5×10^{-16} M
 - 6.1×10^{-10} M
 - 3.0×10^{-13} M
 - 8.8×10^{-9} M
 - 5.4×10^{-14} M
29. Which solution listed has the highest boiling point?
- 2.5 m NaCl
 - 1.5 m CaCl_2
 - 1.0 m Na_3PO_4
 - 2.0 m KBr
 - 1.5 m $\text{Al}(\text{NO}_3)_3$
30. Consider a system at 300 K with the following reaction occurring:
- $$2 \text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2 \text{H}_2\text{O}(\text{l})$$
- What is the amount of work done? Is the work done on the system or by the system?
- 7.5 kJ of work done on the system
 - 2.5 kJ of work done by the system
 - no work done on or by the system
 - 7.5 kJ of work done by the system
 - 2.5 kJ of work done on the system

31. Methanol (CH₃OH) has the following phase data:
 $\Delta H_{\text{fusion}} = 2.20 \text{ kJ/mol}$ $T_{\text{fp}} = -97^\circ\text{C}$
 $\Delta H_{\text{vaporization}} = 37.6 \text{ kJ/mol}$ $T_{\text{bp}} = 65^\circ\text{C}$
 $C_{\text{p,liquid}} = 79.5 \text{ J/mol K}$
 How much heat must be removed from 96.1 g of methanol at 25°C in order to change it to frozen (solid) methanol at -97°C?
 A) 29.1 kJ C) 9.70 kJ E) 11.9 kJ
 B) 35.7 kJ D) 47.3 kJ
32. Which example has $\Delta S < 0$ for the change given?
 A) sugar cube dissolves into water
 B) ethanol liquid evaporates
 C) liquid H₂O freezes into ice
 D) liquid H₂O is electrolyzed into H₂ and O₂
 E) benzene liquid is heated from 25°C to 30°C
33. Consider the gas phase equilibrium:
 $2 \text{ A (g) + B (g) } \rightleftharpoons 3 \text{ C (g)}$
 If the partial pressure of C is doubled, what happens to the reaction quotient, Q ?
 A) it drops to 1/8th its original value
 B) it increases by a factor of 2
 C) Q will not change
 D) it increases by a factor of 8
 E) it drops to 1/4th its original value
34. Consider the decomposition of calcium sulfate:
 $2 \text{ CaSO}_4(\text{s}) \rightleftharpoons 2 \text{ CaO (s) + 2 SO}_2(\text{g}) + \text{O}_2(\text{g})$
 $K_{\text{p}} = 0.032$ at 700 K. A sample of CaSO₄ sits in a sealed container at 700 K long enough to reach equilibrium. What is the total pressure in the container once equilibrium is reached? Assume no other gases were in the container at the start.
 A) 1.2 atm C) 0.60 atm E) 0.80 atm
 B) 0.20 atm D) 0.40 atm
35. A tank holding 2500 liters of water has a pH of 3.50 due to the presence of HCl. How many grams of NaOH must be added to the tank so that the pH is brought to 4.34?
 A) 59 g C) 5 g E) 27 g
 B) 32 g D) 38 g
36. What is the molecular geometry of XeF₄?
 A) square planar
 B) see-saw
 C) tetrahedral
 D) square pyramid
 E) bipyramidal
37. Which of the following neutral atoms will be the easiest to ionize into a +1 cation?
 A) F C) I E) Fe
 B) Rb D) Sc
38. Acetone has the formula CH₃COCH₃. What is the hybridization of the carbon in the middle of the formula?
 A) sp^3 C) sp^3d E) sp^2
 B) sp^3d^2 D) sp
39. A first order reaction has $k = 3.2 \times 10^{-4} \text{ s}^{-1}$ at 300 K. If the reaction begins with 0.15 M of the reactant, how long will it take for the reactant to fall to 0.01M?
 A) 7.3 min D) 1.02 hr
 B) 81.0 hr E) 9.13 hr
 C) 2.35 hr
40. A chemical reaction where $\Delta H_{\text{rxn}} = +23.5 \text{ kJ/mol}$ has an equilibrium constant equal to 4.2×10^{-4} when the reaction is run at 100°C. What is the value of the equilibrium constant when the reaction is run at 300°C?
~~A) 4.2×10^{-4} D) 5.9×10^{-3}~~
~~B) 8.3×10^{-1} E) 6.4×10^4~~
~~C) 7.6×10^{-2}~~

Physics Questions (41 – 60)

On this contest i, j and k are the unit vectors in the $+x$, $+y$ and $+z$ directions respectively, and unless otherwise indicated, you may neglect air resistance in every problem.

41. According to Tyson, what is Pluto's largest moon?
 A) Charon
 B) Europa
 C) Hydra
 D) Nix
 E) Phobos
42. According to Tyson, what geometrical shape has the least surface area but the greatest enclosed volume?
 A) cube
 B) cylinder
 C) ellipsoid
 D) pyramid
 E) sphere
43. According to Tyson, what spacecraft was launched with the stated goal to "complete the reconnaissance of the solar system"?
 A) Hubble Space Telescope
 B) New Horizons
 C) Pioneer 10
 D) Pioneer 11
 E) Voyager
44. According to Tyson, which of the following is not included in the "Pluto system"?
 A) Charon
 B) Hydra
 C) Nix
 D) Phobos
 E) Pluto
45. Given the following two vectors in unit vector notation:
 $\mathbf{A} = (3.00 \text{ m}) \mathbf{i} + (3.00 \text{ m}) \mathbf{j} + (5.00 \text{ m}) \mathbf{k}$
 $\mathbf{B} = (2.00 \text{ m}) \mathbf{i} - (3.00 \text{ m}) \mathbf{k}$
 Determine $\mathbf{A} + \mathbf{B}$ in unit vector notation.
 A) $(5.00 \text{ m}) \mathbf{i} + (5.00 \text{ m}) \mathbf{k}$
 B) $(6.00 \text{ m}) \mathbf{i} - (15.00 \text{ m}) \mathbf{k}$
 C) $(5.00 \text{ m}) \mathbf{i} + (3.00 \text{ m}) \mathbf{j} + (2.00 \text{ m}) \mathbf{k}$
 D) $(5.00 \text{ m}) \mathbf{i} + (3.00 \text{ m}) \mathbf{j} + (8.00 \text{ m}) \mathbf{k}$
 E) $(5.00 \text{ m}) \mathbf{i} + (6.00 \text{ m}) \mathbf{j} + (5.00 \text{ m}) \mathbf{k}$
46. A small fishing boat moves with a constant velocity of 12.0 m/s for 5 minutes. Then the fisherman stops the motor and lets the boat coast while fishing. If the coasting velocity is given by $v_c(t) = v(t_1) \times [t_1/t]^2$ where $t_1 = 5$ minutes. What is the boats displacement from $t_1 < t < \infty$?
 A) 1200 m
 B) 2400 m
 C) 3600 m
 D) 7200 m
 E) 10800 m
47. While standing still on the sidewalk you watch a taxi move away from you with a constant velocity. Which of the following is true?
 A) gravity is the only force acting on the taxi
 B) the net force acting on the taxi is in the opposite direction of motion
 C) the net force acting on the taxi in is the direction of motion
 D) net force on the taxi is zero
 E) no forces are acting on the taxi
48. In the backyard a 25.0 kg little girl swings on a 7.00 m long swing with a maximum speed of 5.60 m/s. What is the vertical angle that the swing makes at when the girl is at the highest point in her motion? You may neglect the mass of the swing and treat the girl as a point mass on the end of the 7.00 m long swing.
 A) 16.4°
 B) 39.5°
 C) 57.1°
 D) 62.8°
 E) 76.8°

49. A tangential force is applied at a distance d from the fixed axis of a freely rotating disk. This force causes an angular acceleration of α to occur. If the same force is applied at a distance $4d$ from the axis then what is the new angular acceleration?
- A) $(1/4)\alpha$
 B) $(1/2)\alpha$
 C) α
 D) 2α
 E) 4α
50. On the moon's surface gravity is given by g_m . A point is located at a distance three times the radius of the moon from the moon's center. What is the moon's acceleration due gravity at this point?
- A) $(1/9)g_m$
 B) $(1/3)g_m$
 C) g_m
 D) $3g_m$
 E) $9g_m$
51. A 13.0 kg box is hung from a steel wire with a diameter of 0.800 mm and an initial length of 1.60 m. Given that Young's modulus for steel is 200 GPa, then how much will the wire stretch under this load?
- A) 8.11×10^{-7} m
 B) 4.06×10^{-7} m
 C) 5.07×10^{-5} m
 D) 6.45×10^{-4} m
 E) 2.03×10^{-3} m
52. An object attached to a spring oscillates on a horizontal frictionless surface with an amplitude of 5.70 cm. If the system has a total mechanical energy of 1.70 J, then what is the spring constant (or force constant) of the spring?
- A) 29.8 N/m
 B) 59.7 N/m
 C) 262 N/m
 D) 523 N/m
 E) 1050 N/m
53. To increase the sound intensity level by 20 dB means you need to increase the sound intensity by a factor of
- A) 2.0
 B) 3.2
 C) 10
 D) 20
 E) 100
54. If a gas absorbs 2.25 MJ of heat when doing 950 kJ of work then what is the change of the gas's internal energy?
- A) 2.25×10^3 J
 B) 9.50×10^5 J
 C) 1.30×10^6 J
 D) 2.25×10^6 J
 E) 3.20×10^6 J
55. How much energy is required to accelerate a particle of mass m from rest to $0.500c$?
- A) $0.155mc^2$
 B) $0.330mc^2$
 C) $0.577mc^2$
 D) $1.15mc^2$
 E) $3.00mc^2$
56. If a positively charged particle is allowed to freely move within a region of electric field E then which of the following is always true
- A) the particle is moving in the direction of E
 B) the particle can come to rest and stay at rest
 C) the particle accelerates in a direction perpendicular to the direction of E
 D) the particle experiences an electric force perpendicular to the direction of E
 E) the particle experiences an electric force in the direction of E

57. The electric potential at the surface of a uniformly charged sphere is 620 V. At a point located 30.0 cm radially from the surface of the sphere the electric potential is 230 V. Given that at a great distance from the sphere the electric potential is zero, then what is the radius of the sphere?
- A) 0.081 m
 - B) 0.088 m
 - C) 0.177 m
 - D) 0.219 m
 - E) 0.481 m
58. The electric field measured at the surface of the Earth is 150 N/C pointing downward. If this is the value over the entire surface and modeling the Earth as a sphere, then what is the net charge of the Earth?
- A) -2.71×10^6 C
 - B) -6.77×10^5 C
 - C) $+2.71 \times 10^5$ C
 - D) $+6.77 \times 10^5$ C
 - E) $+2.71 \times 10^6$ C
59. A series RLC circuit combo with a resistance of 15.0 Ω , an inductance of 4.00 H, and a capacitance of 3.00 μ F is driven by an ideal generator with a peak emf of 125 V. What is the resonance frequency?
- A) 45.9 Hz
 - B) 115 Hz
 - C) 289 Hz
 - D) 1810 Hz
 - E) 13300 Hz
60. A goldfish is 8.0 cm away from the front glass in a spherical bowl with a radius of 25 cm. How far behind the glass does the goldfish appear to be to a woman looking through the front of the bowl? You may neglect the effects of the glass bowl.
- A) 5.6 cm
 - B) 6.0 cm
 - C) 6.5 cm
 - D) 70 cm
 - E) 76 cm

UIL HIGH SCHOOL SCIENCE CONTEST

Contestant Answer Sheet

Contestant # _____

9 10 11 12
CONTESTANT GRADE LEVEL

A 2A 3A 4A 5A
CONFERENCE

PLEASE WRITE ANSWERS WITH CAPITAL LETTERS

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

BIOLOGY SCORE

CHEMISTRY SCORE

PHYSICS SCORE

OVERALL SCORE:

UIL HIGH SCHOOL SCIENCE CONTEST
ANSWER KEY

DISTRICT 1 • 2015

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

PHYSICS KEY for Science Contest • District 1 • 2015

41. (A) “Pluto’s largest moon, Charon, named for the Greek ferryboat driver who would carry your unfortunate soul across the River Acheron to the underworld, ...”
42. (E) “You can show, using freshman-level calculus, that the one and only shape that has the smallest surface area for an enclosed volume is a perfect sphere.”
43. (B) “One of the stated goals for the New Horizons mission was to “complete the reconnaissance of the solar system.””
44. (D) “Two famous celestial nonspheres are Phobos and Deimos, the Idaho-potato-shaped moons of Mars.”
45. (C) $\mathbf{A} + \mathbf{B} = [(3.00 \text{ m}) \mathbf{i} + (3.00 \text{ m}) \mathbf{j} + (5.00 \text{ m}) \mathbf{k}] + [(2.00 \text{ m}) \mathbf{i} + (0.00 \text{ m}) \mathbf{j} - (3.00 \text{ m}) \mathbf{k}]$
 $= (5.00 \text{ m}) \mathbf{i} + (3.00 \text{ m}) \mathbf{j} + (2.00 \text{ m}) \mathbf{k}$
46. (C) $\Delta x = \int v_c(t) dt = \int v(t_1) \times [t_1/t]^2 dt = v(t_1) \times t_1^2 \int [1/t]^2 dt = v(t_1) \times t_1^2 (-1/t) \Big|_{t_1}^{\infty} = v(t_1) \times t_1 = 12[5(60)] = 3600 \text{ m}$
47. (D) Since the taxi moves with a constant velocity then the acceleration of the taxi is zero, and thus the net force on the taxi is zero.
48. (B) By conservation of mechanical energy: $\frac{1}{2}mv^2 = mgh \Rightarrow h = v^2/(2g) = 1.6 \text{ m}$, then by the diagram of the situation $\theta = \cos^{-1}([7.0 - 1.6]/7.0) = 39.5^\circ$
49. (E) By N2L in angular form: $\alpha = \Sigma \tau/I = (Fd)/I$, thus if $d \rightarrow 4d$ then $\alpha \rightarrow 4\alpha$
50. (A) With $g_m = GM_m/R_m^2$, then $g = GM_m/r^2$ with $r = 3R_m \Rightarrow g = GM_m/(3R_m)^2 = (1/9)g_m$
51. (E) By $F/A = Y\Delta L/L_0 \Rightarrow \Delta L = [FL_0]/[YA] = [(13)(9.8)(1.6)]/[(2E+11)\pi(0.4E-3)^2] = 2.03E-3 \text{ m}$
52. (E) By $E_{\text{sho}} = \frac{1}{2}kA^2 \Rightarrow k = 2E_{\text{sho}}/A^2 = 2(1.7)/(0.057)^2 = 1050 \text{ N/m}$
53. (E) By $\beta = 10 \log(I/I_0) \Rightarrow \beta' = \beta + 20 = 10 \log(I'/I_0) \Rightarrow 20 = 10[\log(I'/I_0) - \log(I/I_0)] = 10 \log(I'/I)$
 $\Rightarrow I'/I = 10^2 = 100$
54. (C) $\Delta E_{\text{int}} = Q - W = (+2.25E+6) - (+950E+3) = 1.30E+6 \text{ J}$
55. (A) $\Delta E_{\text{rel}} = \gamma mc^2 - \gamma_0 mc^2 = [1 - 0.5^2]^{-1/2} mc^2 - mc^2 = 0.155mc^2$
56. (E) The electric force on a positively charged particle is always in the same direction as the electric field vector.
57. (C) With $V = kQ/r \Rightarrow 620 = kQ/R$ & $230 = kQ/(R+0.3) \Rightarrow R = [(230)(0.3)]/[620-230] = 0.177 \text{ m}$
58. (B) By Gauss’ law: $\Phi_E = \int \mathbf{E} \cdot d\mathbf{a} = Q_{\text{enc}}/\epsilon_0 = -EA \Rightarrow Q_{\text{enc}} = -(8.85E-12)(150)[4\pi(6.37E+6)^2] = -6.77E+5 \text{ C}$
59. (A) With $f_0 = 1/\{2\pi[LC]^{1/2}\} = 1/\{2\pi[(4)(3E-6)]^{1/2}\} = 45.9 \text{ Hz}$
60. (C) By $n_1/d_o + n_2/d_i = (n_2 - n_1)/r \Rightarrow (1.33/8) + (1.00/d_i) = (1.00 - 1.33)/(-25) \Rightarrow d_i = -6.5 \text{ cm}$