



SCIENCE

Regional • 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.

UNIVERSITY INTERSCHOLASTIC LEAGUE

Making a World of Difference

Periodic Table of the Elements

1A																						8A			
1 H 1.008	2A																					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												13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95							
												8B						1B		2B					
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)

See Reverse Page for Other Useful Information

OTHER USEFUL INFORMATION

Avogadro's Number, $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$

Absolute zero = $0 \text{ K} = -273.15^\circ\text{C}$

Atmospheric pressure, $1 \text{ atm} = 1.013 \times 10^5 \text{ N/m}^2 = 101.3 \text{ kPa} = 760.0 \text{ Torr} = 760.0 \text{ mmHg}$

Standard temperature and pressure (STP) is 0°C and 1 atm

Gram molecular volume at STP = 22.4 L

Mechanical equivalence of heat, $1 \text{ kcal} = 1 \text{ Cal} = 1,000 \text{ cal} = 4,186 \text{ J}$

Gas constant, $R = 1.987 \text{ cal/mol}\cdot\text{K} = 0.08206 \text{ atm}\cdot\text{L/mol}\cdot\text{K} = 8.314 \text{ J/mol}\cdot\text{K}$

Dulong and Petit's constant = $6.0 \text{ amu}\cdot\text{cal/gram}\cdot\text{K}$

Faraday's constant, $1 \text{ F} = 96,485 \text{ C/mol}$

Acceleration of gravity at Earth's surface, $g = 9.80 \text{ m/s}^2$

Gravitational constant, $G = 6.67 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$

Horsepower, $1 \text{ hp} = 746 \text{ W} = 550 \text{ ft}\cdot\text{lbs/s}$

Boltzmann's constant, $k_B = 1.38 \times 10^{-23} \text{ J/K}$

Stefan-Boltzmann constant, $\sigma = 5.67 \times 10^{-8} \text{ W/m}^2\cdot\text{K}^4$

Elementary charge, $e = 1.602 \times 10^{-19} \text{ C}$

Coulomb's law constant, $k = 1/4\pi\epsilon_0 = 8.988 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$

Permittivity of free space, $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{N}\cdot\text{m}^2$

Permeability of free space, $\mu_0 = 4\pi \times 10^{-7} \text{ T}\cdot\text{m/A}$

Electron volt, $1 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$

Vacuum speed of light, $c = 3.00 \times 10^8 \text{ m/s}$

Planck's constant, $h = 6.626 \times 10^{-34} \text{ J}\cdot\text{s} = 4.136 \times 10^{-15} \text{ eV}\cdot\text{s}$

Planck's reduced constant, $\hbar = h/2\pi = 1.054 \times 10^{-34} \text{ J}\cdot\text{s} = 6.582 \times 10^{-16} \text{ eV}\cdot\text{s}$

Atomic mass unit, $1 \text{ amu} = 1 \text{ u} = 1.66 \times 10^{-27} \text{ kg} = 931.5 \text{ MeV}/c^2$

Electron rest mass, $m_e = 9.11 \times 10^{-31} \text{ kg} = 0.000549 \text{ u} = 0.511 \text{ MeV}/c^2$

Proton Mass = $1.6726 \times 10^{-27} \text{ kg} = 1.00728 \text{ u} = 938.3 \text{ MeV}/c^2$

Neutron Mass = $1.6749 \times 10^{-27} \text{ kg} = 1.008665 \text{ u} = 939.6 \text{ MeV}/c^2$

Some standard values for water:

Mass density, $\rho = 1.00 \text{ g/cm}^3 = 1,000 \text{ kg/m}^3$

Heat capacity or Specific heat, $c = 1.00 \text{ cal/gram}\cdot\text{C}^\circ = 1.00 \text{ kcal/kg}\cdot\text{C}^\circ = 4186 \text{ J/kg}\cdot\text{C}^\circ$

Latent heats, $L_f = 79.7 \text{ kcal/kg} = 3.33 \times 10^5 \text{ J/kg}$ & $L_v = 539 \text{ kcal/kg} = 22.6 \times 10^5 \text{ J/kg}$

Index of refraction, $n = 1.33$

Biology Questions (1 – 20)

1. Sugars dissolve in water because _____.
 - A) they are nonpolar molecules
 - B) water can form hydrogen bonds with the hydroxyl groups of the sugars
 - C) they form rings when they are placed in water
 - D) a and b above
 - E) a, b, and c above
2. A piece of *Elodea*, a water plant, and red blood cells are placed in distilled water on a slide and viewed microscopically. Which of the following events will have occurred after about 10 minutes?
 - A) The red blood cells will burst and the plant cells will undergo plasmolysis.
 - B) The red blood cells will shrink and the plant cells will burst.
 - C) The red blood cells will burst and the plant cells will become turgid.
 - D) The red blood cells and the plant cells will remain unchanged.
 - E) None of the above.
3. In which stage of the cell cycle would the largest quantities of DNA polymerase be present?
 - A) G1
 - B) G2
 - C) M
 - D) S
 - E) It would be present in equal amounts in all of these stages.
4. In order for glycolysis to begin, which of the following must occur?
 - A) Glucose must enter mitochondria.
 - B) There must be an input of energy from ATP.
 - C) Oxygen must be available.
 - D) Some hydrogen acceptors must be available.
 - E) None of the above.
5. Mendel's dihybrid crosses provide evidence for all but which of the following?
 - A) independent assortment
 - B) dominance
 - C) linkage
 - D) the presence of two factors in parents and offspring
 - E) segregation of factors
6. Bacteriophages are _____.
 - A) viruses that parasitize bacteria
 - B) bacteria that parasitize viruses
 - C) bacteria that phagocytize viruses
 - D) composed of a protein core surrounded by a nucleic acid coat
 - E) viruses that do not harm their host
7. Which of the following does NOT describe a trend in plant evolution?
 - A) from nonvascular to vascular
 - B) from spores of two types to spores of one type
 - C) from motile gametes to nonmotile gametes
 - D) from seedless to seed-producing
 - E) from gametophyte dominance to sporophyte dominance
8. Which of the following animal groups does NOT have any terrestrial representatives?
 - A) Arthropoda
 - B) Crustacea
 - C) Echinodermata
 - D) Mollusca
 - E) Vertebrata
9. What tissue makes up most of the wood of a tree?
 - A) primary xylem
 - B) secondary xylem
 - C) secondary phloem
 - D) cortex
 - E) vascular cambium
10. What is the function of endosperm?
 - A) providing nutrients for developing flowers
 - B) supplying nuclei necessary for double fertilization
 - C) providing nutrients for germinating embryos
 - D) attracting pollinators to flowers
 - E) attracting animals to disperse seeds

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11. In order to flower, a short-day plant needs _____.
A) a burst of red light in the middle of the night
B) a burst of far red light in the middle of the night
C) a brief period of darkness in the middle of the day
D) a day that is longer than a certain critical length
E) a night that is longer than a certain critical length
12. Which of the following does NOT correctly match an enzyme with its function?
A) pepsin - hydrolysis of sucrose
B) amylase - hydrolysis of starch
C) lactase - hydrolysis of milk sugar
D) trypsin - hydrolysis of protein
E) lipase - hydrolysis of fats
13. In the blood, bicarbonate ions _____.
A) help transport oxygen
B) act as buffers that guard against pH changes
C) are transported by hemoglobin
D) attach to numerous carbon dioxide molecules, keeping them from going into solution
E) are poisonous and must constantly be removed
14. The region of an antibody molecule that binds antigens is the _____.
A) light chain
B) heavy chain
C) suppressor
D) constant region
E) variable region
15. Which of the following is NOT a function of the vertebrate skeleton?
A) storage of red blood cells
B) protection
C) support
D) production of white blood cells
E) storage of minerals
16. The secretion of all the hormones from the anterior pituitary requires _____.
A) stimulation from the posterior pituitary
B) that they first be secreted from neurons of the hypothalamus
C) stimulation from the motor cortex of the brain
D) the action of releasing hormones
E) All of the above
17. The primary control centers for respiration and blood pressure are located in the _____.
A) pulmonary arteries
B) carotid arteries
C) brainstem
D) cerebrum
E) hypothalamus
18. Which of the following is NOT an example of coevolution?
A) a host and a parasite that attacks it
B) an insect and a flower it pollinates
C) a predator and a prey that it hunts
D) a model and its mimic
E) a shark and a dolphin that inhabit the same water
19. Which of the following describes mimicry?
A) An insect's bright colors warn a predator that it tastes bad.
B) The mottled pattern on a fish looks like dead leaves on the bottom of a pond.
C) Two species of mice live in the same area and eat the same kinds of seeds.
D) A harmless frog resembles a poisonous frog.
E) Both kangaroo rats and jackrabbits hop erratically when escaping from predators.
20. Restriction enzymes are useful in genetic engineering because they _____.
A) work at specific recognition sites
B) function only at "sticky ends"
C) produce uniform lengths of DNA
D) only act on bacterial DNA
E) are not as specific as most enzymes are

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Chemistry Questions (21 – 40)

21. Which one of the following compounds is not a salt?
- A) $\text{Ca}(\text{NO}_3)_2$
 - B) NaCHCOO
 - C) KCl
 - D) Ag_2SO_4
 - E) $\text{Ca}(\text{OH})_2$
22. The number of unpaired electrons in the lowest energy electron configuration of an isolated sulfur atom is _____.
- A) 1
 - B) 2
 - C) 4
 - D) 0
 - E) 3
23. Constructive interference of two waves occurs when the two waves _____.
- A) have the same wavelength.
 - B) are exactly out of phase.
 - C) have the same frequencies.
 - D) have the same energies.
 - E) are exactly in phase.
24. For a subsidiary quantum number value of 3, what are the possible values for the angular momentum quantum number, m_l ?
- A) +2, +1, 0, -1, -2
 - B) none of the other choices are correct
 - C) +3, +2, +1, 0, -1, -2, -3
 - D) +3, +2, +1, 0
 - E) +2, +1, 0
25. For the transition metal atoms from $Z=21$ to $Z=28$, the atomic radii is smallest for _____.
- A) nickel
 - B) scandium
 - C) The trend can not be predicted.
 - D) an atom lying halfway between scandium and nickel.
 - E) titanium
26. Which of the following atoms would be expected to have the highest first ionization potential?
- A) Phosphorus
 - B) Oxygen
 - C) Potassium
 - D) Sulfur
 - E) Manganese
27. Choose the pair of names and formulas that do not match.
- A) SnCl_4 , stannic chloride
 - B) N_2O_3 , dinitrogen trioxide
 - C) MgSO_3 , magnesium sulfate
 - D) NaNO_3 , sodium nitrate
 - E) SiCl_4 , silicon tetrachloride
28. The mixing or rearrangement of individual pure atomic orbitals to form new orbitals with different spatial orientations is called _____.
- A) molecular geometry
 - B) delocalization
 - C) resonance
 - D) VSEPR theory
 - E) hybridization
29. A maximum of _____ electrons having a given spin can occupy any given molecular orbital.
- A) 0
 - B) 1/2
 - C) 4
 - D) 2
 - E) 1
30. Rainwater is naturally slightly acidic due to the _____ in the atmosphere that reacts with water to form _____.
- A) SO_2 , sulfuric acid
 - B) CO_2 , carbonic acid
 - C) O_2 , acetic acid
 - D) NO , formic acid
 - E) N_2 , nitric acid

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31. Arrange the following molecules in order of increasing molar enthalpy of vaporization:
 CCl_4 , SiCl_4 , CH_4 , SiBr_4 .
- A) $\text{SiBr}_4 < \text{SiCl}_4 < \text{CH}_4 < \text{CCl}_4$.
 B) $\text{SiBr}_4 < \text{SiCl}_4 < \text{CCl}_4 < \text{CH}_4$.
 C) $\text{CH}_4 < \text{CCl}_4 < \text{SiCl}_4 < \text{SiBr}_4$.
 D) $\text{CCl}_4 < \text{SiCl}_4 < \text{CH}_4 < \text{SiBr}_4$.
 E) $\text{CH}_4 < \text{CCl}_4 < \text{SiBr}_4 < \text{SiCl}_4$.
32. All systems undergoing spontaneous reaction at constant T and P _____.
- A) are fast
 B) have $\Delta H < 0$
 C) have $\Delta S > 0$
 D) have $\Delta G < 0$
 E) give off heat
33. For the elementary reaction
 $\text{CO} + \text{O}_2 \rightarrow \text{CO}_2 + \text{O}$, the order with respect to CO is _____, the overall order is _____ and the units of the rate constant are _____.
- A) 1, 1, s^{-1}
 B) 1, 2, $\text{M}^{-1} \text{s}$
 C) 2, 0, $\text{M}^{-1} \text{s}^{-1}$
 D) 1, 1, $\text{M}^{-1} \text{s}^{-1}$
 E) 0, 1, s^{-1}
34. If $K_c = 0.040$, at 450 C, what is K_p for the reaction?
 $\text{PCl}_5(\text{g}) \rightarrow \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$
- A) 6.7×10^{-4}
 B) 5.2×10^{-2}
 C) 0.40
 D) 2.4
 E) 0.64
35. A 100 ml sample of 0.100 M ammonia (aq) is titrated to the equivalence point with 50 ml of 0.200 M HCl(aq). What is the final $[\text{H}_3\text{O}^+]$? K_b of ammonia is 1.8×10^{-5} .
- A) $3.7 \times 10^{-11} \text{ M}$
 B) $6.1 \times 10^{-6} \text{ M}$
 C) $1.1 \times 10^{-3} \text{ M}$
 D) $8.6 \times 10^{-6} \text{ M}$
 E) $1.0 \times 10^{-7} \text{ M}$
36. How many mL of a 0.0010 M chloride solution must be added to a 100 mL solution of $7.2 \times 10^{-5} \text{ M Ag}^+$ solution for AgCl to begin to precipitate? K_{sp} of AgCl = 1.8×10^{-10}
- A) Need to know the solution pH to solve this problem.
 B) 2.6 mL
 C) 0.25 mL
 D) 0.030 mL
 E) 41. mL
37. In the electrolysis of an aqueous solution of NaCl, _____ is produced at the anode and _____ is produced at the cathode.
- A) Cl_2, H_2
 B) O_2, Cl_2
 C) H_2, O_2
 D) H_2, Cl_2
 E) Cl_2, O_2
38. You can test for lead in housepaint by the reaction
 $3 \text{Pb}^{2+} + \text{Cr}_2\text{O}_7^{2-} + 14 \text{H}^+ \rightarrow 3 \text{Pb}^{4+} + 2 \text{Cr}^{3+} + 7 \text{H}_2\text{O}$
 A paint chip with a mass of 0.234 g requires 5.00 ml of 0.00500 M $\text{K}_2\text{Cr}_2\text{O}_7$ in order to react completely. What is the percentage (by weight) of lead in the paint?
- A) 2.5 %
 B) 13.9 %
 C) 8.8 %
 D) 4.4 %
 E) 6.6 %
39. We mix 41.1 grams of oxygen gas with 30.5 grams of argon gas in a volume of 1001 mL at 139.0 C. What will be the total pressure of the gas mixture?
- A) 97. atm
 B) 69. atm
 C) 125. atm
 D) 28. atm
 E) 152. atm
40. Given that $K_w = 3.995 \times 10^{-13}$ at some temperature, what is the pH of pure water at that temperature?
- A) 6.2
 B) 6.6
 C) 7.0
 D) 7.4
 E) 7.8

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Physics Questions (41 – 60)

41. According to Feynman which of the following statements explain why and/or how Einstein's law of gravitation modified Newton's law of gravitation?
- A) Anything which has energy has mass.
 - B) Signals can NOT be sent faster than the speed of light.
 - C) Einstein's law of gravitation takes into account delays in the force acting over a distance.
 - D) all of the above
 - E) none of the above
42. According to Feynman unified field theory is an attempt to combine which of the following?
- A) electricity and gravitation
 - B) electricity and magnetism
 - C) electricity and wave theory
 - D) gravity and magnetism
 - E) magnetism and wave theory
43. This Texas physicist is interested in theoretical particle physics and has written numerous papers on particle-antiparticle pair production and/or annihilation by computer modeling using Monte Carlo techniques. He/she received his/her Ph.D. from Princeton University.
- A) Tikhon Bykov
 - B) Margaret Cheung
 - C) David Hough
 - D) Gan Liang
 - E) B. F. L. Ward
44. What type of fundamental particle is the W^+ ?
- A) baryon
 - B) boson
 - C) hadron
 - D) lepton
 - E) meson
45. What is the minimum energy of a photon that is able to produce a muon & antimuon pair? Given that the mass of the muon is 1.8835×10^{-28} kg.
- A) 52.84 MeV
 - B) 105.6 MeV
 - C) 188.4 MeV
 - D) 211.3 MeV
 - E) 376.7 MeV
46. A tennis ball is struck such that it leaves the racket horizontally with a speed of 28.0 m/s. The ball hits the court at a horizontal distance of 19.6 m from the racket. What is the height of the tennis ball when it leaves the racket?
- A) 2.40 m
 - B) 3.43 m
 - C) 10.0 m
 - D) 17.2 m
 - E) 22.0 m
47. An object weighs 85.2 N on Earth. The same object on Mercury weighs 32.2 N. What is the acceleration due to gravity on Mercury?
- A) 0.378 m/s^2
 - B) 2.65 m/s^2
 - C) 3.29 m/s^2
 - D) 3.70 m/s^2
 - E) 8.69 m/s^2
48. Consider two random objects; the first has a mass that is twice the mass of the second. This would mean that in general the more massive object also has twice of which of the following quantities?
- A) density
 - B) gravitational acceleration
 - C) inertia
 - D) momentum
 - E) volume
49. A hockey player hits a puck with his stick, giving the puck an initial speed of 5.0 m/s. If the puck slows uniformly and comes to rest in a distance of 20 m across the horizontal surface of the ice, what is the coefficient of kinetic friction between the ice and the puck?
- A) 0.013
 - B) 0.026
 - C) 0.064
 - D) 0.13
 - E) 0.51

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50. A merry-go-round has a radius of 4.40 m and a moment of inertia of $245 \text{ kg}\cdot\text{m}^2$. If a child applies a tangential force of 25.0 N to the edge of the merry-go-round for 20.0 s that was initially at rest then what is the angular velocity after this 20.0 s?
- A) 0.0224 rad/s
 B) 0.232 rad/s
 C) 0.464 rad/s
 D) 4.49 rad/s
 E) 8.98 rad/s
51. A rubber ball of mass m traveling horizontally with a speed v hits a wall and bounces back with the same speed. What is the magnitude of the change in momentum of the ball?
- A) 0
 B) $mv/2$
 C) $-mv$
 D) mv
 E) $2mv$
52. A student doing an experiment pours 0.150 kg of heated copper shot into a 0.375 kg aluminum calorimeter cup containing 0.200 kg of water at 25.0°C . The mixture and the cup come to thermal equilibrium at 28.0°C . What was the initial temperature of the shot? Given that the specific heats are as follows:
 $c_{\text{Al}} = 900 \text{ J}/(\text{kg}\cdot^\circ\text{C}^\circ)$, $c_{\text{Cu}} = 386 \text{ J}/(\text{kg}\cdot^\circ\text{C}^\circ)$ & $c_{\text{H}_2\text{O}} = 4186 \text{ J}/(\text{kg}\cdot^\circ\text{C}^\circ)$.
- A) 33.3°C
 B) 49.8°C
 C) 60.9°C
 D) 68.8°C
 E) 88.9°C
53. A solenoid has a cross sectional area of 4.00 cm^2 and is wound uniformly for 100 turns over a length of 10.0 cm. A second coil with 500 turns is wound uniformly on top of the first and is the same length. What is the mutual inductance of these coils? You may assume that they are ideal solenoids.
- A) $2.51 \times 10^{-4} \text{ H}$
 B) $2.51 \times 10^{-3} \text{ H}$
 C) $2.51 \times 10^{-2} \text{ H}$
 D) $2.51 \times 10^{-2} \text{ H}$
 E) $2.51 \times 10^1 \text{ H}$
54. At what distance from a proton is the magnitude of its electric field $1.0 \times 10^5 \text{ N/C}$?
- A) $1.8 \times 10^{-24} \text{ m}$
 B) $1.4 \times 10^{-14} \text{ m}$
 C) $1.3 \times 10^{-12} \text{ m}$
 D) $1.2 \times 10^{-7} \text{ m}$
 E) $3.8 \times 10^{-5} \text{ m}$
55. A parallel plate capacitor has a capacitance of 500.0 pF and a charge of magnitude $0.200 \mu\text{C}$ on each plate. The plates are 0.600 mm apart. What is the potential difference between the plates?
- A) $2.50 \times 10^{-3} \text{ V}$
 B) $2.40 \times 10^{-1} \text{ V}$
 C) $4.17 \times 10^0 \text{ V}$
 D) $4.00 \times 10^2 \text{ V}$
 E) $6.67 \times 10^5 \text{ V}$
56. Two identical resistors with resistance R are connected in parallel and then wired in series with a 40Ω resistor. If the total equivalent resistance is 55Ω what is the value of R ?
- A) 15Ω
 B) 25Ω
 C) 30Ω
 D) 70Ω
 E) 190Ω
57. A beam of light takes time t to travel a distance L through a liquid. If water is added to the liquid such that the new medium, i.e., the diluted medium, has an index of refraction of half the original, then what is the amount of time for light to travel the same distance in the new medium?
- A) $t/2$
 B) $t/2^{1/2}$
 C) t
 D) $2^{1/2} t$
 E) $2t$
58. If a person's eyeball is 2.7 cm deep instead of the usual 2.5 cm, then the person most likely suffers from which of the following?
- A) Astigmatism
 B) Color blindness
 C) Hyperopia (farsightedness)
 D) Myopia (nearsightedness)
 E) Presbyopia

59. At what angle will the second order diffraction maximum be seen from a diffraction grating with 800 lines/mm when illuminated by light of wavelength 550 nm?
- A) 12.7°
 - B) 26.1°
 - C) 52.2°
 - D) 61.6°
 - E) 66.1°
60. If it requires energy U to accelerate a rocket from rest to $\frac{1}{2}c$, the energy needed to accelerate that rocket from $\frac{1}{2}c$ to c would be
- A) $\frac{1}{2}U$
 - B) U
 - C) $2U$
 - D) $4U$
 - E) more than $4U$

UIL HIGH SCHOOL SCIENCE CONTEST
ANSWER KEY

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- | | | | | | |
|-----|---|-----|-------------------------------|-----|---|
| 1. | B | 21. | E | 41. | D |
| 2. | C | 22. | B | 42. | A |
| 3. | D | 23. | E | 43. | E |
| 4. | B | 24. | C | 44. | B |
| 5. | C | 25. | A | 45. | D |
| 6. | A | 26. | B | 46. | A |
| 7. | B | 27. | C | 47. | D |
| 8. | C | 28. | E | 48. | C |
| 9. | B | 29. | E | 49. | C |
| 10. | C | 30. | B | 50. | E |
| 11. | E | 31. | C | 51. | E |
| 12. | A | 32. | D | 52. | E |
| 13. | B | 33. | B omit
(no correct answer) | 53. | A |
| 14. | E | 34. | D | 54. | D |
| 15. | A | 35. | B | 55. | D |
| 16. | D | 36. | C | 56. | C |
| 17. | C | 37. | A | 57. | A |
| 18. | E | 38. | E | 58. | D |
| 19. | D | 39. | B | 59. | D |
| 20. | A | 40. | A | 60. | E |

PHYSICS KEY for Science Contest • Regional • 2010

41. (D) "Einstein advanced arguments which suggest that we *cannot send signals faster than the speed of light*, so the law of gravitation must be wrong. By correcting it to take the delays into account, we have a new law called Einstein's law of gravitation. One feature of this new law which is quite easy to understand is this: In the Einstein relativity theory, anything which has *energy* has mass..."
42. (A) "Many attempts have been made to unify them; the so-called unified field theory is only a very elegant attempt to combine electricity and gravitation; ..."
43. (E) Dr. B. F. L. Ward, Distinguished Professor of Physics at Baylor University, is interested in theoretical particle physics and has written numerous papers on particle-antiparticle pair production and/or annihilation by computer modeling using Monte Carlo techniques.
44. (B) The W^+ is a boson and mediates the weak force.
45. (D) $E_{\text{photon}} \geq E_{\text{mu}^+} + E_{\text{mu}^-} = 2E_{\text{mu}} = 2(1.8835 \times 10^{-28})(2.998 \times 10^8)^2 = 3.3858 \times 10^{-11} \text{ J} = 211.3 \text{ MeV}$
46. (A) $t = 19.6/28 = 0.7 \text{ s} \Rightarrow y_0 = \frac{1}{2}(9.8)(0.7)^2 = 2.40 \text{ m}$
47. (D) $(mg_{\text{Mercury}})/(mg_{\text{Earth}}) = 32.2/85.2 \Rightarrow g_{\text{Mercury}} = (32.2/85.2)9.8 = 3.70 \text{ m/s}^2$
48. (C) Since only the mass has been specified then the correct quantity can only depend upon the mass of the objects, which is the inertia of the objects. Recall that mass is a measure of the inertia of the object, which is the ability of an object to resist changes in its state of motion.
49. (C) By kinematics: $a = (v^2 - v_0^2)/(2(\Delta x)) = (0^2 - 5^2)/(2(20)) = -0.628 \text{ m/s}^2$ & by the free body diagram:
 $F_N = mg$ & $\Sigma F = F_{\text{fr}} = ma \Rightarrow \mu_k = F_{\text{fr}}/F_N = ma/mg = 0.628/9.8 = 0.064$
50. (E) There are many ways to solve this problem one way is by the rotational form of the 2nd law: $\alpha = \Sigma \tau / I = rF / I = 4.4(25)/245 = 0.4490 \text{ rad/s}^2$ & by rotational kinematics $\omega = 0 + \alpha t = 0.4490(20) = 8.98 \text{ rad/s}$
51. (E) $|\Delta p| = |mv - mv_0| = |m(+v) - m(-v)| = 2mv$ (p.s. don't forget the directions of the velocities)
52. (E) By the method of mixtures: $Q_{\text{Cu}} + Q_{\text{H}_2\text{O}} + Q_{\text{Al}} = 0$ with $Q = mc\Delta T \Rightarrow$
 $0.15(386)[28 - T] + 0.2(4186)[28 - 25] + 0.375(900)[28 - 25] = 0 \Rightarrow T = 88.9 \text{ }^\circ\text{C}$
53. (A) $M = \Phi_B / I = N_{\text{outer}} B_{\text{inner}} A_{\text{inner}} / I = N_{\text{outer}} (\mu_0 N_{\text{inner}} I / L) A_{\text{inner}} / I = \mu_0 N_{\text{inner}} N_{\text{outer}} A_{\text{inner}} / L$
 $= 4\pi \times 10^{-7} (100)(500)[0.0004] / (0.1) = 2.51 \times 10^{-4} \text{ H}$ (p.s. watch your units!)
54. (D) From $E = kq/r^2 \Rightarrow r = (kq/E)^{1/2} = [8.998 \times 10^9 (1.602 \times 10^{-19}) / 1.0 \times 10^5]^{1/2} = 1.2 \times 10^{-7} \text{ m}$
55. (D) $V = Q/C = 0.2 \times 10^{-6} / 500 \times 10^{-12} = 400 \text{ V}$
56. (C) $R_{\parallel} = (R^{-1} + R^{-1})^{-1} = R/2$ & $R_{\text{eq}} = R/2 + 40 = 55 \Rightarrow R = 30 \text{ } \Omega$
57. (A) $n = \frac{1}{2}n_0 \Rightarrow c/v = \frac{1}{2}(c/v_0) \Rightarrow v = 2v_0$ and thus for the same distance the time will be half as long.
58. (D) One of the common causes of myopia is an elongated eyeball.
59. (D) With $d = 1/(\text{lines/length}) = 1/800 = 0.00125 \text{ mm} = 1.25 \times 10^{-6} \text{ m}$ & from $d \sin \theta = n\lambda \Rightarrow$
 $\theta = \sin^{-1}(n\lambda/d) = \sin^{-1}(2(550 \times 10^{-9}) / 1.25 \times 10^{-6}) = 61.4^\circ$
60. (E) It takes an infinite amount of energy to accelerate a mass to the speed of light, which is why c is usually referred to as the universal speed limit.