



# The 62<sup>nd</sup> Annual Merck State Science Day Competition May 22, 2012

## INTEGRATED SCIENCE

### Directions:

**PLEASE DO NOT OPEN THE EXAM BOOKLET UNTIL DIRECTED.**

Be sure to fill in your name on the answer sheet both by printing it in the correct space and by filling in the corresponding letter in the spaces provided.

**Use a #2 pencil only.**

Carefully erase any errors, and do not make any extraneous marks on the answer sheet. Do NOT use *White-Out* on any portion of the answer sheet.

The test has **100 items** that will be scored. You have **90** minutes in which to answer all the questions.

There is only one correct answer per question. Do not spend too much time on any one question. Do the items you find easier first, and then go back to those you find more difficult or time consuming during the time you have remaining. Your individual score will be computed on the basis of the number of correctly answered items. (There is no penalty for guessing.)

In addition to the periodic table, there are several subject-specific items below that you may find useful in answering certain questions. Be sure to read them immediately after you are told to begin. You may refer to them at any time during the test.

### INFORMATION THAT MAY BE USEFUL IN SOLVING SOME PROBLEMS

$$1 \text{ calorie} = 4.184 \text{ joules}$$

$$1/f = 1/d_o + 1/d_i$$

$$C = 2f$$

$$h_i/h_o = d_i/d_o$$

$$E = hf$$

$$\text{speed of light in vacuum} = 3.0 \times 10^8 \text{ m/sec}$$

$$\text{Planck's constant, } h = 6.63 \times 10^{-34} \text{ joule-sec}$$

$$v = c \sqrt{1 - v^2/c^2}$$

$$\text{Avogadro's Number} = 6.02 \times 10^{23}$$

$$Q = mc\Delta T$$

$$KE_{\text{ave}} = 1/2mv^2$$

$$PE_{\text{grav}} = mgh$$

$$W = F \times S$$

$$K_f \text{ water} = 1.86 \text{ }^\circ\text{C/m}$$

$$\text{Universal gas constant: } R = 8.31 \text{ kPa-liter/(mole-K)} = 0.0821 \text{ atm-liter/(mole-K)}$$

$$W = Vq$$

$$v_{\text{avg}} = s/t$$

$$s = v_o t + 1/2at^2$$

$$v_f^2 = v_i^2 + 2as$$

$$v_f = v_i + at$$

$$c = f\lambda$$

$$P_1V_1/T_1 = P_2V_2/T_2$$

$$I = V/R$$

$$1 \text{ C} = 6.25 \times 10^{18} \text{ e}$$

$$D = M/V$$

$$v = f\lambda$$

$$P = W/t$$

$$1 \text{ e} = 1.6 \times 10^{-19} \text{ C}$$

$$K_b \text{ water} = 0.51 \text{ }^\circ\text{C/m}$$

# Periodic Table of the Elements

1 H 1.00794																1 H 1.00794	2 He 4.002602
3 Li 6.941	4 Be 9.012182											5 B 10.811	6 C 12.0107	7 N 14.00674	8 O 15.9994	9 F 18.9984032	10 Ne 20.1797
11 Na 22.989770	12 Mg 24.3050											13 Al 26.981538	14 Si 28.0855	15 P 30.973761	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.955910	22 Ti 47.867	23 V 50.9415	24 Cr 51.9961	25 Mn 54.938049	26 Fe 55.845	27 Co 58.933200	28 Ni 58.6934	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.92160	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.90585	40 Zr 91.224	41 Nb 92.90638	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.90550	46 Pd 106.42	47 Ag 107.8682	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.760	52 Te 127.60	53 I 126.90447	54 Xe 131.29
55 Cs 132.90545	56 Ba 137.327	57 La 138.9055	72 Hf 178.49	73 Ta 180.9479	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.217	78 Pt 195.078	79 Au 196.96655	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.98038	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 (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 (269)	111 (272)	112 (277)		114 (289) (287)		116 (289)		118 (293)

58 Ce 140.116	59 Pr 140.90765	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.964	64 Gd 157.25	65 Tb 158.92534	66 Dy 162.50	67 Ho 164.93032	68 Er 167.26	69 Tm 168.93421	70 Yb 173.04	71 Lu 174.967
90 Th 232.0381	91 Pa 231.03588	92 U 238.0289	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)

S.E. Van Bramer, 7/22/99

1995 IUPAC masses and Approved Names from <http://www.chem.qmw.ac.uk/iupac/AtWt/>  
masses for 107-111 from C&EN, March 13, 1995, P 35

112 from <http://www.gsi.de/z112e.html>

114 from C&EN July 19, 1999

116 and 118 from <http://www.lbl.gov/Science-Articles/Archive/elements-116-118.html>

**Multiple Choice**

Identify the letter of the choice that best completes the statement or answers the question and place your selection ON THE ANSWER SHEET.

1. You determine the melting point of a material to be  $7^{\circ}\text{C}$ . Suppose your lab measurement could be in error as much as  $2^{\circ}\text{C}$  either way. Which could be the unknown solid(s)?

material	melting point, $^{\circ}\text{C}$	boiling point, $^{\circ}\text{C}$
W	-7.5	8.0
X	6.0	150
Y	5.0	9.0
Z	4.5	8.0

- A) W and X  
B) X and Y  
C) Y and Z  
D) W, X, and Y  
E) only Y
2. Which properties of a gas vary directly with its temperature?  
I volume at constant pressure  
II pressure at constant volume  
III kinetic energy of the molecules  
IV size of the molecules
- A) I & II only  
B) I & III only  
C) II & III only  
D) I, II, and III only  
E) all of them
3. How many molecules of phosphorus trichloride gas,  $\text{PCl}_3$ , are in a 2.50 L container at a pressure of 14.0 atm and a temperature of  $25.0^{\circ}\text{C}$ ?  
A) 1.43  
B) 17.1  
C) 197  
D)  $8.62 \times 10^{23}$   
E)  $1.03 \times 10^{25}$
4. A vessel contains equal numbers of oxygen and of hydrogen molecules. The pressure is 760 mm Hg when the volume is 50.0 L. Which statement is *FALSE*?  
A) Equal numbers of moles of each gas are present.  
B) The average kinetic energies of oxygen and hydrogen are the same.  
C) If the oxygen were removed from the system, the pressure would drop to 109 mm Hg.  
D) On the average, the hydrogen molecules are traveling faster than the oxygen molecules.  
E) On the average, more hydrogen molecules strike the walls per second than oxygen molecules.
5. A container of water is being constantly heated. When a thermometer is placed in the water we find that the temperature of the water remains constant. What is the added energy doing to the system?  
A) Creating bubbles of air in the liquid.  
B) Breaking the water into hydrogen and oxygen gas.  
C) Creating bonds between the water droplets.  
D) Breaking the intermolecular forces in the water.  
E) Increasing the volume of the dissolved gases.



13. Consider the following equilibrium reaction:



What is the equilibrium constant expression for this system?

- A)  $K_{eq} = \frac{[\text{HCN}]^4 [\text{OH}^-]^2 [\text{Ca}^{2+}]^2}{[\text{Ca}(\text{CN})_2]^2 [\text{H}_2\text{O}]^3}$       D)  $K_{eq} = [\text{HCN}]^4 [\text{OH}^-]^2 [\text{Ca}^{2+}]^2$   
B)  $K_{eq} = \frac{[\text{HCN}][\text{OH}^-][\text{Ca}^{2+}]}{[\text{Ca}(\text{CN})_2][\text{H}_2\text{O}]}$       E)  $K_{eq} = [\text{HCN}][\text{OH}^-][\text{Ca}^{2+}]$   
C)  $K_{eq} = \frac{[\text{Ca}(\text{CN})_2]^2 [\text{H}_2\text{O}]^3}{[\text{HCN}]^4 [\text{OH}^-]^2 [\text{Ca}^{2+}]^2}$

14. Knowing which property would help the most in identifying a solid?

- A) mass      D) density  
B) volume      E) luster  
C) conductivity

15. In a jar of multicolored candies there are, 47 green.

How many red candies are in it, if there are:

- 3 blues for every 5 greens,  
2 reds for every 4 yellows,  
6 yellows for every 1 green,  
5 blues for every 6 yellows?

- A) 3      D) 141  
B) 4      E) 564  
C) 11

16. How many moles are in 232 grams of liquid bromine?

- A) 1.45 moles      D) 8120 moles  
B) 2.90 moles      E) 37100 moles  
C) 6.62 moles

17. How many grams of carbon dioxide contain  $5.6 \times 10^{24}$  molecules?

- A) 9.3 g      D)  $1.5 \times 10^{50}$  g  
B) 410 g      E)  $4.1 \times 10^{58}$  g  
C)  $3.4 \times 10^{48}$  g

18. The molecule,  $\text{Cu}(\text{H}_2\text{NCH}_2\text{CO}_2)_2(\text{H}_2\text{O})_2$  contains how many atoms?

- A) 5      D) 25  
B) 9      E) 44  
C) 13

19. Joseph Priestley discovered oxygen when he strongly heated mercury(II) oxide. It decomposed into its elements. What mass of oxygen is produced when 250. g of HgO is strongly heated?

- A) 18.5 g      D) 125 g  
B) 36.9 g      E) 846 g  
C) 73.9 g



28. A cell from an elodea is placed into a hypotonic environment. What will happen to this cell?
- Water will enter the cell causing the cell to explode
  - Water will enter the cell creating turgor pressure
  - Water will exit the cell causing the cell to shrink
  - Water will exit the cell causing the cell to lyse
  - Water will exit the cell creating osmotic pressure
29. How does the sodium-potassium pump create electrical impulses?
- ATP molecules lose **one** phosphate group which creates unbalanced charges
  - ATP molecules lose **two** phosphate groups which creates unbalanced charges
  - Exchange of three sodium ions for two potassium ions creates an electrical gradient
  - Exchange of two sodium ions for three potassium ions creates an electrical gradient
  - Both A and C are correct
30. What would occur to a cell that went through mitosis but not cytokinesis?
- The cell would contain two nuclei
  - The cell would contain half the number of chromosomes of the original cell
  - The cell would produce a cell plate
  - The cell would immediately die
  - The cell would immediately begin mitosis
31. How does the presence of lactose impact the *Lac Operon*?
- Lactose binds to the promoter region preventing the transcription of the gene
  - Lactose binds to the promoter region causing the gene to change shapes which allows transcription to occur
  - Lactose binds to the repressor protein which causes a change in the shape of the protein
  - Lactose binds to the repressor protein which causes the protein to bind to the promoter region of the gene
  - Lactose binds to the repressor protein which causes the cell to engulf the protein
32. Scientists are currently using gene therapy to treat genetic disorders such as cystic fibrosis. Which of the following are needed in order to accomplish this?
- |                        |                                  |
|------------------------|----------------------------------|
| A) Restriction Enzymes | D) Drosophila Cells              |
| B) Gel Electrophoresis | E) None of the above are correct |
| C) Stem Cells          |                                  |
33. Ecologists have estimated in a certain ecosystem that there is 20,000 Kcal of energy in the fourth trophic level. How much energy is estimated to exist in the second trophic level?
- |                 |                    |
|-----------------|--------------------|
| A) 2000 Kcal    | D) 2,000,000 Kcal  |
| B) 200 Kcal     | E) 20,000,000 Kcal |
| C) 200,000 Kcal |                    |
34. Below is a given food chain, what would happen if there were a decrease in the number of lions?
- Sunflower---Rabbit---Wolf---Lion
- The number of rabbits will decrease while the number of wolves will increase
  - The number of sunflowers, rabbits, and wolves will all increase
  - The number of sunflowers, rabbits, and wolves will all decrease
  - The number of wolves will increase while the number of rabbits will decrease and sunflowers will increase
  - The number of wolves will decrease while the number of rabbits and sunflowers will increase.

35. Which of the following are true concerning the rate of photosynthesis?
- A) As the temperature increases, the rate of photosynthesis decreases
  - B) As the temperature increases, the rate of photosynthesis plateaus
  - C) As the amount of light (light intensity) increases, the rate of photosynthesis decreases
  - D) As the amount of light (light intensity) increases the rate of photosynthesis remains the same
  - E) As the amount of light (light intensity) increases, the rate of photosynthesis increases and then plateaus
36. How would photosynthesis be impacted if there was no concentration gradient of protons in the thylakoid membrane?
- A) Without the concentration gradient, the electrons would not move along the electron transport chain
  - B) ADP would not be phosphorylated to form ATP
  - C) AMP would be phosphorylated to form ADP
  - D) Water would not be broken down to release oxygen
  - E) Both A and B are correct
37. What is needed to convert pyruvic acid into acetyl coA?
- A) ATP
  - B) NADH
  - C) FADH<sub>2</sub>
  - D) O<sub>2</sub>
  - E) Both B and C are correct
38. Which of the following statements is true about the Krebs Cycle?
- A) Acetyl coA combines with citric acid to form oxaloacetic acid
  - B) It occurs in the cristae of the mitochondria
  - C) It is dependent on glycolysis
  - D) Acetyl coA combines with glucose to form citric acid
  - E) Acetyl coA combines with glucose to form maltose
39. In minks, black hair is dominant to white hair. A mink breeder wants to determine whether his black haired mink, Henry, is homozygous or heterozygous. How could he do this?
- A) The mink breeder should mate Henry with another black haired mink.
  - B) The mink breeder should mate Henry's mother with a white haired mink.
  - C) The mink breeder should mate Henry with a white haired mink.
  - D) There mink breeder should mate Henry's father with a white haired mink.
  - E) There is no way to determine Henry's exact genotype.
40. In peas, green is dominant to yellow and smooth is dominant to wrinkled. The F1 generation of a cross between two plants yielded a phenotypic ratio of 9:3:3:1. What can you conclude about the parents in this genetic cross?
- A) Both parents are homozygous
  - B) Both parents are heterozygous
  - C) Both parents showed an incomplete dominance pattern of inheritance
  - D) One parent is homozygous dominant while the other parent is heterozygous
  - E) One parent is homozygous dominant while the other parent is homozygous recessive



41. Three genes (C,D,and E) are on the same chromosome. However, only C and E are usually expressed together in the same phenotype. Which answer below most logically explains this?
- A) The genes C and E are sex linked.
  - B) The genes C and E are probably located very close together so crossing over doesn't occur very often
  - C) The genes C and E are probably dominant while D is not.
  - D) The genes C and E do not follow Mendel's law of independent assortment.
  - E) The genes C and E do not follow Mendel's law of dominance.
42. Sharon and Bob Johnson are not colorblind. However, their son Tony is colorblind. Which answer below is the most logical explanation for this?
- A) Bob Johnson was a carrier for the colorblind allele
  - B) There was a mix up in the hospital and Tony is not really their son.
  - C) Sharon Johnson was a carrier for the colorblind allele
  - D) Colorblindness is a recessive allele and Sharon and Bob must be heterozygous for colorblindness
  - E) Colorblindness follows a co dominance pattern of inheritance
43. Which of the following statements would Darwin NOT agree with?
- A) More offspring are produced than can survive to maturity
  - B) Individual organisms should not compete with each other for limited resources
  - C) The individuals in a population have a variety of different traits
  - D) The environment selects the traits that are necessary for survival
  - E) Only some organisms survive long enough to reproduce
44. A scientist discovers a new fossil in the remote areas of Egypt. The scientist noted that the structure must have been some sort of wing. He also noted that it had a very similar resemblance to a penguin's fin; thus the scientist concludes that a penguin must have evolved from this organism. What type of evidence is the scientist using for his hypothesis?
- A) Vestigial Structures
  - B) Homologous Structures
  - C) Analogous Structures
  - D) Biochemical Evidence
  - E) Embryological Evidence
45. Which of the following words best completes the analogy below:
- vestigial : functional :: vacated : \_\_\_\_\_
- A) Used
  - B) Visceral
  - C) Broken
  - D) Homologous
  - E) Occupied
46. The numbers below correspond to the numbers of organisms found in different trophic levels. Which number corresponds to the highest trophic level?
- A) 5
  - B) 50
  - C) 500
  - D) 5000
  - E) 50,000

47. A raccoon usually lives in forested areas and feeds on insects; however, with the human population explosion these raccoons have been forced to live in rural environments and feed on garbage. This shift in behavior most closely relates to which terms?
- A) Subdividing and co-dividing resources
  - B) Generalists and Specialists
  - C) Predator and Prey
  - D) Intraspecific and interspecific competition
  - E) Fundamental vs. Realized Niche
48. What role do bacteria serve in the carbon cycle?
- A) Bacteria excrete carbon compounds into the soil
  - B) Bacteria convert carbon dioxide into carbon monoxide
  - C) Bacteria release carbon dioxide during cellular respiration
  - D) Bacteria release carbon compounds during photosynthesis
  - E) Bacteria break down carbon compounds
49. A student is trying to determine what type of fertilizer works best for her plants. She has three pots of ferns and adds Agway Fertilizer to one plant, Miracle Grow to the second plant, and no fertilizer to the third plant. Which of the following is true?
- A) The plant with the Miracle Grow is a control group
  - B) The plant with no fertilizer is the experimental group
  - C) The plant with the Agway Fertilizer is the control group
  - D) The independent variable is the plant
  - E) None of the above are correct
50. Below is an aquatic food chain. Which statement accurately describes this food chain?

Phytoplankton--Shrimp--Pufferfish--Tuna

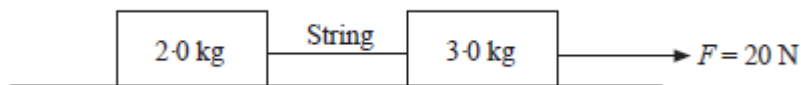
- A) Secondary is the highest trophic level in the food chain.
  - B) Based on this food chain, the pufferfish would be considered an omnivore.
  - C) Based on this food chain, the tuna would be considered a scavenger
  - D) The pufferfish is in the fourth (quaternary) trophic level.
  - E) Toxicants such as mercury levels would be highest in the tuna.
51. The Universe is \_\_\_\_\_ as proven by \_\_\_\_\_ of \_\_\_\_\_.
- A) expanding / blue shift / galactic groups
  - B) expanding / red shift / galactic clusters
  - C) contracting / blue shift / galaxies
  - D) contracting / red shift / solar systems
  - E) expanding / blue shift / solar systems
52. Which of the following does NOT contribute to how we experience the changing of the seasons?
- A) The varying length of day/night.
  - B) Earth's tilted axis.
  - C) The varying concentration of sunlight.
  - D) The distance from the Earth to the Sun.
  - E) The presence of the Earth's atmosphere

53. Put the following objects in the correct order, starting with the object that is closest to Earth and ending with the object that is farthest away.
- A) Moon, Sun, Clouds, Pluto, Stars
  - B) Clouds, Stars, Moon, Sun, Pluto
  - C) Clouds, Moon, Sun, Pluto, Stars
  - D) Clouds, Moon, Sun, Stars, Pluto
  - E) Clouds, Moon, Saturn, Venus, Pluto
54. Earthquakes are usually associated with all of the following EXCEPT: .
- A) California and Alaska
  - B) volcanoes
  - C) the edge of a tectonic plate.
  - D) the middle of a tectonic plate
  - E) mountain ranges
55. Which of the following responses most closely explains why it is hotter in Maine in June than it is in December?
- A) The Sun gives off more heat energy in June.
  - B) The Sun appears higher in the sky and provides more hours of daylight in June.
  - C) The Northern Hemisphere is closer to the Sun in June.
  - D) The Earth is closer to the Sun in June.
  - E) Snow reflects sunlight energy while foliage absorbs it.
56. Tides are not exactly 6 hours apart because:
- A) the Earth's rotation has to catch up to the Moon's orbital revolution
  - B) the Moon's rotation has to catch up to the Earth's rotation.
  - C) the Earth's rotation has to catch up to the Moon's rotation.
  - D) the Earth's orbital revolution has to catch up to the Moon's rotation.
  - E) the seabed exerts a frictional force on the water
57. Tectonically, Normal Faults are associated with \_\_\_\_\_ zones
- A) Divergent
  - B) Convergent
  - C) Strike-Slip
  - D) Lateral
  - E) Transformal
58. The Moon's diameter is about 1/4 that of earth. IF the two bodies had exactly the same average composition, the mass of the earth would be about \_\_\_\_\_ times the mass of the moon.
- A) 32
  - B) 34
  - C) 64
  - D) 67
  - E) 4290
59. Which would NOT be considered a reliable source of evidence supporting Plate Tectonic Theory?
- A) Real Time GPS measurements
  - B) Paleomagnetic reconstruction
  - C) Continental Fossil Correlation
  - D) Similarities in current Flora populations
  - E) Seismic and Volcanic activity
60. The following 5 objects are at various distances in SpaceTime from Earth. Which object would be in the **middle** of the list if these were ranked from closest to farthest?
- A) The Moon
  - B) The edge of the Virgo Cluster
  - C) The center of the Milky Way
  - D) The closest star
  - E) The Andromeda Galaxy

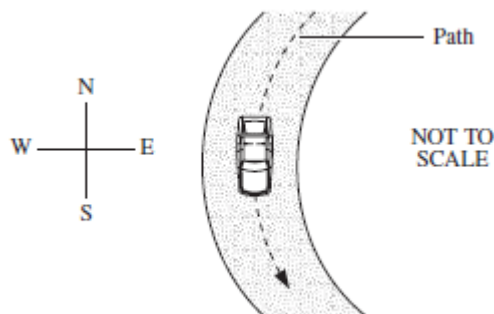
61. If a Mars Rover camera detects an obstacle in its path, what is the minimum time required between detection by the camera and evasive action to begin? (Assume that the rover is being steered by an operator on Earth which is, on average, 90 Mkm away.)
- A) 300 minutes
  - B) 90 minutes
  - C) 10 minutes
  - D) 5 minutes
  - E) 30 seconds
62. On approximately June 21, the Sun can be seen Directly Over Head At Noon at
- A) 23.50° N. Lat.
  - B) 23.50° S. Lat.
  - C) 0° Lat.
  - D) 43° N. Lat.
  - E) 43° S. Lat.
63. It is warmer in Portland, Maine than in Pierre, South Dakota on December 21 because:
- A) Maine is closer to the Sun on December 21
  - B) Maine is at a higher elevation
  - C) Maine is at a higher latitude
  - D) Maine is closer to a large body of water
  - E) Maine has a higher surface albedo
64. At the South Pole, on June 21, you get \_\_\_\_\_ hours of daylight
- A) 24
  - B) 18
  - C) 12
  - D) 6
  - E) 0
65. The half-life of carbon-14 is about 6000 years. Assume that a sample of charcoal formed by burning of living wood 15,000 years ago. How much of the original carbon-14 would remain today?
- A) between one-half and one-fourth
  - B) more than one-half
  - C) between one-half and one-third
  - D) between one-fourth and one-eighth
  - E) cannot be determined
66. Why are the Peruvian fisherman impacted by El Nino?
- A) The associated temperature changes of the water forced them to change their hunting strategy.
  - B) El Nino's affects caused many fish to die leaving a minimal amount left to hunt.
  - C) The high pressure over the west coast of South America creates difficult fishing conditions.
  - D) The fish's eating habits changed causing them to relocate.
  - E) The fishermen were not impacted by El Nino.
67. The time between a direct high tide and an indirect high tide is approximately
- A) 6 hours
  - B) 12 hours
  - C) 24 hours
  - D) 2 weeks
  - E) 1 month
68. The following is true about Deep Ocean Currents EXCEPT:
- A) They are generally interconnected worldwide to other ocean currents.
  - B) They have little to no effect on global climate and ocean health.
  - C) They may resurface thousands of kilometers from their source.
  - D) They are partially responsible for local & global climate change.
  - E) They are slow currents leading to long residence times for deep ocean water

69. The density of Seawater is  $1.03 \text{ kg/m}^3$ . The density of Ice is  $0.92 \text{ kg/m}^3$ . What fraction of a floating iceberg will typically be above water?
- A) 1/2
  - B) 1/4
  - C) 1/5
  - D) 1/8
  - E) 1/10
70. From these choices, the Earth is closest to the Sun on:
- A) December 21
  - B) March 21
  - C) June 21
  - D) September 21
  - E) The distance is almost constant.
71. Australia has summer weather on New Year's Eve while we have winter weather because:
- A) the southern Pacific Ocean acts as a heat reservoir.
  - B) the earth's orbit is elliptical
  - C) Australia is closer to the equator than New Jersey
  - D) the earth's axis is tilted relative to its orbit
  - E) the antarctic ozone hole is much bigger than the arctic one.
72. If an earthquake occurs on an island with a magnitude of 7 on the Richter scale and, later, an after-shock occurs with a magnitude of 4, the original quake was more powerful by what factor?
- A) 1.4 times
  - B) 3 times
  - C) 30 times
  - D) 300 times
  - E) 1000 times
73. Seismologists locate the epicenters of earthquakes by:
- A) measuring the time difference of S and P waves
  - B) measuring the amplitude of the strongest wave on a seismograph
  - C) comparing the seismograph recordings from 3 different locations
  - D) both b and c
  - E) both a and c
74. Mauna Loa in Hawaii is one of the largest (by volume) volcanoes in the world. It is classed as type:
- A) cinder cone
  - B) shield
  - C) composite
  - D) lava dome
  - E) pyroclastic
75. Which of the following gases is NOT generally observed in volcanic emissions?
- A)  $\text{SO}_2$
  - B)  $\text{H}_2\text{S}$
  - C)  $\text{HCl}$
  - D)  $\text{O}_3$
  - E)  $\text{CO}_2$
76. Today, the standard unit of time is defined in terms of
- A) the electromagnetic waves emitted by cesium atoms.
  - B) the motion of the moon around the earth.
  - C) the motion of a precision pendulum.
  - D) the average solar day.
  - E) the speed of light.
77. Which one of the following pairs of units may *not* be added together, even after the appropriate unit conversions have been made?
- A) grams and milligrams
  - B) millimeters and light years
  - C) miles and kilometers
  - D) centimeters and yards
  - E) kilograms and kilometers

78. The minimum takeoff speed for a certain airplane is 75 m/s. What minimum acceleration is required if the plane must leave a runway of length 950 m? Assume the plane starts from rest at one end of the runway.  
 A) 1.5 m/s<sup>2</sup>    B) 3.0 m/s<sup>2</sup>    C) 4.5 m/s<sup>2</sup>    D) 6.0 m/s<sup>2</sup>    E) 7.5 m/s<sup>2</sup>
79. A woman points her rowboat due north, straight across a river of width 100 m. The river flows from west to east. She rows steadily at 0.75 m/s and reaches the other side of the river at a point 150 m downstream from her starting point. What is the speed of the river?  
 A) 0.38 m/s    B) 0.67 m/s    C) 1.1 m/s    D) 6.7 m/s    E) 7.5 m/s
80. A rock is thrown horizontally from the top of a cliff with an initial speed of 20m/s. It strikes the level ground below exactly 40m from the base of the cliff. Approximately, how high is the cliff?  
 A) 5m    B) 10m    C) 15m    D) 20m    E) 40m
81. Two unequal masses separated by a distance  $R$ , experience a gravitational force  $F$  on each other. Which of the following would cause the gravitational force to quadruple to  $4F$ ?  
 A) Increase each mass by a factor of 4.  
 B) Increase the distance between them to  $4R$ .  
 C) Increase the distance between them to  $2R$ .  
 D) Decrease the distance between them to  $R/4$ .  
 E) Decrease the distance between them to  $R/2$ .

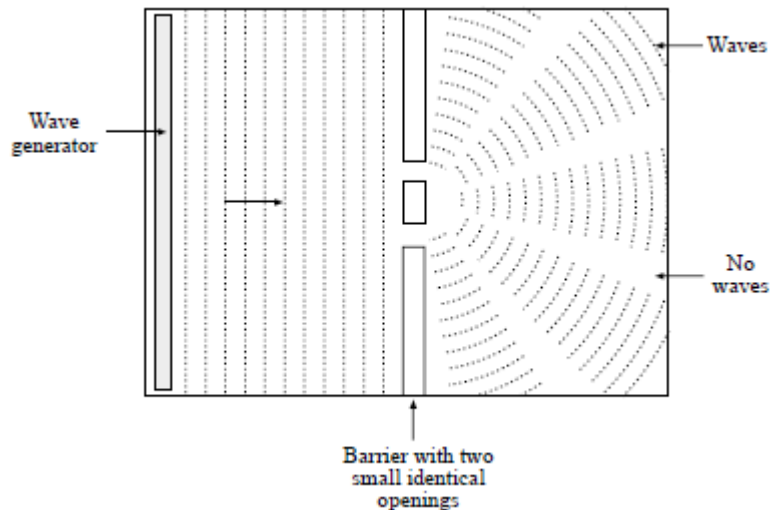


82. Two masses joined by a string are pulled along a horizontal, frictionless surface, as shown in the diagram above. What is the tension in the string joining the masses?  
 A) 2 N    B) 4 N    C) 8 N    D) 16 N    E) 20 N
83. A car is moving at a *constant* speed along a circular path, as shown in the diagram.



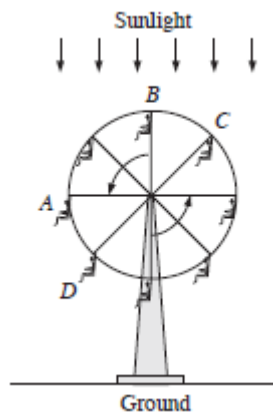
- At the instant shown, the car is moving south. Which statement best describes the acceleration at this instant?  
 A) The acceleration is directed to the south.  
 B) The acceleration is directed to the west.  
 C) The acceleration is directed to the east.  
 D) The acceleration is directed to the north.  
 E) The acceleration is zero.

84. The diagram below shows a pattern of water waves in a ripple tank. The depth of water is the same throughout the tank.



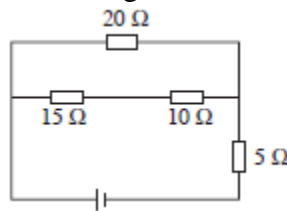
Which two properties of waves best explain the pattern on the right-hand side of the barrier?

- A) diffraction and reflection  
 B) interference and refraction  
 C) refraction and diffraction  
 D) refraction and reflection  
 E) diffraction and interference
85. At EPCOT Center in central Florida, the midday the sun shines directly down onto a Ferris wheel ride as shown below. The physics students on the ride are undergoing uniform circular motion. Their shadows appear on the ground directly beneath the Ferris wheel. At the instant shown above, the student whose shadow has the smallest linear speed on the ground is



- A) A  
 B) B  
 C) C  
 D) D  
 E) All shadow speeds are equal

86. This question refers to the following circuit diagram.



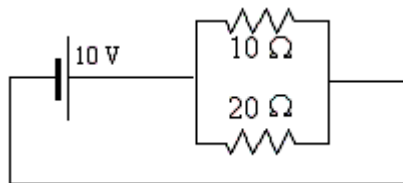
The value of the total resistance of this circuit is closest to

- A)  $12 \Omega$       B)  $16 \Omega$       C)  $25 \Omega$       D)  $50 \Omega$       E)  $96 \Omega$

87. The *electron volt* is a unit of

- A) energy.                                  D) electric potential difference.  
 B) electric field strength.                E) electric power.  
 C) electric charge.

88. What is the total power dissipated in the two resistors in the circuit shown?



- A) 10 W      B) 15 W      C) 33 W      D) 67 W      E) 670 W

89. The magnitude of the magnetic force that acts on a charged particle in a magnetic field is independent of

- A) the sign of the charge.  
 B) the magnitude of the charge.  
 C) the magnitude of the magnetic field.  
 D) the direction of motion of the particle.  
 E) the velocity components of the particle.

90. Which one of the following statements concerning a virtual image produced by a mirror is true?

- A) It is always larger than the object.  
 B) It is always smaller than the object.  
 C) It is always upright relative to the object.  
 D) It is always inverted relative to the object.  
 E) It can be seen from any vantage point.

91. Which one of the following expressions determines the critical angle for quartz ( $n = 1.5$ ) immersed in oil ( $n = 1.1$ )?

- A)  $\theta_c = 1.1/1.5$                                   D)  $\theta_c = \cos^{-1}(1.1/1.5)$   
 B)  $\theta_c = \sin^{-1}(1.5/1.1)$                         E)  $\theta_c = \tan^{-1}(1.1/1.5)$   
 C)  $\theta_c = \sin^{-1}(1.1/1.5)$



92. White light enters a glass prism and the color components of the light are observed to emerge from the prism; as on the cover of the best selling album of all time by a British band, *Dark Side of the Moon* by Pink Floyd. Which one of the following statements best explains this observation?

- A) The separation of white light into its color components is due to the increase in the speed of light within the glass.
- B) Some of the color components of the white light are absorbed by the glass and only the remaining components are observed.
- C) The index of refraction of the glass is dependent on the wavelength, so the color components are refracted at different angles.
- D) Only some of the color components are refracted by the glass; and these are the ones that are observed.
- E) White light is separated into its color components by total internal reflection within the prism.

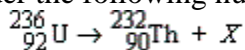
93. The Michelson-Morley experiment

- A) confirmed that time dilation occurs.
- B) proved that length contraction occurs.
- C) verified the conservation of momentum in inertial reference frames.
- D) supported the relationship between mass and energy.
- E) indicated that the speed of light is the same in all inertial reference frames.

94. The energy of a photon depends upon which one of the following parameters?

- A) mass
- B) amplitude
- C) polarization
- D) frequency
- E) phase relationships

95. Consider the following nuclear decay:



What is X ?

- A)  $\alpha$
- B)  $\text{P}^+$
- C)  $\beta^+$
- D)  $\beta^-$
- E) n

96. How much energy is dissipated in braking a 1000-kg car to a stop from an initial speed of 20 m/s?

- A) 10 KJ
- B) 20 KJ
- C) 200 KJ
- D) 400 KJ
- E) 2,000 KJ

97. An object of mass  $3m$ , initially at rest, explodes breaking into two fragments of mass  $m$  and  $2m$  respectively. Which one of the following statements concerning the fragments *after the explosion* is true?

- A) They may fly off at right angles.
- B) They may fly off in the same direction.
- C) The smaller fragment will have twice the speed of the larger fragment.
- D) The larger fragment will have twice the speed of the smaller fragment.
- E) The smaller fragment will have four times the speed of the larger fragment.

98. A sled of mass  $m$  is coasting on the icy surface of a frozen river. While it is passing under a bridge, a package of equal mass  $m$  is dropped straight down and lands on the sled (without causing any damage). The sled plus the added load then continue along the original line of motion. How does the kinetic energy of the sled + load compare with the original kinetic energy of the sled?
- A) It is  $1/4$  the original kinetic energy of the sled.
  - B) It is  $1/2$  the original kinetic energy of the sled.
  - C) It is  $3/4$  the original kinetic energy of the sled.
  - D) It is the same as the original kinetic energy of the sled.
  - E) It is twice the original kinetic energy of the sled.
99. Which of the following conditions results in the buildup of static charge on an object?
- A) when neutrons outnumber electrons
  - B) when there are more protons than neutrons
  - C) when there are more electrons than protons
  - D) when all neutrons have been removed from the object
  - E) when electrons outnumber neutrons
100. The specific heat of wood is about  $1,700 \text{ J/kg} \cdot ^\circ\text{C}$ . How much energy is required to heat a 12 kg piece of wood from  $20^\circ\text{C}$  to  $30^\circ\text{C}$ ?
- A) 1,400 J
  - B) 17,000 J
  - C) 204,000 J
  - D) 408,000 J
  - E) 612,000 J

Merck State Science Day 2012  
Answer Key

Integrated Science

Multiple Choice

- |                    |                    |        |
|--------------------|--------------------|--------|
| 1. B               | 40. B              | 80. D  |
| 2. D               | 41. B              | 81. E  |
| 3. D               | 42. <del>B</del> C | 82. C  |
| 4. C               | 43. B              | 83. C  |
| 5. D               | 44. B              | 84. E  |
| 6. B               | 45. E              | 85. A  |
| 7. B               | 46. A              | 86. B  |
| 8. A               | 47. E              | 87. A  |
| 9. E               | 48. C              | 88. B  |
| 10. A              | 49. E              | 89. A  |
| 11. C              | 50. E              | 90. C  |
| 12. C              | 51. B              | 91. C  |
| 13. D              | 52. D              | 92. C  |
| 14. D              | 53. C              | 93. E  |
| 15. D              | 54. D              | 94. D  |
| 16. A              | 55. B              | 95. A  |
| 17. B              | 56. A              | 96. C  |
| 18. D              | 57. A              | 97. C  |
| 19. <del>C</del> A | 58. <del>B</del> C | 98. B  |
| 20. A              | 59. D              | 99. C  |
| 21. C              | 60. C              | 100. C |
| 22. C              | 61. C              |        |
| 23. D              | 62. A              |        |
| 24. E              | 63. D              |        |
| 25. D              | 64. E              |        |
| 26. E              | 65. D              |        |
| 27. E              | 66. A              |        |
| 28. B              | 67. B              |        |
| 29. C              | 68. B              |        |
| 30. A              | 69. D              |        |
| 31. C              | 70. A              |        |
| 32. A              | 71. D              |        |
| 33. D              | 72. E              |        |
| 34. D              | 73. E              |        |
| 35. E              | 74. B              |        |
| 36. B              | 75. D              |        |
| 37. B              | 76. A              |        |
| 38. C              | 77. E              |        |
| 39. C              | 78. B              |        |
|                    | 79. C              |        |