The 61st Annual
Merck State Science Day Competition
May 17, 2011

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 **115 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 calorie = 4.184 joules

$1/f = 1/d_o + 1/d_l$

$C = 2f$

$h_i/h_o = d_i/d_o$

$E = hf$

speed of light in vacuum = 3.0×10^8 m/sec

Planck's constant, h = 6.63×10^{-34} joule-sec

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

Avogadro's Number = 6.02×10^{23}

$Q = mc\Delta T$

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

$PE_{grav} = mgh$

$W = F \times S$

$W = Vq$

$v_{avg} = s/t$

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

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

$v_f = v_i + at$

$c = f\lambda$

$P_1V_1/T_1 = P_2V_2/T_2$

$I = V/R$

1 C = 6.25×10^{18} e⁻

$D = M/V$

$v = f\lambda$

$P = W/t$

K_f water = 1.86 °C/m

K_b water = 0.51°C/m

Universal gas constant: R = 8.31 kPa-liter/(mole-K) = 0.0821 atm-liter/(mole-K)

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

1. The correct name for anion, OH^-, is
   A) hydrogen oxide
   B) oxyhydride
   C) hydroxide
   D) hypoxate
   E) hydroxate

2. An element X forms a compound with the formula XCl_2 that is 52.0% Cl (35.5 g/mole) by mass. X is:
   A) S
   B) Fe
   C) Zn
   D) Mg
   E) Ti

3. An example of the law of multiple proportions is:
   A) A sample of chlorine is found to contain three times as much Cl-35 as Cl-37.
   B) Two different compounds formed from carbon and oxygen have the following mass ratios:1.33 g O: 1 g C and 2.67 g O: 1 g C.
   C) The atomic weight of sulfur is twice that of oxygen and they are in the same family.
   D) The atomic mass of bromine is found to be 79.90 amu.
   E) Two different samples of table salt are found to have the same ratio of sodium to chlorine.

4. Where are electrons found in atoms?
   A) In the nucleus
   B) In orbits around the nucleus
   C) Traveling through the nucleus
   D) In clouds around the nucleus.
   E) Traveling between the inside and outside of the nucleus

5. One reaction involved in the conversion of iron ore to the metal is:

$$FeO(s) + CO(g) \rightarrow Fe(s) + CO_2(g)$$
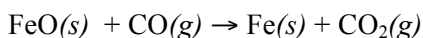
reaction	ΔH^o
$3\ Fe_2O_3(s) + CO(g) \rightarrow 2Fe_3O_4(s) + CO_2(g)$	-47.0 kJ
$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$	-25.0 kJ
$Fe_3O_4(s) + CO(g) \rightarrow 3FeO(s) + CO_2(g)$	19.0 kJ

   The ΔH^o for this reaction is:

   A)   -26.7 kJ
   B)   -11.0 kJ
   C)   -3.0 kJ
   D)   +11.0 kJ
   E)   +14.0 kJ

6. What is the correct procedure for students to follow if a chemical is spilled?
   A) Panic and run madly about the room.
   B) Cover it so your teacher won't see it.
   C) Splash large amounts of water onto the spill.
   D) Stand back and advise the teacher of the spill.
   E) Take a picture with your cell phone and send to your best freind in another class.

7. An HCl solution is titrated to a pink phenolphthalein endpoint with a NaOH solution while stirring. If the solution becomes pink throughout but loses its color upon standing for a short time, what should be done to restore the color?
   A) Add an additional drop of NaOH solution.
   B) Add an additional drop of HCl solution.
   C) An error has occurred, repeat titration.
   D) Add more phenolphthalein indicator.
   E) Stir more vigorously.

8. Which element reacts with water most rapidly at room temperature to produce a gas?
   A) zinc
   B) carbon
   C) sulfur
   D) potassium
   E) phosphorus

9. How many atoms are described by the formula $Na_2CO_3 \cdot 10H_2O$
   A) 4
   B) 16
   C) 36
   D) 60
   E) 96

10. What is the molarity of a 10 mL solution in which 3.7 g of KCl are dissolved?
    A) 0.05 M
    B) 0.1 M
    C) 1 M
    D) 5 M
    E) 10 M

11. Which represents a set of allotropes
    A) O_2 and O_3
    B) C-12 and C-14
    C) CO_2 and CO
    D) C_4H_{10} and C_4H_{10}
    E) PCl_3 and PCl_5

12. A copper salt solution is heated in a flame.. The expected color observed would be: Eliminated
    A) red
    B) orange
    C) yellow
    D) green
    E) blue

13. The name for $HClO_4$ is:
    A) chloric acid
    B) perchloric acid
    C) chlorous acid
    D) hypochlorous acid
    E) hydrocloric acid

14. Every amino acid contains carbon, hydrogen, oxygen, and
    A) Sulfur
    B) Phosphorus
    C) Nitrogen
    D) Nitrogen and sulfur
    E) Nitrogen and phosphorus

15. How many unpaired electrons are present in the ground state of gaseous Fe^{2+}?
    A) 0
    B) 3
    C) 4
    D) 5
    E) 6

16. In balancing the following aqueous reaction, the sum of the coefficients of the **products** is:

$$\_CrCl_3(aq) + \_H_2O_2(aq) + \_NaOH(aq) \rightarrow \_Na_2CrO_4(aq) + \_H_2O(aq) + \_NaCl(aq)$$

    A) 3
    B) 5
    C) 13
    D) 16
    E) 31

17. At equilibrium the concentrations were 0.020 M SO_2 and 0.030 M O_2. After equilibrium was reached the concentration of SO_3 was 0.040 M. What is K_c for this reaction?

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$
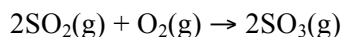
A) 0.0075 D) 67
B) 0.015 E) 133
C) 0.053

18. The reaction profile below is for the chlorination of methane, which of the following statements is **true**:
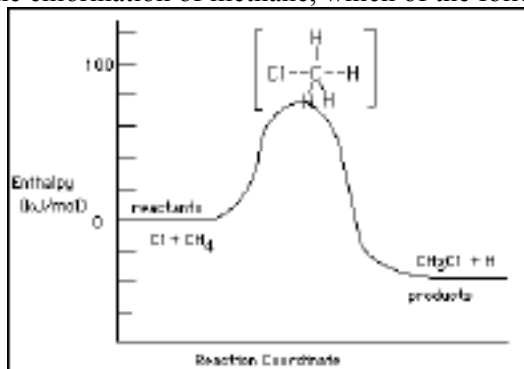
I.   The activation energy for the forward reaction is about 80 kJ/mol.
II. The overall reaction is exothermic.
III. The species at the top of the barrier is the activated complex.

A) I and II D) I, II and III
B) I and III E) I only
C) II and III

19. A weather balloon with a 2-meter diameter at ambient temperature holds 525 grams of helium. What type of electronic probe could be used to determine the pressure inside the balloon?
A) barometric D) spectrophotometric
B) calorimetric E) pH
C) thermometric

20. A sample of carbon dioxide gas occupies a volume of 20 L at standard temperature and pressure (STP). What will be the volume of a sample of argon gas that has the same number of moles and pressure but twice the absolute temperature?
A) 10 L D) 60 L
B) 20 L E) 80 L
C) 40 L

21. A mass of 5.4 grams of aluminum (Al) reacts with an excess of copper (II) chloride ($CuCl_2$) in solution, as shown by the equation:.
$$3\ CuCl_2\ + 2\ Al\ \rightarrow\ 2\ AlCl_3\ +\ 3\ Cu$$
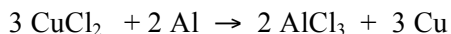
What mass of solid copper (Cu) is produced?
A) 0.65 g D) 13 g
B) 5.4 g E) 19 g
C) 8.5 g

22. The picture below shows a light bulb connected to a battery with the circuit interrupted by a solution. When dissolved in the water to form a 1.0 molar solution, all of the following substances will complete a circuit allowing the bulb to light *except*

A) sucrose
B) table salt
C) sodium nitrate
D) hydrochloric acid.
E) ammonium sulfate

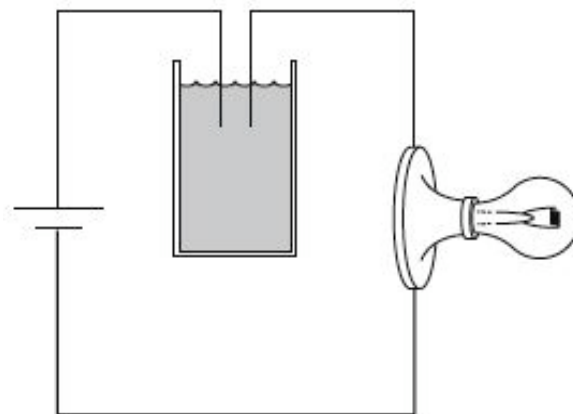**23.** Why is bleach, sodium hypoclorite (NaClO), sometimes added to wash laundry?
A) It oxidizes stains.
B) It reduces fabric dye.
C) It acts as a water softener.
D) It acts as a detergent booster.
E) It combines with fibers to make them stonger.

24. Which of these is an example of an exothermic chemical process?
A) melting ice
B) dissolving of salt
C) evaporation of water
D) freezing of water
E) photosynthesis of glucose

25. The volume of 400 mL of chlorine gas at 400 mm Hg is decreased to 200 mL at constant temperature. What is the new gas pressure?
A) 200 mm Hg
B) 300 mm Hg
C) 400 mm Hg
D) 650 mm Hg
E) 800 mm Hg

26. On which date would the Earth be at an equinox?
A) January 3rd
B) February 14th
C) June 21st
D) September 23rd
E) December 21st

27. When the Southern Hemisphere is tilted toward the lit half of the Earth, which would be your most likely activity here in New Jersey?

A) shoveling snow
B) enjoying your summer break
C) smelling the fresh spring breeze
D) crunching through the autumn leaves
E) you cannot tell based on the given information.

28. If there were more of a tilt, Earth would experience _____.
   A) the same seasons we experience today
   B) completely opposite seasons from today (winter when we used to have summer)
   C) warmer seasons on average everywhere
   D) less wild seasonal changes than we experience today
   E) more wild seasonal changes than we experience today

 # 29, 30, 31, Use the following air temperature and dew point graphs for Walpack, NJ and Woodbine, NJ:

GRAPH A   GRAPH B

GRAPH C   GRAPH D
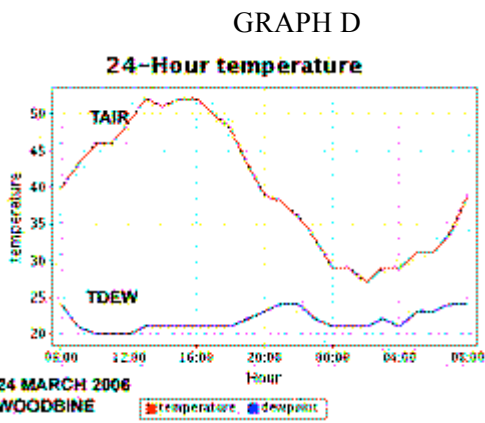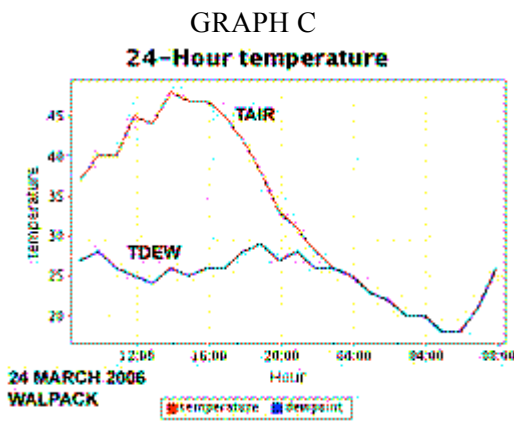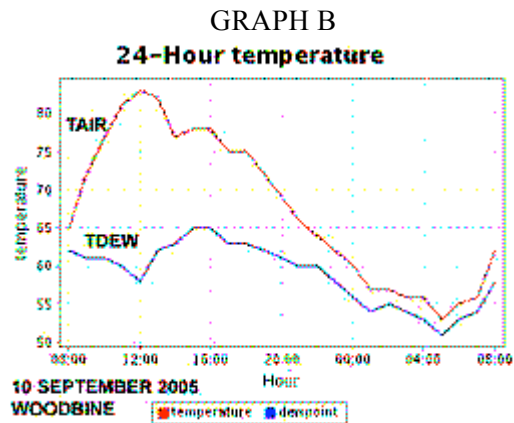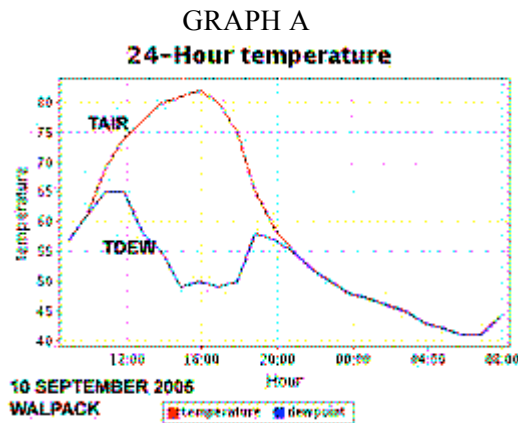
Hours: 12:00 16:00 20:00 00:00 04:00 08:00

29. When did frost begin to occur at Walpack on the evening of 10 September 2005?
   A) 12pm (1200)   **D)** 7am (0700)
   B) 8pm (2000)   **E)** Frost never occurred.
   C) 12am (0000)

30. The graph with the warmest HIGH temperature is _____.

   A) Graph A   **D)** Graph D
   B) Graph B   **E)** Unable to be determined by the data.
   C) Graph C

31. The graph that is saturated at the warmest air temperature is _____.

   A) Graph A   **D)** Graph D
   B) Graph B   **E)** Unable to be determined by the data
   C) Graph C

32. This type of cloud would most likely occur along a cold front.
- **A)** Stratus
- **B)** Cirrus
- **C)** Cumulonimbus
- **D)** Altocumulus
- **E)** Cirrostratus

#33 & 34, use the weather map below.
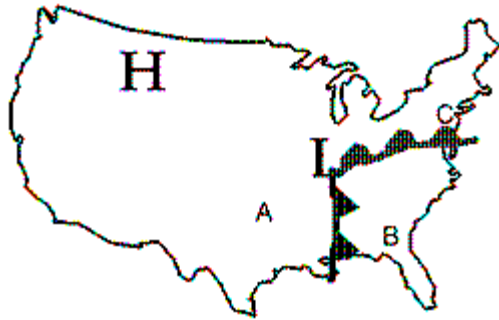
U.S. Surface Weather Map

33. What is the weather like at location A?
- **A)** warm and humid with scattered clouds and showers
- **B)** cool and cloudy with steady rain or snow
- **C)** cold and dry with few or no clouds
- **D)** warm and dry with few or no clouds
- **E)** cold and moist with steady snow

34. What type of front exists between locations B and C?
- **A)** cold front
- **B)** warm front
- **C)** stationary front
- **D)** occluded front
- **E)** pressure front

35. Aphelion means that _____.
- **A)** The Earth is at its farthest point from the Sun
- **B)** The Earth is at its closest point from the Sun
- **C)** The Moon is at its farthest point from the Sun
- **D)** The Moon is at its closest point from the Sun
- **E)** The Sun is at its apogee.

36. Kepler's Law of Equal Areas says that _____.
- **A)** the area covered throughout January by an imaginary line drawn from the Earth to the Sun would be the same as the area covered in July
- **B)** the area covered throughout January by an imaginary line drawn from the Earth to the Sun would be greater than the area covered in July
- **C)** the area covered throughout January by an imaginary line drawn from the Earth to the Sun would be less than the area covered in July
- **D)** the orbits of all objects around the Sun are elliptical
- **E)** the orbits of all objects around the Sun are circular

37. What is the "new" gravitational force (F) between two objects if you take 1/8 the mass of both objects and 1/8 the distance between them? Note: $F = [(G)(m_1)(m_2)] / [d^2]$
   A) The new force = the old force
   B) The new force = 1/4 the old force
   C) The new force = 4 times the old force
   D) The new force = 8 times the old force
   E) The new force = 16 times the old force

38. The closest star to the Earth is _____.
   A) Vega
   B) Proxima Centauri
   C) Betelgeuse
   D) the Moon
   E) the Sun

39. Red and green light combine to make _____ light.
   A) yellow
   B) white
   C) blue
   D) magenta
   E) cyan

40. LUNAR eclipses will tend to occur within an hour or two of _____.
   A) Midnight
   B) Noon
   C) Sunset
   D) 9pm
   E) 6am

41. Proxima Centauri, the closest star to the Sun is located _____ away.
   A) 4.2 Astronomical Units
   B) 1 Light Year
   C) 4.2 Light Years
   D) 100,000 Light Years
   E) 4,200,000,000 miles

42. The Big Bang theory states that _____.
   A) a supermassive white hole spewed forth one galaxy at a time
   B) a huge sphere of carbon expanded outward, creating clusters of galaxies
   C) a huge sphere of hydrogen expanded outward, creating clusters of galaxies
   D) supermassive black holes suddenly appeared in different places, causing stars to form
   E) a gigantic supernova exploded, creating galaxies that spun off to form other, smaller galaxies

43. At which point on Earth would you most likely be taking photos of penguins?
   A) $(84^oS, 4^oE)$
   B) $(40^oN, 75^oE)$
   C) $(62^oS, 171^oW)$
   D) $(7^oS, 60^oW)$
   E) $(26^oS, 131^oE)$

44. Which of the following is a renewable resource?
   A) geothermal
   B) coal
   C) oil
   D) natural gas
   E) tar sands

45. The layer of the Earth that is COMPLETELY LIQUID is the _____.
   A) outer core
   B) mantle
   C) crust
   D) inner core
   E) exosphere

46. This mineral represents a "7" on Moh's Hardness Scale.
   A) calcium
   B) calcite
   C) gypsum
   D) corundum
   E) quartz

47.
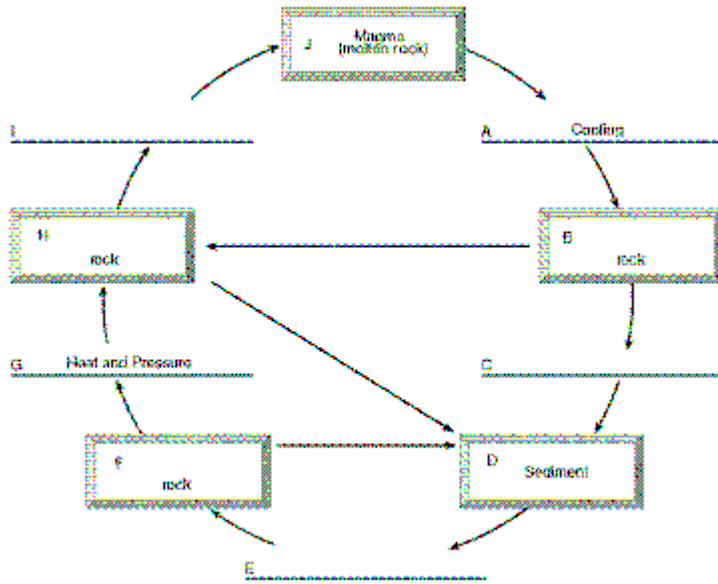
Figure 1

What PROCESS occurs at Location E in the above figure?

- **A)** melting
- **B)** weathering/erosion
- **C)** compaction/cementation
- **D)** metamorphism
- **E)** heat and pressure

48. Stalactite and stalagmite formations in caverns are usually made out of _____.

- **A)** granite
- **B)** limestone
- **C)** rock salt
- **D)** clastic
- **E)** shale

49. The location underground where the rock on either side of a fault line slips is known as the _____.

- **A)** epicenter
- **B)** shadow zone
- **C)** body line
- **D)** focus
- **E)** thermocline

50. Which are possible warning signs of an approaching tsunami?

- **A)** Water pulling away from the coastline
- **B)** Local wildlife fleeing the area
- **C)** An earthquake
- **D)** both A and B
- **E)** A, B and C could all be tsunami warning signs

51. Shield volcanoes have long, broad, gently sloping sides due primarily to _____.

- **A)** the liquid, easily flowing nature of their lava
- **B)** their tremendous outward explosions
- **C)** their very rare rate of erupting lava
- **D)** the Law of Superposition
- **E)** both A and C

#52 & 53, Use the following table to answer the question for the location marked "X".

Diagram	Boundary Type	Motion at Boundary	Feature Formed	Example
	Transform	Sliding/ side-to-side		
			Trenches and volcanic mountains	Andes Mountains, South America
X	Convergent - Collision			
		Spreading Apart		Mid-Atlantic Ridge

52. The diagram for this boundary includes:
 A) oceanic crust subducting underneath oceanic or continental crust
 B) continental crust spreading away from continental crust
 C) continental crust colliding with continental crust
 D) two plates moving side by side
 E) both B and C

53. This is a _____ boundary.
 A) convergent-subduction
 B) divergent
 C) transform
 D) concave
 E) convergent-collision

54. What does evapotranspiration mean?
 A) plant life giving water vapor back to the atmosphere
 B) water flowing underground
 C) all wet surfaces and plant life giving water vapor back to the atmosphere
 D) water leaving the surface and condensing into clouds
 E) both A and B

55. _____ are the major producers of energy from photosynthesis in the ocean, requiring a mix of _____.
 A) Phytoplankton , sunlight and salt
 B) Phytoplankton , nutrients and sunlight
 C) Fish , nutrients and sunlight
 D) Phytopericellis , sunlight and salt
 E) Fish, sunlight and salt

56. The condition that is directly manipulated by the experimenter in a controlled experiment is the
 A) dependent variable
 B) free variable
 C) experimental variable
 D) independent variable
 E) controlled variable

57. A covalent double bond could form between any of the following atom pairs except:
- **A)** carbon and another carbon
- **B)** carbon and hydrogen
- **C)** carbon and nitrogen
- **D)** carbon and oxygen
- **E)** nitrogen and oxygen

58. Which bonds must be broken in order for water to go from a liquid to a gas?
- **A)** covalent
- **B)** ionic
- **C)** hydrogen
- **D)** disulfide bridge
- **E)** coordinate covalent

59. Because the water molecule has two distinct ends, each with a partial electrical charge, water is said to be
- **A)** ionic
- **B)** liquid
- **C)** magnetic
- **D)** polar
- **E)** nonpolar

60. Proteins are polymers of
- **A)** amino acids
- **B)** nucleotides
- **C)** fatty acids
- **D)** monosaccharides
- **E)** polysaccharides

61. The chemical reaction by which monosaccharides are linked together is
- **A)** catalysis
- **B)** hydrolysis
- **C)** peptide bonding
- **D)** ester linkage
- **E)** dehydration synthesis

62. Which of the following is not part of a nucleotide?
- **A)** phosphate
- **B)** amino acid
- **C)** pentose sugar
- **D)** nitrogenous base
- **E)** all are part of a nucleotide

63. In some places a protein molecule may twist or fold back on itself. This is called_____and the coils or folds are held in place by
- **A)** tertiary structure...hydrogen bonds
- **B)** secondary structure...hydrogen bonds
- **C)** secondary structure...peptide bonds
- **D)** tertiary structure...covalent bonds
- **E)** primary structure....peptide bonds

64. Proteins whose tertiary structure has been detrimentally and permanently altered are referred to as being
- **A)** energized
- **B)** deconstructed
- **C)** denatured
- **D)** rendered
- **E)** destroyed

65. ATP energizes cellular processes by
- **A)** acting as a catalyst
- **B)** releasing heat upon hydrolysis
- **C)** direct chemical transfer of a phosphate group
- **D)** releasing ribose electrons to an electron transport chain
- **E)** none of the above

66. The function of which of the following would be most affected by a poison interfering with the formation of proteins?
- **A)** ribosomes
- **B)** chloroplasts
- **C)** centrioles
- **D)** mitochondria
- **E)** golgi bodies

67. Facilitated diffusion is not the same as active transport because facilitated diffusion
- **A)** moves many kinds of materials with the same carrier
- **B)** cannot transport negative ions such as Cl⁻
- **C)** does not depend on cellular energy
- **D)** transports material only inward
- **E)** all of the above

68. A cell possesses ribosomes, a plasma membrane, a cell wall, and other parts. It could not be
- **A)** a bacterium
- **B)** a cell from a corn plant
- **C)** a cell from a mouse
- **D)** a cell from an oak tree
- **E)** a cell from a palm tree

69. Within a leaf, there are many air spaces between the cells of the
- **A)** palisade layer
- **B)** spongy mesophyll
- **C)** upper epidermis
- **D)** lower epidermis
- **E)** there are no air spaces within a leaf

70. When leaves are viewed under a microscope, generally there is a gap above each pair of guard cells. What purpose does this chamber serve?
- **A)** regulates the size of the stomata
- **B)** prevents water from evaporating
- **C)** helps the guard cells to open and close
- **D)** provides a place for gas molecules to diffuse in or out of the mesophyll
- **E)** all of the above

71. Green leaves kept in the dark for several days are tested for starch and no starch is found. What hypothesis would this investigation test?
- **A)** starch turns to sugar
- **B)** light is necessary for starch production
- **C)** plants store starch in their roots
- **D)** chlorophyll uses starch for food
- **E)** plants never produce starch

72. The site of the light reactions in photosynthesis is
- **A)** the thylakoid
- **B)** the cristae
- **C)** the stroma
- **D)** the cytoplasm
- **E)** waxy cuticle

73. Photorespiration starts when
- **A)** alcoholic fermentation starts
- **B)** oxygen combines with RuBP
- **C)** light intensities are low
- **D)** ATP molecules are needed
- **E)** light intensities are high

74. ~~Which of the following is not produced in the light reactions?~~ Eliminated
- ~~**A)** oxygen~~
- ~~**B)** NADPH~~
- ~~**C)** G3P~~
- ~~**D)** carbon dioxide~~
- ~~**E)** none of the above~~

75. The final acceptor for all electrons produced in cellular respiration is
- **A)** water
- **B)** carbon dioxide
- **C)** ATP
- **D)** oxygen
- **E)** hydrogen

76. Lactate (lactic acid) formation in the muscles produces pain. The lactate is formed from
- **A)** pyruvate in the presence of oxygen
- **B)** pyruvate in the absence of oxygen
- **C)** acetate in the presence of oxygen
- **D)** acetate in the absence of oxygen
- **E)** none of the above

77. In the inner membranes of mitochondria and chloroplasts, what supplies the energy needed to move and concentrate protons onto one side of a membrane?
   A) the energy in the chemical bonds of molecular oxygen
   B) the breakdown of water into hydroxyl and hydrogen ions
   C) the flow of electrons through a series of redox reactions
   D) the flow of sodium ions from the inside to the outside of the membrane
   E) all of the above

78. In RNA, the code word AUG that specifies methionine can also serve as a(n)
   A) anticodon
   B) termination codon
   C) initiation codon
   D) stop codon
   E) amino acid

79. If the coding strand of DNA has the nitrogenous base sequence ATCGT, the RNA copied from it has the sequence
   A) TAGCA
   B) TUGCU
   C) UAGCU
   D) UAGCA
   E) AGUTC

80. All of the following can result from chromosomal non-disjunction except
   A) polyploidy
   B) Down's Syndrome
   C) Turner's Syndrome
   D) Edwards Syndrome
   E) sickle cell anemia

81. The greater the distance between two linked genes the
   A) more likely it is that all parental type offspring will result
   B) more likely it is that there will be recombinations
   C) less likely it is that there will be recombinations
   D) more likely it is that the genes will mutate
   E) less likely the gene will mutate

82. If a pea plant that is heterozygous for round, yellow peas (RrYy) is crossed with a pea plant that is homozygous for round peas but heterozygous for yellow peas (RRYy), how many different phenotypes are their offspring expected to show?
   A) 2
   B) 4
   C) 8
   D) 16
   E) 24

83. A cross of a black chicken (BB) with a white chicken (WW) produces all speckled offspring (BW). This type of inheritance is known as
   A) incomplete dominance
   B) polygenic inheritance
   C) codominance
   D) multiple alleles
   E) none of the above

84. Unlike mitosis, meiosis results in the formation of
   A) two genetically identical cells
   B) four genetically different cells
   C) four genetically identical cells
   D) two genetically different cells
   E) eight genetically different cells

85. If a man with blood type A and a woman with blood type B produce an offspring, what <u>might</u> be the offspring's blood type?
   A) AB or O
   B) A,B, or O
   C) A,B,AB, or O
   D) AB only
   E) O only

86. When you listen to your favorite radio station, NJ 105.9 News, it involves which area of physics?
- **A)** optics
- **B)** relativity
- **C)** mechanics
- **D)** thermodynamics
- **E)** vibrations and wave phenomena
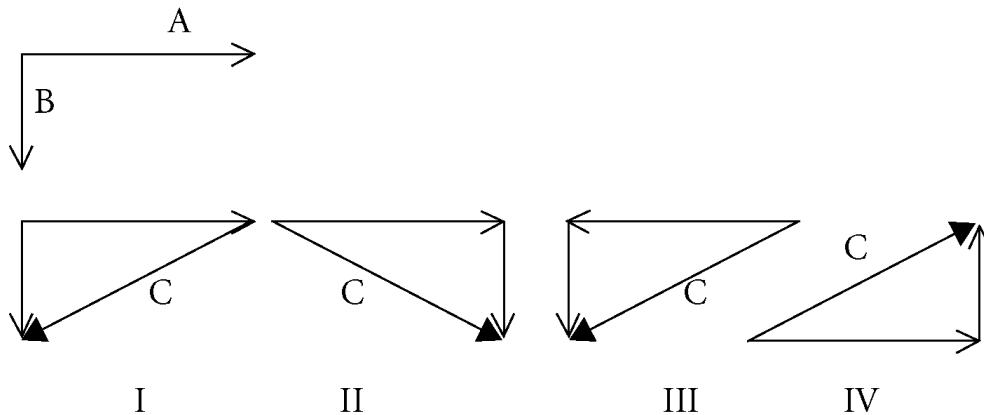
87. In the figure above, which diagram represents the vector addition **C** = **A** + **B**?
- **A)** I
- **B)** II
- **C)** III
- **D)** IV
- **E)** None of the above

88. When both velocity and acceleration are negative, what is happening to an object's motion?
- **A)** The car slows down.
- **B)** The car stops.
- **C)** The car travels at constant speed.
- **D)** The car speeds up.
- **E)** The car remains at rest.

89. A newton is equivalent to which of the following quantities?
- **A)** kg
- **B)** kg•m/s
- **C)** $kg•m^2/s$
- **D)** $kg•(m/s)^2$
- **E)** $kg•m/s^2$

90. Work, by definition, is done when
- **A)** the displacement is not zero.
- **B)** the displacement is zero.
- **C)** the force is zero.
- **D)** the force and displacement are perpendicular.
- **E)** energy is lost.

91. Which of the following parameters does *not* depend on how resistant a spring is to being compressed or stretched?
- **A)** compression distance
- **B)** relaxed length
- **C)** spring constant
- **D)** stretching distance
- **E)** material made from

92. What do we call the *rate at which work is done*?
- **A)** potential energy
- **B)** kinetic energy
- **C)** mechanical energy
- **D)** power
- **E)** force per time

93. Which of the following has the greatest momentum?
    A) a tortoise with a mass of 275 kg moving at a velocity of 0.5 m/s
    B) a rabbit with a mass of 2 kg moving at a velocity of 7 m/s
    C) a turtle with a mass of 5 kg moving at a velocity of 1.4 m/s
    D) a roadrunner with a mass of 2 kg moving at a velocity of 20 m/s
    E) the earth in orbit about the sun

94. In a perfectly inelastic collision between two unequal masses,
    A) the total momentum of the system will increase.
    B) the total momentum of the system will decrease.
    C) the kinetic energy of one object will increase by the amount that the kinetic energy of the
       other object decreases.
    D) the momentum of one object will increase by the amount that the momentum of the other
       object decreases.
    E) None of the above are correct.

95. When a very comfortable school bus makes a sharp left turn, what causes you, a passenger, to slide to your right?
    A) centripetal acceleration   D) inertia
    B) centripetal force   E) friction
    C) centrifugal force

96. Which of the following statements about a completely submerged object resting on the bottom of an aquarium is
    correct?
    A) The buoyant force acting on the object is equal to the object's weight.
    B) The apparent weight of the object depends on the object's density.
    C) The displaced volume of fluid is greater than the volume of the object.
    D) The weight of the object and the buoyant force are equal and opposite.
    E) The apparent weight of the object depends on the object's shape.

97. In a perfectly elastic collision between two perfectly smooth ball bearings, kinetic energy is conserved. If there is
    no change in potential energy, which of the following is true?
    A) $\Delta U > 0$
    B) $\Delta U = 0$
    C) $\Delta U < 0$
    D) ΔU depends on the initial velocities of the bearings.
    E) ΔU cannot be determined for this event.

98. A simple pendulum swings in simple harmonic motion. At maximum displacement,
    A) the acceleration is a maximum.   D) the restoring force is zero.
    B) the velocity is a maximum.   E) acceleration is a maximum.
    C) the acceleration is zero.

99. When a mechanical wave's amplitude is reduced by half, the energy the wave carries in a given time interval is
    A) doubled.   D) increased by a factor of four..
    B) increased by a factor of 1.4.   E) decreased to one-fourth.
    C) decreased to one-half.

100. Waves arriving at a fixed rigid boundary are
    A) neither reflected nor inverted.   D) inverted but not reflected.
    B) reflected but not inverted.   E) totally absorbed.
    C) reflected and inverted.

101. The Doppler effect occurs with
    A) only sound waves.   D) all waves.
    B) only transverse waves.   E) only in extreme cases of very high speeds.
    C) only water waves.

102. If the intensity of a sound is increased by a factor of 100, the new decibel level will increase
- **A)** by two units.
- **B)** to twice the old one.
- **C)** by a factor of 10.
- **D)** by 10 units.
- **E)** by 20 units.

103. Which of the following optical devices can be used to create an enlarged upright image?
- **A)** flat mirror
- **B)** concave mirror
- **C)** convex mirror
- **D)** two-way mirror
- **E)** diverging lens

104. For a spherical mirror, both concave and convex, the focal length is ____ the radius of curvature of the mirror.
- **A)** one-fourth
- **B)** one-third
- **C)** one-half
- **D)** the squareroot of
- **E)** the square of

105. What actually happens when a rubber or plastic rod is rubbed with a piece of fur, resulting in the rod obtaining a net negative charge?
- **A)** Protons are removed from the rod.
- **B)** Electrons are removed to the rod.
- **C)** Electrons are added to the fur.
- **D)** Protons are added to the fur..
- **E)** Electrons are added to the rod.

106. If the distance between two charges is changed from 2 cm apart to 10 cm apart, by what factor does the resulting electric force between them change?
- **A)** 25
- **B)** 8
- **C)** 5
- **D)** $\dfrac{1}{5}$
- **E)** $\dfrac{1}{25}$

107. Considering an isolated, uniformly charged, hollow metallic sphere, like that of a Van de Graff generator, where is the electric field the greatest?
- **A)** at infinity
- **B)** at the center of the sphere
- **C)** at the sphere's inner surface
- **D)** at the sphere's outer surface
- **E)** at a distance equal to twice the radius of the sphere.

108. Which process will double the power dissipated by a resistor?
- **A)** doubling the current while doubling the resistance
- **B)** doubling the current and making the resistance half as big
- **C)** doubling the current and doubling the potential difference
- **D)** doubling the potential difference and making the current half as big
- **E)** doubling the current while making the potential difference half as big

109. Three resistors with values of 4.0 Ω, 6.0 Ω, and 10.0 Ω are connected in parallel. What is their equivalent resistance?
- **A)** 20.0 Ω
- **B)** 7.3 Ω
- **C)** 6.0 Ω
- **D)** 1.9 Ω
- **E)** 0.6 Ω

110. What is the frequency of a photon with an energy of 1.99×10^{-19} J?
   ($h = 6.63 \times 10^{-34}$ J•s)

   A) 1.00×10^{14} Hz   D) 4.00×10^{14} Hz
   B) 2.00×10^{14} Hz   E) 5.00×10^{14} Hz
   C) 3.00×10^{14} Hz

111. According to de Broglie, as the momentum of a moving particle is tripled, the corresponding wavelength changes
    by what factor?
    A) $\frac{1}{9}$ D) 3

    B) $\frac{1}{3}$ E) 9

    C) 1

112. What is the binding energy of a nucleus?
    A) the average energy with which any nucleon is bound in the nucleus
    B) the energy released when nucleons form a stable nucleus
    C) the energy needed to remove one of the nucleons
    D) the mass of the nucleus times c^2
    E) the mass of the nucleus times c

113. When are heavy nuclei most stable?
    A) When there is no Coulomb force.
    B) When they contain more protons than neutrons.
    C) When they contain more neutrons than protons.
    D) When they contain equal numbers of protons and neutrons.
    E) When the Coulomb force is stronger than the nuclear force.

114. What particle is emitted when $^{32}_{15}P$ decays to $^{32}_{16}S$?
    A) alpha   D) gamma
    B) beta   E) neutron
    C) positron

115. Which interaction of nature is weakest?
    A) strong   D) gravitational
    B) weak   E) electro-weak
    C) electromagnetic

END

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Answer Key

Multiple Choice

1. C	41. C	81. B
2. C	42. C	82. A
3. B	43. A	83. C
4. D	44. A	84. B
5. B	45. A	85. C
6. D	46. E	86. E
7. A	47. C	87. B
8. D	48. B	88. D
9. C	49. D	89. E
10. D	50. E	90. A
11. A	51. A	91. B
12. ~~D~~ **Eliminate**	52. C	92. D
13. B	53. ~~B~~ **E**	93. E
14. C	54. C	94. ~~D~~ **E**
15. C	55. B	95. D
16. D	56. D	96. B
17. E	57. B	97. B
18. D	58. C	98. A
19. A	59. D	99. E
20. C	60. A	100. C
21. E	61. E	101. D
22. A	62. B	102. E
23. A	63. B	103. C
24. D	64. C	104. C
25. E	65. C	105. E
26. D	66. A	106. E
27. A	67. C	107. D
28. E	68. C	108. B
29. E	69. B	109. D
30. B	70. D	110. C
31. A	71. B	111. B
32. C	72. A	112. B
33. C	73. B	113. C
34. B	74. ~~C~~ **Eliminate**	114. B
35. A	75. D	115. D
36. A	76. B	
37. A	77. C	
38. E	78. C	Merck
39. A	79. D	
40. A	80. E	