The 64th Annual
Merck State Science Day Competition
May 19, 2014

INTEGRATED SCIENCE

DIRECTIONS

The "answer panel" at the bottom of the window is pre-set to show 10 answer boxes per page.

1.The current question has a black border.

2. Enter your answer choice using the keyboard.

3. Click Confirm to record your answer.

4. Questions that have been answered will be tinted Green

5. Any answer can be edited. Confirm the correction.

6.> moves to the next set of questions (<moves back)

7.Click on any number to answer that question.

8. Confirm all entries. Each answer is recorded only when Confirm is used.

9. When finished, use FINISHED TEST in lower left.

There is a Periodic Table for your use also.

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, $h = 6.63 \times 10^{-34}$ joule-sec

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

Avogadro's Number = 6.02×10^{23}

$Q = mc\Delta T$

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

$PE_{grav} = mgh$

$W = F \times S$

$W = Vq$

$v_{avg} = s/t$

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

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

$v_f = v_i + at$

$c = f\lambda$

$P_1 V_1/T_1 = P_2 V_2/T_2$

$I = V/R$

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)

The Periodic Table of the Elements

1																	2
H Hydrogen 1.00794																	**He** Helium 4.003
3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012182											5 **B** Boron 10.811	6 **C** Carbon 12.0107	7 **N** Nitrogen 14.00674	8 **O** Oxygen 15.9994	9 **F** Fluorine 18.9984032	10 **Ne** Neon 20.1797
11 **Na** Sodium 22.989770	12 **Mg** Magnesium 24.3050											13 **Al** Aluminum 26.981538	14 **Si** Silicon 28.0855	15 **P** Phosphorus 30.973761	16 **S** Sulfur 32.066	17 **Cl** Chlorine 35.4527	18 **Ar** Argon 39.948
19 **K** Potassium 39.0983	20 **Ca** Calcium 40.078	21 **Sc** Scandium 44.955910	22 **Ti** Titanium 47.867	23 **V** Vanadium 50.9415	24 **Cr** Chromium 51.9961	25 **Mn** Manganese 54.938049	26 **Fe** Iron 55.845	27 **Co** Cobalt 58.933200	28 **Ni** Nickel 58.6934	29 **Cu** Copper 63.546	30 **Zn** Zinc 65.39	31 **Ga** Gallium 69.723	32 **Ge** Germanium 72.61	33 **As** Arsenic 74.92160	34 **Se** Selenium 78.96	35 **Br** Bromine 79.904	36 **Kr** Krypton 83.80
37 **Rb** Rubidium 85.4678	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.90585	40 **Zr** Zirconium 91.224	41 **Nb** Niobium 92.90638	42 **Mo** Molybdenum 95.94	43 **Tc** Technetium (98)	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.90550	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.8682	48 **Cd** Cadmium 112.411	49 **In** Indium 114.818	50 **Sn** Tin 118.710	51 **Sb** Antimony 121.760	52 **Te** Tellurium 127.60	53 **I** Iodine 126.90447	54 **Xe** Xenon 131.29
55 **Cs** Cesium 132.90545	56 **Ba** Barium 137.327	57 **La** Lanthanum 138.9055	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.9479	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.207	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.217	78 **Pt** Platinum 195.078	79 **Au** Gold 196.96655	80 **Hg** Mercury 200.59	81 **Tl** Thallium 204.3833	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.98038	84 **Po** Polonium (209)	85 **At** Astatine (210)	86 **Rn** Radon (222)
87 **Fr** Francium (223)	88 **Ra** Radium (226)	89 **Ac** Actinium (227)	104 **Rf** Rutherfordium (261)	105 **Db** Dubnium (262)	106 **Sg** Seaborgium (263)	107 **Bh** Bohrium (262)	108 **Hs** Hassium (265)	109 **Mt** Meitnerium (266)	110 (269)	111 (272)	112 (277)	113	114				

58 **Ce** Cerium 140.116	59 **Pr** Praseodymium 140.90765	60 **Nd** Neodymium 144.24	61 **Pm** Promethium (145)	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.964	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.92534	66 **Dy** Dysprosium 162.50	67 **Ho** Holmium 164.93032	68 **Er** Erbium 167.26	69 **Tm** Thulium 168.93421	70 **Yb** Ytterbium 173.04	71 **Lu** Lutetium 174.967
90 **Th** Thorium 232.0381	91 **Pa** Protactinium 231.03588	92 **U** Uranium 238.0289	93 **Np** Neptunium (237)	94 **Pu** Plutonium (244)	95 **Am** Americium (243)	96 **Cm** Curium (247)	97 **Bk** Berkelium (247)	98 **Cf** Californium (251)	99 **Es** Einsteinium (252)	100 **Fm** Fermium (257)	101 **Md** Mendelevium (258)	102 **No** Nobelium (259)	103 **Lr** Lawrencium (262)

Merck State Science Day 2014   Integrated Science

1. Darwin's finches are a great example of adaptive radiation. Which of the following best describes this adaptive radiation?
   A) The evolutionary process of adaptation of species through a form of polymorphism
   B) The evolutionary process allows for the changes that occur within the same lineage
   C) A sudden diversification (punctuated equilibrium) of a group of organisms from closely related species
   D) The evolutionary process by which different forms, adapted to different niches arose from a common ancestor
   E) The genetic variability that can be found among individuals of the same species

2. Which of the following best supports the endosymbiotic theory?
   A) Like prokaryotes, mitochondria have a double membrane with the inner membrane highly folded
   B) The process of cellular respiration in certain prokaryotes is similar to that occurring in mitochondria and chloroplasts
   C) Mitochondria and chloroplasts have DNA and ribosomes that are similar to those of prokaryotes
   D) Mitochondria and chloroplasts have DNA and proteins that are very similar to those in eukaryotes
   E) Chloroplasts and eukaryotes have similar cell wall structures

3. A population of iguanas was studied, and the presence of brown skin was noted to be the result of a homozygous recessive condition. If the number of the brown iguanas in a population of 1000 was 360, what is the predicted number of iguanas heterozygous for the color trait? (Assume that the population is in Hardy-Weinberg equilibrium).
   A) 160
   B) 320
   C) 480
   D) 640
   E) not enough information is provided

4. If a plant had a deficiency in the amount of K^+ available for the guard cells, all of the following would occur except;
   A) rate of photosynthesis would decrease
   B) rate of transpiration would decrease
   C) roots would take up less water
   D) plant temperature would decrease
   E) stomata would be closed

5. Which of the following is not considered to be an emergent property of water?
   A) cohesion
   B) moderation of temperature
   C) transpiration
   D) insulation of bodies of water by floating ice
   E) a versatile solvent

6. With regard to photosynthesis, photorespiration
   A) predominates in C3 plants in cool weather when water is plentiful
   B) is more efficient in producing carbohydrates
   C) predominates in C4 plants on hot days when water is scarce
   D) is the primary pathway for CAM plants
   E) is considered a wasteful process in regard to the carbon atoms under dry, hot conditions in C3 plants

7. Which of the following is <u>not</u> part of maintaining the osmotic gradient necessary for the concentration of urine in mammals?
   A) countercurrent flow of filtrate through the loop of Henle
   B) decreased hypothalamic signals leading to a decrease in ADH production
   C) pressure filtration in the glomerulus
   D) impermeability of the descending limb of the loop of Henle to Na^+, Cl^- and other solutes
   E) impermeability of the ascending limb of the loop of Henle to water

8. When a muscle contracts, which of the following would occur?
   A) cross bridges between the actin and myosin filaments are broken and reformed
   B) ATP is necessary for the phosphorylation of the myosin heads
   C) actin fibers are drawn toward the middle of the sarcomere during contraction and away on relaxation
   D) depolarization causes the sarcoplasmic reticulum to release calcium ions that bind to troponin , exposing binding sites on actin
   E) all of the above need to occur for a muscle contraction

9. Altruism often occurs in populations because
   A) it deprives members of the population of territory and results in agonistic behavior
   B) it can result in the passing on of the altruistic member's genes
   C) it can result in a bond between the altruist member and the recipient of the altruism, and the recipient might later reciprocate the altruism
   D) it can result in the maximizing of the altruistic member's genetic representation in a population, if the altruistic member's behavior is directed toward a close relative
   E) it can result in intraspecies competition and eliminate undesirable genes

10. The allele that causes sickle-cell disease is found in greater frequency in Africa, where malaria is more of a threat, than other regions. Which genetic condition most likely contributes to the difference in this increased frequency?
    A) heterozygote advantage
    B) balanced polymorphism
    C) frequency-dependent selection
    D) neutral variation
    E) heterozygote protection theory

11. Considering the following factors, which would <u>not</u> contribute to allopatric speciation?
    A) A population becomes geographically isolated from the parent population
    B) The separated population is small, and genetic drift occurs
    C) The different environments of the two populations cause different mutations to occur so the each population can adapt and survive
    D) Gene flow between the two isolated populations is minimal or does not occur
    E) The isolated population is exposed to different selective pressures than the parent population

12. Which of the following best describes the process of double fertilization in angiosperms?
    A) When a compatible pollen grain lands on the stigma, it forms a pollen tube to deliver the two sperm to the ovule
    B) Two sperm that enter through the micropyle fertilize the two polar nuclei to form the zygote and endosperm
    C) Two sperm that enter through the micropyle; one sperm fertilizes the egg to produce the zygote and the other sperm fuses with the two polar nuclei to produce the triploidy endosperm
    D) Two sperm that enter through the micropyle; each sperm fuses with each of the two polar nuclei to produce the zygote and the triploid endosperm
    E) The pollen grain enters the micropyle and release two sperm that both fuse with the egg which then splits (divides) into the developing embryo and the endosperm for the nutritive value for the embryo

13. A DNA sample was analyzed for the number and types of bases. Which result would be consistent with Chargaff's base-pair rule?
    A) A = G
    B) A + G = C + T
    C) A + T = C + G
    D) A = C
    E) G = T

14. Most cell receptors are membrane proteins. Which best describes their function?
    A) They change their conformation after binding with signal polypeptides and set up signal transduction pathways
    B) They are more likely to bind with lipid or glycolipid signal molecules
    C) They open and close in response to protein signals
    D) They lead to changes in intracellular ion concentrations
    E) They are usually only peripheral proteins

15. Two tailed mice with the genotype Tt are mated. After many offspring, 2/3 are tailed and 1/3 are not tailed. (a 2:1 ratio). Mendelian genetics would predict in this cross to produce a 3:1 ratio. What is the most likely conclusion from this experimental cross?
    A) The mice did not produce enough offspring for the ratio calculation to be match the expected
    B) Nondisjunction occurred
    C) A mutation masked the homozygous condition
    D) T is lethal in the homozygous form and caused death early in development
    E) A mutation masked the effects of the t allele

16. Methylation of genes results in
    A) increases the pH of the nucleus
    B) causes the histones tighten their shape and does not allow for transcription
    C) modifies the nucleotides of the promoter region of the DNA molecule and accelerates the transcription rate
    D) causes the histones to loosen their shape and allows for transcription
    E) the binding of transcriptional factors and attracts RNA polymerase

17. Crossing over and independent assortment both produce variation in offspring. These events must occur during
    A) prophase I and metaphase I
    B) prophase I and metaphase II
    C) prophase II and metaphase I
    D) prophase II and metaphase I
    E) G2 of interphase and prophase I

18. The lionfish is becoming a serious problem in many of the Caribbean coral reefs. The concern over the presence of the lionfish is that they are considered
  A) indicator species as they are sensitive to the environmental conditions and will allow researchers to measure the health of these coral reefs
  B) invasive species and have no natural predators to keep their populations in check and this leads to a decrease in biodiversity in these regions
  C) keystone species and have a negative effect on other species, as they have no natural predators
  D) introduced species and will increase the biodiversity in these regions as they are a new species
  E) introduced species and are a new source of food for la few local species, and these local species are now increasing exponentially disrupting the trophic balance

19. Eutrophication is often the result of pollutants entering an aquatic environment. Which of the following pairs has the greatest effect driving this process?
  A) carbon and sulfur
  B) nitrogen and phosphorus
  C) nitrogen and magnesium
  D) carbon dioxide and phosphorus
  E) magnesium and phosphorus

20. The age-structure data for Mexico is shown below. What does this imply about the future population of Mexico?
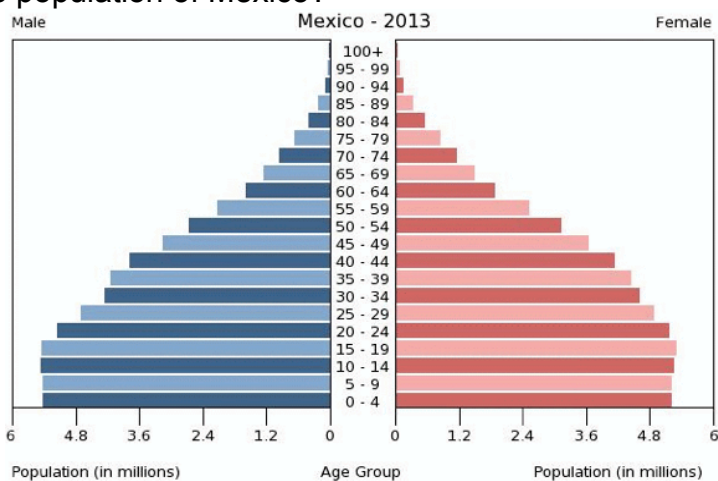
  A) strong economic gains stimulated by population growth
  B) a decreased demand for infrastructures such as schools
  C) an increased demand for resources based on population growth
  D) a decreased demand for medical services due to the small number of elderly citizens
  E) the population will probably decrease rapidly

21. A resistant strain of a particular bacteria is found in a hospital in which this had not been a problem prior, but was in a related strain of bacteria. The most likely event that allowed the bacterial strain to acquire this new resistance is
  A) mutation
  B) transduction
  C) sexual reproduction
  D) conjugation
  E) transformation

22. After several years of spraying broad range fungicides on an orange orchid, the agriculturist has documented a steady decline in the productivity of his crop. The best explanation for the decline in the production of oranges is:
    A) The fungicides consistently interfered with the light reaction of photosynthesis by disrupting the electron transport chain
    B) The fungicides did not only kill the fungus on the fruit itself, but also weakened the composition of the tree bark and allowed a secondary infection to weaken the phloem flow so there was less sugars available to produce the fruit
    C) The fungicides did not only weaken the fruit walls and caused the fruit to not fully develop but also leached into the ground water and destroyed the lichen association of the plant roots
    D) The fungicides did not only kill the fungus on the fruit itself, but also leached into the ground water that destroyed the mycorrhizial association of the plant roots
    E) This is only a coincidence and there is no sound science that could explain the connection between the two events

23. Which two functional groups are always found in amino acids?
    A) amine and sulfhydryl
    B) carbonyl and carboxyl
    C) ketone and amine
    D) alcohol and aldehyde
    E) carboxyl and amine

24. The net movement of glucose across a semipermeable tubing during an experiment is measured to occur at a slower rate than that of an intact small intestine membrane. The glucose is also moving down it's concentration gradient. What is the most likely process that explains the faster rate of movement of the glucose from the small intestine?
    A) active transport
    B) facilitated diffusion
    C) osmosis
    D) passive transport
    E) activation of receptor tyrosine kinases

25. One of the major facts that came as a surprise to the researchers from the Human Genome Project was just how few genes humans have. The human genome has only about one-third more genes than the simple nematode, *C. elegans*. Which of the following best explains how the more complex humans can have relatively few genes?
    A) The amount of introns found in human genes are actually involved in the regulation of gene expression
    B) More than one polypeptide can be produced from one gene by alternative splicing, making more combinations for various proteins
    C) The human genome has a very high proportion of noncoding DNA
    D) The large number of SNPs (single nucleotide polymorphisms) in the human genome provides for a great deal of genetic variability
    E) Human genes code form many more types of domains

26. The following are evidence of Plate Tectonic Theory, EXCEPT:
    A) Continents fit together like puzzle pieces
    B) Fossil and Rock Correlation
    C) Antarctic Ice Core Analysis
    D) Magnetic Reversal Correlation in ocean cores
    E) Seismic & Volcanic Pattern Correlation

27. The focus of the 3/11/11 Tohoku Earthquake in Japan occurred at
    A) a transform plate boundary
    B) a subduction zone
    C) an ocean ridge
    D) a hot spot
    E) a divergent plate boundary

28. The best theory for how Life began on The Earth is:
    A) There is no theory, only hypotheses.
    B) God made life approx. 6000 years ago.
    C) Aliens brought it here.
    D) Primordial Soup.
    E) Cometary seeding.

29. In Vulcanism, "Red" eruptions
    A) produces flowing lava.
    B) produces pyroclastic flows.
    C) occurs at island arcs.
    D) kill many people.
    E) come from supervolcanoes.

30. Striations indicate the following event occurred:
    A) lava flow
    B) faulting
    C) glaciation
    D) crystallization
    E) clastic deposition

31. Sedimentary layering indicates the following event occurred:
    A) lava flow
    B) faulting
    C) glaciation
    D) crystallization
    E) clastic deposition

32. All of the following statements are false Except:
    A) Humans cohabited with dinosaurs.
    B) Scientists have a theory as to how life began on the Earth.
    C) The Big Bang directly caused a mass extinction.
    D) Uniformatarianism allows us to understand the past and hypothesize the future.
    E) Evolution is only a theory, and therefore only an unsubstantiated opinion.

33. Compared to Oceanic Crust, Continental Crust is
    A) denser.
    B) richer in metals.
    C) much thinner.
    D) poorer in silicates.
    E) less dense.

34. The Sun is _____ times farther from the Earth than the Moon is from the Earth, whereas the Sun's diameter is _____ times larger than the Moon's diameter.
A) 150,000,000, 150,000,000
B) 93,000,000, 93,000,000
C) 27.3, 29.5
D) 100, 400
E) 400, 400

35. Which is the correct order for objects closest to farthest from the Earth
A) Heliopause, The Closest Star, Andromeda Galaxy, The Moon, Proxima Centauri
B) The Moon, The Closest Star, Heliopause, Proxima Centauri, Andromeda Galaxy
C) The Closest Star, Heliopause, The Moon, Andromeda Galaxy, Proxima Centauri
D) Andromeda Galaxy, Heliopause, The Closest Star, Andromeda Galaxy, The Moon,
E) Proxima Centauri, The Moon, The Closest Star, Proxima Centauri, Heliopause

36. Zubenelgenubi is approximately 75 light years from our solar system. How many years will it take a radio waves emitted by Zubenelgenubi to reach the Earth?
A) 75
B) Radio waves cannot travel through space.
C) 300,000
D) 710 Trillion
E) 93 Million

37. When viewed over a 3 month period, a celestial object's parallax shift is 2" of arc. Its distance from the observer is approximately:
A) 1.64 ly.   **B)** 1 pc   **C)** 9.47e12 km   **D)** 3.27 ly.   **E)** 6.54 ly.

38. An ocean wave with a wavelength of 10 meters will break in water with a depth of approximately
A) 5 meters   **B)** 20 meters   **C)** 13 meters   **D)** 7.5 meters   **E)** 10 meters

39. The _____ the wave height, the _____ shore the wave will break.
A) larger / farther from
B) larger / nearer to
C) smaller / farther from
D) larger / closer to
E) none of these choices

40. Sub Polar ocean surface currents in the Earth's Northern Hemisphere always move
A) counter-clockwise
B) to the west
C) to the east
D) vertically
E) clockwise

41. The following statement is always true about ocean water:
    A) The deeper you go, the saltier the water.
    B) The deeper you go, the denser the water
    C) The deeper you go, the colder the water.
    D) The shallower you go, the less saline the water.
    E) The shallower the water, the warmer the water.

42. The same tide arrives later each day because
    A) of the indirect high tide.
    B) of Plate Tectonics.
    C) the Earth's revolution has to catch up to the Moon's rotation.
    D) the Earth's rotation has to catch up to the Moon's revolution.
    E) the Earth's revolution has to catch up to the Moon's revolution.

43. The oceans receive the *majority* of their salts from which of the following?
    A) continental erosional runoff.
    B) black smokers.
    C) hydrothermal vents.
    D) tectonic activity.
    E) ocean ridges.

44. Weather is _____ , while climate is_____ atmospheric phenomena.
    A) regional & long term / local and short term
    B) regional & short term / local and long term
    C) local & short term / regional and long term
    D) local & long term / regional and short term
    E) N/A: Weather and Climate are the same thing.

45. Weather and climate phenomena occur in the
    A) Tropopause
    B) Stratosphere
    C) Exosphere
    D) Troposphere
    E) Stratopause

46. Which statement is the most inaccurate?
    A) Hot Air rises under its own power.
    B) Colder air displaces warmer air upward.
    C) Denser Air moves towards less dense air.
    D) Gravity assists in thermodynamic differentiation.
    E) Moist air is less dense than dry air.

47. Which of the following statements are true?
    A) As you move higher in altitude, the temperature of the air can increase.
    B) The Atmosphere consists of approximately 80% Oxygen and 20% Nitrogen.
    C) The Sun can be at zenith at noon in Canada.
    D) The Earth is closest to the Sun on July 4th.
    E) Humans are not responsible for Global Climate Change.

48. In the center of a Hurricane, the air is moving
   A) down.   **B)** up.   **C)** north.   **D)** south   **E)** not at all.

49. Rain that evaporates before it reaches the ground is called
   A) derecho.   **B)** scirocco.   **C)** monsoon.   **D)** virga.   **E)** chinook.

50. Thunderstorms are associated with _____ clouds.
   A) stratus
   B) cirrus
   C) cumulus
   D) cumulonimbus
   E) contrails

51. The Monsoon
   A) brings rain to Southern California in summer.
   B) brings rain to India from the Arabian Sea.
   C) brings rain to western Australia in January.
   D) brings rain to western sub-Saharan Africa in June.
   E) All of the above.

52. A stream is 30-m wide and has a current of 1.5 m/s southward. A toy boat is launched with a constant velocity of 2 m/s eastward from the west bank of the stream.
   What is the magnitude of the boat's resultant velocity as it crosses the stream?
   A) 0.5 m/s
   B) 1.5 m/s
   C) 2 m/s
   D) 2.5 m/s
   E) 3.5 m/s

53. How much time is required for the toy boat in #1 above to reach the opposite bank of the stream?
   A) 8.6 sec
   B) 12 sec
   C) 15 sec
   D) 60 sec
   E) Can't tell without more info.

54. In a very famous NASA video clip that you may have seen in class, astronaut David Scott of the Apollo 15 mission on the moon in 1971 dropped a hammer and a falcon feather on the surface of the Moon simultaneously and they hit the surface of the Moon at the same time. Since the acceleration of gravity on the surface of the Moon is about $\frac{1}{6}$ the value we have here on Earth, how long did the fall take if dropped from a height of 2m?
   A) 0.3 sec
   B) 0.6 sec
   C) 1.2 sec
   D) 1.5 sec
   E) 2.5 sec

55. William Tell, the semi-famous archer who used his own kid for practice, shoots two identical arrows from the same bow using the same string force. The 1st arrow is shot at 60° with the horizontal and the 2nd at 45°. Compared to the arrow shot at 60°, the 2nd one has a
A) longer flight time and longer horizontal range.
B) longer flight time and shorter horizontal range.
C) shorter flight time and longer horizontal range.
D) shorter flight time and shorter horizontal range.
E) can't tell without knowing the mass of the arrow.

56. Earth's mass is about 81 times the mass of our moon. If earth exerts a gravitational force of magnitude F on the moon, the magnitude of the gravitational force of the moon on the earth is
A) $F/81$
B) $F/9$
C) F
D) $9F$
E) $81F$

57. A student standing on a bathroom scale in our elevator reads a value greater than the weight of the student at rest. Which of the following situations would cause this?
A) sitting stationary
B) moving upward at constant speed
C) moving downward at increasing speed
D) moving upward at increasing speed
E) moving downward at constant speed.

58. Which quantity is a measure of the rate at which work is done?
A) energy
B) kinetic energy
C) momentum
D) acceleration
E) power

59. A 0.1-kg ball dropped from a height of 2-m bounces back to a height of 1.6-m above the floor. The mechanical energy "lost" by this collision with the floor is
A) Zero
B) 0.16 J
C) 0.4 J
D) 0.6 J
E) 1.0 J

60. Which statement is consistent with Kepler's Laws of planetary motion?
A) The planets move at a constant speed around the sun.
B) The speed of a planet is directly proportional to the radius of the planet orbit.
C) The more massive the planet, the slower it moves around the sun.
D) An imaginary line drawn from a planet to the sun sweeps out equal areas in equal times.
E) An imaginary line drawn from a planet to the sun sweeps out equal size arcs in equal times.

61. Radio waves are propagated through the interactions of
   A) nuclear & electric fields
   B) electric & magnetic fields.
   C) gravitational & magnetic fields
   D) electric & gravitational fields
   E) nuclear & magnetic fields

62. A 6-W resistor is connected to a variable potential difference. When the applied voltage is decreased from 12V to 6V, the current passing through the resistor
   A) remains the same.
   B) doubles
   C) halves
   D) quadruples
   E) drops to one-quarter original.

63. Two equal resistors connected in series have an effective resistance of 4W. When the same two resistors are connected in parallel, the effective resistance is
   A) 1W
   B) 2W
   C) 4W
   D) 8W
   E) 16W

64. What is the speed of a 5.1×10^{14} Hz light beam while traveling through a block of sodium chloride? (n = 1.544)
   A) 1.54×10^8 m/s
   B) 1.95×10^8 m/s
   C) 2.50×10^8 m/s
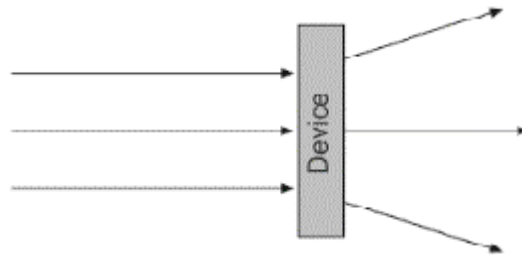   **D)** 3.00×10^8 m/s
   E) 4.62×10^8 m/s

65.
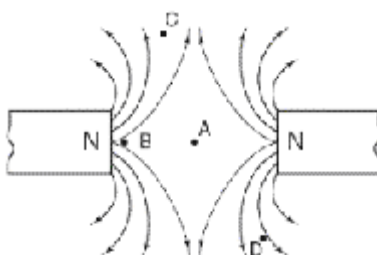
The diagram shows the lines of magnetic force between two north magnetic poles. At which point is the magnetic field strength greatest?
   A) A
   B) B
   C) C
   D) D
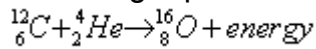   **E)** Field strength is the same everywhere between the magnets.

66.

The device hidden behind the shaded box above could be a:
A) double convex glass lens
B) rectangular glass block
C) plane mirror
D) equilateral triangular glass prism
E) concave glass lens

67. A metal sphere has a net negative charge of 1.1 x 10^{-6}C. Approximately how many more electrons than protons are on the sphere?
A) 1.8 x 10^{12}
B) 5.7 x 10^{12}
C) 6.9 x 10^{12}
D) 9.9 x 10^{12}
E) 1.6 x 10^{13}

68. The Millikan oil drop experiment was designed to determine the
A) sign of the charge on an electron.
B) mass of a proton.
C) ratio of charge to mass of an electron.
D) magnitude of the charge of a neutron.
E) magnitude of the charge of an electron.

69. The energy of a photon is inversely proportional to its
A) wavelength
B) frequency
C) speed
D) phase
E) intensity

70. Of the following phenomena, which provides the best evidence that light can have particle properties?
A) Interference of light in thin films
B) Electron diffraction
C) X-ray diffraction
D) Electromagnetic radiation
E) Photoelectric effect

71. A potassium $^{40}_{19}K$ nucleus emits a beta particle and becomes:
A) $^{36}_{17}Cl$

B) $^{44}_{21}Sc$

C) $^{40}_{18}Ar$

D) $^{40}_{19}K$

E) $^{40}_{20}Ca$

72. What does the **X** represent in the nuclear reaction $^2_1H + {}^2_1H \rightarrow {}^3_2He + X$?
   A) an alpha particle
   B) a beta particle
   C) a gamma photon
   D) a neutron
   E) a proton

73. The following equation is an example of what kind of nuclear reaction
   $$^{12}_6C + {}^4_2He \rightarrow {}^{16}_8O + energy$$
   A) fission
   B) fusion
   C) alpha decay
   D) beta decay
   E) positron decay

74. A new element, named *Fizzonium* (symbol **Fizz**) is discovered to undergo triple alpha decay and double beta positive decay simultaneously. Amazingly, this causes the material to decay into an element called *Cheeter* (symbol **Cheet**). What is the correct nuclear representation of the (Cheet) daughter nucleus?

$$^{2014}_{250}Fizz \rightarrow 3\left({}^4_2He\right) + 2\left({}^0_1e\right) + {}^?_?Cheet$$
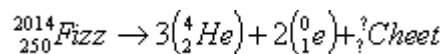
   A) $^{2014}_{245}Cheet$
   B) $^{2002}_{245}Cheet$
   C) $^{2002}_{242}Cheet$
   D) $^{2014}_{242}Cheet$
   E) $^{1998}_{197}Cheet$

75. When a radioactive nucleus emits a gamma ray the number of
   A) protons increases by one while the number of neutrons decreases by one.
   B) protons decrease by one while the number of neutrons increases by one.
   C) protons and neutrons each decrease by two
   D) protons and neutrons each increase by two
   E) protons and neutrons remain unchanged

76. The present theory of the nature of light suggests it
   A) is a wave only
   B) consists of particles
   C) is a mixture of both waves and particles
   D) exhibits either waves or particles depending on the situation.
   E) exhibits neither wave nor particle properties

77. What are the two types of pure substances?
   A) elements and subatomic particles
   B) protons and electrons
   C) atoms and compounds
   D) cations and anions
   E) homogenous and heterogeneous

78. The following elements are in the fourth period of the periodic table: Ca, Mn, Co, Zn, Se. Which ones have unpaired electrons in the ground state electron configuration?
    A) Ca, Mn, Co, Zn
    B) Mn, Co, Zn
   C) Ca, Zn, Se
    D) Ca, Mn, Se
    E) Mn, Co, Se

79. If a liter of CO_2 is compared to a liter of H_2, both at 25 °C and one atmosphere pressure, then:
    A) the mass of one liter of CO_2 equals the mass of one liter of H_2.
    B) there are more H_2 molecules than CO_2 molecules.
    C) the average kinetic energy of the CO_2 molecules is greater than that of the H_2 molecules.
    D) the CO_2 molecules are on the average moving more slowly than the H_2 molecules.
    E) the CO_2 molecules are flammable and the H_2 molecules are not.

80. Which of the following elements has the highest first ionization energy?
    A) H
    B) O
    C) N
    D) F
    E) Xe

81. These graphs describe the pathways of one reaction. How was the reaction altered to give the pathway shown in II?
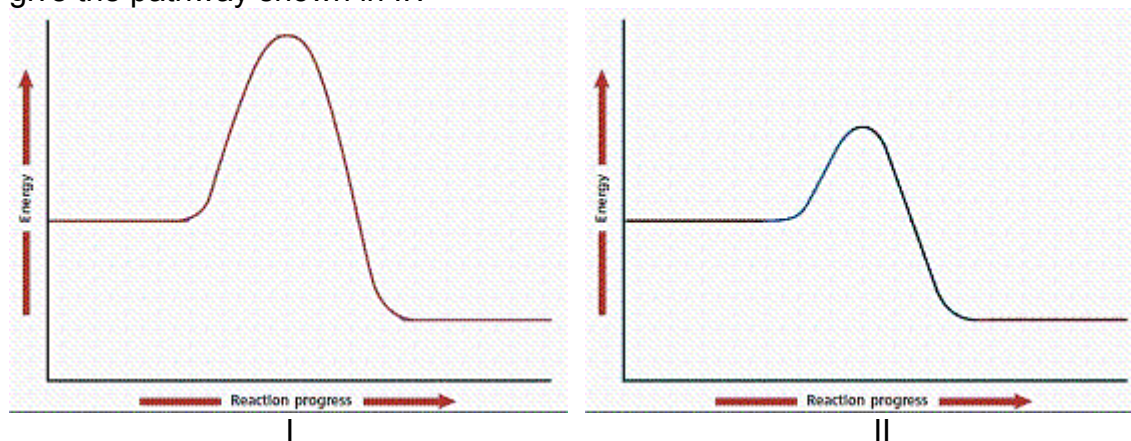
    A) the reaction was heated
    B) the reaction was cooled
    C) pressure was increased
    D) a catalyst was added
    E) reactants molecules were removed

82. Select the row in which all the names are correct for the following compounds:

	$Fe(NO_3)_3$	KBr	N_2O_3
A)	iron (III) nitrate	potassium bromate	dinitrogen oxide
B)	iron (III) nitrate	potassium bromide	dinitrogen trioxide
C)	iron nitride	potassium bromide	nitrogen oxide
D)	iron nitrate	potassium bromate	dinitrogen trioxide
E)	iron (III) nitride	potassium bromate	nitrogen oxide

83. Which ion produces a bright emerald green color in a flame test?
   A) K^+
   B) Cu^{2+}
   C) Li^+
   D) Ca^{2+}
   E) Zn^{2+}

84. Ignition occurs when chlorine is passed into ammonia, forming nitrogen and ammonium chloride. What is the sum of the coefficients when its equation is balanced using the smallest whole numbers?

$$\underline{\hspace{1cm}}NH_3 + \underline{\hspace{1cm}}Cl_2 \Rightarrow \underline{\hspace{1cm}}NH_4Cl + \underline{\hspace{1cm}}N_2$$
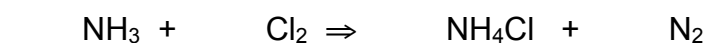
   A) 12
   B) 13
   C) 16
   D) 18
   E) None of these

85. Using the following activity series, which of the following reactions will take place?

Metal		Oxidation Reaction	
Li	→	$Li^+ + e^-$	
Na	→	$Na^+ + e^-$	
Cr	→	$Cr^{3+} + 3\,e^-$	Ease of
Ni	→	$Ni^{+2} + 2\,e$	oxidation increases
H_2	→	$2\,H^+ + 2\,e^-$	
Cu	→	$Cu^{+2} + 2\,e^-$	
Ag	→	$Ag^+ + e^-$	
Au	→	$Au^{+3} + 3\,e^-$	

   A) $Cu + 2H^+ \Rightarrow Cu^{2+} + H_2$
   B) $Cr^{3+} + 3Ag \Rightarrow Cr + 3Ag^+$
   C) $2Na + 2H^+ \Rightarrow 2Na^+ + H_2$
   D) $3\,Ag^+ + Au \Rightarrow 3Ag + Au^{3+}$
   E) all will react

86. A white substance melts with some decomposition at $730\,^\circ C$. As a solid, it is a nonconductor of electricity, but it dissolves in water to form a conducting solution. What kind of material is the white substance?
   A) a molecular solid.
   B) a covalent network solid.
   C) an amorphic solid.
   D) a metallic solid.
   E) an ionic solid.

An old method of producing pure hydrogen sulfide, H_2S, in the laboratory was done by reacting aluminum sulfide with water according to the following unbalanced expression:

___$Al_2S_3(s)$ + ___ $H_2O(l)$ ⇒ ___ $Al(OH)_3(s)$ + ___ $H_2S(g)$

	molar masses (g/mole)
Al_2S_3	150.2
H_2O	18.0
$Al(OH)_3$	78.0
H_2S	34.1

87. When the reaction above is balanced using the smallest whole numbers, the coefficient for H_2S is:
A) 1
B) 2
C) 3
D) 4
E) 6

88. When 25.0 g of Al_2S_3 and 15.0 g of H_2O are reacted, the theoretical yield in grams of H_2S is:
A) 6.81 g
B) 14.2 g
C) 17.0 g
D) 27.2 g
E) 56.8 g

89. At 27 °C and 0.993 atm (755 torr), what is the volume occupied by 35.0 grams of butane, C_4H_{10}?
A) 0.0126 L
B) 0.0197 L
C) 1.35 L
D) 15.0 L
E) 868 L

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

$FeO(s)$ + $CO(g)$ ⇒ $Fe(s)$ + $CO_2(g)$
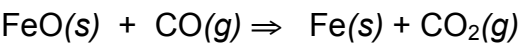
REACTION	$\Delta H°$
3 $Fe_2O_3(s)$ + $CO(g)$ ⇒ 2 $Fe_3O_4(s)$ + $CO_2(g)$	-47.0 kJ
$Fe_2O_3(s)$ + 3 $CO(g)$ ⇒ 2 $Fe(s)$ + 3 $CO_2(g)$	-25.0 kJ
$Fe_3O_4(s)$ + $CO(g)$ ⇒ 3 $FeO(s)$ + $CO_2(g)$	+19.0 kJ

The standard enthalpy change for this reaction based on the reactions in the table is:
A) 4.7 kJ
B) -7.8 kJ
C) -11.0 kJ
D) -53 kJ
E) -66 kJ

91. Because you never learned dimensional analysis, you end up working at McDonald's. Each hour you wrap 150 burgers, you work 8 hours a day for 5 days for every week. You get paid every 2 weeks with a take home salary of $850. How many million (M) hamburgers will you have to wrap to make your first million dollars?
    A) 1.76 M
    B) 2.82 M
    C) 7.06 M
    D) 14.1 M
    E) 6.38 ´ 10^3 M

92. How many of these molecules are exceptions to the octet rule?
    CO_2 NO_2 O_3 BF_3 PF_3 SF_4
    A) 1
    B) 2
    C) 3
    D) 4
    E) 5

93. Exactly 34.65 mL of 0.1010 $Ca(OH)_2$ was needed to titrate to the equivalence point with a 20.10 mL of an unknown concentration of H_3PO_4. What is the molarity of the H_3PO_4 solution?
    A) 0.05804 M
    B) 0.1161 M
    C) 0.1741 M
    D) 0.3452 M
    E) 0.3906 M

94. In general, when comparing ions to their atoms, what trend is observed?
    A) Positive ions are smaller and negative ions are larger than their corresponding atoms.
    B) Positive ions are smaller and negative ions are smaller than their corresponding atoms.
    C) Positive ions are larger and negative ions are larger than their corresponding atoms.
    D) Positive ions are larger and negative ions are smaller than their corresponding atoms.
    E) Ions are the same size as their corresponding ions.

95. Which CO_2 sample contains the most oxygen atoms at STP?
    A) 11.0 grams CO_2
    B) 0.24 moles CO_2
    C) 2.0 x 10^{23} molecules CO_2
    D) 5.6 liters CO_2 at STP
    E) all these samples of CO_2 molecules have the same number of oxygen atoms.

96. If at 780 torr and 25°C, a gas occupies 1.80 L. What will be its temperature if its volume is increased to 2.00 L and the pressure is 2.0 atm?
    A) -273°C
    B) -272°C
    C) 54.1°C
    D) 372°C
    E) 645°C

97. Which photon has the highest speed?
   A) radio waves
   B) blue light
   C) X-rays
   D) gamma rays
   E) All travel at the same speed

98. Consider:
$$2\ Q(s) + R(g) \Leftrightarrow 2\ Z(g)$$
   If 0.40 mol Q, 0.60 mol R and 0.20 mol Z are present in a 2.0 L flask at equilibrium, what is the K_c?
   A) 0.417
   B) 0.599
   C) 0.83
   D) 1.20
   E) 1.67

99. . A student is given a soluble metal nitrate salt containing one of 8 possible cations: sodium, magnesium, potassium, barium, ammonium, copper(I), silver(I), lead(II) Three to four drops of 3M HCl are added to a solution of the salt. No precipitate results. Which set of cations are **absent**?

   A) Ba^{2+}, Mg^{2+}, NH_4^+
   B) Ba^{2+}, Fe^{2+}, K^+
   C) Cu^+, Pb^{2+}, Ag^+
   D) Na^+, K^+, NH_4^+
   E) none of these

100. If a radioactive isotope $^{237}_{93}Np$ undergoes a decay sequence in which an alpha particle and then two beta particles are released, what symbol would represent the isotope remaining after the decays had occurred?
   A) $^{233}_{93}Np$
   B) $^{233}_{92}U$
   C) $^{233}_{91}Pa$
   D) $^{235}_{91}Pa$
   E) $^{233}_{89}Ac$