The 65th Annual
Merck State Science Day Competition
May 19, 2015
Integrated Test

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 below.

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

Hint: The size of the lettering in the test or in the bottom answer panel can be adjusted using CTRL + to magnify the browser view.

The Periodic Table of the Elements

1 **H** Hydrogen 1.00794																	2 **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)

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

Merck State Science Day 2015 **Integrated Science**

Multiple Choice

Identify the choice that best completes the statement or answers the question and place your selection ON THE ANSWER PANEL, then "Confirm."

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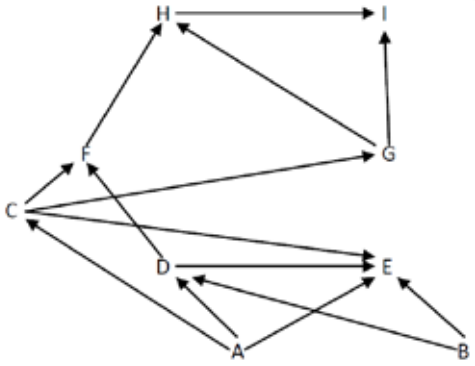
1. Of the following, which best describes the process of evolution?
   - **A)** The organisms need for particular traits drives the evolution of the traits.
   - **B)** The grand plan of nature determines how organisms will evolve to become perfect organisms
   - **C)** The most fit organisms will survive and therefore reproduce to pass on the favorable traits for the current conditions
   - **D)** The change in the genetic makeup of successive generations of a species
   - **E)** The selective pressures of nature act on genotypes to select the most favorable individuals of a population

2. The diagram below shows a food web. (Arrows represent energy flow and letters represent species.)

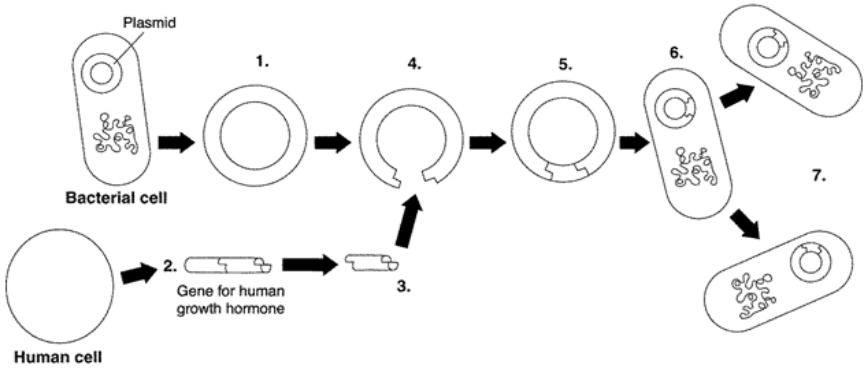


Which species would you label as an omnivore?

A) F **B)** I **C)** C **D)** G **E)** E

3. During DNA replication, why is DNA ligase most active on the lagging strand vs the leading strand?
   - **A)** The lagging strand is synthesized more slowly, and DNA ligase speeds up the DNA polymerase
   - **B)** The lagging strands contain more short DNA segments than the leading strand, and these Okazaki fragments are joined together by DNA ligase
   - **C)** The lagging strand synthesizes DNA in the 3' --> 5' direction
   - **D)** The lagging strand requires DNA ligase to attach the RNA primer to the Okazaki fragments
   - **E)** The lagging strand has no RNA primase activity, it is replaced by DNA ligase

4. The following diagram illustrates a procedure used in DNA technology.



What is segment #2 called and what gene did the plasmid have to contain in # 1?

A) DNA: ampR (resistance to ampicillin)
B) RNA: ori (origin of replication)
C) cDNA: F (fertility factor)
D) cDNA: ori (origin of replication)
E) cDNA: ampP (resistance to penicillin)

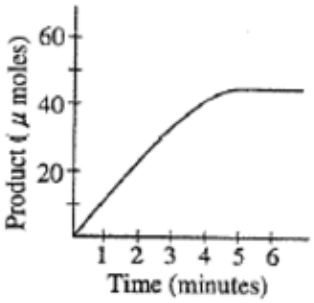
5. When an individual suffers from short-term starvation, most available food is then used to provide energy rather than for anabolic reactions. Which hormone would be the most active in times of this food shortage?

A) glucagon
B) calcitonin
C) insulin
D) ACTH
E) HGH (human growth hormone)

6. Which of the following are products of the light reactions in photosynthesis that are necessary to complete the Calvin-Benson cycle?

A) CO_2 and ATP
B) H_2O and O_2
C) $C(H_2O)$ and ADP + P_i
D) electrons and H^+
E) ATP and NADPH

7. Using the diagram of an enzyme-substrate reaction below: What is the most likely explanation for the change in the slope of the line between 3 and 5 minutes?



A) There was a dramatic drop in the pH of the solution
B) The enzyme had denatured
C) A large amount of the substrate had been catalyzed
D) The enzyme had achieved it's maximum rate of reaction
E) An allosteric inhibitor appeared

8. A cell lacking oligosaccharides on the extra-cellular matrix surface of its cell membrane would likely be inefficient in
A) cell-to-cell recognition
B) attaching to the cytoskeleton and maintaining cell shape
C) transporting ions against an electrochemical gradient
D) maintaining the fluidity of the phospholipid bilayer
E) establishing cell receptors for protein recognition such as insulin

9. Which of the following would <u>not</u> be a consequence of global climate change?
A) shift in agriculture regions
B) increase in invasive species
C) decrease in atmospheric moisture
D) increase in sea levels around the world
E) increase in environmental refugees

10. Which of the following may show enzymatic activity?
I. Lipids II. Proteins III. RNA
A) I only
B) II only
C) III only
D) I and II
E) II and III

11. If nondisjunction happens during meiosis I;
- **A)** the resulting gametes (sex cells) are diploid
- **B)** all gametes will lack a sex chromosome
- **C)** only one half of the gametes will be n, one-fourth will be n + 1 and one-fourth will be n - 1
- **D)** one-half of the gametes will be n + 1 and the other half will be n - 1
- **E)** one-half of the gametes will be 2n and one-half will be n

12. For most species that exhibit sexual dimorphism, the selection of a mate is the choice of the
- **A)** male
- **B)** female
- **C)** parents
- **D)** larger individual, no matter the species
- **E)** more colorful individual

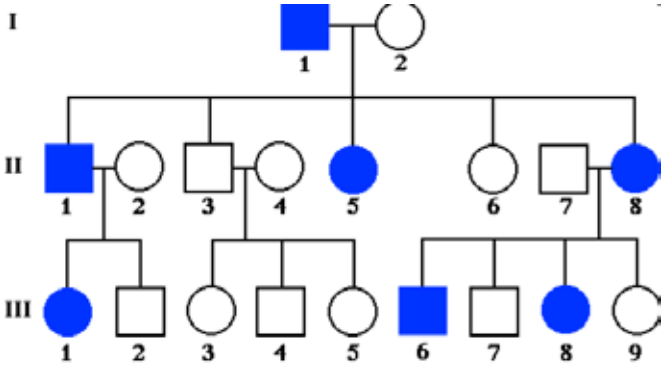
13. A researcher discovered a terrestrial animal with the following characteristics: tracheal system for gas exchange, exoskeleton, modified segmentation. A zoologist would predict that its adults most likely would also have
- **A)** a water vascular system
- **B)** a sessile lifestyle
- **C)** wings
- **D)** eight legs
- **E)** parapodia

14. A plant is tested with a particular chemical that interferes with the establishment and maintenance of proton gradients across the membranes of plant cells. Which of the following processes would <u>not</u> be directly affected?
- **A)** stomatal opening
- **B)** cellular respiration
- **C)** xylem transport
- **D)** photosynthesis
- **E)** none: all would be directly affected

15. A number of physiological reactions occur when a person is exposed to stressful stimuli. Which of the following is <u>not</u> correctly matched with the stress related hormones?

A) Epinephrine - stimulate glucose production from glycogen
B) Glucocorticoids - reduce immune system activity
C) Mineralocorticoids - increase blood pressure and volume
D) ACTH - stimulate adrenal medulla to secrete epinephrine
E) Norepinephrine - increase breathing rate

16. What mode of inheritance is the most likely type for the following pedigree? (Shaded are affected individuals; non-shaded are not affected.)



A) autosomal recessive
B) autosomal dominant
C) sex-linked recessive
D) sex-linked dominant
E) mitochondrial recessive

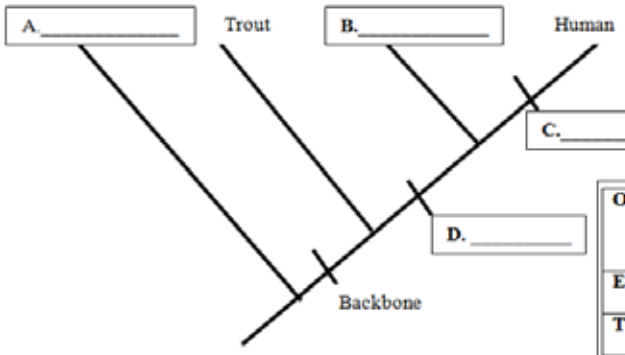
17. Red-green color blindness in humans is caused by a recessive allele on the X chromosome. The daughter of a woman who is colorblind has normal vision and marries a man that is color-blind. This couple has a son. What is the probability that the son is color-blind?

A) 0 **B)** 1/4 **C)** 1/2 **D)** 3/4 **E)** 1

18. A large forested area is fragmented into small forest tracts separated by agricultural areas. This change will most likely lead to

A) a decrease in the gene flow within species of the original forest
B) a more stable regional climate
C) an increase in the population of top carnivores
D) an improvement in the dispersal mechanisms of forest species
E) increase in biodiversity as selective pressures will decrease

19. The cladogram and chart below show the evolutionary connections of four groups of animals.



Organism	Derived Character		
	Backbone	Legs	Hair
Earthworm	Absent	Absent	Absent
Trout	Present	Absent	Absent
Lizard	Present	Present	Absent
Human	Present	Present	Present

If you were to complete the cladogram with the information from the chart, the labels would be

A) A: Earthworm, B: Lizard, C: Legs, D: Hair
B) A: Lizard, B: Earthworm, C: Hair, D: Legs
C) A: Earthworm, B: Lizard, C: Hair, D: Legs
D) A: Lizard, B: Earthworm, C: Legs, D: Hair
E) A: Earthworm, B: Hair, C: Legs, D: Lizard

20. Due to a hereditary condition, an individual has abnormal microtubules. Which organs or tissues would you expect to be affected?

A) egg cells, kidneys, pancreas
B) microvilli, alveoli, glomeruli
C) salivary and sebaceous glands
D) small intestine, gall bladder, bronchioles
E) sperm, trachea, larynx

21. When ATP releases energy, it also releases an inorganic phosphate. What might happen with this inorganic phosphate?

A) It can only be used to regenerate more ATP in the mitochondria
B) It can be added to water and excreted through the kidneys
C) It can enter the nucleus and activate transcriptional factors
D) It can be attached to other molecules in order to activate them
E) It can attach to RuBP and fix carbon for the production of glucose

22. Many advanced malignant tumor cells have very abnormal chromosomes and often an abnormal number of chromosomes. Which of the following best explains why this can occur?

A) Cancer cells are no longer anchorage dependent
B) Cancer cells are no longer density dependent
C) Cells with abnormal chromosomes can still have normal metabolism and function properly
D) Transduction introduces new genetic material into these cells
E) Cells with abnormal chromosomes can still go through cell cycle checkpoints

23. An orange orchard was experiencing a fungal infection and was then sprayed with a fungicide periodically over the growing season. The following year, the yield of the crop declined, although there was no fungal infection to the trees. The best explanation would be

A) there was an increase in the number of decomposing bacteria
B) there was an increase in *Rhizobium* in the soil that absorbed the available nutrients
C) there was a decrease in productivity due to the death of mycorrhizae
D) there was a decrease in available root hairs for water absorption
E) there was an increase rate of evapotranspiration as the guard cells were affected

24. Which of the following would be beneficial for the seeds of orchids? The seeds are among the smallest known, with reduced amounts of endosperm and with very small seed leaves.

A) They require long periods of dormancy during which the embryo develops
B) They are surrounded by brightly colored, sweet fruit
C) They germinate very quickly after being released from the ovary
D) They developing embryo is dependent upon the gametophyte for nutrition
E) The sporophytes that produce these seeds are wind pollinated

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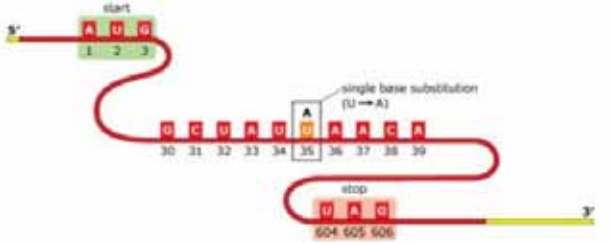
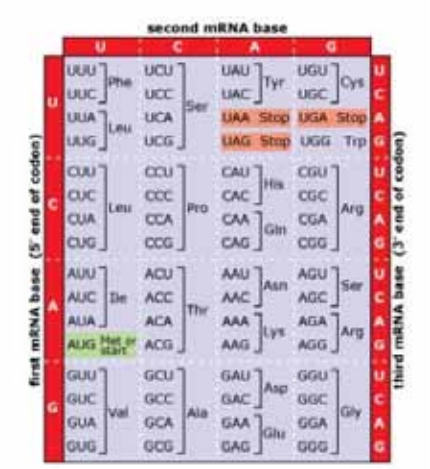
25. The diagram below shows an mRNA molecule that encodes a protein with 202 amino acids. The start and stop codons are highlighted, and a portion of the nucleotide sequence in the early part of the of the molecule is shown in detail. At position 35, a single base-pair substitution in the DNA has changed that would have been a uracil (U) in the mRNA to an adenine (A). Based on the genetic code chart below, which of the following would be the result of this single base-pair substitution?





A) a silent mutation will occur
B) a frameshift mutation will occur
C) a missense mutation will occur
D) a nonsense mutation will occur
E) a single amino acid change will occur which may or may not affect the function of the protein

26. A car, starting from rest at a toll booth on the Jersey Turnpike, accelerates in a straight line path at a constant 2 m/s^2. How far will this car travel in 12 seconds?

A) 6 m **B)** 24 m **C)** 144 m **D)** 180 m **E)** 288 m

27. A ball is thrown vertically upward from the surface of the earth. Consider the following quantities of the ball:

I. the speed of the ball
II. the velocity of the ball
III. the acceleration

Which of these is (are) zero when the ball has reached the maximum height?

A) I only **C)** I & II only **E)** I, II, & III
B) II only **D)** I & III only

28. During a three-hour tour, a small boat, the USS Minnow, travels 240 km north and then travels 180 km east. What is the magnitude of the boat's average velocity for the three-hour trip?

A) 20 km/hr **B)** 30 km/hr **C)** 60 km/hr **D)** 100 km/hr **E)** 140 km/hr

29. A boat that can travel at 4 km/h in still water crosses a river with a current of 2 km/h. At what angle must the boat be pointed upstream, relative to its actual path, to go straight across the river?

A) 27^o **B)** 30^o **C)** 45^o **D)** 60^o **E)** 90^o

30. A boy pulls a 5 kg sled with a rope that makes a 60.0° angle with respect to the horizontal surface of a frozen pond. The boy pulls on the rope with a force of 10 N; and the sled moves with constant velocity. What is the coefficient of friction between the sled and the ice?

A) 0.06 **B)** 0.09 **C)** 0.12 **D)** 0.18 **E)** 0.24

31. A car traveling at 20 m/s follows a curve in the road so that its centripetal acceleration is 5 m/s^2. What is the radius of the curve?

A) 4 m **B)** 8 m **C)** 80 m **D)** 160 m **E)** 640 m

32. An asteroid in our solar system has a circular orbital radius 4 times as far from the Sun as is Earth. What is the orbital period of this asteroid?

A) 0.25 yr **B)** 4 yrs **C)** 8 yrs **D)** 16 yrs **E)** 32 yrs

33. Which one of the following statements concerning kinetic energy is true?

A) Kinetic energy is always positive or zero.
B) Kinetic energy is a quantitative measure of inertia.
C) Kinetic energy is directly proportional to velocity.
D) Kinetic energy can be measured in watts.
E) Kinetic energy is always equal to the potential energy.

34. A bowling ball is dropped from the roof of Science Building and falls vertically. Just before it reaches the ground, the speed of the bowling ball is 17 m/s. Neglect air resistance and determine the height of Science Building.

A) 15 m **B)** 17 m **C)** 21 m **D)** 33 m **E)** 42 m

35. You are at Six Flags Great Adventure for Physics Day 2015. You witness a bumper car collision between two identical bumper cars travelling at the same speed and with drivers of the same weight. Car A is traveling due north and Car B is traveling due east. After the collision, Car A rebounds in the due south direction. What compass direction correctly represents the final direction of Car B?

A) East **B)** West **C)** Northwest **D)** Northeast **E)** Southeast

36. What is the angular speed in *rad/s* of the second hand of a watch?

A) $\frac{\pi}{60}\frac{rad}{s}$ **B)** $\frac{\pi}{30}\frac{rad}{s}$ **C)** $\pi\frac{rad}{s}$ **D)** $2\pi\frac{rad}{s}$ **E)** $4\pi\frac{rad}{s}$

37. Which one of the following statements is the best explanation for the fact that metal pipes that carry water often burst during cold winter months like we had in early 2015?

A) Water contracts upon freezing while the metal expands at lower temperatures.
B) The metal contracts to a greater extent than the water.
C) Water expands upon freezing while the metal contracts at lower temperatures.
D) Both the metal and the water expand, but the water expands to a greater extent.
E) The interior of the pipe contracts less than the outside of the pipe.

38. The term *heat* most accurately describes

A) the molecular motion inside of an object.
B) the flow of energy due to a temperature difference.
C) the absolute temperature of an object.
D) a measure of how hot an object is.
E) the internal energy of an object.

39. The absolute temperature of an ideal gas is directly proportional to

A) the average translational kinetic energy of the gas.
B) the number of molecules in the sample.
C) the average momentum of a molecule of the gas.
D) the amount of heat required to raise the temperature of the gas by 1 C°.
E) the relative increase in volume of the gas for a temperature increase of 1 C°.

40. When a hair brush is run vigorously through hair, the brush becomes negatively charged as
A) negative charges are transferred from the hair to the brush.
B) negative charges are transferred from the brush to the hair.
C) positive charges are created on the surface of the brush.
D) positive charges are transferred from the brush to the hair.
E) positive charges are transferred from the hair to the brush.

41. Two positive point charges Q and $2Q$ are separated by a distance R. If the charge Q experiences a force of magnitude F when the separation is R, what is the magnitude of the force on the charge $2Q$ when the separation is $2R$?
A) $F/4$ **B)** $F/2$ **C)** F **D)** $2F$ **E)** $4F$

42. Three resistors, 4.0 Ω, 8.0 Ω, & 24 Ω, are connected in parallel in a circuit. What is the equivalent resistance of this combination of resistors?
A) 0.33 Ω
B) 2.4 Ω
C) 3 Ω
D) 12 Ω
E) 36 Ω

43. Three resistors, 4.0 Ω, 8.0 Ω, & 24 Ω, are connected in series in a circuit. What is the equivalent resistance of this combination of resistors?
A) 0.33 Ω
B) 2.4 Ω
C) 3 Ω
D) 12 Ω
E) 36 Ω

44. The unit *kilowatt · hour* measures
A) potential drop. **C)** voltage **E)** power
B) current. **D)** energy

45. Consider the following four quantities pertaining to a charged particle moving in a magnetic field.

I. Magnitude of the charge.
II. Magnitude of the velocity component that is perpendicular to the magnetic field lines.
III. Polarity of the charge (positive or negative).
IV. Magnitude of the magnetic field strength.

Which of the above four quantities dictates the path of the moving charged particle in the magnetic field?

A) I & II only **C)** II & III only **E)** All four quantities.
B) I, II, & IV only **D)** I, III, & IV only

46. Which one of the following statements concerning the wavelength of light traveling from the Sun to Earth through the vacuum of space is true?

A) The wavelength is directly proportional to the frequency of the wave.
B) The wavelength is the same for all types of electromagnetic waves.
C) The wavelength is inversely proportional to the speed of the wave.
D) The wavelength is inversely proportional to the frequency of the wave.
E) The wavelength is independent of the speed of the wave for a fixed frequency.

47. The radius of curvature of a spherical concave mirror is 50 cm. What is the focal length of this mirror?

A) +25 cm **B)** -25 cm **C)** +50 cm **D)** -50 cm **E)** +100 cm

48. The "critical" angle is the angle of incidence that will produce an angle of refraction of

A) infinity.
B) zero
C) 90^{o}
D) half the size of the incident angle.
E) twice the size of the incident angle.

49. In 1905, Albert Einstein introduced the "particle" or photon nature of light to describe

A) interference of light through diffraction gratings.
B) photoelectric effect.
C) electron diffraction.
D) polarization of light.
E) diffraction of light.

50. A Beta particle emitted from an unstable nucleus results in

A) the nucleus gaining one proton and gaining one unit of mass.
B) the nucleus gaining one proton and losing one unit of mass.
C) the nucleus losing one proton and losing one unit of mass.
D) the nucleus losing one proton and gaining one unit of mass.
E) the nucleus gaining one proton and mass remains unchanged.

51. How does the size of the halide ion compare to the corresponding atom?

A) The halide is smaller than the halogen atom.
B) The halide is larger than the halogen atom.
C) The halide is the same size as the halogen atom.
D) Only those halides that have *d*-shell electrons are larger than the halogen atom.
E) Halides that make cations are always larger.

52. How does the electron affinity of the halogens change?

A) Increase down the family.
B) Decrease down the family.
C) The halogens with *d*-shell electrons have negative electron affinities.
D) All have a zero electron affinity.
E) Halogens with a positive oxidation number are larger than those with a negative oxidation number.

53. Carbon-14, ^{14}C, has a half-life of 5700 years. How can you shorten this half-life?

A) Double its absolute temperature.
B) Double its pressure (*i.e.*, put it in a pressure chamber).
C) Combine it with oxygen-15 (^{15}O has a half-life of 122 seconds) to make CO_2.
D) Subject it to gamma radiation.
E) The half-life cannot be changed.

54. A block of salt is placed on a tared piece of paper (mass = 1.233g) and the balance reads 10.163g. Its dimensions are measured as 2.35 cm x 1.905 cm x 0.92 cm. What should be its reported density?

A) 2.168207235 g/cm^3
B) 2.168 g/cm^3
C) 2.17 g/cm^3
D) 2.2 g/cm^3
E) 2 g/ cm^3

55. What is the composition of a calcium-40 ion, $^{40}_{20}Ca^{2+}$?

A) 20 protons, 20 neutrons, 20 electrons
B) 20 protons, 20 neutrons, 22 electrons
C) 20 protons, 20 neutrons, 18 electrons
D) 20 protons, 40 neutrons, 2 electrons
E) 20 protons, 20 electrons, 2 neutrons

56. What chemical species will be produced when potassium dichromate, an orange solid, $K_2Cr_2O_7$, is dissolved in water?

A) $K_2Cr_2O_7(aq)$
B) $K_2(aq) + Cr_2(aq) + O_7(aq)$
C) $2\ K^+(aq) + 2\ Cr^{3+}(aq) + 7\ O^{2-}(aq)$
D) $2\ K^+(aq) + Cr_2O_7^{2-}(aq)$
E) $K^{2+}(aq) + Cr^{2+}(aq) + O^{7-}(aq)$

57. When baking soda, sodium hydrogen carbonate, $NaHCO_3$, is added to vinegar, acetic acid, CH_3COOH, a large amount of fizzing occurs. Which expression best represents what happens?

A) $NaHCO_3(s) + CH_3COOH(aq) \rightarrow Na^+(aq) + H_2O(l) + CO_2(g) + CH_3COO^-(aq)$
B) $NaHCO_3(s) + CH_3COOH(aq) \rightarrow NaCH_3COO(aq) + H_2CO_3(g)$
C) $NaHCO_3(s) + CH_3COOH(aq) \rightarrow Na^+(aq) + CH_4(g) + CO_2(g) + HCOO^-(aq)$
D) $NaHCO_3(s) + CH_3COOH(aq) \rightarrow Na^+(aq) + H_2(g) + CH_4(g) + CO_2(g)$
E) $NaHCO_3(s) + CH_3COOH(aq) \rightarrow Na^+(aq) + H_2O\ (g) + CH_4(g) + CO_2(g)$

58. A compound contain only carbon, hydrogen, and oxygen is 63.16% C and 8.88% H. It was determined that it had a molar mass of 114. What are its empirical formula and its molecular formula?

A) $C_4H_{18}O_3$, $C_4H_{18}O_3$
B) $C_5H_6O_3$, $C_{10}H_{12}O_6$
C) C_3H_5O, $C_6H_{10}O_2$
D) $C_7H_{14}O$, $C_7H_{14}O$
E) $C_7H_7O_2$, $C_{3.5}H_{3.5}O$

59. Aluminum carbonate reacts with hydrochloric acid to produce carbon dioxide gas and 3 other products according to the following reaction:

$$Al_2(CO_3)_3(s) + 6\ HCl(aq) \rightarrow 2\ Al^{3+}(aq) + 6\ Cl^-(aq) + 3\ CO_2(g) + 3\ H_2O(l)$$

If 35.1 g of aluminum carbonate reacts completely, what volume of CO_2, measured at STP, can be produced?

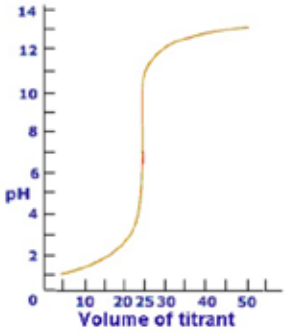
A) 3.36 L
B) 10.1 L
C) 22.4 L
D) 67.2 L
E) 67.2 L

60. When equal moles of 4 different compounds are added to separate 1-litre containers of water, which solution would contain the highest concentration of electrolytes?

A) $C_6H_{12}O_6$, molar mass = 180.0 g/mol
B) H_2S, molar mass = 34.1 g/mol
C) SiO_2, molar mass = 60.1 g/mol
D) $BaSO_4$, molar mass = 233.4 g/mol
E) Ag_2I, molar mass = 342.7 g/mol

61. Which titration curve would indicate the neutralization of weak acid by a weak base?

A)



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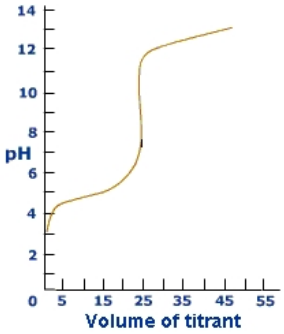

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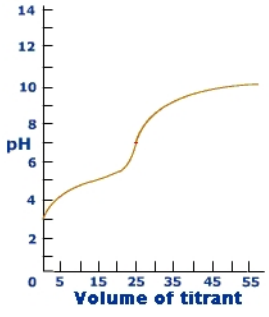

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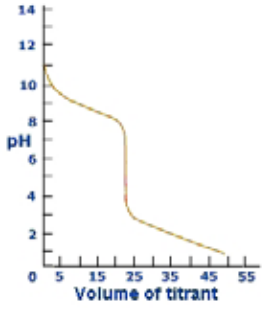


E) None of the above.

62. What is the difference between a *complete ionic equation* and a *net ionic equation*?

A) A net ionic equation has the precipitate removed.
B) A net ionic equation does not include spectator ions.
C) A complete ionic equation has a balance of cations and anions.
D) Only a complete ionic equation represents the law of definite composition.
E) A net ionic equation obeys the law of multiple proportions.

63. What is the molarity of a solution in which 12.5 g of NaOH are dissolved in enough water to make 250. mL of solution?

A) 0.05 *M*
B) 0.313 *M*
C) 1.25 *M*
D) 3.13 *M*
E) 20 *M*

64. A white solid was tested and the following results were reported:

- dissolves readily in water
- produces a purple color in a flame test
- a solution gives a white precipitate when a drop of dilute silver nitrate solution is added

Based on these results, which of the following compounds could it be?

A) $CuSO_4 \cdot 5H_2O$
B) KNO_3
C) KCl
D) CH_3COOH
E) PbI_2

65. A student tested the pH of two solutions. Solution A had a pH of 2 while solution B had a pH of 4. Which statement is true concerning these solutions?

A) Solution A has twice the $[H_3O^+]$ as solution B.
B) Solution B has twice the $[H_3O^+]$ as solution A.
C) Solution A has 100 times the $[H_3O^+]$ as solution B.
D) Solution B has 100 times the $[H_3O^+]$ as solution A.
E) Solution A is an acid, solution B is a base

66. What is the main reason that the melting point of KI higher than that of water?

A) KI is heavier.
B) KI has more electrons.
C) KI has ionic bonds.
D) Water has hydrogen bonding.
E) Both K and I are bigger atoms than H and O.

67. Consider a 2.0 L container at 27°C with 3.00 grams of each of these gases: O_3, SO_2, CO_2 (assume no chemical interaction).

gas	molar mass(g/mol)	Boiling point (K)	molar heat of vaporization, ΔH_{vap} (kJ/mol)
O_3	48.0	165	13.8
SO_2	64.1	263	25.4
CO_2	44.0	195 (subl.)	16.9

Which gas has particles with the highest average kinetic energy?

A) O_3
B) SO_2
C) CO_2
D) All have the same average kinetic energy.
E) The one with the greatest number of molecules.

68. Consider the reaction: A+ 2 B → 2 C + D

A series of experiments measuring initial rate of various concentration of reactants gives these data)

Experiment	[A] *M*	[B] *M*	$Rate_{init}$ (*M*/sec)
1	0.10	0.10	0.04
2	0.10	0.20	0.08
3	0.20	0.20	0.32
4	0.30	0.30	?

What would be the initial reaction rate for experiment 4?

A) 0.48
B) 0.64
C) 1.96
D) 1.08
E) 1.28

69. Initially 2.50 mol of nitrogen and 4.00 mol of hydrogen gas are introduced into an evacuated 5.00 L container at constant temperature. After the mixture is allowed to react and come to equilibrium the molar concentration of ammonia if found to be 1.44 *M*. What is the equilibrium constant, K_c, for this reaction?

$$N_2(g) + 3\ H_2(g) \rightleftarrows 2\ NH_3(g)$$

A) 0.0123
B) 0.131
C) 3.60
D) 7.66
E) cannot be determined from the information given.

70. Hydrogen gas reacts with solid sulfur to produce hydrogen sulfide gas.

$$H_2(g) + S(s) \rightleftarrows H_2S(g) \qquad \Delta H_{rxn} = -20.2\ \text{kJ/mol}$$

Which would maximize the conversion of reactants to products?

A) add more sulfur
B) double the volume
C) lower the temperature
D) add a catalyst
E) adding helium gas

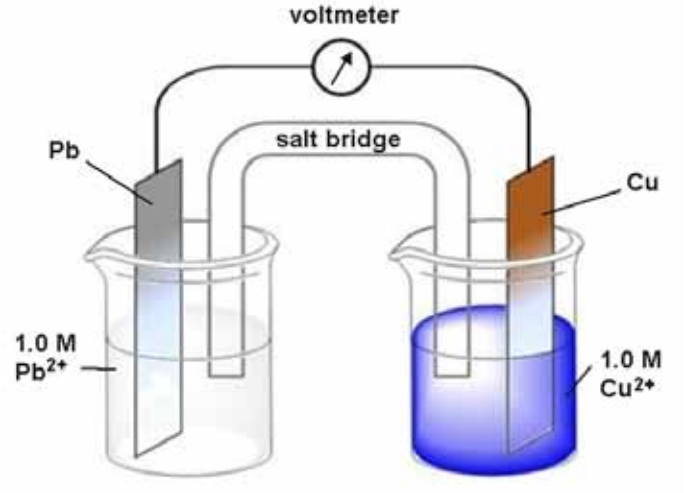
71. Consider the following Brönsted-Lowry acid-base reaction.

$$HSO_4^- + HCO_3^- \rightleftarrows SO_4^{2-} + H_2CO_3 \quad \text{(all aqueous)}$$

What is the conjugate base of HSO_4^-?

A) HCO_3^-
B) SO_4^{2-}
C) H_2CO_3
D) H_2SO_4
E) S^{2-}

72. Consider the diagram of and electrochemical cell and the reduction potential table.



Half-reaction	E° (V)
$Pb^{4+}(aq) + 2e^- \rightarrow Pb^{2+}(aq)$	+1.80
$O_2(g) + 4\ H^+(aq) + 4e^- \rightarrow 2\ H_2O(l)$	+1.229
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	+0.337
$Cu^{2+}(aq) + 1e^- \rightarrow Cu^+(aq)$	+0.153
$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$	-0.126
$2\ H_2O(l) + 2e^- \rightarrow H_2(g) + OH^-(aq)$	-0.828

What is the maximum potential for this cell under standard conditions?

A) 0.211 V
B) 0.463 V
C) 1.165 V
D) 2.63 V
E) –0.027 V

73. Magnesium reacts with dilute hydrochloric acid to produce hydrogen gas. Silver does not react in dilute hydrochloric acid. Based on this information, which reaction will occur as written?

A) $H_2(g) + Mg^{2+}(aq) \rightarrow 2\ H^+(aq) + Mg(s)$

B) $2\ Ag(s) + Mg^{2+}(aq) \rightarrow 2\ Ag^+(aq) + Mg(s)$

C) $2\ Ag^+(aq) + Mg(s) \rightarrow 2\ Ag(s) + Mg^{2+}(aq)$

D) $2\ Ag(s) + 2\ H^+(aq) \rightarrow H_2(g) + 2\ Ag^+(aq)$

E) $2\ Ag(s) + Mg(s) \rightarrow Ag_2Mg\ (s)$

74. & 75. Refer to the following reaction and data table

$$2\ H_2O(l) + 3\ SO_2(g) + Pb_3O_4(s) \rightarrow 3\ PbSO_4(s) + 2\ H_2(g)$$

compound	standard enthalpy of formation, $\Delta H_f°$, (kJ/mol)
$H_2O(l)$	-285.8
$SO_2(g)$	-296.1
$Pb_3O_4(s)$	-734.7
$PbSO_4(s)$	-920.1

74. Calculate the enthalpy change, ΔH_{rxn}, for the reaction.

A) +396.5 kJ

B) -565.7 kJ

C) -4954.9

D) Can't be calculated because the standard enthalpy of formation for $H_2(g)$ is missing.

E) Depends on the pressure and concentration of the SO_2 gas.

75. What is reduced?

A) hydrogen in the water and sulfur in the sulfur dioxide

B) hydrogen in the water and lead in the lead oxide

C) sulfur in the sulfur dioxide and lead in the lead oxide

D) sulfur in the sulfur dioxide, lead in the lead oxide, and hydrogen in the water

E) None are reduced, in a chemical reaction the mass of the products equals the mass of the reactants, *i.e.*, the Law of Conservation of Mass.

76. Which of the following is the correct sequence of proto-plate tectonic events
A) ocean formation, crustal cooling, plate subduction, back arc formation, continent development
B) continent development, crustal cooling, ocean formation, plate subduction, back arc formation,
C) plate subduction, crustal cooling, ocean formation, back arc formation, continent development
D) crustal cooling, ocean formation, plate subduction, back arc formation, continent development
E) back arc formation, crustal cooling, ocean formation, plate subduction, continent development

77. The focus of the 4/25/15 Nepal Earthquake occurred at
A) a transform plate boundary
B) a convergent plate boundary
C) an ocean ridge
D) a hot spot
E) a divergent plate boundary

78. After Life began on The Earth….
A) There is no scientific theory that explains the causes of the events that follow.
B) God controlled all of the events that followed.
C) Aliens controlled all of the events that followed.
D) There is no life on Earth.
E) There is a scientific theory that explains the causes of the events that follow.

79. In Vulcanism, "Gray" eruptions
A) produces explosive lava.
B) produces pyroclastic flows.
C) occurs at island arcs.
D) kill many people.
E) all of the above

80. All of the following are evidence of glaciation, except:
A) striations
B) nuee ardente
C) cirque
D) moraine
E) kettle

81. Folding indicates the following event occurred:
A) metamorphism
B) faulting
C) glaciation
D) glassification
E) clastic deposition

82. All of the following statements are true Except:
A) Humans cohabited with dinosaurs.
B) Scientists have a hypothesis as to how life began on the Earth.
C) The Big Bang directly caused the origin of the universe.
D) Uniformatarianism allows us to understand the past and hypothesize the future.
E) Evolution is the only theory that explains how life changes over time.

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

84. The approximate ratio of the Sun's tidal force to the Moon's tidal force, as felt on the Earth's surface is:
A) 400:1
B) 2:1
C) 1:2
D) 1:400
E) the Sun exerts no tidal force

85. Which is the correct order for objects farthest to closest to 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, Proxima Centauri, Heliopause, The Closest Star, The Moon,
E) Proxima Centauri, The Moon, The Closest Star, Andromeda Galaxy Heliopause

86. Zubeneschamali is approximately 185 light years from our solar system. How many years will it take an x-ray waves emitted by Zubeneschamali to reach the Earth?
A) 93 Million
B) Radio waves cannot travel through space.
C) 300,000
D) 710 Trillion
E) 185

87. Approximately, how many kilometers away from our solar system is Zubeneschamali?
A) 185
B) 10 Billion
C) 300,000
D) 1751 Trillion
E) 93 Million

88. The Big Bang
A) is a lie created by atheist scientists
B) happened in Tunguska, Siberia in 1908.
C) happened approximately 13.8 BYA.
D) destroyed The Earth.
E) is the event that will end the Universe.

89. When viewed over a 6 month period, a celestial object's parallax shift is 8" of arc. Its distance from the observer is approximately:
A) 1.64 l.y. **B)** 4 pc **C)** 9.47e12 km **D)** 6.54 l.y. **E)** 13.08 l.y.

90. An ocean wave with a wavelength of 20 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

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

92. All of the following are false about ocean density currents EXCEPT:
A) they can cause global warming.
B) they move quickly, at 10 km/hr
C) they kill many types of sea life.
D) they tend to originate at surface polar regions
E) they are small localized currents.

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

94. The same tide arrives later each day because
A) the Moon's orbit and the Earth's spin are in the same direction.
B) the Moon's orbit and the Earth's spin are in opposite directions.
C) the Moon's spin and the Earth's orbit are in the same direction.
D) the Moon's spin and the Earth's orbit are in opposite directions.
E) the Moon does not spin as it orbits the Earth.

95. The oceans...
A) will continually increase in salinity.
B) will continually increase in volume due to added water.
C) will gradually evaporate away to space.
D) maintain a fairly constant salinity range through precipitate deposition.
E) decrease in salinity during periods of glaciation.

96. The term “Global Warming”
A) was created by climate scientists.
B) can be misunderstood to mean that everywhere is getting much hotter.
C) would be better changed to “Global Anthrogenic Climate Change”.
D) does not mean that local weather could be anomalously cooler in the short term
E) All of the above.

97. Which statement is the most accurate?
A) Hot Air rises under its own power.
B) Colder air displaces warmer air upward.
C) Denser Air moves away from less dense air.
D) Laws of Thermodynamics are lies.
E) Moist air is more dense than dry air.

98. Water vapor, when removed from the air, makes the air
A) denser. **B)** lighter. **C)** moister. **D)** warmer. **E)** less dense.

99. 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.

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

END OF TEST