raTOSS UP

1. BIOLOGY: *Short Answer:* In 1890, this German physician published four criteria by which a casual relationship between a causative microbe and disease could be established. In addition to his work in formulating the postulates that now bear his name, he isolated the bacteria that cause antharax, cholera, and tuberculosis. Name this founder of bacteriology.

ANSWER: ROBERT KOCH

BONUS

1. BIOLOGY: *Short Answer:* Match the following bacterial morphologies to their correct described shapes  
  
1. spherical shape  
2. helically-twisted cylinder

3. rod shape

A. spirochete

B. coccus

C. bacillus

ANSWER: 1. C 2. A 3. B

TOSS UP

2. CHEMISTRY: *Multiple Choice:* The cesium chloride structure, typified by cesium chloride is common in compounds with a with a radius ratio greater than that of 0.7. In this structure, each unit cell can be thought of as  
  
W) face-centered cubic  
X) body-centered cubic

Y) hexagonal  
Z) tetragonal primitive  
  
ANSWER: X) body-centered cubic

BONUS

2. CHEMSITRY: *Short Answer:* Through X-ray crystallography, it is determined that the atoms of a metal form body-centered cubic unit cells. If the radius of the atom is r, what is the length of one of the sides of the unit cell, expressed in terms of r?  
  
ANSWER: 4r/(sqrt 3)

TOSS UP

3. PHYSICS: *Multiple Choice:* The Standard Model of particle physics is a theory concerning the interactions of the fundamental forces. Which of the following statements is NOT TRUE of the standard model?  
  
W) fermions are categorized into three generations, with particle mass increasing as generation number increases

X) the Z boson mediates the weak interaction and is electrically neutral as well as its own antiparticle

Y) although quarks in generations two and three rapidly decay, neutrinos in generations higher than one are stable  
Z) bosons are particles governed by Bose-Einstein statistics and include composite particles such as stable nuclei of even mass number, e.g. helium-4

ANSWER: Y) although quarks in generations two and three rapidly decay, neutrinos in generations higher than one are stable

BONUS

3. PHYSICS: *Short Answer:* Order the following 4 leptons from heaviest to lightest: top quark, up quark, muon neutrino, strange quark  
  
ANSWER: top quark, strange quark, up quark, muon neutrino

TOSS UP

4. MATHEMATICS: *Short Answer:* What is the slope of the tine tangent to the equation

x2 -y2 = 1 at the point (sqrt 2, 1)?

ANSWER: sqrt 2

BONUS

4. MATHEMATICS: *Short Answer:* By name or number, identify all the of following 4 statements that are TRUE about the equation y = (x3 + x2 - 3)/x  
  
1. it is symmetrical about the x-axis  
2. it is symmetrical about the y-axis  
3. it is symmetrical about the origin  
4. it is symmetrical about the line y = x  
  
ANSWER: 2 only

TOSS UP

5. EARTH AND SPACE SCIENCE: *Multiple Choice:* Peridotite is an ultramafic rock composed almost entirely of dark silicate minerals and is believed to be the main constituent of the upper mantle. Peridotite would be expected to be most DEFICIENT in

W) sodium rich feldspar

X) calcium rich feldspar

Y) olivine

Z) pyroxene  
  
ANSWER: W) sodium rich feldspar

BONUS

5. EARTH AND SPACE SCIENCE: *Multiple Choice:* Which of the following geologic periods is described by the following statement: beginning of Paleozoic era, all major invertebrate groups appear, golden age of trilobites  
  
W) Cambrian

X) Devonian  
Y) Permian  
Z) Pennsylvanian

ANSWER: W) Cambrian

TOSS UP

6. BIOLOGY: *Multiple Choice:* Which of the following cellular components is present in eukaryotic cells but NOT prokaryotic cells?  
  
W) flagella  
X) plasma membrane

Y) chromosomes

Z) nuclear envelope

ANSWER: Z) nuclear envelope

BONUS

6. BIOLOGY: *Multiple Choice:* Cell fractionation is a technique for studying cell structure and function. It involves centrifuging a cell homogenate produced by blending cells, resulting in the isolation of cell components based on size and density. Fractionation at low speeds would produce pellets most rich in  
  
W) mitochondria  
X) nuclei and cellular debris  
Y) pieces of plasma membrane  
Z) ribosomes  
  
ANSWER: X) nuclei and cellular debris

TOSS UP

7. CHEMISTRY: *Multiple Choice:* A reaction occurs such that delta S system is positive and delta H system is negative. Which of the following is TRUE regarding the reaction?  
  
W) the reverse reaction is always spontaneous

X) the entropy of the surroundings must increase

Y) the change in Gibbs free energy of the reaction is positive  
Z) heat flows from the surrounds into the system

ANSWER: Z) heat flows from the surrounds into the system

BONUS

7. CHEMISTRY: *Multiple Choice:* The combination of two atomic chlorine radicals to yield one molecule of chlorine gas can be classified as a:   
  
W) initiation reaction  
X) propagation reaction  
Y) termination reaction  
Z) heterolytic reaction

TOSS UP

8. PHYSICS: *Multiple Choice:* Viscosity is internal friction in a fluid that oppose relative motion. Which of the following statements is NOT TRUE about viscosity?

W) as the temperature of a viscous gas increases, its viscosity decreases

X) Bernoulli's equation cannot be applied to the motion of a viscous fluid through a pipe

Y) the velocity of a viscous fluid moving through a pipe at the pipe wall is zero

Z) as the viscosity of a fluid increases, its tendency for laminar flow also increases  
  
ANSWER: W) as the temperature of a viscous gas increases, its viscosity decreases

BONUS

8. PHYSICS: *Short Answer:* A force of 100 N is required to force a fluid through a pipe. If both the length of the pipe and its radius are halved, what must be the new force, in Newtons, required to sustain the same volume flow rate through the pipe?  
  
ANSWER: 800 N

TOSS UP

9. MATHEMATICS: *Short Answer:* If sin(2) is equal to 0.91, what is sin(-2) equal to?

ANSWER: -0.91

BONUS

9. MATHEMATICS: *Multiple Choice:* The function f(x) = x3 + 12x - 24 is  
  
W) decreasing on -2 is less than x is less than 2  
X) decreasing for x is less than 0

Y) increasing for all x  
Z) decreasing for all x  
  
ANSWER: Y) increasing for all x

TOSS UP

10. EARTH AND SPACE SCIENCE: *Short Answer:* As the universe expanded and cooled in the time following the big bang, the glow from the warm gas faded into infrared wavelengths. This marked the beginning of a period where the gas was too cool to emit visible wavelengths, but was not yet able to form stars. As a result the universe was totally pitch black. What term do cosmologists give to this period lasting for about 400 million years?

ANSWER: Dark Age

BONUS

10. EARTH AND SPACE SCIENCE: *Short Answer:* Order the following cosmological time periods following the big bang from first to last: photon and particle soup, dark age, recombination, reionization, nucleosynthesis

ANSWER: PHOTON AND PARTICLE SOUP, NUCLEOSYNTHESIS, RECOMBINATION, DARK AGE, REIONIZATION

TOSS UP

11. BIOLOGY: *Multiple Choice:* The four blood types seen in humans: A, B, AB, and O are an example of  
  
W) pleiotropy  
X) multiple alleles  
Y) codominance  
Z) incomplete dominance  
  
ANSWER: X) MULTIPLE ALLELES

BONUS

11. BIOLOGY: *Short Answer:* What term is given to the phenotypic range that results due to the influence that an individual's environment can have on a given phenotype regardless of genotype? An example would be red blood cell count, which is partly dependent on genotype but also on factors such as altitude, and health.

ANSWER: NORM OF REACTION

TOSS UP

12. CHEMISTRY: *Multiple Choice:* Ligands are ions or molecules that bind to a central metal atom to form a coodination complex. The ligands typically act as a  
  
W) Lewis acid  
X) Lewis base

Y) Bronsted Lowry base

Z) Bronsted Lowry acid

ANSWER: X) Lewis bases

BONUS

12. CHEMISTRY: *Short Answer:* What term is given to the formation of multiple coordinate bonds between a polydentate ligand and a single central metal atom? The result of this process often inactivates the ions so that they are unreactive and become more soluble.

ANSWER: CHELATION

TOSS UP

13. PHYSICS: *Short Answer:* A 1 kg box is pulled by a rope at an angle of 60 degrees above the horizontal. A constant force of 10 N of friction acts upon the block. If the tension in the rope is 30 N and the block is pulled though 5 m, what is the total work done on the box?

ANSWER: 25 N

BONUS

13. PHYSICS: *Short Answer:* A 1000 kg elevator slows from 3m/s downwards to a stop to allow a passenger to get off at his floor. If the elevator takes 2 seconds to stop and the passenger weighs 60 kg, what is the passengers apparent weight, in Newtons as the elevator slows. Assume constant acceleration of the elevator and take g = 9.8 m/s squared.

ANSWER: 678 N

TOSS UP

14. MATHEMATICS: *Short Answer:* At what point of the graph of y = sqrt x is the tangent line equal to the slope between the points (0,0) and (9,3)?

ANSWER: sqrt (3/2)

BONUS

14. MATHEMATICS: *Multiple Choice:* The equation of the line tangent to the graph of y = (2x+3)/(3x-2) at the point (1,5) is

W) 13x - y = 18  
X) 13x + y = 18  
Y) -2x + 3y = 13  
Z) x+13y = 15  
  
ANSWER: X) 13x + y = 18

TOSS UP

15. EARTH AND SPACE SCIENCE: *Multiple Choice:* When the moon is in the first quarter or third quarter position, what type of tidal ranges are produced?   
  
W) spring

X) neap

Y) semidiurnal

Z) mixed  
  
ANSWER: X) NEAP

BONUS

15. EARTH AND SPACE SCIENCE: *Short Answer:* Tidal current is the term used to describe the horizontal flow of water accompanying the rise and fall of the tides. Rising and falling tides generate flood and ebb currents, respectively. What term refers to period of little or no current?

ANSWER: slack water

TOSS UP

16. BIOLOGY: *Multiple Choice:* Which of the following chromosomal systems for determining sex has no sex chromosomes? Females in this system develop from fertilized eggs and are diploid, while males develops from unfertilized eggs and are haploid and fatherless:

W) X-Y

X) X-0

Y) Z-W

Z) haplo-diploid

ANSWER: Z) haplo-diploid

BONUS

16. BIOLOGY: *Short Answer:* Color-blindness is a X-linked recessive trait. A color-blind male mates with a female who is heterozygous dominant. By name or number, identify all of the following four statements that would be expected to be TRUE of their children:  
  
1) all of their male children will be color blind

2) none of their children will be color blind  
3) the sons of their daughters will have a 50% chance of colorblindness

4) none of their children will be carriers of colorblindness  
  
ANSWER: 2 AND 3

TOSS UP

17. CHEMISTRY: *Short Answer:* What are the electron pair and molecular geometry of sulfur tetrafluoride?  
  
ANSWER: TRIGONAL BIPYRAMIDAL, SEESAW

BONUS

17. CHEMISTRY: *Multiple Choice:* Which of the following atoms/ions would be considered to have the highest polarizing power?  
  
W) Magnesium2+

X) Fluorine-  
Y) Strontium2+  
Z) Argon

ANSWER: W) Magnesium2+

TOSS UP

18. PHYSICS: *Short Answer:* Magnet quenching is an abnormal termination of magnet operation when part of the superconducting coil enters a normal state. By name or number, identify all of the following four situations that could result in a quench:

1. the magnetic field inside the magnet is too large

2. the rate of change of the field inside the magnet is too large

3. defects inside the magnet itself

4. the magnetic field is repelled under the physical surface of the magnet  
  
ANSWER: ALL OF THEM

BONUS

18. PHYSICS: *Multiple Choice:* Two point charges are placed on a vertical rod that is free to spin about its center. The charge at the top of the bar has a charge of +2q, and the charge at the bottom of the bar has a charge of -q. An electric field is applied such that the field lines pass perpendicular to the bar and point right. Which of the following statements describes the bar right after the field is applied.   
  
W) there is a net force to the right and the bar rotates clockwise  
X) there is a net force to the right and the bar rotates counterclockwise  
Y) there is a net force to the left and the bar rotates clockwise  
Z) there is a net force to the left and the bar rotates counterclockwise

ANSWER: W) there is a net force to the right and the bar rotates clockwise

TOSS UP

19. MATHEMATICS: *Short Answer:* John has 69 marbles. He gives a third of his marbles to Amy, and then half of the remaining marbles to Joseph. How many marbles is John left with?

ANSWER: 23

BONUS

19. MATHEMATICS: *Short Answer:* 6 pints of a 20% alcohol solution in water are mixed with 4 pints of a 10% alcohol solution. What is the percentage of alcohol in the resulting solution?  
  
ANSWER: 16%

TOSS UP

20. EARTH AND SPACE SCIENCE: *Multiple Choice:* The trapezium is a tight open cluster responsible for the formation of the HII region of the Orion Nebula. The star responsible for the majority of the ionization of the hydrogen has a spectral class of   
  
W) G  
X) B  
Y) F  
Z) O  
  
ANSWER: Z) O

BONUS

20. EARTH AND SPACE SCIENCE: *Multiple Choice:* Which of the following stars would expected to have a convective core throughout its entire volume and no radiative envelope?  
  
W) Barnard's star

X) Rigel A  
Y) Betelgeuse  
Z) Spica A  
  
ANSWER: W) Barnard's star

TOSS UP

21. BIOLOGY: *Short Answer:* Retroviruses are the class of RNA animal viruses with the most complicated reproductive cycles. What enzyme do retroviruses contain, which transcribe a RNA template into DNA, allowing diseases such as HIV to insert their genetic information into their host's DNA?

ANSWER: REVERSE TRANSCRIPTASE

BONUS

21. BIOLOGY: *Short Answer:* What biochemical technology allows the amplification and replication of a single or few copies of a piece of DNA through a process of repeated heating and cooling to allow DNA melting and enzymatic replication?  
  
ANSWER: POLYMERASE CHAIN REACTION

TOSS UP

22. CHEMISTRY: *Multiple Choice:* The central atom in an octahedral arrangement of electron pairs is likely  
  
W) sp2 hybridized  
X) sp3 hybridized  
Y) sp3d hybridized  
Z) sp3d2 hybridized  
  
ANSWER: Z) sp3d2 hybridized

BONUS

22. CHEMSITRY: *Short Answer:* Given that the enthalpy of formation of methane is -75 kJ/mol, that of water's is -242 kJ/mol, and that of carbon dioxide's is -394 kJ/mol, estimate the change of enthalpy when one mole of methane is reacted with an excess of oxygen.

ANSWER: 803 kJ

TOSS UP

23. PHYSICS: *Short Answer:* A washer is pushed with some initial velocity v and slides along a tabletop. If the washer is coated in Teflon such that the coefficient of kinetic friction is halved and then pushed at the same initial velocity, how much farther will it slide along the table?  
  
ANSWER: 2 times

BONUS

23. PHYSICS: *Multiple Choice:* A car travelling at 30 m/s on an icy road when the brakes suddenly lock. The car skids and comes to a stop in 200 m. What is the coefficient of friction between the tires and road, to the nearest tenth?

W) 0.1

X) 0.2  
Y) 0.3  
Z) 0.4  
  
ANSWER: X) 0.2

TOSS UP

24. MATHEMATICS: *Short Answer:* How many x-intercepts does the graph of y = 3x2 + 8x + 5 have?

ANSWER: 2

BONUS

24. MATHEMATICS: *Multiple Choice:* Let f be defined as the following:

f(x) = (sqrt 2x+5) - (sqrt x + 7) all over (x - 2) for x is not equal to 2  
and f(2) is equal to k  
If f is continuous at x = 2, then k is equal to  
  
W) 1/6  
X) 1/3  
Y) 1  
Z) 7/5  
  
ANSWER: W) 1/6

TOSS UP

25. EARTH AND SPACE SCIENCE: *Short Answer:* What widely-accepted model explains the formation and evolution of the Solar System and holds that planets form from the protoplanetary disk and are left behind after the disk clears?  
  
ANSWER: Solar nebula theory

BONUS

25. EARTH AND SPACE SCIENCE: *Short Answer:* Order the following 4 stages of Earth's development in order from first to last: cratering, flooding, slow surface evolution, differentiation  
  
ANSWER: differentiation, cratering, flooding, slow surface evolution