TOSS-UP

1) Chemistry *Short Answer* Give the molecular structure of the following three compounds, respectively: 1) ammonia, 2) boron trichloride, 3) iodine heptafluoride.

ANSWER: 1) TRIGONAL PYRAMIDAL, 2) TRIGONAL PLANAR, 3) PENTAGONAL BIPYRAMIDAL

BONUS

1) Chemistry *Short Answer* What two bond angle measures are present in a pentagonal bipyramidal geometry?

ANSWER: 72º AND 90º

TOSS-UP

2) Earth and Space Science *Multiple Choice* According to the Benchmark Model, which of the following components of the universe is dominant today?

W) matter
X) radiation
Y) empty space
Z) cosmological constant

ANSWER: Z) COSMOLOGICAL CONSTANT

BONUS

2) Earth and Space Science *Short Answer* What Greek letter denotes the ratio of the current density of the universe to the critical density of the universe?

ANSWER: OMEGA

TOSS-UP

3) Biology *Short Answer* What type of immunity arises from the ability of T and B cells to retain memory of each specific pathogen they encounter?

ANSWER: ACQUIRED IMMUNITY

BONUS

3) Biology *Short Answer* After hematopoiesis occurs in the bone marrow, differentiated T cells migrate to what organ in the human body?

ANSWER: THYMUS

TOSS UP

3) Math- *Short Anser* If the width of a square is doubled, by what percent would it's area increase?

Answer: Y) 300%

BONUS

3) Math- *Short Answer* Solve for x in the equation sin(x)*sec(x)=1 in the interval (0,pi)

Answer: (π/4)

TOSS-UP

5) Physics *Multiple Choice* Which of the following experiments first led to the proposition of the Lorentz-Fitzgerald contraction?

W) Michelson-Morley experiment
X) Hafele-Keating experiment
Y) Miller oil drop experiment
Z) Davisson-Germer experiment

ANSWER: W) MICHELSON-MORLEY EXPERIMENT

BONUS

5) Physics *Short Answer* By number, identify all of the following statements which are true about potentials: 1) The minimum of any potential curve behaves as a quadratic; 2) The Lagrangian is the quantity calculated by subtracting the potential energy from the kinetic energy of a system; 3)

The gravitational potential of a system approaches infinity as the objects travel infinitely far apart.

ANSWER: 1 AND 2

TOSS-UP

6) Earth and Space Science *Short Answer* What is the only type of moraine which lies perpendicular to the path of the glacier?

ANSWER: TERMINAL MORAINE

BONUS

6) Earth and Space Science *Multiple Choice* Which term describes a universe that is completely empty with negative curvature?

W) Einstein-de Sitter universe
X) Milne universe
Y) Friedmann universe
Z) de Sitter universe

ANSWER: X) MILNE UNIVERSE

TOSS-UP

7) Math *Short Answer* Given log3(a)=c and log3(b)=2c, what is a in terms of b?

ANSWER: a = sqrt(b)

BONUS

7) Math *Short Answer* Each side of the base of a square pyramid is reduced by 90%. By what factor must the height of the square pyramid be multiplied in order to maintain the same volume as the original square pyramid?

ANSWER: 100

TOSS-UP

8) Physics *Short Answer* The delay in voltage response of a MOSFET is usually modeled using what circuit element?

ANSWER: CAPACITOR

BONUS

8) Physics *Short Answer* By name or number, list all of the following statements which are true about Gauss's law: 1) The electric field due to any spherical distribution of charge is equal to that of an equivalent point charge at its geometric center, 2) The flux through a closed surface by a point charge outside the surface is equal to its quantity of charge divided by the electric permittivity constant, 3) The flux through a closed surface of arbitrary shape or size is the same as that through a spherical surface, as long as the enclosed charge is the same.

ANSWER: 1 AND 3

TOSS-UP

9) Earth and Space Science Multiple Choice Which of the following convergence patterns does NOT result in subduction or obduction?

W) oceanic-oceanic convergence
X) oceanic-continental convergence
Y) continental-continental convergence
Z) none of the above

ANSWER: Y) CONTINENTAL-CONTINENTAL CONVERGENCE

BONUS

9) Earth and Space Science Short Answer What term describes the rise of land masses after the removal of a large mass such as a glacier from the surface of the land?

ANSWER: ISOSTATIC REBOUND

TOSS-UP

10) Biology Multiple Choice Which of these describes an adaptation to an arid environment?

W) A short loop of Henle, which allows more filtrate to be removed from the blood
X) A short loop of Henle, which allows less water to be removed from the filtrate
Y) A long loop of Henle, which allows more filtrate to be removed from the blood
Z) A long loop of Henle, which allows more water to be removed from the filtrate

ANSWER: Z) A LONG LOOP OF HENLE, WHICH ALLOWS MORE WATER TO BE REMOVED FROM THE FILTRATE

BONUS

10) Biology Multiple Choice Which of the following would a researcher test a person's blood for to determine whether that person has been infected by a virus in the past?

W) antibodies
X) natural killer cells
Y) antigens
Z) macrophages

ANSWER: W) ANTIBODIES

TOSS-UP

11) Biology Short Answer In Sanger sequencing, ddNTPs are used. What does ddNTP stand for?

ANSWER: DIDEOXINUCLEOTIDES TRIPHOSPHATES

BONUS

11) Biology Short Answer At the end of Sanger sequencing, the sequence that is displayed on the gel electrophoresis results is AATCGATT. What is the DNA sequence of the original strand? Include 3' and 5' ends.

ANSWER: 3' AATCGATT 5'

TOSS-UP

12) Math Short Answer In a recursive sequence where a(n) = a(n-1) + a(n-2), what is a(4) if a(1) equals 1 and a(2) equals 4?

ANSWER: 9

BONUS

12) Math Short Answer Kelli can mow half of a lawn in 30 minutes. Josiah can mow a third of a lawn in 10 minutes. Joseph can mow a fifth of a lawn in 3 minutes. How fast can they mow 42 lawns working together?

ANSWER: 6 hours

TOSS UP

20) Math- *Multiple Choice* The graph of $x^2/4 - y^2/9 = 49$ is which of the following?

W. Hyperbola
X. Semi-circle
Y. Ellipse
Z. Parabola

Answer: W

BONUS

20) Math- *Short Answer* What is the length of the major axis of an ellipse defined by the equation $9x^2 - 54x + 16y^2 - 64y = 3455$?

Answer: 40

14) Toss-up (earth and space) short answer: During which period did sharks begin to appear?

Ans: Silurian period

14) Bonus: (earth and space) short answer: What is the name of smooth lava that forms a ropy surface, coming from high-temperature and lower volume volcanic eruptions.

Ans: Pahoehoe

15) Toss-up (physics) short answer: Name the theorem that states that states that no physical theory of local hidden variables can ever reproduce all of the predictions of quantum mechanics.
Ans: Bell's theorem

15) Bonus: (physics) short answer: Name the scientist who, in 1964, proposed a mechanism for the existence of the Higgs Boson.

Ans: Peter Higgs

TOSS UP

6) Chemistry- Flask A has 1 liter of pure water. Flask B has 1 liter of a 0.5 M NaOH solution. By number, list all of the following that are true about these flasks: 1)Flask A has a higher boiling point. 2) Flask B has a higher osmotic pressure 3)Flask A has a higher vapor pressure.

Answer: 3 only

BONUS

6) Chemistry- *Short Answer* A barometer is used to measure the vapor pressure of a diethyl ether. Diethyl ether's meniscus is at 215 mm in the tube. Calculate the vapor pressure of diethyl ether.

Answer: 545 mm Hg

TOSS-UP

17) PHYSICS *Short Answer* By name or number, rank the following particles by increasing mass: 1) tau neutrino 2) electron neutrino 3) Higgs boson 4) muon

ANSWER: 2 1 4 3

BONUS

17) PHYSICS *Multiple Choice* Which of the following is NOT a characteristic of an antineutrino?

W) opposite lepton number to neutrino
X) no charge
Y) integer spin
Z) opposite chirality to neutrino

ANSWER: Y) INTEGER SPIN

TOSS-UP

18) EARTH AND SPACE *Short Answer* What is the term for the luminosity at which the radiation pressure causing a star to expand outward is equal to the pressure of gravity pulling itself inward?

ANSWER: EDDINGTON LIMIT

BONUS

18) EARTH AND SPACE *Short Answer* By name or number, list all of the following planets on which metallic hydrogen does NOT exist: 1) Jupiter; 2) Neptune; 3) Uranus; 4) Saturn

ANSWER: 2 AND 3

TOSS-UP

19) BIOLOGY *Multiple Choice* Organisms that reproduce sexually exhibit zygotic, gametic, or sporic meiosis. One way to determine the type of life cycle an organism has is by:

W) comparing the diploid and haploid forms of the organism
X) determining if gametes are multicellular or unicellular
Y) observing embryonic development
Z) determining when in the life cycle fertilization occurs

ANSWER: W) COMPARING THE DIPLOID AND HAPLOID FORMS OF THE ORGANISM

BONUS

19) BIOLOGY *Multiple Choice* Populations that are likely to be living at a density near the limit of their resources are characterized as:

W) K-selected
X) R-selected
Y) P-selected
Z) Q-selected

ANSWER: W) K-SELECTED

TOSS-UP

20) BIOLOGY *Multiple Choice* Which of the following is NOT a characteristic of Lamarckian evolution?

W) a tendency toward complexity
X) evolution based on use or disuse of anatomical features
Y) transmission of acquired characteristics
Z) possibility of extinction

ANSWER: Z) POSSIBILITY OF EXTINCTION

BONUS

20) BIOLOGY *Short Answer* What type of speciation occurs when a new species develops from a surviving ancestral species while both inhabit the same geographic region?

ANSWER: SYMPATRIC SPECIATION

TOSS-UP

21) CHEMISTRY *Multiple Choice* What type of bond is formed between a Lewis acid/base pair?

W) Coordinate-Covalent bond
X) Covalent bond
Y) Ionic bond
Z) Metallic bond

ANSWER: W) COORDINATE-COVALENT BOND

BONUS

21) CHEMISTRY *Short Answer* If the particles in a colloid are spheroid, the Tyndall scattering that occurs can be analyzed according to what theory, which also describes scattering by particles whose sizes are comparable to the wavelength of light?

ANSWER: MIE THEORY

TOSS-UP

22) MATH *Short Answer* The position of a particle constrained to move on the y-axis is described by $y=\frac{1}{2}kt^2+4t$, where t=time and k is an unknown constant. If the velocity of the particle at time t=5s is 24m/s, what is the value of k? No units are necessary.

ANSWER: K=4

BONUS

22) MATH *Short Answer* Adrian is playing a version of Minecraft in which two chickens can fit in one block of space and one cow can fit in one block of space. If Adrian makes a 5x5-block farm and puts either two chickens or one cow on each block, and there are 40 animals in total, how many chickens and how many cows are there?

ANSWER: 30 CHICKENS, 10 COWS

TOSS-UP

23) EARTH AND SPACE *Short Answer* By name or number, list all of the following species which are used by astronomers to map the distribution of gas in the interstellar medium due to their significant radio emission: 1) H_2 2) H_2O 3) He 4) CO

ANSWER: 1, 4

BONUS

23) EARTH AND SPACE *Short Answer* What specific relation relates the velocity dispersion of an elliptical galaxy to its mass distribution?

ANSWER: FABER-JACKSON RELATION

TOSS-UP

24) PHYSICS *Multiple Choice* What is the name of the angle of incidence with a medium at which the reflected ray is perpendicular to the refracted ray?

W) critical angle
X) Snell's angle
Y) Newton's angle
Z) Brewster's angle

ANSWER: Z) BREWSTER'S ANGLE

BONUS

24) PHYSICS *Multiple Choice* Light in vacuum is incident on the surface of a glass slab. In the vacuum, the beam makes an angle of 45º with the normal to the surface, while in the glass it makes an angle of 30º with the normal. What is the index of refraction of the glass? Give your answer in exact form.

ANSWER: sqrt(2)

TOSS-UP

25) CHEMISTRY *Short Answer* What is the name of the effect of cooling a real gas by expansion through a throttle?

ANSWER: JOULE-THOMSON EFFECT

BONUS

25) CHEMISTRY *Short Answer* Rank the third ionization energies of the following elements from lowest to highest: 1) aluminum, 2) magnesium, 3) lithium, 4) beryllium

ANSWER: 1 2 3 4