TOSS-UP

1) CHEMISTRY *Short Answer* In a molecule with dsp^3 hybridization and no lone pairs, what is the angle between two of the equatorial bonds?

ANSWER: 120 DEGREES

BONUS

1) CHEMISTRY *Multiple Choice* If a molecule with d^2sp^3 hybridization has two lone pairs, what shape will the molecule adopt?:

W) trigonal planar
X) square pyramidal
Y) square planar
Z) t-shaped

ANSWER: Y) SQUARE PLANAR

TOSS-UP

2) PHYSICS *Short Answer* What is the name given to the emission of short bursts of light from imploding bubbles in a liquid when excited by sound?

ANSWER: SONOLUMINESCENCE

BONUS

2) PHYSICS *Visual Short Answer* Answer the following three questions about the diagram:

1. What type of apparatus would be used to generate this diagram?
2. Which two particles are represented by the curvy lines at B and C?
3. Which effect causes the appearance of the particle at E?

ANSWER: 1. CLOUD CHAMBER (Accept: BUBBLE CHAMBER) 2. POSITRON AND ELECTRON 3. COMPTON EFFECT

TOSS-UP

3) BIOLOGY *Short Answer* The active forms of carbonic anhydrase, DNA polymerase, and pyruvate dehydrogenase are all examples of which general type of enzyme that requires that involves an apoenzyme bonded to a cofactor?

ANSWER: HOLOENZYME

BONUS

3) BIOLOGY *Short Answer* Name all of the following four options that are true of enzymes:

1. All enzymes will each act on only one specific substrate
2. The lock-and-key model explains the stabilized transition states of enzyme-catalyzed reactions
3. Enzymes catalyze reversible reactions in both directions
4. The double reciprocal plot was originally used by Lineweaver and Burk to describe enzyme kinetics

ANSWER: 1, 3 AND 4

TOSS-UP

4) ASTRONOMY *Multiple Choice* Which of the following is true of quasars?

W) quasars are powered by accretion disks around a supermassive black hole
X) all currently known quasars are expected to keep emitting radiation for a minimum of 10 billion years
Y) no currently known quasars are observable with small telescopes
Z) the Andromeda galaxy is an example of a nearby quasar

ANSWER: W) QUASARS ARE POWERED BY ACCRETION DISKS AROUND A SUPERMASSIVE BLACK HOLE

BONUS

4) ASTRONOMY *Visual Short Answer* Answer the following questions about the diagram:

1. What is the common name for this astronomical object, used as evidence for Einstein's theory of General Relativity?
2. What effect is demonstrated by the diagram?

ANSWER: 1. EINSTEIN CROSS 2. GRAVITATIONAL LENSING

TOSS-UP

5) MATH *Short Answer* In statistics, what type of distribution is most often used to approximate a given statistic based on a random sample of size n and is known to become more normally distributed as the sample size n is above 30?

ANSWER: SAMPLING DISTRIBUTION

BONUS

5) MATH *Multiple Choice* Which of the following is false of ANOVA models?

W) ANOVA tests commit type I errors less often than two-tailed t tests when comparing three of more means
X) ANOVA assumes that the cases being studied are independent of each other
Y) Fixed effect ANOVA models assume that the samples are normally distributed
Z) ANOVA tests commit type II errors more often than t-tests when comparing two means

ANSWER: Z) ANOVA TESTS COMMIT TYPE II ERRORS MORE OFTEN THAN T-TESTS WHEN COMPARING TWO MEANS

TOSS-UP

6) EARTH SCIENCE *Short Answer* The following six conditions are required for the formation of what tropical weather phenomenon: warm sea surface temperatures, atmospheric instability, high humidity in the lower troposphere, enough Coriolis force to develop a low pressure center, a preexistence disturbance, and a low vertical wind shear?

ANSWER: TROPICAL CYCLONE

BONUS

6) EARTH SCIENCE *Visual Short Answer* Answer the following questions about the diagram:

1. What general type of storm is depicted in the diagram?
2. This type of storm starts via an air mass being drawn to the northeast via which fast moving air current?
3. The specific storm pictured in the diagram caused which event in 2006?

ANSWER: 1. NOR'EASTER 2. JET STREAM 3. NORTH AMERICAN BLIZZARD OF 2006

TOSS-UP

7) GENERAL SCIENCE *Multiple Choice* Which of the following analytical methods would most likely be used in experimentally determining the rate of a reaction?

W) gravimetry
X) spectroscopy
Y) chromatography
Z) titration

ANSWER: X) SPECTROSCOPY

BONUS

7) GENERAL SCIENCE *Short Answer* Which piece of lab equipment is usually used in gravimetric analysis and used to heat small quantities of materials to high temperatures?

ANSWER: CRUCIBLE

TOSS-UP

8) EARTH SCIENCE *Short Answer* In atmospheric optics, which phenomenon, also known as volumetric lighting, is characterized by light streaming through clouds at around dawn or dusk?

ANSWER: CREPUSCULAR RAYS

BONUS

8) EARTH SCIENCE *Short Answer* Answer the following questions about the displayed optical phenomena:

1. Classify A through D as either: Earthshadow, Zodiacal Light, Alexander's Band, and iridescence

2. Of A, B, C, and D, which of these phenomena often occurs at the same time as sylvanshine?

ANSWER: A – IRIDESCENCE B – ALEXANDER'S BAND C – EARTHSHADOW D – ZODIACAL LIGHT 2. D – ZODIACAL LIGHT

TOSS-UP

9) CHEMISTRY *Short Answer* Which two of the following four are true of resonance structures?

1. The oxygens in a carboxyl functional group are sp2 hybridized
2. According to valence bond theory, resonance is a delocalization of pi electrons
3. Measuring the bond length in a carboxyl residue would reveal a length intermediate between a single bond and a double bond.
4. Resonant structures are considered isomers of each other

ANSWER: 1 AND 3

BONUS

9) CHEMISTRY *Multiple Choice* Which of the following equations correctly describes the half-life of a second-order reaction?

W) $t_{\frac{1}{2}} = \frac{[A_0]}{2k}$

X) $t_{\frac{1}{2}} = \frac{\ln(2)}{k}$

Y) $t_{\frac{1}{2}} = \frac{1}{k[A]_0}$

Z) $t_{\frac{1}{2}} = \frac{3}{2k[A]_0^{\,2}}$

ANSWER: Y) $t_{\frac{1}{2}} = \frac{1}{k[A]_0}$

TOSS-UP

10) PHYSICS *Multiple Choice* Which of the following changes would increase the angle of rotation in a system displaying the Faraday effect?

W) decreasing the Verdet constant
X) decreasing path length
Y) decreasing the speed of moving charge
Z) increasing the magnetic flux density

ANSWER: Z) INCREASING MAGNETIC FLUX DENSITY

BONUS

10) PHYSICS *Short Answer* Name all of the following four statements that are true of black bodies:

1. A hohlraum is an experimental approximation of a black body
2. The power radiated by a black body is given by Wein's Law
3. Black bodies are perfect Lambertian radiators
4. While increasing the temperature of a black body shortens the emitted wavelength, a black body will never become invisible

ANSWER: 1, 3 AND 4

TOSS-UP

11) BIOLOGY *Short Answer* Name all of the following three choices that are true of immunoglobulins:

1. VDJ recombination allows immunoglobulins to bind to a variety of antigens
2. IgD and IgE are most often involved in activating mast cells and basophils
3. All antibodies are glycoproteins

ANSWER: ALL OF THEM

BONUS

11) BIOLOGY *Short Answer* Answer the following questions about the diagram:

1. Which organ is this image of?
2. Which type of cell is represented by the letter e?
3. Which piece of lab equipment would most likely be used to produce this sample for imaging?

ANSWER: 1. HEART 2. RED BLOOD CELL (Accept: ERYTHROCYTE) 3. MICROTOME

TOSS-UP

12) ASTRONOMY *Multiple Choice* Which of the following correctly describes a Type II (read as: two) supernova?

W) a white dwarf accretes over 1.44 solar masses of material and collapses
X) a Wolf-Rayet star collapses after shedding its outer envelope
Y) a star of above 9 solar masses undergoes core collapse, fusing helium to carbon
Z) a neutron star collides with a black hole

ANSWER: Y) A STAR OF ABOVE 9 SOLAR MASSES UNDERGOES CORE COLLAPSE, FUSING HELIUM TO CARBON

BONUS

12) ASTRONOMY *Multiple Choice* Approximately how much time does it take the solar system to travel 1 Astronomical Unit, assuming it moves at 220 kilometers per second?:

W) $1/8^{th}$ days
X) 8 days
Y) 20 days
Z) 200 days

ANSWER: X) 8 DAYS

TOSS-UP

13) MATH *Short Answer* What is the inverse of the matrix with first row terms 4, -6 and second row terms -1, 1.5?

ANSWER: NONEXISTANT

BONUS

13) MATH *Visual Short Answer* Assuming that the first circle has an area of one and the common ratio is 2/3rds, what is the sum of all the circles in the series?

ANSWER: 3 (THREE)

Solution: Q3-Q1

TOSS-UP

14) EARTH SCIENCE *Short Answer* What is the term for the layer of a lake that is characterized by a rapid change in water density?

ANSWER: PYCNOCLINE

BONUS

14) EARTH SCIENCE *Multiple Choice* Which of the following correctly describes the formation of a bore, also known as an aegir?:

W) an incoming tide is funneled into a narrow river via a broad bay
X) a large volume of water is displaced underwater, causing a sudden increase in water level
Y) a low pressure weather system causes an offshore rise of water that carries forward towards land
Z) wind and waves force water towards the shore and sideways, causing a net displacement of volume

ANSWER: W) AN INCOMING TIDE IS FUNNELED INTO A NARROW RIVER VIA A BROAD BAY

TOSS-UP

15) GENERAL SCIENCE *Multiple Choice* Which of the following is true of laboratory sterilization?

W) autoclaves sterilize equipment with high pressure and steam at 121 degrees Celsius
X) hot air is just as capable of sterilization as steam
Y) ozone, while easy to produce and store, is not a good sterilizer
Z) prions can only be sterilized by application of hydrogen peroxide for an hour

ANSWER: W) AUTOCLAVES STERILIZE EQUIPMENT WITH HIGH PRESSURE AND STEAM AT 121 DEGREES CELSIUS

BONUS

15) GENERAL SCIENCE *Short Answer* Answer the following questions about the diagram:

1. What general type of analytical procedure is this equipment used for?
2. What state of matter is the material analyzed by this equipment in?
3. Which law regarding radiation flux is used to draw conclusions about the analyzed material?

ANSWER: 1. ATOMIC ABSORPTION SPECTROSCOPY 2. GAS 3. BEER-LAMBERT LAW

TOSS-UP

16) ASTRONOMY *Multiple Choice* Which of the following is false about the constellation Orion?

W) By apparent brightness, Rigel is the brightest star in the constellation
X) When Betelgeuse finally explodes, it will be visible even during daytime
Y) Bellatrix will explode in a supernova at the end of its life
Z) Alnitak is the brightest O class star in the sky

ANSWER: Y) BELLATRIX WILL EXPLODE IN A SUPERNOVA AT THE END OF ITS LIFE

BONUS

16) ASTRONOMY *Short Answer* By name or number, choose all of the following three options that are true of star metallicity:

1. The oldest observed stars tend to be Population II stars
2. The sun is considered a Population I star
3. Population II stars can be found in the outer rim of the Milky Way galaxy

ANSWER: 1 AND 2

TOSS-UP

17) CHEMISTRY *Multiple Choice* Which of the following would shift the equilibrium to the right in reversible exothermic reaction $N_2 + 3H_2 \rightarrow 2NH_3$ plus heat?

W) adding NH_3 to the system
X) decreasing the pressure of the system
Y) addition of an inert gas
Z) lowering the temperate

ANSWER: Z) LOWERING THE TEMPERATURE

BONUS

17) CHEMISTRY *Visual Short Answer* Answer the following questions about the diagram:
1. What is the general name for this type of diagram?
2. What functional group is the peak labeled 1 characteristic of?
3. What type of compound are the peaks at 1500 and 1600 wavenumbers characteristic of?

ANSWER: 1. INFRARED SPECTRUM 2. ALCOHOL (Accept: HYDROXYL) 3. BENZENE

TOSS-UP

18) PHYSICS *Multiple Choice* Which of the following changes would increase the capacitance of a parallel plate capacitor?

W) decreasing the area of overlap between the two plates
X) increasing the voltage
Y) increasing the distance between the two plates
Z) decreasing the distance between the two plates

ANSWER: Z) DECREASING THE DISTANCE BETWEEN THE TWO PLATES

BONUS

18) PHYSICS *Short Answer* By name or number, choose all of the following three options that are true:
1. According to molecular orbital theory, oxygen is a diradical
2. Paramagnetism is a product of molecules possessing unpaired electrons
3. All conductors act diamagnetically in a changing magnetic field due to eddy currents

ANSWER: ALL OF THEM

TOSS-UP

19) BIOLOGY *Short Answer* By name or number, choose two of the following four options that are true of photosynthesis:

1. The reactions in photosystem II are a solid-state process, and therefore achieve an efficiency of nearly 100%
2. In cyclic electron flow, plastoquinine transfers electrons back to photosystem II
3. In the Calvin cycle, fixation of 3 carbons uses 9 ATP and 6 NADPH molecules
4. At low temperatures, the rate of photorespiration is higher

ANSWER: 1 AND 3

BONUS

19) BIOLOGY *Short Answer* Answer the following questions about the diagram:

1. Label A, B, C, and D.
2. Is this plant a monocot or a dicot?
3. From what part of the plant is this cross section from?

ANSWER: 1. A – PITH B – EPIDERMIS C – XYLEM D – PHLOEM 2. DICOT 3. STEM

TOSS-UP

20) ASTRONOMY *Short Answer* Atmospheric Cherenkov telescopes are meant to indirectly detect what form of radiation?

ANSWER: HIGH ENERGY GAMMA RAYS

BONUS

20) ASTRONOMY *Short Answer* By name or number, choose all of the following four options that are true of coronal mass ejections:

1. Coronal mass ejections are made of up electrons and protons
2. Coronal mass ejections are caused by solar flares
3. Coronal mass ejections occur with heightened frequency during the solar minima
4. Unlike solar flares, coronal mass ejections cannot damage radio equipment

ANSWER: JUST 1

TOSS-UP

21) MATH *Short Answer* Which function is famously known to be a function of a complex variable s that analytically continues the sum of the infinite series 1 divided by n to the s power?

ANSWER: REIMANN ZETA FUNCTION

BONUS

21) MATH *Short Answer* By name or number, choose all of the following four choices that are true in set theory:

1. Abelian groups are also known as commutative groups
2. If a group can be generated by a single element, it is known as a cyclic group
3. Galois theory can effectively reduce field theory problems to group theory problems
4. Crystalline structure can be effectively modeled using symmetry groups

ANSWER: ALL OF THEM

TOSS-UP

22) GENERAL SCIENCE *Multiple Choice* Which of the following is a common usage of potash alum?

W) fertilizer
X) water purification
Y) souring of food
Z) glue

ANSWER: X) WATER PURIFICATION

BONUS

22) GENERAL SCIENCE *Multiple Choice* Which of the following properties of potash alum makes it useful in reducing bleeding from cuts?

W) alum crystals have mordant-like properties
X) it has the properties of an acidulent
Y) it has the properties of an astringent
Z) it has properties similar to tannins

ANSWER: Y) IT HAS THE PROPERTIES OF AN ASTRINGENT

TOSS-UP

23) CHEMISTRY *Multiple Choice* What is the hybridization of the center carbon in allene, or C_3H_4?

ANSWER: SP

BONUS

23) CHEMISTRY *Visual Short Answer* Answer the following questions about the diagram:

1. What is the general name for these types of compounds?
2. What is the general name for the ammonia molecules?
3. If EDTA was added to this solution, how many times would it bind to each cobalt atom?

ANSWER: 1. COORDINATION COMPOUND 2. LIGANDS 3. SIX

TOSS-UP

24) PHYSICS *Multiple Choice* Which theory correctly explains why muons are observed to have a longer half-life when descending from the atmosphere than when in the lab?

ANSWER: SPECIAL RELATIVITY

BONUS

24) PHYSICS *Short Answer* What theory predicts the existence of neutralinos, charginos, and guaginos?

ANSWER: SUPERSYMMETRY

TOSS-UP

25) BIOLOGY *Short Answer* What is the term for the maximum number of cell divisions a cell can undergo before its telomeres are too short to support more division?

ANSWER: HAYFLICK LIMIT

BONUS

25) BIOLOGY *Visual Short Answer* This is a picture taken using fluorescence microscopy. Answer the following questions about the diagram:

1. Which model organism is being visualized in this picture?
2. Which type of cell is currently fluorescing in the picture?
3. Label A and B with the parts of the cell they are pointing to.

ANSWER: 1. CAENORHABDITIS ELEGANS (Accept: C. elegans) 2. NEURONS 3. A – SOMA (Accept: Cell Body) B - DENDRITES