TOSS-UP

1) BIOLOGY  *Short Answer*  Recently, the number of American bee colonies has been seriously diminished due to sudden, massive, unexplained die-offs. The agent of this epidemic has not yet been conclusively identified. What is the name of this disease?

**ANSWER:** COLONY COLLAPSE DISORDER (ACCEPT: CCD)

BONUS

1) BIOLOGY  *Multiple Choice*  While hiking in Arizona, you come over a rise, hear a rattling sound and see a western diamondback rattlesnake coiled and ready to strike. Indicate which of the following physiological responses would NOT occur in you?

W) Gluconeogenesis would occur in the liver  
X) Blood vessels in the gut and skin would constrict  
Y) Heart rate and blood pressure would increase  
Z) Adipose tissue would release fatty acids to the blood stream

**ANSWER:** W) GLUCONEOGENESIS WOULD OCCUR IN THE LIVER

TOSS-UP

2) PHYSICS  *Multiple Choice*  Which of the following best describes why arches and domes are more stable than flat roofed structures?

W) They transmit compressive forces along their length to the ground, uniformly bearing the load of gravity upon the structure  
X) Each section is under great tension, using the stronger dimension of the components  
Y) Torsional resistance to sideways swaying ensures that such structures are stable, even in high winds  
Z) The surface tension of the arched shape allows the building components to be hollowed out, saving weight

**ANSWER:** W) THEY TRANSMIT COMPRESSIVE FORCES ALONG THEIR LENGTH TO THE GROUND, UNIFORMLY BEARING THE LOAD OF GRAVITY UPON THE STRUCTURE

BONUS

2) PHYSICS  *Short Answer*  Given a piece of glass with an index refraction of 2, what is the optimal index of refraction, to one decimal place, for an antireflection coating?

**ANSWER:** 1.4
**TOSS-UP**

3) CHEMISTRY  *Short Answer*  Providing your answer as a decimal, what is the bond order for the oxygen-oxygen bonds in ozone?

**ANSWER: 1.5**

**BONUS**

3) CHEMISTRY  *Short Answer*  Which of the following is the local VSEPR geometry of a triply-bonded alkyne carbon?

W) Tetrahedral  
X) Trigonal planar  
Y) Linear  
Z) Bent

**ANSWER: Y) LINEAR**

**TOSS-UP**

4) EARTH AND SPACE  *Multiple Choice*  Which of the following best describes the absorption characteristics of dust in the interstellar medium?

W) Its effects are strongest in radio wavelengths  
X) It absorbs light at all wavelengths with about the same efficiency  
Y) It preferentially absorbs optical light at redder wavelengths  
Z) It preferentially absorbs optical light at bluer wavelengths

**ANSWER: Z) IT PREFERENTIALLY ABSORBS OPTICAL LIGHT AT BLUER WAVELENGTHS**

**BONUS**

4) EARTH AND SPACE  *Short Answer*  A binary star system has one star with an apparent magnitude of 5 and a brown dwarf companion with an apparent magnitude of 15. The first star is how many times as luminous as the brown dwarf?

**ANSWER: 10,000**
TOSS-UP

5) MATH  Short Answer  If $\log_b(5) = c$, then what does $b^c$ equal?

ANSWER: 625

BONUS

5) MATH  Short Answer  The three sides of a triangle are 5 centimeters, 6 centimeters, and 8 centimeters. What is the cosine of the smallest angle in reduced fractional form?

ANSWER: 25/32

TOSS-UP

6) ENERGY  Short Answer  Gasoline is sold as “unleaded gas,” which is a misnomer because gasoline does not naturally contain lead. Lead was added to gasoline from the 1940s to 1980s. What was the reason for adding lead to gasoline?

ANSWER: STOP ENGINE KNOCK (ACCEPT: KNOCKING, AUTOIGNITION, INCREASE OCTANE RATING)

BONUS

6) ENERGY  Short Answer  Given $g$ as 10 meters per second squared, how much power in megawatts can a perfectly efficient dam 100 meters high produce if 2000 kilograms of water pass through its turbines every second?

ANSWER: 2
TOSS-UP

7) BIOLOGY  Multiple Choice  Horseshoe crabs are most closely related to which of the following organisms?

W) Spiders
X) Millipedes
Y) Centipedes
Z) Insects

ANSWER: W) SPIDERS

BONUS

7) BIOLOGY  Multiple Choice  Cloning a gene into a plasmid often requires you to amplify the target DNA sequence, then digest and paste the target sequence into the plasmid. Several purified enzymes are important in this process. Which of the following enzymes would act LAST in the cloning process?

W) Polymerase [POL-uh-muh-rays]
X) Ligase [LY-gays]
Y) Exonuclease [eks-uh-NOO-klee-ays]
Z) Restriction endonuclease [en-duh-NOO-klee-ays]

ANSWER: X) LIGASE

TOSS-UP

8) PHYSICS  Multiple Choice  A nubbin-on-a-spring keeps a door from hitting the wall. If the nubbin is flicked, such that the nubbin passes its rest point more than once before coming to rest, which of the following is true?

W) It is undamped
X) It is underdamped
Y) It is critically damped
Z) It is overdamped

ANSWER: X) IT IS UNDERDAMPED

BONUS

8) PHYSICS  Short Answer  A potential of 10 volts is applied to a parallel plate capacitor with capacitance of 1 microfarad and a plate separation of 10 micrometers. What is the electrical force in newtons between the plates?

ANSWER: 10
TOSS-UP

9) CHEMISTRY  Multiple Choice  Which of the following is NOT an aliphatic hydrocarbon?

W) Benzene
X) Propane
Y) Cyclopropane
Z) Cyclopentene

ANSWER: W) BENZENE

BONUS

9) CHEMISTRY  Short Answer  Determine the entropy, in calories per mole Kelvin, of a system that is at 27° Celsius and which has undergone a 1500 calorie per mole decrease in Gibbs free energy accompanied by a negligible change in enthalpy.

ANSWER: -5

TOSS-UP

10) EARTH AND SPACE  Multiple Choice  In special relativity, Lorentz contraction states that for an object moving relative to an observer, the observer will measure the object’s length to be which of the following?

W) Longer
X) Shorter
Y) Exactly the same
Z) Impossible to tell

ANSWER: X) SHORTER

BONUS

10) EARTH AND SPACE  Short Answer  With regard to Earth’s axis, what are the two principal reasons that the Sun’s position in the sky traces an analemma [an-l-EM-uh] from a fixed position at the same time each day?

ANSWER: EARTH IS TILTED AND EARTH HAS A ELLIPTICAL ORBIT
TOSS-UP

11) MATH  Multiple Choice  Which of the following is \( \lim_{x \to 0} \frac{|x|}{x} \) [the limit as x approaches 0 of the absolute value of x over x]?

W) -1  
X) 0  
Y) 1  
Z) The limit does not exist  

ANSWER: Z) THE LIMIT DOES NOT EXIST

BONUS

11) MATH  Short Answer  A square has a side of 8 millimeters. Providing your answer in terms of \( \pi \) and in square millimeters, what is the difference between the areas of its circumscribed circle and its inscribed circle?

ANSWER: 16\( \pi \)

TOSS-UP

12) ENERGY  Multiple Choice  OTEC is which of the following?

W) A method of producing hydrogen gas using solar energy  
X) A form of tidal energy that harnesses the ebb and flow of ocean water  
Y) An organization of oil-rich countries  
Z) A method of energy generation from the thermal gradient of ocean waters  

ANSWER: Z) A METHOD OF ENERGY GENERATION FROM THE THERMAL GRADIENT OF OCEAN WATERS

BONUS

12) ENERGY  Multiple Choice  There are several ways to store wind energy for non-windy days. Which of the following methods is NOT currently being used?

W) Pumping air into underground storage  
X) Pumping water up to elevated storage and then releasing it to drive an electric generator  
Y) Pumping water into underground storage  
Z) Charging batteries  

ANSWER: Y) PUMPING WATER INTO UNDERGROUND STORAGE
TOSS-UP

13) BIOLOGY  Multiple Choice  Which of the following does the enzyme aminoacyl-tRNA synthetase [uh-mee-noh-AS-il T-R-N-A SIN-thuh-tays] catalyze?

W) Base-pairing between the tRNA and the mRNA  
X) Transfer of the amino acid from the tRNA to form a peptide bond  
Y) Charging of a tRNA with an amino acid  
Z) Synthesis of tRNA molecules

ANSWER: Y) CHARGING OF A tRNA WITH AN AMINO ACID

BONUS

13) BIOLOGY  Short Answer  DNA replication involves many different steps. By number, arrange the following four steps in order from start to finish: 1) DNA polymerase [POL-uh-muh-rays] synthesizes a new DNA strand, 2) DNA ligase [LY-gays] repairs nicks in the phosphodiester [fos-foh-dy-ES-tuhr] backbone, 3) replication bubble opens at origin, 4) primase builds the primer.

ANSWER: 3, 4, 1, 2

TOSS-UP

14) EARTH AND SPACE  Multiple Choice  Which of the following is NOT true about the outer core of the Earth?

W) It is composed of iron and nickel  
X) It is highly viscous and ductile  
Y) Its temperature is greater than 4000 degrees Celsius  
Z) It is the source of Earth’s magnetic field

ANSWER: X) IT IS HIGHLY VISCOUS AND DUCTILE

BONUS

14) EARTH AND SPACE  Short Answer  The Himalayas are the result of the collision between which two tectonic plates?

ANSWER: INDIAN AND EURASIAN
TOSS-UP

15) BIOLOGY  Multiple Choice  Which of the following is an example of a covalent bond or bonds?

W) The bond between two adjacent amino acids in a polypeptide chain
X) The bond between a tRNA anticodon and an mRNA codon
Y) The bonds between the large subunit and the small subunit of the ribosome [RY-buh-sohm]
Z) The bonds between the small ribosomal subunit and the mRNA

ANSWER: W) THE BOND BETWEEN TWO ADJACENT AMINO ACIDS IN A POLYPEPTIDE CHAIN

BONUS

15) BIOLOGY  Short Answer  An F1 individual plant is heterozygous for each of four traits and is allowed to self-fertilize. The plant produces 128 offspring. How many of the offspring would you expect to have the genotype AaBBccDd [big A little a big B big B little c little c big D little d]?

ANSWER: 2

TOSS-UP

16) PHYSICS  Multiple Choice  Work $W$ is done to extend a spring beyond its natural length by a small distance $x$. Assuming a spring constant of 1, which of the following is the magnitude of the maximum force done by the person stretching the spring?

W) $x$
X) $x/2W$
Y) $2W/x$
Z) $2W/x^2$

ANSWER: Y) $2W/x$

BONUS

16) PHYSICS  Short Answer  If a spaceship moving at relativistic speed $v$ appears to be shortened to 4/5 its original length, what is its speed as a fraction of the speed of light, $c$, in lowest terms?

ANSWER: $3c/5$ OR $(3/5)c$
TOSS-UP

17) CHEMISTRY  Multiple Choice  Which of the following has the lowest freezing point?

W) Water
X) Chloroform
Y) Acetic acid
Z) Ethanol

ANSWER: Z) ETHANOL

BONUS

17) CHEMISTRY  Short Answer  Given that the $K_b$ of a particular solvent is 2.53 °C per molal and providing your answer to two decimal places, by how many degrees Celsius would the boiling point of a solution be raised if it contains 3.0 moles of a nonelectrolyte in 6.0 kilograms of solvent?

ANSWER: 1.27 (ACCEPT: 1.26)

TOSS-UP

18) EARTH AND SPACE  Short Answer  What protects Earth’s atmosphere from being directly struck by solar wind?

ANSWER: EARTH’S MAGNETIC FIELD (ACCEPT: MAGNETOSPHERE)

BONUS

18) EARTH AND SPACE  Short Answer  List the three most common gases in dry atmosphere on Earth from highest percentage to least.

ANSWER: NITROGEN, OXYGEN, AND ARGON (ANSWERS MUST BE IN THIS ORDER)
TOSS-UP

19) MATH  Short Answer  Find the measure in degrees of the largest angle of a triangle with sides of 24 centimeters, 7 centimeters, and 25 centimeters.

ANSWER: 90°

BONUS

19) MATH  Short Answer  Providing your answers as improper fractions in lowest terms, solve \(-7 + |3 - 2x| = 15\) for \(x\).

ANSWER: -19/2 AND 25/2

TOSS-UP

20) ENERGY  Short Answer  What is the common name of the process by which heavy hydrocarbons are broken down into simpler molecules such as light hydrocarbons?

ANSWER: CRACKING

BONUS

20) ENERGY  Short Answer  What is the name for the prediction that an ideal blackbody would emit short wavelength radiation with infinite power?

ANSWER: ULTRAVIOLET CATASTROPHE (ACCEPT: RAYLEIGH-JEANS CATASTROPHE)
TOSS-UP

21) MATH  Short Answer  How many points of intersection exist for the graphs of \( y = 2^x \) and \( y = -x^2 + 2 \)?

ANSWER: 2

BONUS

21) MATH  Short Answer  A different universe has nine spatial dimensions. If an object travels four meters in all nine dimensions, then what is the object’s displacement in meters in this universe?

ANSWER: 12

TOSS-UP

22) PHYSICS  Short Answer  What two word phrase describes an electromagnetic wave in which the electric field lies in a single plane along the direction of propagation?

ANSWER: LINEARLY POLARIZED

BONUS

22) PHYSICS  Multiple Choice  Planets A and B are in circular orbits about the same star. Planet A’s orbital radius is three times as large as Planet B’s. Which of the following is the ratio of Planet A’s orbital period to Planet B’s?

W) \( \sqrt{3} \)
X) \( \sqrt{\frac{3}{2}} \)
Y) \( 3^{\frac{3}{2}} \) [three to the power of the quantity three over two]
Z) \( 3^{\frac{2}{3}} \) [three to the power of the quantity two over three]

ANSWER: Y) \( 3^{\frac{3}{2}} \)
TOSS-UP

23) CHEMISTRY  Short Answer  Carbon nanotubes are potentially useful in applications such as nanotechnology, optics, and electronics. What allotrope of carbon makes up these cylinders?

ANSWER: FULLERENE (ACCEPT: BUCKMINSTERFULLERENE OR BUCKYTUBE)

BONUS

23) CHEMISTRY  Short Answer  The wavelength of light emitted from a quantum dot generally depends on what feature of the dot?

ANSWER: SIZE (ACCEPT: DIAMETER)

TOSS-UP

24) EARTH AND SPACE  Multiple Choice  During the Earth’s equinoxes, which of the following is NOT true?

W) Daytime and nighttime are equal in length
X) They occur at the perihelion and aphelion of Earth’s orbit
Y) They occur during fall and spring
Z) The Sun is directly overhead at the equator

ANSWER: X) THEY OCCUR AT THE PERIHELION AND APHELION OF EARTH’S ORBIT

BONUS

24) EARTH AND SPACE  Multiple Choice  Which of the following is NOT used as evidence for plate tectonic theory?

W) Deposition of glacial dropstones in Australian bedrock
X) Elevation and increased heat flow at the Mid-Atlantic Ridge
Y) Correlation of fossils between Africa and South America
Z) Successively deeper earthquakes at the Peru-Chili trench

ANSWER: W) DEPOSITION OF GLACIAL DROPSTONES IN AUSTRALIAN BEDROCK
TOSS-UP

25) BIOLOGY  Short Answer  On a phylogenetic [fy-LOJ-uh-neek] tree, two species are grouped in the same clade. What is represented by the branch point that joins these two species?

ANSWER: COMMON ANCESTOR

BONUS

25) BIOLOGY  Multiple Choice  You’re investigating guinea pig coat genetics, and you’ve found an interesting new phenotype: spiral guinea pig fur. If you take a purebred wavy-hair guinea pig and cross it with a purebred kinked-hair guinea pig, you get all spiral-hair progeny. If you mate spiral-hair guinea pigs with each other, the progeny have a phenotypic ratio of 9 spiral: 3 wavy: 3 kinked: 1 straight. Which of the following is most likely to be true given your experimental results?

W) There are two different genes that result in the wavy and kinked phenotypes, and there is an epistatic interaction between them
X) There are two different genes that result in the wavy and kinked phenotypes, and they are linked
Y) There are two different genes that result in the wavy and kinked phenotypes, and they are independently assorting
Z) There is only one gene with a number of different alleles

ANSWER: Y) THERE ARE TWO DIFFERENT GENES THAT RESULT IN THE WAVY AND KINKED PHENOTYPES, AND THEY ARE INDEPENDENTLY ASSORTING