

TOSS-UP

1) Biology — *Short Answer* Rotational accelerations are detected by the mammalian vestibular [*ves-TIB-u-lar*] system through what structure composed of three interconnected tubes?

ANSWER: SEMICIRCULAR CANALS (ACCEPT: SEMICIRCULAR DUCTS)

BONUS

1) Biology — *Short Answer* What is the most abundant protein in plant leaves?

ANSWER: RUBISCO (ACCEPT: RIBULOSE 1,5-BISPHOSPHATE CARBOXYLASE/OXYGENASE)

TOSS-UP

2) Chemistry — *Short Answer* What is the conjugate base of nitric acid?

ANSWER: NITRATE (ACCEPT: NO_3^-)

BONUS

2) Chemistry — *Short Answer* Rank the following three elements in order of increasing electronegativity: 1) Silicon; 2) Nitrogen; 3) Phosphorus.

ANSWER: 1, 3, 2

TOSS-UP

3) Earth and Space — *Multiple Choice* In the North Atlantic, what is the term for the precursor of a hurricane that has wind speeds of less than 61 kilometers per hour?

- W) Tropical depression
- X) Tropical storm
- Y) Monsoon
- Z) Typhoon

ANSWER: W) TROPICAL DEPRESSION

BONUS

3) Earth and Space — *Short Answer* What type of stream flow occurs when all streamlines flow parallel to the stream channel?

ANSWER: LAMINAR

TOSS-UP

4) Energy — *Multiple Choice* Scientists at Lawrence Berkeley National Lab are studying how plant leaves emit a single-carbon alcohol. What is the name of this alcohol?

- W) Ethanol
- X) Propanol
- Y) Methanol
- Z) Butanol

ANSWER: Y) METHANOL

BONUS

4) Energy — *Multiple Choice* Oak Ridge National Lab researchers are developing better N95 respirators by testing the permeability of masks made of different materials. To test the permeability to SARS-CoV-2 virus particles, they used aerosols of sodium chloride with particle sizes closest to which of the following?

- W) 1 nanometer
- X) 100 nanometers
- Y) 10 microns
- Z) 1 millimeter

ANSWER: X) 100 NANOMETERS

TOSS-UP

5) Math — *Multiple Choice* Which of the following curves encloses a region of finite area?

- W) Ellipse
- X) Line
- Y) Hyperbola
- Z) Parabola

ANSWER: W) ELLIPSE

BONUS

5) Math — *Short Answer* What is the smallest 4-digit positive integer that has three 5's as digits and is divisible by 9?

ANSWER: 3,555

TOSS-UP

6) Physics — *Multiple Choice* Paul is simulating a moving object, and can adjust its speed, density, and volume. He wants to cut its speed in half while keeping its kinetic energy constant. Which of the following other changes could he make to keep the kinetic energy constant?

- W) Double the volume
- X) Double the density
- Y) Double both the volume and the density
- Z) Double the volume and quadruple the density

ANSWER: Y) DOUBLE BOTH THE VOLUME AND THE DENSITY

BONUS

6) Physics — *Short Answer* Nick walks north at an average velocity of 0.8 meters per second. In meters, what is his displacement after 30 minutes?

ANSWER: 1440

TOSS-UP

7) Biology — *Multiple Choice* Which of the following best describes features observed in two or more species that were inherited from a common ancestor?

- W) Orthologous
- X) Paralogous
- Y) Synonymous
- Z) Viviparous

ANSWER: W) ORTHOLOGOUS

BONUS

7) Biology — *Multiple Choice* Amanda graphs the relationship between environmental temperature and metabolic rate for different animals, where temperature is plotted on the x -axis and metabolic rate is plotted on the y -axis. For the interval from 10 to 20 degrees Celsius, which of the following animals would Amanda expect to have the largest positive slope?

- W) Mouse
- X) Elephant
- Y) Iguana
- Z) Human

ANSWER: Y) IGUANA

TOSS-UP

8) Chemistry — *Multiple Choice* Which of the following species has the largest number of reasonable resonance structures?

- W) Cl^-
- X) CN^-
- Y) CO_3^{2-}
- Z) OH^-

ANSWER: Y) CO_3^{2-}

BONUS

8) Chemistry — *Multiple Choice* Soapy water is better at cleaning surfaces than plain water is because the soap changes what property of the water?

- W) Surface tension
- X) Electronegativity
- Y) Boiling point
- Z) Freezing point

ANSWER: W) SURFACE TENSION

TOSS-UP

9) Earth and Space — *Short Answer* The galactic center of the Milky Way is in what constellation?

ANSWER: SAGITTARIUS

BONUS

9) Earth and Space — *Short Answer* What type of object did Jocelyn Bell discover in 1967 that emitted bursts of radio waves at very precise intervals?

ANSWER: PULSAR (do not accept: neutron star)

TOSS-UP

10) Energy — *Short Answer* Scientists at Argonne National Lab are developing methods to reduce the amount of what precious metal in fuel cell catalysts?

ANSWER: PLATINUM (ACCEPT: Pt)

BONUS

10) Energy — *Multiple Choice* Scientists at Pacific Northwest National Lab are studying soil. What soil horizon is primarily unweathered bedrock?

- W) A
- X) O
- Y) B
- Z) R

ANSWER: Z) R



TOSS-UP

11) Math — *Short Answer* What is the distance between the points (0, 2) and (3, 3)?

ANSWER: $\sqrt{10}$

BONUS

11) Math — *Short Answer* A trapezoid has two angles that measure 64 and 107 degrees, respectively. What are the degree measures of the other two angles?

ANSWER: 73 AND 116 (accept in either order)



TOSS-UP

12) Physics — *Multiple Choice* What is the term for the type of wave in which disturbances are in the same direction as the propagation of the wave, so that the wave consists of periodic compressions and rarefactions?

- W) Longitudinal
- X) Rayleigh
- Y) Standing
- Z) Transverse

ANSWER: W) LONGITUDINAL

BONUS

12) Physics — *Short Answer* A 60-watt equivalent LED light bulb actually consumes 9 watts of power. Expressing your answer to the nearest integer, how many minutes must an LED lightbulb be left on to consume as much energy as a 60-watt incandescent lightbulb does in 10 minutes?

ANSWER: 67

TOSS-UP

13) Biology — *Multiple Choice* Which of the following organisms is an example of a bivalve?

- W) Snail
- X) Oyster
- Y) Slug
- Z) Limpet

ANSWER: X) OYSTER

BONUS

13) Biology — *Short Answer* What nucleobase does thymine [**THIGH-meem**] pair with in DNA?

ANSWER: ADENINE (ACCEPT: A)



TOSS-UP

14) Chemistry — *Multiple Choice* How many orbitals can have a principal quantum number of four and angular momentum quantum number of two?

- W) 5
- X) 4
- Y) 3
- Z) 2

ANSWER: W) 5

BONUS

14) Chemistry — *Short Answer* What neutral nitrogen oxide contains nitrogen atoms with an average oxidation number of +3?

ANSWER: N_2O_3 (ACCEPT: DINITROGEN TRIOXIDE)

TOSS-UP

15) Earth and Space — *Multiple Choice* A rock sequence is gradually covered in sedimentary layers, causing an increase in the confining pressure, increasing the temperature to 200 degrees Celsius, and leading to the formation of zeolite minerals. Which of the following best describes this type of metamorphism?

- W) Regional metamorphism
- X) Contact metamorphism
- Y) Shock metamorphism
- Z) Burial metamorphism

ANSWER: Z) BURIAL METAMORPHISM

BONUS

15) Earth and Space — *Multiple Choice* What gas can be found in volcanic emissions and has a characteristic rotten egg smell?

- W) Sulfur dioxide
- X) Nitrogen dioxide
- Y) Hydrogen sulfide
- Z) Dihydrogen

ANSWER: Y) HYDROGEN SULFIDE

TOSS-UP

16) Energy — *Multiple Choice* A consortium of Department of Energy labs is working to create carbon-free hydrogen fuel cells for heavy-duty vehicles. These fuel cells produce what chemical byproduct as exhaust?

- W) O₂
- X) H₂
- Y) H₂O
- Z) O₃

ANSWER: Y) H₂O

BONUS

16) Energy — *Multiple Choice* Researchers at Ames Laboratory have been able to create a precursor chemical for nylon by treating what common polyphenolic [*poly-feh-NOH-lik*] waste byproduct in paper manufacturing with aqueous sodium hydroxide?

- W) Hemicellulose
- X) Cellulose
- Y) Lignin
- Z) Guaiacol [*GWYE-cole*]

ANSWER: Y) LIGNIN

TOSS-UP

17) Math — *Short Answer* If the universal set contains 40 elements, how many elements are in the complement of a set with 27 elements?

ANSWER: 13

BONUS

17) Math — *Short Answer* What value of x minimizes the function f of x equals $x^2 + 28x - 17$?

ANSWER: -14

TOSS-UP

18) Physics — *Multiple Choice* The volume of a gas must remain constant in which of the following types of thermodynamic processes?

W) Adiabatic [*ad-ee-ah-BAT-ik*]

X) Isothermal

Y) Isobaric [*eye-soh-BARE-ik*]

Z) Isochoric [*eye-soh-KOR-ik*]

ANSWER: Z) ISOCHORIC

BONUS

18) Physics — *Short Answer* A particle starts at rest and undergoes a constant acceleration for 5 seconds, causing it to travel 50 meters. In meters per second squared, what was its acceleration?

ANSWER: 4