

## TOSS-UP

1) Energy — *Multiple Choice* Scientists at Brookhaven National Lab are studying magnesium anodes. Typically, magnesium is used as a sacrificial anode. Which of the following metals could NOT be protected from oxidation by a magnesium sacrificial anode?

- W) Aluminum
- X) Iron
- Y) Copper
- Z) Cesium

ANSWER: Z) CESIUM

## BONUS

1) Energy — *Multiple Choice* Scientists at SLAC National Accelerator Lab are exploring theories involving supersymmetry. Which of the following best describes supersymmetry?

- W) Symmetry between matter and antimatter
- X) Relationship between gravity and electromagnetism
- Y) Symmetry of reversing the direction of time
- Z) Correspondences between fermion and boson particles

ANSWER: Z) CORRESPONDENCES BETWEEN FERMION AND BOSON PARTICLES

## TOSS-UP

2) Math — *Short Answer* What is 22 factorial divided by 20 factorial?

ANSWER: 462

## BONUS

2) Math — *Short Answer* Teams A and B are playing dodgeball. Team A has a 10% chance of winning each individual game, and all games are independent. What is the probability that team A wins a best-of-three series?

ANSWER: 0.028 (ACCEPT: 7/250, 2.8%)

## TOSS-UP

3) Physics — *Short Answer* A mass is undergoing uniform circular motion about a fixed point. If the distance to that point is doubled and the velocity of the mass is tripled, by what factor is its centripetal acceleration multiplied?

ANSWER: 4.5 (ACCEPT:  $9/2$ ,  $4 \frac{1}{2}$ )

## BONUS

3) Physics — *Short Answer* A magpie is flying horizontally at 16 meters per second when it drops the coin it is carrying. If the coin is 6 meters above the ground when it is dropped, then, to the nearest meter per second, what is the magnitude of its velocity with respect to the ground when it hits the ground?

ANSWER: 19

### TOSS-UP

4) Biology — *Short Answer* Travelers' diarrhea is most commonly caused by an enterotoxigenic [*en-tur-o-tox-ih-JEN-ik*] strain of what bacterium?

ANSWER: E. COLI (ACCEPT: ESCHERICHIA COLI)

### BONUS

4) Biology — *Multiple Choice* In accessory fruits, the majority of the fruit tissue is derived from outside the floral ovary. Which of the following fruits is an example of an accessory fruit?

- W) Peanut
- X) Blackberry
- Y) Strawberry
- Z) Tomato

ANSWER: Y) STRAWBERRY

## TOSS-UP

5) Chemistry — *Short Answer* Consider the proton NMR spectrum of butan-2-one [*byoo-tan-too-own*]. What is the multiplicity of the CH<sub>3</sub> group adjacent to the CH<sub>2</sub> group?

ANSWER: TRIPLET (ACCEPT: 3)

## BONUS

5) Chemistry — *Multiple Choice* Which of the following indicators would be most useful for a strong base-strong acid titration [*tie-TRAY-shun*]?

- W) Phenol red
- X) Methyl [*METH-il*] red
- Y) Methyl orange
- Z) Phenolphthalein [*fee-nawlf-THAY-leen*]

ANSWER: W) PHENOL RED

## TOSS-UP

6) Earth and Space — *Short Answer* In the triple-alpha process, two alpha particles combine to form beryllium. The product beryllium combines with another alpha particle to form what isotope?

ANSWER: CARBON-12

## BONUS

6) Earth and Space — *Short Answer* From the perspective of an observer on Earth, what percent of the Moon's surface is illuminated during a First Quarter Moon?

ANSWER: 50

## TOSS-UP

7) Energy — *Multiple Choice* Scientists at SLAC National Accelerator Laboratory are studying ways to use gravitational-lensing data to measure the Hubble constant. Expressed in SI units, what are the units of the Hubble constant?

- W) Meters per second
- X) One over seconds
- Y) Dimensionless
- Z) Seconds

ANSWER: X) ONE OVER SECONDS

## BONUS

7) Energy — *Multiple Choice* Scientists supported by the Department of Energy are developing novel semiconductors. Which of the following silicon dopants is an n-type dopant?

- W) Boron
- X) Antimony [*AN-tih-moh-nee*]
- Y) Gallium [*GAL-ee-um*]
- Z) Indium [*IN-dee-um*]

ANSWER: X) ANTIMONY

## TOSS-UP

8) Math — *Multiple Choice* Let  $f$  of  $x$  be a continuous and differentiable function on the closed interval from 4 to 7. Which of the following could be the  $x$ -value guaranteed by the mean value theorem for this situation?

W) 3

X) 5

Y) 7

Z) 9

ANSWER: X) 5

## BONUS

8) Math — *Short Answer* What is the average value of the function  $f$  of  $x$  equals  $x^2 + 6x$  over the interval from one to four?

ANSWER: 22

## TOSS-UP

9) Physics — *Multiple Choice* Which of the following is the term for the phenomenon by which a changing magnetic field creates a current in a circuit?

- W) Conduction
- X) Amplification
- Y) Transmutation
- Z) Induction

ANSWER: Z) INDUCTION

## BONUS

9) Physics — *Short Answer* Three resistors of 2 ohms, 5 ohms, and 7 ohms, respectively, are connected in parallel. What is the equivalent resistance of the circuit?

ANSWER:  $70/59$  (ACCEPT:  $1\ 11/59$ )

## TOSS-UP

10) Biology — *Multiple Choice* Which of the following describes the location of the 3-prime UTR in a strand of eukaryotic mRNA?

- W) Between the transcription start site and the start codon
- X) Between the stop codon and the poly-A tail
- Y) Before the transcription start site
- Z) After the poly-A tail

ANSWER: X) BETWEEN THE STOP CODON AND THE POLY-A TAIL

## BONUS

10) Biology — *Short Answer* What is the term for incomplete walls that divide the hyphae [*HIGH-fee*] of some fungi into cell-like compartments?

ANSWER: SEPTA (ACCEPT: SEPTUM)

## TOSS-UP

11) Chemistry — *Multiple Choice* Which of the following polymers is made of alpha-D-glucose monomers?

- W) Cellulose
- X) Amylose
- Y) Cellobiose
- Z) Chitin

ANSWER: X) AMYLOSE

## BONUS

11) Chemistry — *Short Answer* Identify all of the following four functional groups that contain a carbon double-bonded to an oxygen:

- 1) Carboxylic [*CAR-box-ILL-ik*] acid; 2) Ether [*EE-thur*];
- 3) Aldehyde [*AL-deh-hide*]; 4) Amide.

ANSWER: 1, 3, 4

## TOSS-UP

12) Earth and Space — *Short Answer* Losing streams are streams whose surface is above what hydrologic feature?

ANSWER: WATER TABLE (do not accept: AQUIFERS)

## BONUS

12) Earth and Space — *Short Answer* Identify all of the following three geologic settings in which you would expect to find primarily shallow-focus earthquakes: 1) At convergent boundaries; 2) At divergent boundaries; 3) Within plates

ANSWER: 2, 3

## TOSS-UP

13) Energy — *Short Answer* Scientists at Brookhaven National Lab are studying the most common element by mass in Earth's core. What is this element?

ANSWER: IRON

## BONUS

13) Energy — *Multiple Choice* Scientists supported by the Department of Energy are developing hardware for training artificial neural networks. One important aspect of a neural network is the activation function. Which of the following functions best approximates the “all-or-none” behavior of a neuron?

- W) Sigmoid
- X) Linear
- Y) Step function
- Z) Exponential

ANSWER: Y) STEP FUNCTION

## TOSS-UP

14) Math — *Short Answer* The graph of a line passes through the origin and the point  $(-3, 6)$ . What is the slope-intercept equation of the line?

ANSWER:  $y = -2x$  (ACCEPT:  $y = -2x + 0$ )

## BONUS

14) Math — *Multiple Choice* What is the range of the function  $f$  of  $x$  equals the fraction with numerator  $x^2 - 7x + 12$  and denominator  $x - 3$ ?

- W) All real numbers
- X) All real numbers except  $-1$
- Y) All real numbers except  $3$
- Z) All real numbers except  $4$

ANSWER: X) ALL REAL NUMBERS EXCEPT  $-1$

## TOSS-UP

15) Physics — *Short Answer* What is the term for the physical quantity calculated by multiplying a force by the length of its lever arm?

ANSWER: TORQUE

## BONUS

15) Physics — *Short Answer* A 38-newton load stretches a spring by 18 centimeters. In newtons per meter and to two significant figures, what is the spring constant of the spring?

ANSWER: 210

## TOSS-UP

16) Biology — *Short Answer* What term describes an allele that influences two or more phenotypic traits?

ANSWER: PLEIOTROPIC (ACCEPT: PLEIOTROPY)

## BONUS

16) Biology — *Multiple Choice* Progesterone levels reach a peak at which of the following points of the human menstrual cycle?

- W) Proliferative phase
- X) Secretory [*SEH-kreh-tory*] phase
- Y) Menstruation
- Z) Ovulation

ANSWER: X) SECRETORY PHASE

## TOSS-UP

17) Chemistry — *Multiple Choice* Consider a reaction that has a negative enthalpy of reaction, and a positive change in entropy. Under what conditions will the reaction occur spontaneously?

- W) Never spontaneous
- X) Always spontaneous
- Y) Only at low temperatures
- Z) Only at high temperatures

ANSWER: X) ALWAYS SPONTANEOUS

## BONUS

17) Chemistry — *Short Answer* Rank the following three elements in order of increasing ionization energy: 1) Krypton; 2) Neon; 3) Fluorine.

ANSWER: 1, 3, 2

## TOSS-UP

18) Earth and Space — *Short Answer* What second-century mathematician is responsible for developing the geocentric model of the solar system that persisted for centuries until it was displaced by the heliocentric model?

ANSWER: PTOLEMY (ACCEPT: PTOLEMY OF ALEXANDRIA, CLAUDIUS PTOLEMY, CLAUDIUS PTOLEMAEUS)

## BONUS

18) Earth and Space — *Multiple Choice* A comet passes between Earth and the Sun at its perihelion [*peh-ree-HEEL-yun*]. In what direction is its ion tail pointing?

- W) Toward Earth
- X) Toward the Sun
- Y) In the direction of its origin
- Z) In the direction of travel

ANSWER: W) TOWARD EARTH

Before we leave, let's confirm the team's score. What score does the Official Scorekeeper have? And what is the final score in the Chat Box? Does anyone disagree?

I'd like to remind the Scorekeeper to submit the official scoresheet. Best of luck to the team and thanks for competing in today's event.