

## ROUND 3

### TOSS-UP

1) MATH *Short Answer* What is the circumference of the circle with equation  $(x + 3)^2 + (y - 5)^2 = 25$  ?

ANSWER:  $10\pi$

### BONUS

1) MATH *Multiple Choice* Which of the following is the sum of the first three nonzero terms of the Taylor series of  $\sin(x)$  around 0?

W)  $x + x^3/3! + x^5/5!$  (read as: x plus x cubed over 3 factorial plus x to the fifth over 5 factorial)

X)  $x - x^3/3! + x^5/5!$

Y)  $1 - x^2/2! + x^4/4!$

Z)  $1 + x^2/2! + x^4/4!$

ANSWER: X)  $x - x^3/3! + x^5/5!$

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### TOSS-UP

2) CHEMISTRY *Multiple Choice* Which of the following types of decay does uranium-238 experience in order to yield thorium-234?

W) Alpha

X) Beta

Y) Double beta

Z) Gamma

ANSWER: W) ALPHA

### BONUS

2) CHEMISTRY *Short Answer* According to the second law of thermodynamics, what effect does a spontaneous reaction have on the entropy of the universe?

ANSWER: INCREASES THE ENTROPY OF THE UNIVERSE (ACCEPT: INCREASES)

### TOSS-UP

3) EARTH AND SPACE *Short Answer* Excluding dwarf galaxies, what is the most distant galaxy in the local group?

ANSWER: TRIANGULUM GALAXY (ACCEPT: M33, NGC 598)

### BONUS

3) EARTH AND SPACE *Multiple Choice* Mineral grains weathered from continental rocks and transported to the oceans are deposited as which of the following kinds of sediments?

- W) Calcareous (read as: kahl-KEHR-ee-is) ooze
- X) Atoll
- Y) Terrigenous (read as: teh-RI-jeh-nis)
- Z) Hydrogenous

ANSWER: Y) TERRIGENOUS

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### TOSS-UP

4) CHEMISTRY *Multiple Choice* Which of the following is the term for the mixing of atomic orbitals to explain covalent bonds?

- W) Transmutation
- X) Ionization
- Y) Hybridization
- Z) Localization

ANSWER: Y) HYBRIDIZATION

### BONUS

4) CHEMISTRY *Short Answer* How many moles of oxygen are contained in one mole of ammonium sulfate?

ANSWER: 4

### TOSS-UP

5) BIOLOGY *Multiple Choice* Which of the following is NOT a way that monarch butterflies manage energy on their migrations?

- W) Fat storage in the abdomen
- X) Flying with the wind
- Y) Switching to higher-energy food sources
- Z) Gliding instead of flapping

ANSWER: Y) SWITCHING TO HIGHER-ENERGY FOOD SOURCES

### BONUS

5) BIOLOGY *Short Answer* By name or number, identify all of the following four plants that are C4 plants: 1) corn, 2) rice, 3) soybeans, 4) wheat.

ANSWER: CORN (ACCEPT: 1)

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### TOSS-UP

6) CHEMISTRY *Multiple Choice* Denatured alcohol contains which of the following toxic substances added to ethanol?

- W) Propanol
- X) Methanol
- Y) Hexanol
- Z) Octanol

ANSWER: X) METHANOL

### BONUS

6) CHEMISTRY *Multiple Choice* Pyrex glassware contains silicon dioxide, which has acidic properties and should not be used to store which of the following?

- W) Dihydrogen monoxide
- X) Acetic acid
- Y) Sodium chloride
- Z) Sodium hydroxide

ANSWER: Z) SODIUM HYDROXIDE

**TOSS-UP**

7) MATH *Short Answer* In degrees, what is the smallest angle  $x > 0$  such that  $\sin(x) + \cos(2x) = 1$ ?

ANSWER:  $30^\circ$

**BONUS**

7) MATH *Short Answer* Considering the function  $f(x) = x^2$ , use a left Riemann sum with 4 equal subintervals to estimate the integral from 2 to 10 to the nearest integer.

ANSWER: 240

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**TOSS-UP**

8) PHYSICS *Short Answer* A train moving at 35 meters per second emits a whistle with a frequency of 900 hertz. Assuming that the speed of sound in air is 350 meters per second, what is the frequency, in hertz, measured by a stationary observer in front of the train?

ANSWER: 1000

**BONUS**

8) PHYSICS *Short Answer* A particle that is constrained to travel in one dimension moves in simple harmonic motion about the origin with an amplitude of 5 meters and a period of 2 seconds. Providing your answer in terms of  $\pi$ , what is the maximum acceleration experienced by the particle in meters per second squared?

ANSWER:  $5\pi^2$

**TOSS-UP**

9) BIOLOGY *Short Answer* When food reaches the stomach in humans, secretion of hydrochloric acid is stimulated by which hormone?

ANSWER: GASTRIN

**BONUS**

9) BIOLOGY *Short Answer* If a plant that is heterozygous for each of three independently-assorting traits is allowed to self-fertilize, what proportion of the offspring would be heterozygous for all three traits?

ANSWER: 1/8

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**TOSS-UP**

10) CHEMISTRY *Short Answer* What is the name given to the only temperature and pressure at which all three phases of water can be in equilibrium with each other?

ANSWER: TRIPLE POINT

**BONUS**

10) CHEMISTRY *Short Answer* What subshell is incompletely filled in all of the elements in the lanthanide series?

ANSWER: 4f

### TOSS-UP

11) PHYSICS *Short Answer* In 15 seconds,  $2 \times 10^{13}$  protons pass a particular point. Given that the charge on the proton is  $1.6 \times 10^{-19}$  coulombs, and providing your answer as a decimal to the nearest tenth, what is the current in microamperes?

ANSWER: 0.2

### BONUS

11) PHYSICS *Multiple Choice* What is the average force, in newtons, exerted on a 25-gram egg by a bed-sheet if the egg hits the sheet at 4 meters per second and takes 0.2 seconds to stop?

- W) 0.5
- X) 1.5
- Y) 5
- Z) 50

ANSWER: W) 0.5

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### TOSS-UP

12) EARTH AND SPACE *Multiple Choice* If Omega is exactly one, which of the following is TRUE about the universe?

- W) It will expand forever at an accelerating rate
- X) It will expand forever, but the speed of its expansion will slowly approach zero
- Y) It will eventually collapse upon itself
- Z) It will eventually be destroyed by a black hole

ANSWER: X) IT WILL EXPAND FOREVER, BUT THE SPEED OF ITS EXPANSION WILL SLOWLY APPROACH ZERO

### BONUS

12) EARTH AND SPACE *Short Answer* By name or number, indicate in which of the following three locations the deflection of wind due to the Coriolis effect is strongest: 1) the mid-latitudes, 2) the poles, or 3) the equator.

ANSWER: THE POLES (ACCEPT: 2)

**TOSS-UP**

13) PHYSICS *Multiple Choice* Which of the following represents one advantage of an electromagnet over a permanent magnet?

- W) It does not require a power source
- X) It does not have magnetic polarity
- Y) It can be turned on and off by switching current on and off
- Z) It can readily be found in nature

ANSWER: Y) IT CAN BE TURNED ON AND OFF BY SWITCHING CURRENT ON AND OFF

**BONUS**

13) PHYSICS *Short Answer* A 4-ampere current is maintained in a simple circuit with a total resistance of 2 ohms. How much energy in joules is delivered in 45 seconds?

ANSWER: 1440

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**TOSS-UP**

14) ENERGY *Short Answer* What kind of coal is rated poor for its heating value because of its low carbon content of 25 to 35 percent?

ANSWER: LIGNITE (ACCEPT: BROWN COAL, ROSEBUD COAL)

**BONUS**

14) ENERGY *Short Answer* By name or number, rank the energy efficiency of the following four lighting technologies from least to most efficient: 1) light emitting diodes, 2) incandescent, 3) neon, 4) compact fluorescent.

ANSWER: INCANDESCENT, NEON, COMPACT FLUORESCENT, AND LIGHT EMITTING DIODES (ACCEPT: 2, 3, 4, 1)

**TOSS-UP**

15) MATH *Multiple Choice* The line with equation  $y = -3x - 5$  contains points in each quadrant EXCEPT which of the following?

- W) I
- X) II
- Y) III
- Z) IV

ANSWER: W) I

**BONUS**

15) MATH *Short Answer* The three vertices of a triangle have coordinates (4, 8), (-2, 5), and (3, 1). The longest side of the triangle is opposite which of these three vertices?

ANSWER: (-2, 5)

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**TOSS-UP**

16) EARTH AND SPACE *Multiple Choice* Which of the following characteristics changes most significantly in local water bodies when rock salt is sprayed on icy winter roads?

- W) Water temperature
- X) Freezing temperature
- Y) pH
- Z) Phosphate concentration

ANSWER: X) FREEZING TEMPERATURE

**BONUS**

16) EARTH AND SPACE *Multiple Choice* Which of the following is NOT true of satellites in geostationary orbits?

- W) They are in the line-of-sight of more than one third of the Earth's surface
- X) They are useful for weather monitoring and communications
- Y) They provide excellent views of the polar regions
- Z) They can receive transmissions from free-floating balloons, buoys, and remote automatic data collection stations

ANSWER: Y) THEY PROVIDE EXCELLENT VIEWS OF THE POLAR REGIONS



### TOSS-UP

17) PHYSICS *Multiple Choice* Which of the following statements BEST describes specific heat capacity?

- W) The amount of thermal energy required to change the temperature of a substance by a certain amount per unit of mass
- X) The amount of thermal energy required to alter the physical state of a given substance
- Y) The total amount of thermal energy in a specific system
- Z) The average kinetic energy of molecules in a system

ANSWER: W) THE AMOUNT OF THERMAL ENERGY REQUIRED TO CHANGE THE TEMPERATURE OF A SUBSTANCE BY A CERTAIN AMOUNT PER UNIT OF MASS

### BONUS

17) PHYSICS *Short Answer* A block with a mass of 20 kilograms is being pulled across a level surface. Assuming other forces are negligible and  $g$  is 9.8 meters per second squared, what is the coefficient of friction between the two surfaces if a 60-newton force is required to maintain a constant velocity? Provide your answer as a decimal to the nearest tenth.

ANSWER: 0.3

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### TOSS-UP

18) MATH *Multiple Choice* Which of the following is an even function?

- W) Sine
- X) Cosine
- Y) Tangent
- Z) Cotangent

ANSWER: X) COSINE

### BONUS

18) MATH *Short Answer* Let  $n$  be the number of faces of a regular polyhedron. What is the sum of all possible values of  $n$ ?

ANSWER: 50

**TOSS-UP**

19) ENERGY *Short Answer* Tidal energy is difficult to practically harness because the difference between high tide and low tide needs to be at least 16 feet. What country is the largest producer of electricity from tidal energy?

ANSWER: FRANCE

**BONUS**

19) ENERGY *Short Answer* What is the name of the process by which impurities are added to an intrinsic semiconductor to modulate its electrical properties?

ANSWER: DOPING

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**TOSS-UP**

20) BIOLOGY *Short Answer* What is the term for the process of programmed cell death that may occur in multicellular organisms?

ANSWER: APOPTOSIS

**BONUS**

20) BIOLOGY *Multiple Choice* Transfer RNA has all of the following characteristics, EXCEPT which of the following?

- W) It travels from the nucleus to the cytoplasm in eukaryotes
- X) It is attached to an amino acid at the 5 prime end
- Y) Its three dimensional structure is roughly L-shaped
- Z) It can be used repeatedly

ANSWER: X) IT IS ATTACHED TO AN AMINO ACID AT THE 5 PRIME END

### TOSS-UP

21) MATH *Short Answer* Each side of a cube is white. Two sides are selected at random and painted green. What is the probability that two selected sides will have a common edge?

ANSWER: 4/5

### BONUS

21) MATH *Short Answer* A triangle has two sides with lengths of 4 feet and 5 feet, and a 60-degree included angle. What is the length, in feet and in simplest form, of the third side of the triangle?

ANSWER:  $\sqrt{21}$

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### TOSS-UP

22) BIOLOGY *Multiple Choice* Which of the following organic groups is NEVER bound to the central carbon atom of an amino acid?

- W) Carboxyl
- X) Methyl
- Y) Amine
- Z) Nitrile

ANSWER: Z) NITRILE

### BONUS

22) BIOLOGY *Short Answer* By name or number, identify all of the following four biological processes that rely on the participation of calcium ions: 1) oxygen transport, 2) sweat production, 3) digestion, 4) muscular contraction?

ANSWER: MUSCULAR CONTRACTION (ACCEPT: 4)

**TOSS-UP**

23) ENERGY *Multiple Choice* Which of the following does NOT represent a potential benefit of smart grids?

- W) Facilitation of the use of plug-in hybrids and electric vehicles
- X) Optimization of power plant utilization
- Y) Integration of renewable energy sources
- Z) Uni-directional metering

ANSWER: Z) UNI-DIRECTIONAL METERING

**BONUS**

23) ENERGY *Short Answer* Taking the speed of light to be 300,000,000 meters per second, about how much energy in kilowatt hours is given by converting 1 nanogram of mass into energy?

ANSWER: 25

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**TOSS-UP**

24) PHYSICS *Short Answer* When a proton undergoes beta-plus decay, what two particles are created along with the beta particle?

ANSWER: NEUTRON AND NEUTRINO

**BONUS**

24) PHYSICS *Short Answer* A position-time graph for position  $x$  and time  $t$  is defined by the equation  $x = -t^2 + 4t$  for  $t \geq 0$ . If positive represents forward motion and negative represents backward motion, during which time intervals in seconds would motion be forward and backward, respectively?

ANSWER: FORWARD FOR  $t < 2$  (ACCEPT:  $0 \leq t < 2$ ) AND BACKWARD FOR  $t > 2$

### TOSS-UP

25) BIOLOGY *Multiple Choice* In plants, which of the following groups of cells is responsible for the growth of shoots?

- W) Secondary meristem
- X) Parenchyma (read as: pah-REHN-ki-mah) cells
- Y) Guard cells
- Z) Apical (read as: AY-pi-kahl) meristem

ANSWER: Z) APICAL MERISTEM

### BONUS

25) BIOLOGY *Short Answer* By name or number, identify all of the following four organisms that are nonvascular plants: 1) moss, 2) liverwort, 3) St. John's wort, 4) hornwort.

ANSWER: MOSS, LIVERWORT, AND HORNWORT (ACCEPT: 1, 2, AND 4)