

**ROUND 16A**

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**TOSS-UP**

1) Math – *Short Answer* What is the sum of the infinite geometric series with first term  $1/4$  and second term  $1/16$ ?

ANSWER:  $1/3$

**BONUS**

1) Math – *Multiple Choice* A regular decagon is inscribed in a circle with radius 8. Which of the following is the length of one of its sides?

- W)  $8 \sin 36^\circ$
- X)  $8 \cos 36^\circ$
- Y)  $16 \sin 18^\circ$
- Z)  $16 \cos 18^\circ$

ANSWER: Y)  $16 \sin 18^\circ$

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**TOSS-UP**

2) Physics – *Short Answer* What law of electromagnetism states that the total electric flux through a closed surface is equal to the total electric charge inside the surface divided by the permittivity of free space?

ANSWER: GAUSS'S LAW (ACCEPT: GAUSS'S)

**BONUS**

2) Physics – *Short Answer* When a material transitions into a superconducting state, it actively excludes magnetic fields from its interior. What is the name of this electromagnetic phenomenon?

ANSWER: MEISSNER EFFECT

**TOSS-UP**

3) Earth and Space – *Short Answer* Identify all of the following three minerals that are formed by oxidative weathering: 1) Hematite; 2) Limonite; 3) Goethite.

ANSWER: ALL OF THEM

**BONUS**

3) Earth and Space – *Multiple Choice* As Earth's temperature rises, sea levels will also rise due to the melting of continental ice. Why won't this effect be canceled by increased evaporation of seawater from the oceans?

- W) The thermohaline [*thermo-HAY-line*] circulation will slow down
- X) When ice sheets melt, they release latent heat
- Y) Saltwater evaporates much more slowly than freshwater
- Z) The atmosphere is a much smaller water reservoir than the ocean

ANSWER: Z) THE ATMOSPHERE IS A MUCH SMALLER WATER RESERVOIR THAN THE OCEAN

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**TOSS-UP**

4) Biology – *Short Answer* What cytoskeletal component is composed of actin?

ANSWER: MICROFILAMENTS (ACCEPT: CYTOSKELETAL FILAMENTS, THIN FILAMENTS)

**BONUS**

4) Biology – *Multiple Choice* Which of the following is true regarding the differences between New World and Old World monkeys?

- W) New World monkeys evolved from prosimians, while Old World monkeys evolved from anthropoids
- X) New World monkeys are all arboreal, while Old World monkeys include some ground-dwelling species
- Y) New World monkeys lack prehensile tails, while Old World monkeys have prehensile tails
- Z) New World monkeys have downward pointed noses, while Old World monkeys have flat, spreading noses

ANSWER: X) NEW WORLD MONKEYS ARE ALL ARBOREAL, WHILE OLD WORLD MONKEYS INCLUDE SOME GROUND-DWELLING SPECIES

**TOSS-UP**

5) Chemistry – *Multiple Choice* According to VSEPR theory, which of the following could NOT be the molecular geometry of a compound with a trigonal bipyramidal electron-pair geometry?

- W) Trigonal bipyramidal [*BYE-peer-ah-MID-al*]
- X) Trigonal pyramidal
- Y) Linear
- Z) See-saw

ANSWER: X) TRIGONAL PYRAMIDAL

**BONUS**

5) Chemistry – *Short Answer* Consider the reaction A plus B yields C, which is second-order in the reactant A and first-order in the reactant B. If the concentrations of both A and B are doubled, then by what factor is the reaction rate multiplied?

ANSWER: 8



**TOSS-UP**

6) Energy – *Multiple Choice* Breeder reactors use uranium-238. Based on the abundance of this isotope, which of the following best estimates how many years breeder reactors could operate with the Earth's supply of uranium-238?

- W) 500
- X) 5,000
- Y) 5 million
- Z) 5 billion

ANSWER: Z) 5 BILLION

**BONUS**

6) Energy – *Short Answer* Identify all of the following three statements that are true regarding carbon sequestration practices on farms: 1) Groundcover is used to prevent soil from being washed or blown away; 2) Groundcover is used as protection from the Sun to attract microbes; 3) Livestock are only allowed to graze in one spot for 3-4 days at a time.

ANSWER: 1, 2, 3 (ACCEPT: ALL OF THEM)

**TOSS-UP**

7) Math – *Multiple Choice* Consider a restaurant menu with nine meals. A table at the restaurant has  $n$  diners, all of whom order different meals. For which of the following values of  $n$  could the table add a diner without changing the number of combinations of meals the table can order?

- W) 1
- X) 2
- Y) 4
- Z) 8

ANSWER: Y) 4

**BONUS**

7) Math – *Short Answer* Find the product of the following three complex numbers:  
 $2i, -11 + 2i, 4 - 5i$

ANSWER:  $-126 - 68i$



**TOSS-UP**

8) Biology – *Multiple Choice* Baker's yeast is an example of what type of fungi?

- W) Basidiomycete [*bah-sid-ee-oh-MY-seet*]
- X) Ascomycete [*az-koh-MY-seet*]
- Y) Zygomycete [*zye-go-MY-seet*]
- Z) Imperfect fungus

ANSWER: X) ASCOMYCETE

**BONUS**

8) Biology – *Short Answer* In the process of peptide synthesis by ribosomes, what specific macromolecule catalyzes the amide bond formation?

ANSWER: RNA (ACCEPT: RIBONUCLEIC ACID; DO NOT ACCEPT: RIBOZYME)

### TOSS-UP

9) Energy – *Multiple Choice* Which of the following is a major concern introduced with demand response programs and smart grids in general:

- W) Increased flow of energy in distribution and power systems.
- X) Decrease in system reliability due to intermittency of generation of renewable energy sources
- Y) Increased rates of cost of electricity
- Z) Hackers can gain access to smart grid control software

ANSWER: Z) HACKERS CAN GAIN ACCESS TO SMART GRID CONTROL SOFTWARE

### BONUS

9) Energy – *Short Answer* Research and development on next generation nuclear plants at Department of Energy labs demonstrates the technical viability of very high temperature gas-cooled reactors. What gas will be used to cool the reactors?

ANSWER: HELIUM

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### TOSS-UP

10) Chemistry – *Multiple Choice* Which of the following alkaline metal hydroxides has the highest solubility in water?

- W) Magnesium hydroxide
- X) Calcium hydroxide
- Y) Strontium hydroxide
- Z) Barium hydroxide

ANSWER: Z) BARIUM HYDROXIDE

### BONUS

10) Chemistry – *Short Answer* Identify all of the following three compounds or ions that contain atoms that violate the octet rule: 1) Azide ion; 2) Triiodide [*try-EYE-oh-died*] ion; 3) Carbon dioxide.

ANSWER: 2 ONLY

**TOSS-UP**

11) Earth and Space – *Short Answer* The Kansan, Nebraskan, Illinoian, and Wisconsinan glacial events occurred in what geological epoch?

ANSWER: PLEISTOCENE

**BONUS**

11) Earth and Space – *Multiple Choice* Which of the following would best approximate the temperature, in kelvins, of a star with very strong Balmer absorption lines?

- W) 30,000
- X) 20,000
- Y) 10,000
- Z) 5000

ANSWER: Y) 10,000



**TOSS-UP**

12) Physics – *Multiple Choice* If all of the following objects are of equal mass and equal radius, which will have the greatest rotational inertia?

- W) Solid cylinder about central axis
- X) Solid sphere about any diameter
- Y) Thin spherical shell about any diameter
- Z) Hoop about a central axis

ANSWER: Z) HOOP ABOUT A CENTRAL AXIS

**BONUS**

12) Physics – *Short Answer* What type of spectroscopy relies on the inelastic scattering of monochromatic light in order to gather information about the vibrational modes of a system?

ANSWER: RAMAN SPECTROSCOPY

**TOSS-UP**

13) Math – *Short Answer* What is the lateral surface area of a cone whose height is 12 cm and whose base diameter is 10 cm?

ANSWER: 65 pi

**BONUS**

13) Math – *Short Answer* Find the derivative with respect to  $x$  of the product of the two binomials  $4x^3 - 12$  and  $8x^4 + 7$ .

ANSWER:  $224x^6 - 384x^3 + 84x^2$



**TOSS-UP**

14) Biology – *Multiple Choice* A deletion mutation that results in loss of the final 3 nucleotides of an organism's histidine tRNA gene will impair what function of the tRNA?

- W) Folding into functional tertiary structure
- X) Codon-anticodon base pairing with mRNA
- Y) Binding to histidine
- Z) Transcription of the gene encoding histidine

ANSWER: Y) BINDING TO HISTIDINE

**BONUS**

14) Biology – *Multiple Choice* Which of the following is the most superficial layer of the epidermis?

- W) Stratum [*STRAAT-um*] lucidum [*LOO-sih-dum*]
- X) Stratum corneum [*KOR-nee-um*]
- Y) Stratum spinosum [*spih-NOH-sum*]
- Z) Stratum granulosum [*gran-yoo-LOH-sum*]

ANSWER: X) STRATUM CORNEUM

### TOSS-UP

15) Energy – *Multiple Choice* According to the International Energy Agency, third-generation technologies for energy production are those not yet widely demonstrated or commercialized. Which of the following is NOT a third-generation technology for energy production?

- W) Biomass gasification
- X) Solar heating
- Y) Solar thermal stations
- Z) Ocean energy

ANSWER: X) SOLAR HEATING

### BONUS

15) Energy – *Short Answer* Identify all of the following three statements that are TRUE regarding biodiesel: 1) B20 is commonly used in diesel equipment without modifications; 2) Water is a common biodiesel additive to reduce corrosion; 3) Biodiesel is produced via the Fischer-Tropsch process.

ANSWER: 1

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### TOSS-UP

16) Physics – *Short Answer* What equation explains why the pressure in a pipe decreases as the velocity of the fluid flowing through it increases?

ANSWER: BERNOULLI'S EQUATION

### BONUS

16) Physics – *Multiple Choice* Two loudspeakers, A and B, are placed 4 meters apart and facing each other. The loudspeakers produce sound at 171 hertz in phase with one another. A microphone is moved with varying speed along a straight line that joins A and B. Which of the following statements is true?

- W) The microphone detects sound with no amplitude fluctuations as it moves
- X) The microphone detects sound with amplitude fluctuations that increase as its speed decreases
- Y) The microphone detects sound with amplitude fluctuations that increase as its speed increases
- Z) The microphone detects no sound

ANSWER: Y) THE MICROPHONE DETECTS SOUND WITH AMPLITUDE FLUCTUATIONS THAT INCREASE AS ITS SPEED INCREASES

### TOSS-UP

17) Earth and Space – *Short Answer* What is the magnitude of the faintest stars that can be seen with the naked eye?

ANSWER: 6

### BONUS

17) Earth and Space – *Short Answer* What is the term for the feature formed when a moving glacier separates from stagnant ice, creating a crevasse?

ANSWER: BERGSCHRUND (ACCEPT: SCHRUND)

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18) Chemistry – *Multiple Choice* Which of the following statements concerning intermolecular forces is NOT true?

- W) Ion-induced dipole forces decay more quickly with distance than ion-dipole forces
- X) The Lennard-Jones potential has a single minimum value
- Y) Isooctane experiences larger London dispersion forces than linear n-octane
- Z) Van der Waals interaction potentials decay with the inverse sixth-power of molecular separation

ANSWER: Y) ISOOCTANE EXPERIENCES LARGER LONDON DISPERSION FORCES THAN LINEAR N-OCTANE

### BONUS

18) Chemistry – *Short Answer* Identify all of the following three reactions that can be considered metathesis reactions: 1) The reaction of acetic acid with sodium bicarbonate; 2) The reaction of hydrochloric acid with sodium hydroxide; 3) The reaction of solid copper with silver nitrate.

ANSWER: 1 AND 2

**TOSS-UP**

19) Math – *Short Answer* The graph of the function  $f(x)$  lies in the first quadrant. The function  $g(x)$  equals negative 2 times  $f(x)$ . In what quadrant does the graph of the function  $f(x) + g(x)$  lie?

ANSWER: FOURTH (ACCEPT: 4)

**BONUS**

19) Math – *Short Answer* What is the cross product of the vectors  $i + j + k$  and  $j$ ?

ANSWER:  $-i + k$  (ACCEPT:  $-1i + 0j + 1k$ ,  $-1i + 1k$ )



**TOSS-UP**

20) Earth and Space – *Short Answer* Landscapes that have been shaped by the dissolving power of water are said to exhibit what type of topography?

ANSWER: KARST

**BONUS**

20) Earth and Space – *Multiple Choice* According to Bowen's reaction series, which of these minerals is the first to crystallize in cooling magma?

- W) Calcium-rich plagioclase
- X) Quartz
- Y) Sodium-rich plagioclase
- Z) Muscovite

ANSWER: W) CALCIUM-RICH PLAGIOCLASE

### TOSS-UP

21) Physics – *Multiple Choice* According to the equipartition theorem, by what factor of the Boltzmann constant does each translational degree of freedom of an ideal gas contribute to the heat capacity?

- W) 1/2
- X) 1
- Y) 2
- Z) 3

ANSWER: W) 1/2

### BONUS

21) Physics – *Short Answer* What particles are thought to interact with standard particles via a force similar in strength to the weak force and are among the leading candidates for the composition of dark matter?

ANSWER: WIMPS (ACCEPT: WEAKLY INTERACTING MASSIVE PARTICLES)

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### TOSS-UP

22) Biology – *Multiple Choice* *Helicobacter pylori* [**HEEL-ik-oh-bak-tur pie-LOR-ee**] is associated with which of the following disorders?

- W) SARS
- X) Tuberculosis
- Y) Stomach ulcers
- Z) Anemia

ANSWER: Y) STOMACH ULCERS

### BONUS

22) Biology – *Multiple Choice* Vitamin K is important to which of the following processes?

- W) Metabolism
- X) Calcium absorption
- Y) Night vision
- Z) Blood clotting

ANSWER: Z) BLOOD CLOTTING

### TOSS-UP

23) Chemistry – *Short Answer* What is the bond order of  $N_2^+$ ?

ANSWER: 2.5

### BONUS

23) Chemistry – *Short Answer* Identify all of the following three statements concerning chemical kinetics that are TRUE: 1) Zero-order rate constants have units of inverse seconds; 2) First-order reactions have half-lives that are dependent on time; 3) Catalysts cannot appear in the rate law for a reaction.

ANSWER: NONE OF THEM