

### TOSS-UP

1. Chemistry *Multiple Choice* Which of the following correctly gives the orbital hybridizations of the carbon and nitrogen atoms in formamide, or  $\text{HCONH}_2$ ?

- W)  $\text{sp}^2$ ,  $\text{sp}^2$
- X)  $\text{sp}^2$ ,  $\text{sp}^3$
- Y)  $\text{sp}^3$ ,  $\text{sp}^2$
- Z)  $\text{sp}^3$ ,  $\text{sp}^3$

ANSWER: W)  $\text{sp}^2$ ,  $\text{sp}^2$  [YL]

### BONUS

1. Chemistry *Short Answer* The  $\text{pK}_a$  of acetic acid is 4.8. To two significant figures, what is the pH of a solution of 1 molar acetic acid?

ANSWER: 2.4 [YL]

### TOSS-UP

2. Math *Multiple Choice* A 45 degree arc in circle A has the same length as a 60 degree arc in circle B. What is the ratio of the area of circle A to that of circle B?

- W) 4 to 9
- X) 9 to 4
- Y) 16 to 9
- Z) 9 to 16

ANSWER: Y) 16 to 9 [EZ]

### BONUS

2. Math *Short Answer* A hexagon is inscribed in a circle. Yunyi draws two triangles using each of the vertices of the hexagon exactly once. What is the probability that the two triangles intersect?

ANSWER: 7/10 [EZ]

### TOSS-UP

3. Earth and Space *Multiple Choice* Which of the following correctly describes the directions of hurricanes and anticyclones, respectively, in the Northern hemisphere?

- W) Clockwise, clockwise
- X) Clockwise, counterclockwise
- Y) Counterclockwise, clockwise
- Z) Counterclockwise, counterclockwise

ANSWER: Y) COUNTERCLOCKWISE, CLOCKWISE [YL]

### BONUS

3. Earth and Space *Short Answer* Lunar and solar eclipses occur when the Sun, Earth, and Moon are all in one line. What is the term for such an event where three celestial objects are aligned?

ANSWER: SYZYGY [YL]

### TOSS-UP

4. Biology *Multiple Choice* Evan was walking outside when suddenly a bear started chasing him. Terrified, he started running for his life. Which of the following results would most likely happen?

- W) His parasympathetic nervous system increases his blood pressure
- X) His parasympathetic nervous system decreases his blood pressure
- Y) His sympathetic nervous system increases his blood pressure
- Z) His sympathetic nervous system decreases his blood pressure

ANSWER: Y) HIS SYMPATHETIC NERVOUS SYSTEM INCREASES HIS BLOOD PRESSURE [KD]

### BONUS

4. Biology *Multiple Choice* Suddenly the bear dies and Evan obtains some of its cells. If he wants to visualize the surface of the bear's cells, which of the following types of microscopy would he MOST likely use?

- W) Light Microscopy
- X) Scanning Electron Microscopy
- Y) Transmission Electron Microscopy
- Z) Cryo-Electron Microscopy

ANSWER: X) SCANNING ELECTRON MICROSCOPY [KD]

### TOSS-UP

5. Physics *Short Answer* Baryons and mesons together comprise what class of subatomic particles characterized by being made up of two or more quarks?

ANSWER: HADRONS [YL]

### BONUS

5. Physics *Short Answer* A 132 meter long train is moving at a speed of  $\frac{5}{13}c$  when it passes through a tunnel. What must the rest length of the tunnel be such that a passenger inside the train measures the tunnel to be exactly the length of the train?

ANSWER: 143 [SC]

### TOSS-UP

6. Chemistry *Multiple Choice* Which of the following halides will form the most soluble silver salt in water?

- W) Fluoride
- X) Chloride
- Y) Bromide
- Z) Iodide

ANSWER: W) FLUORIDE [YL]

### BONUS

6. Chemistry *Short Answer* If the bond dissociation energy of hydrogen gas is 436 kilojoules per mole, what is the enthalpy of formation of hydrogen gas?

ANSWER: 0 [YL]

### TOSS-UP

7. Math *Short Answer* Kite ABCD is inscribed in a circle. If the area of the kite is 48 and BD is 6 units long, what is the area of the circle?

ANSWER:  $64\pi$  [EZ]

### BONUS

7. Math *Short Answer* Unit square ABCD has A at the origin and C at (1,1). A dilation of scale factor 2 centered at (-1, -1) is applied. What is the sum of the x and y coordinates of all 4 vertices of the square after the dilation?

ANSWER: 16 [EZ]

**TOSS-UP**

8. Earth and Space *Multiple Choice* Which of the following minerals does anhydrite turn into when exposed to water?

- W) Halite
- X) Gypsum
- Y) Corundum
- Z) Calcite

ANSWER: X) GYPSUM [YL]

**BONUS**

8. Earth and Space *Multiple Choice* Which of the following glacial features would not likely be found on a mountain?

- W) Cirque
- X) Drumlin
- Y) Arete
- Z) Tarn

ANSWER: X) DRUMLIN [SC]

**TOSS-UP**

9. Biology *Multiple Choice* Which of the following biochemical pathways is NOT exergonic?

- W) Glycolysis
- X) Citric Acid Cycle
- Y) Calvin Cycle
- Z) Beta-oxidation

ANSWER: Y) CALVIN CYCLE [KD]

**BONUS**

9. Biology *Short Answer* According to the island biogeography model, identify all of the following 4 changes to an island that would likely increase its species diversity:

- 1) Increasing size
- 2) Decreasing size
- 3) Increasing distance from mainland
- 4) Decreasing distance from mainland

ANSWER: 1 AND 4 [KD]

### TOSS-UP

10. Physics *Multiple Choice* A capacitor is connected to a battery and fully charged. While still connected to the voltage source, a dielectric is inserted between the parallel plates. Which of the following best describes the new voltage and charge stored across the capacitor after a long time?

- W) Voltage increases, charge increases
- X) Voltage decreases, charge decreases
- Y) Voltage stays the same, charge increases
- Z) Voltage stays the same, charge decreases

ANSWER: Y) Voltage stays the same, charge increases [YL]

### BONUS

10. Physics *Multiple Choice* One way electricity is generated through the use of various methods to turn turbines in a magnetic field using wind, power, and other sources. Which of the following underlying principles is the basis for this electricity generation?

- W) Gauss's law for electricity
- X) Gauss's law for Magnetism
- Y) Faraday's law
- Z) Ampere's law

ANSWER: Y) Faraday's law [RY]

### TOSS-UP

11. Chemistry *Short Answer* What organic substitution mechanism involves a pentavalent transition state and occurs in a single step?

ANSWER: S<sub>N</sub>2 (ACCEPT SUBSTITUTION NUCLEOPHILIC BIMOLECULAR) [AY]

### BONUS

11. Chemistry *Short Answer* Stephen is trying to find the voltage of a galvanic cell that has nonstandard concentrations and is at 50 kelvins. What equation commonly used in

electrochemistry would he use to calculate the voltage given the standard reduction potentials of the two half-cells?

ANSWER: NERNST EQUATION [YL]

### TOSS-UP

12. Math *Multiple Choice* Which of the following values is largest?

W)  $\sin(\pi/3)$

X)  $\sin(\pi/4)$

Y)  $\sin(\pi/5)$

Z)  $\sin(\pi/6)$

ANSWER: W)  $\sin(\pi/3)$  [EZ]

### BONUS

12. Math *Short Answer* A tetrahedron has a base in the shape of an equilateral triangle with sides of length 4. If the tetrahedron's height is 3, what is its volume?

ANSWER:  $4\sqrt{3}$  [EZ]

### TOSS-UP

13. Earth and Space *Short Answer* An object has a recessional velocity of 480 km/s. To the nearest megaparsec, how far is it from the Milky Way?

ANSWER: 7 [SC]

### BONUS

13. Earth and Space *Short Answer* Order the following 3 features of a coastal subduction zone from most landward to most seaward:

1) Accretionary wedge

2) Volcanic arc

3) Forearc basin

ANSWER: 2, 3, 1 [KW]

### TOSS-UP

14. Biology *Short Answer* Rank the following 3 sugars in terms of increasing number of carbons:

- 1) Ribose
- 2) Fructose
- 3) Lactose

ANSWER: 1, 2, 3 [KD]

### BONUS

14. Biology *Short Answer* Order the following 3 groups from most to least closely related to plants:

- 1) Charophytes [CARE-o-fites]
- 2) Red Algae
- 3) Chlorophytes

ANSWER: 1, 3, 2 [KW]

### TOSS-UP

15. Physics *Short Answer* Jason is listening to Tchaikovsky's first Piano Concerto. If the frequency of a B-flat note he hears is 466 Hz, what is the frequency, in Hertz, of the B-flat note an octave below what he hears?

ANSWER: 233 [JY]

### BONUS

15. Physics *Short Answer* What is the efficiency of an ideal Carnot engine operating between temperatures of 300 and 900 K?

ANSWER:  $\frac{2}{3}$  [YL]

### TOSS-UP

16. Chemistry *Short Answer* What is the VSEPR [VESPER] structure of xenon tetrafluoride?

ANSWER: SQUARE PLANAR [LK]

### BONUS

16. Chemistry *Multiple Choice* Walter White is making hydrogen iodide in a sealed chamber according to the equation  $\text{H}_2(\text{g}) + \text{I}_2(\text{s}) \rightarrow 2\text{HI}(\text{g})$ . The reaction is currently in equilibrium. Doing what will shift the equilibrium towards the products?

- W) Adding Argon gas into the container
- X) Crushing the iodine into smaller pieces
- Y) Adding hydrogen gas into the container
- Z) Decreasing the volume of the container

ANSWER: Y) ADDING HYDROGEN GAS INTO THE CONTAINER [EY]

### TOSS-UP

17. Math *Multiple Choice* A regular  $n$  gon has integer angle measures. Which of the following could be the value of  $n$ ?

- W) 13
- X) 14
- Y) 15
- Z) 16

ANSWER: Y) 15 [EZ]

### BONUS

17. Math *Short Answer* What is the name of the function that when given a number  $n$ , returns the number of integers less than  $n$  that are relatively prime to  $n$ ?

ANSWER: TOTIENT (ACCEPT: EULER'S TOTIENT) [EZ]

### TOSS-UP

18. Earth and Space *Short Answer* Order the following 3 volcanoes in terms of increasing angle of repose:

- 1) Stratovolcano
- 2) Shield volcano
- 3) Cinder cones

ANSWER: 2, 1, 3 [YL]

### BONUS

18. Earth and Space *Short Answer* Identify all of the following 3 minerals that are silicates:



- 1) Olivine
- 2) Mica
- 3) Pyroxene

ANSWER: ALL [KD]

### TOSS-UP

19. Biology *Multiple Choice* Which of the following most accurately describes the effect of inbreeding on a population?

- W) Inbreeding increases the proportion of homozygotes
- X) Inbreeding increases the frequency of recessive alleles
- Y) Inbreeding causes new gene mutations to arise in offspring
- Z) Inbreeding causes the introduction of new hybrid species

ANSWER: W) INBREEDING INCREASES THE PROPORTION OF HOMOZYGOTES [KD]

### BONUS

19. Biology *Multiple Choice* DNA polymerase is synthesizing the complementary sequence to 5' TGATG 3'. If it just added a Cytosine base, what is the next base it is going to add to the growing complementary sequence?

- W) Cytosine
- X) Guanine
- Y) Thymine
- Z) Adenine

ANSWER: Z) ADENINE [KD]

### TOSS-UP

20. Physics *Short Answer* A high-energy photon interacts with a nucleus to produce an electron and a positron. What is the name of this process?

ANSWER: PAIR PRODUCTION [YL]

### BONUS

20. Physics *Multiple Choice* Yunyi releases a ball from a ramp with friction of height  $h$  where the ball rolls smoothly down to the floor. When the ball reaches the floor, the ball now rolls up another ramp, now without friction. Which of the following choices best describes the ball when it is at the top of the second ramp?

- W) The ball reaches a height less than  $h$  with zero angular velocity
- X) The ball reaches a height less than  $h$  with a non zero angular velocity
- Y) The ball reaches a height equal to  $h$  with zero angular velocity
- Z) The ball reaches a height equal to  $h$  with a non zero angular velocity

ANSWER: X) THE BALL REACHES A HEIGHT LESS THAN  $h$  WITH A NON ZERO ANGULAR VELOCITY **[RY]**