

### TOSS-UP

1. Chemistry *Multiple Choice* Which of the following aqueous ions is least intensely colored?

W)  $\text{Cr}^{3+}$

X)  $\text{Fe}^{3+}$

Y)  $\text{Mn}^{2+}$

Z)  $\text{Ni}^{2+}$

ANSWER: Y)  $\text{Mn}^{2+}$  [YL]

### BONUS

1. Chemistry *Multiple Choice* A mixture of two liquids leads to a negative deviation from Raoult's [rau-OOLT] law. What must be true about these two liquids?

W) The mixing of these liquids is exothermic.

X) The mixing of these liquids is endothermic.

Y) The volume of these liquids is not additive when mixed.

Z) The interaction between the two liquids is stronger than the interaction within either of the two liquids.

ANSWER: Z) THE INTERACTION BETWEEN THE TWO LIQUIDS IS STRONGER THAN THE INTERACTION WITHIN EITHER OF THE TWO LIQUIDS [AY]

### TOSS-UP

2. Math *Short Answer* A fair four sided die is rolled and the sum of the numbers on the three visible faces are added. What is the expected value of the sum?

ANSWER: 7.5 [EZ]

### BONUS

2. Math *Short Answer* Kian is fishing. He has a 40 percent chance of catching a fish every hour. What is the probability he has at least 1 fish after 3 hours?

ANSWER: 98/125 [EZ]

### TOSS-UP

3. Earth and Space *Short Answer* Identify all of the following 4 seismic waves that are considered to be surface waves:

1) S-waves

- 2) P-waves
- 3) Rayleigh waves
- 4) Love waves

ANSWER: 3 AND 4 [YL]

### BONUS

3. Earth and Space *Short Answer* Identify all of the following 3 changes that would increase ocean salinity:

- 1) Increased precipitation
- 2) Increased ice formation
- 3) Increased evaporation

ANSWER: 2 AND 3 [YL]

### TOSS-UP

4. Biology *Multiple Choice* Which of the following best describes the result after a cell undergoes meiosis, then each of those daughter cells undergoes mitosis?

- W) 4 diploid cells
- X) 4 haploid cells
- Y) 8 diploid cells
- Z) 8 haploid cells

ANSWER: Z) 8 HAPLOID CELLS [KD]

### BONUS

4. Biology *Short Answer* Katherine is analyzing a trihybrid cross between two lions heterozygous for genes A, B, and C. What proportion of the offspring will also be heterozygous for all 3 genes?

ANSWER:  $\frac{1}{8}$  [KD]

### TOSS-UP

5. Physics *Multiple Choice* Kian is running a race on a straight track of length 180 m. If the maximum magnitude of his acceleration is  $5 \text{ m/s}^2$  and he must start and end at rest, what is the shortest amount of time, in seconds, Kian can finish the race?

- W) 4

- X) 6
- Y) 12
- Z) 18

ANSWER: Y) 12 **[CW]**

### BONUS

5. Physics *Short Answer* Yunyi's position on a line can be determined by the function  $x(t) = 3t^4 - 2t^3 + 4t^2 + 10t - 50$ . What is his acceleration at  $t = 2$ ?

ANSWER: 128 **[W: CW]**

### TOSS-UP

6. Chemistry *Short Answer* What principle states that no two fermions can have the same set of quantum numbers?

ANSWER: PAULI EXCLUSION PRINCIPLE **[AY]**

### BONUS

6. Chemistry *Multiple Choice* Which of the following best explains why nitrogen has a higher first ionization energy than oxygen?

- W) Nitrogen has a larger atomic radius than oxygen
- X) Oxygen has more valence electrons than nitrogen
- Y) Oxygen experiences more electron-electron repulsion than nitrogen
- Z) Nitrogen is less electronegative than oxygen

ANSWER: Y) OXYGEN EXPERIENCES MORE ELECTRON-ELECTRON REPULSION THAN NITROGEN **[AY]**

### TOSS-UP

7. Math *Short Answer* Kian is chasing Evan through the halls after Evan stole his copy of Campbell Biology. Luckily, Evan has a head start of 3 kilometers. If Evan can run at 5 meters per second and Kian at 25 meters per second, how much time, in seconds, will it take for Kian to catch up to him?

ANSWER: 150 **[EZ]**

### BONUS

7. Math *Short Answer* On planet Y, a Yong is worth 5 Yings, a Ying is worth 8 Yangs, and a Yang is worth 3 dollars. If Yunyi has 6 Yongs, 4 Yings, and 7 Yangs, how much money in dollars does he have?

ANSWER: 837 [EZ]

### TOSS-UP

8. Earth and Space *Multiple Choice* Kian is taking a USABO test when he comes across a question about climates. He really does not like ESS so he asks you for help. Which of the following climates generally has hot, dry summers, mild, rainy winters, and high risk of wildfires in the fall?

- W) Desert
- X) Chaparral
- Y) Temperate deciduous forest
- Z) Grassland

ANSWER: X) CHAPARRAL [YL]

### BONUS

8. Earth and Space *Short Answer* Gravitational lensing by a galaxy may allow an observer to view an object lying behind it if the galaxy is massive enough. On Earth, an observer would view this as an arc of light around the lens galaxy. What is the name for this phenomenon?

ANSWER: EINSTEIN RING (ACCEPT: CHWOLSON RING, EINSTEIN-CHWOLSON RING)  
[YL]

### TOSS-UP

9. Biology *Multiple Choice* Chris is studying frogs in the rainforest when he stumbles upon a frog that has bright red skin and is known to produce a potent toxin. Which of the following types of coloration is this an example of?

- W) Cryptic
- X) Batesian
- Y) Aposematic
- Z) Müllerian

ANSWER: Y) APOSEMATIC [MS]

### BONUS

9. Biology *Multiple Choice* In the context of gene regulation in eukaryotes, which of the following roles does DNA methylation most commonly play?

- W) Enhancing gene transcription
- X) Inhibiting gene transcription
- Y) Enhancing gene translation
- Z) Inhibiting gene translation

ANSWER: X) INHIBITING GENE TRANSCRIPTION [MS]

### TOSS-UP

10. Physics *Multiple Choice* Which of the following four particles is a fermion?

- W) Photon
- X) Gluon
- Y) Neutrino
- Z) Higgs Particle

ANSWER: Y) NEUTRINO [YL]

### BONUS

10. Physics *Short Answer* Two current-carrying wires are placed parallel to each other. If each current is doubled and the distance between the wires is halved, by what factor is the force on each wire multiplied?

ANSWER: 8 [YL]

### TOSS-UP

11. Chemistry *Multiple Choice* Pure substance A melts at a temperature of 70C. Pure substance B melts at a temperature of 85C. Assuming A and B do not interact or form a solid solution, which of the following best describes the melting point of a mixture of A and B?

- W) Its melting point is greater than 85C.
- X) Its melting point is less than 70C.
- Y) Its melting point is between 70 and 85C.
- Z) There is not enough information to determine the melting point.

ANSWER: X) ITS MELTING POINT IS LESS THAN 70C [AY]

### BONUS

11. Chemistry *Short Answer* What type of nuclear decay is Carbon-14 most likely to undergo?

ANSWER: BETA MINUS DECAY (ACCEPT BETA DECAY, DO NOT ACCEPT BETA PLUS)  
[AY]

### TOSS-UP

12. Math *Short Answer* A triangle has two sides of length 5 and 6. What is the maximum possible area of the triangle?

ANSWER: 15 [EZ]

### BONUS

12. Math *Short Answer* 8 adults and 12 children go to the movies. However, the cashier swapped the number of adults and children, making the total 20 dollars higher than it should be. If 1 adult and 1 child ticket cost 13 dollars, what is the price of a child ticket?

ANSWER: 4 [EZ]

### TOSS-UP

13. Earth and Space *Multiple Choice* Over which of the following types of faults can monoclines NOT form?

- W) Normal
- X) Thrust
- Y) Reverse
- Z) Transform

ANSWER: Z) TRANSFORM [KW]

### BONUS

13. Earth and Space *Short Answer* Order the following 3 types of changes in Earth's orbit by increasing cycle duration:

- 1) Change in eccentricity
- 2) Change in axis tilt
- 3) Precession

ANSWER: 3, 2, 1 [KW]

### TOSS-UP

14. Biology *Short Answer* While Schwann cells myelinate the axons of neurons in the peripheral nervous system, what type of cell myelinates neurons in the central nervous system?

ANSWER: OLIGODENDROCYTES [MS]

### BONUS

14. Biology *Short Answer* Cooking vegetables for an extended amount of time often turns their color from bright green to a dull muddy green. This change is caused by a hydrogen ion replacing what ion at the center of chlorophyll?

ANSWER: MAGNESIUM (ACCEPT: Mg, MAGNESIUM 2+) [EY]

### TOSS-UP

15. Physics *Short Answer* Quantum computers are a newly developing technology that may vastly increase the efficiency of modern day computers. Quantum computers utilize what fundamental analogues of classical bits as their most simple components?

ANSWER: QUBITS [YL]

### BONUS

15. Physics *Multiple Choice* Two identical blocks of mass  $m$  are connected by a spring. If the system is placed vertically where the bottom block never leaves the floor and the top block undergoes simple harmonic oscillation, the period of oscillation is  $T$ . If instead the whole system oscillates vertically in free fall, by what factor does the period of oscillation decrease?

- W) 4
- X) 2
- Y)  $\sqrt{2}$
- Z) 1

ANSWER: Y)  $\sqrt{2}$  [RY]

### TOSS-UP

16. Chemistry *Multiple Choice* Which of the following is a strong Lewis acid but not a Brønsted-Lowry acid?

- W) Antimony Pentafluoride
- X) Perchloric acid
- Y) Sulfuric Acid

Z) Sodium Bromide

ANSWER: W) ANTIMONY PENTAFLUORIDE [EY]

**BONUS**

16. Chemistry *Multiple Choice* Which of the following is an endothermic process?

W) Water boiling

X) Combustion of propane

Y) Metal solidifying after being poured

Z) Water droplets condensing on a cool surface

ANSWER: W) WATER BOILING [EY]

**TOSS-UP**

17. Math *Short Answer* What is the maximum possible number of rounds in a double elimination tournament with 32 participants if there are no ties?

ANSWER: 63 [CW]

**BONUS**

17. Math *Short Answer* If the average grade in Mr. Lodal's class is a 60 with a standard deviation of 10, what is Evan's z-score if he has a 33?

ANSWER: -2.7 (ACCEPT: -27/10) [CW]

**TOSS-UP**

18. Earth and Space *Short Answer* What is the term for the large group of asteroids that share Jupiter's orbit around the sun?

ANSWER: TROJANS [KD]

**BONUS**

18. Earth and Space *Short Answer* Order the following 3 regions of the Earth in order of increasing P wave velocity:

1) Crust

2) Mantle

3) Inner core



ANSWER: 1, 3, 2 **[SC]**

**TOSS-UP**

19. Biology *Short Answer* Order the following 3 macromolecules in terms of increasing size:

- 1) Human Chromosome 1
- 2) Insulin
- 3) Lactose

ANSWER: 3, 2, 1 **[KD]**

**BONUS**

19. Biology *Multiple Choice* In a population of rhinos, individuals with very large or very small horns are more successful at reproducing than those with intermediate-sized horns. Over time, what type of selection will most likely occur in this species?

- W) Directional
- X) Disruptive
- Y) Stabilizing
- Z) Sexual

ANSWER: X) DISRUPTIVE **[MS]**

**TOSS-UP**

20. Physics *Multiple Choice* Spaceman Fred sees a linear plank of wood in space, and throws a ball of glue at it. The ball hits the plank of wood on its end and sticks. Which of the following is not true about this collision?

- W) Momentum is conserved
- X) Angular momentum is conserved
- Y) Kinetic energy is conserved
- Z) Heat is produced

ANSWER: Y) KINETIC ENERGY IS CONSERVED **[SC]**

**BONUS**

20. Physics *Multiple Choice* Kepler's second law of planetary motion states that the imaginary line joining a planet and the Sun sweeps equal areas of space during equal time intervals as the

planet orbits. This is a direct consequence of the conservation of which of the following quantities?

- W) Total energy
- X) Momentum
- Y) Angular momentum
- Z) Kinetic energy

ANSWER: Y) ANGULAR MOMENTUM **[RY]**