

### TOSS-UP

1. Chemistry *Short Answer* What type of covalent bond is characterized by cylindrical symmetry?

ANSWER: SIGMA BOND [YL]

### BONUS

1. Chemistry *Short Answer* The compressibility factor of a gas is a measurement of how much a real gas deviates from ideal behavior. Rank the following 3 gasses in order of increasing compressibility factor:

- 1) Helium
- 2) Sulfur hexafluoride
- 3) Dinitrogen

ANSWER: 2, 3, 1 [YL]

### TOSS-UP

2. Math *Short Answer* 2 integers are chosen at random without replacement from the first 10 positive integers. What is the probability that their product is odd?

ANSWER: 2/9 [EZ]

### BONUS

2. Math *Multiple Choice* Which of the following platonic solids does not have triangular faces?

- W) Tetrahedron
- X) Octahedron
- Y) Dodecahedron
- Z) Icosahedron

ANSWER: Y) DODECAHEDRON [EZ]

### TOSS-UP

3. Earth and Space *Short Answer* When walking in the Grand Erg Oriental, James sees many crescent-shaped solitary sand dunes. What is the name of this kind of dune?

ANSWER: BARCHAN (ACCEPT: CRESCENTIC) [ZG]

### BONUS

3. Earth and Space *Short Answer* The Interplanetary Transport Network is a collection of low-energy trajectories that can be used to maneuver a satellite across the Solar System with very little fuel. It is efficient in part because it exploits what critical points in the Solar System's total potential well?

ANSWER: LAGRANGE POINTS [SC]

#### TOSS-UP

4. Biology *Multiple Choice* In a healthy adult, which of the following organs would you expect to have the highest expression of telomerase in order to maintain genomic integrity?

- W) Ovary
- X) Liver
- Y) Skin
- Z) Pancreas

ANSWER: W) OVARY [KW]

#### BONUS

4. Biology *Short Answer* In a certain population of walrus, the long hair allele is dominant to the short hair allele and the 3-tusks allele is dominant to the 2-tusks allele. When a walrus heterozygous at both loci was mated to a short-haired, 2-tusked walrus, 45 of the 100 offspring had short hair and 2 tusks. Given this information, what is the most likely map distance between the hair length and tusk number genes?

ANSWER: 10 [KD]

#### TOSS-UP

5. Physics *Multiple Choice* How does the wavelength of a photon change after reflecting off of an electron via Compton scattering?

- W) It increases
- X) It stays the same
- Y) It decreases
- Z) The photon is absorbed

ANSWER: W) IT INCREASES [YL]

#### BONUS

5. Physics *Short Answer* Two waves with amplitudes of 3 and 8 have a phase difference of  $\pi/3$ . What is the amplitude of the resulting wave?

ANSWER: SQRT(97) [YL]

**TOSS-UP**

6. Chemistry *Multiple Choice* In which of the following solvents will hydrochloric acid be the least acidic?

- W) Ammonia
- X) Glacial acetic acid
- Y) Water
- Z) Pyridine

ANSWER: X) GLACIAL ACETIC ACID [YL]

**BONUS**

6. Chemistry *Multiple Choice* Which of the following compounds contains oxygen in an oxidation state other than -2?

- W)  $\text{Cr}_2\text{O}_7^{2-}$
- X)  $\text{H}_2\text{O}$
- Y)  $\text{N}_2\text{O}_4$
- Z)  $\text{OF}_2$

ANSWER: Z)  $\text{OF}_2$  [YL]

**TOSS-UP**

7. Math *Multiple Choice* 3 fair dice are rolled. How many ways are there for the top faces to sum to 16?

- W) 3
- X) 4
- Y) 5
- Z) 6

ANSWER: Z) 6 [EZ]

**BONUS**

7. Math *Short Answer* One of the 21 dots of a standard, 6-sided die is removed randomly. What is the expected value of a roll of the new die?

ANSWER: 10/3 [EZ]

### TOSS-UP

8. Earth and Space *Short Answer* You are a fossilized reef triggerfish who happily resides in the middle of a sedimentary bed. Identify all of the following 3 intrusions that are at risk of cutting through your home:

- 1) Batholith
- 2) Dike
- 3) Sill

ANSWER: 1 AND 2 [KW]

### BONUS

8. Earth and Space *Multiple Choice* Which of the following best explains why tachylite, a mafic, glassy igneous rock without vesicles, is relatively rare?

- W) Most mafic magmas are high in volatiles, which form vesicles
- X) Most mafic magmas quickly form crystals at depth due to their low viscosity
- Y) Most mafic magmas cool too slowly at the surface to form a glassy texture
- Z) Most mafic magmas erupt explosively, forming pyroclastic rocks instead

ANSWER: X) MOST MAFIC MAGMAS QUICKLY FORM CRYSTALS AT DEPTH DUE TO THEIR LOW VISCOSITY [KW]

### TOSS-UP

9. Biology *Short Answer* What is the term for the blind spot in the human eye that is caused by an area in the retina without any light-sensitive cells?

ANSWER: OPTIC DISC [MS]

### BONUS

9. Biology *Multiple Choice* Which of the following is the MOST accurate description of how chloroplasts and mitochondria have changed since their initial endosymbiosis?

- W) They have lost their double membrane
- X) They have decreased in size
- Y) Their ribosomes have changed from 70s to 80s
- Z) Most of their genes have been transferred to nuclear DNA

ANSWER: Z) MOST OF THEIR GENES HAVE BEEN TRANSFERRED TO NUCLEAR DNA  
[KD]

### TOSS-UP

10. Physics *Short Answer* Identify all of the following 3 thermodynamic cycles that have ideal efficiency under all conditions:

- 1) Carnot cycle
- 2) Otto cycle
- 3) Brayton cycle

ANSWER: 1 ONLY [YL]

### BONUS

10. Physics *Short Answer* Which of the following would decrease the frictional force of a block moving on an inclined plane with friction?

- W) Increasing the coefficient of kinetic friction
- X) Increasing the angle of inclination of the plane
- Y) Increasing the mass of the block
- Z) Increasing the gravitational acceleration

ANSWER: X) INCREASING THE ANGLE OF INCLINATION OF THE PLANE [JY]

### TOSS-UP

11. Chemistry *Multiple Choice* Which of the following metals does not react with water at standard conditions?

- W) Lithium
- X) Strontium
- Y) Magnesium
- Z) Calcium

ANSWER: Y) MAGNESIUM [EY]

### BONUS

11. Chemistry *Short Answer* The standard reduction potential of  $\text{Ag}^+$  into Ag is 0.8V and the standard reduction potential of  $\text{Dy}^{3+}$  into Dy is -2.3V. A galvanic cell is made using Ag,  $\text{AgNO}_3$ ,

Dy(NO<sub>3</sub>)<sub>3</sub>, and Dy, with all species at standard concentrations. In volts, what is the voltage generated by the cell?

ANSWER: 3.1 [GT]

#### TOSS-UP

12. Math *Short Answer* What is the sum of the coefficients in the trinomial expansion of  $(2x - 3y + 4z)^5$ ?

ANSWER: 243 [EZ]

#### BONUS

12. Math *Short Answer* What is the largest power of 6 that divides 50!?

ANSWER: 22 [EZ]

#### TOSS-UP

13. Earth and Space *Multiple Choice* Natural levees lining the banks of a river most directly cause which of the following to form?

- W) Peneplains
- X) Yazoo tributaries
- Y) Oxbow lakes
- Z) Braided streams

ANSWER: X) YAZOO TRIBUTARIES [KW]

#### BONUS

13. Earth and Space *Short Answer* Identify all of the following 3 atmospheric circulation cells in which air flows toward the poles at the Earth's surface:

- 1) Hadley
- 2) Ferrel
- 3) Polar

ANSWER: 2 ONLY [KW]

#### TOSS-UP

14. Biology *Multiple Choice* Andy is playing minecraft and finds a flower that has large amounts of nectar but no noticeable odor. Which of the following animals likely pollinates this flower?

- W) Bumblebee
- X) Fruit Bat
- Y) Hummingbird
- Z) Butterfly

ANSWER: Y) HUMMINGBIRD [KD]

### BONUS

14. Biology *Multiple Choice* Jason is attempting to perform PCR on a DNA segment he obtained, but he forgets to change the temperature and performs it at room temperature instead. In which of the following stages would this PCR stop, and for what reason?

- W) Denaturation, DNA strands cannot separate
- X) Annealing, RNA primers cannot attach
- Y) Extension, DNA polymerase cannot add new nucleotides
- Z) It will proceed but have many inaccuracies in the synthesized strands

ANSWER: W) DENATURATION, DNA STRANDS CANNOT SEPARATE [KD]

### TOSSUP

15. Physics *Short Answer* The speed of a non-viscous, incompressible fluid flowing through a circular tube is proportional to the radius raised to what power?

ANSWER: -2 [CW]

### BONUS

15. Physics *Short Answer* Yunyi is trying to set up a circuit with resistors of 200 ohms and 300 ohms. By what factor is the resistance multiplied by if the resistors are in series instead of in parallel?

ANSWER: 25/6 [CW]

### TOSS-UP

16. Chemistry *Short Answer* Identify all of the following three molecules that have a tetrahedral geometry:

- 1) CH<sub>4</sub>
- 2) SF<sub>4</sub>
- 3) XeO<sub>4</sub>

ANSWER: 1 AND 3 [YL]

**BONUS**

16. Chemistry *Short Answer* A salt  $AB_2$  has a molar solubility of 1.0 M. What is the  $K_{sp}$  of this salt?

ANSWER: 4.0 [EY]

**TOSS-UP**

17. Math *Short Answer* Identify all of the following 3 polygons that can tessellate a plane:

- 1) Square
- 2) Pentagon
- 3) Hexagon

ANSWER: ALL [EZ]

**BONUS**

17. Math *Multiple Choice* According to Descartes' rule of signs, which of the following can not be a possibility for the number of positive roots for the polynomial  $x^5 - 4x^4 + 8x^3 - 3x^2 - 2x + 7$ ?

- W) 0
- X) 1
- Y) 2
- Z) 4

ANSWER: X) 1 [EZ]

**TOSS-UP**

18. Earth and Space *Multiple Choice* Which of the following is true about star trails?

- W) They are great circles in the celestial sphere
- X) They are always parallel to the horizon
- Y) They are centered on the North Celestial Pole
- Z) They all have the same length

ANSWER: Y) THEY ARE CENTERED ON THE NORTH CELESTIAL POLE [SC]

**BONUS**



18. Earth and Space *Short Answer* Yunyi is journeying through space and stops for lunch at a cool 1.5 solar mass star. Checking his magical stethoscope, he sees that the star has a degenerate core. However, after finishing his meal half an hour later, he sees that the core is now no longer degenerate and has drastically increased in temperature. What kind of event likely happened during Yunyi's lunch?

ANSWER: HELIUM FLASH [SC]

### TOSS-UP

19. Biology *Short Answer* Order the following 3 levels of chromosome compaction from least to most compact:

- 1) Metaphase chromosome
- 2) Beads on a String
- 3) 30 nm fiber

ANSWER: 2, 3, 1 [KD]

### BONUS

19. Biology *Short Answer* In a certain population consisting of 4 species, species A is preyed on equally by species B and C, and species B is preyed on by species D. If species A has 4000 kilojoules of energy, what amount of this energy, in kilojoules, is passed on to species D?

ANSWER: 20 [KD]

### TOSS-UP

20. Physics *Short Answer* The **single slit** experiment of light shows that light can exhibit wave-like behavior. Which of the following 3 wave phenomena are demonstrated in this experiment?

- 1) Diffraction
- 2) Interference
- 3) Refraction

ANSWER: 1 AND 2 [RY]

### BONUS

20. Physics *Short Answer* A train is traveling at a constant speed of 25 meters per second. Snow begins falling onto the train at a rate of 6 kilograms per second. Neglecting friction from

the ground, how much energy, in kilojoules, must the train's engine output over the span of a minute if the train is to maintain its current speed?

ANSWER: 225 [YL]