

### **TOSS-UP**

1. Chemistry *Multiple Choice* Which of the following functional groups will react with LiAlH<sub>4</sub> but not with NaBH<sub>4</sub>?

- W) Aldehyde
- X) Ester
- Y) Ether
- Z) Acyl chloride

ANSWER: X) ESTER [YL]

### **BONUS**

1. Chemistry *Short Answer* Evan wishes to find the rate law for the reaction between crystal violet and sodium hydroxide. To accomplish this, he uses a large excess of sodium hydroxide and measures the crystal violet concentration over time. Evan finds that a graph of one over the crystal violet concentration is linear with time, and that doubling the sodium hydroxide concentration halves the slope. What is the overall order of the reaction?

ANSWER: 1 [YL]

### **TOSS-UP**

2. Math *Short Answer* Kian is buying chicken nuggets. If McEvans sells nuggets in boxes of 7 and 10, what is the largest number of nuggets that Kian WON'T be able to buy?

ANSWER: 53 [EZ]

### **BONUS**

2. Math *Short Answer* Evan is bored, so he decides to call Jason to help him clean his floor with his stash of pineapples. If Evan would take 2 hours to clean his house and Jason would take 3, how long would it take them to clean the floor together?

ANSWER: 6/5 (Accept: 1.2) [CW]

### **TOSS-UP**

3. Earth and Space *Short Answer* If a cove is calm enough, longshore transport can extend a spit into a ridge of sand that seals off the cove completely. What is the name for this feature?

ANSWER: BAYMOUTH BAR [KW]

## BONUS

3. Earth and Space *Multiple Choice* Which of the following kinds of fog is produced by adding moisture to air rather than by cooling air that is already nearly saturated?

- W) Upslope
- X) Advection
- Y) Radiation
- Z) Frontal

ANSWER: Z) FRONTAL [KW]

## TOSS-UP

4. Biology *Short Answer* While eating his corn on the cob, Yunyi notices that some of the kernels have prematurely germinated. This is likely due to a deficiency in what plant hormone?

ANSWER: ABSCISIC ACID [KD]

## BONUS

4. Biology *Multiple Choice* Interferon production would most likely increase following infection by which of the following types of pathogens?

- W) Bacteria
- X) Fungi
- Y) Protists
- Z) Viruses

ANSWER: Z) VIRUSES [KD]

## TOSS-UP

5. Physics *Short Answer* Christy shines a green laser and a red laser into the same piece of glass at the same angle, and notices that the green laser is refracted at a substantially larger angle. What effect is she observing?

ANSWER: DISPERSION [SC]

## BONUS

5. Physics *Short Answer* Yunyi is singing a note at 425 Hz while Jason drives towards him at 60 m/s. What is the frequency of sound that Jason will perceive Yunyi singing, in Hertz? Assume the speed of sound to be 340.

ANSWER: 500 (ACCEPT: 500 HERTZ) [EY]

**TOSS-UP**

6. Chemistry *Multiple Choice* Which of the following hydrocarbons CANNOT contain a double bond?

- W)  $C_5H_{10}$
- X)  $C_{12}H_{26}$
- Y)  $C_6H_{10}$
- Z)  $C_3H_4$

ANSWER: X)  $C_{12}H_{26}$  [YL]

**BONUS**

6. Chemistry *Short Answer* Identify all of the following four processes that must be considered when setting up a Born-Haber Cycle for calculating the lattice enthalpy of calcium chloride:

- 1) Enthalpy of hydration of  $Cl^-$
- 2) First ionization energy of gaseous calcium
- 3) Enthalpy of formation of  $CaCl_2$
- 4) Bond dissociation energy of  $Cl_2$

ANSWER: 2, 3, AND 4 [YL]

**TOSS-UP**

7. Math *Short Answer* Arjun is on a constant-velocity elevator starting on the first floor. What is the ratio of the time it takes him to go to the 25th floor to the time it takes him to go to the 5th floor?

ANSWER: 6 [EZ]

**BONUS**

7. Math *Short Answer* Let triangle ABC be an arbitrary triangle. Identify all of the following 3 centers that must be inside triangle ABC:

- 1) circumcenter
- 2) incenter
- 3) orthocenter

ANSWER: 2 ONLY [CW]

### **TOSS-UP**

8. Earth and Space *Short Answer* Identify all of the following 4 types of precipitation that form when supercooled water droplets freeze upon contact at Earth's surface:

- 1) sleet
- 2) freezing rain
- 3) graupel
- 4) rime

ANSWER: 2 AND 4 [KW]

### **BONUS**

8. Earth and Space *Short Answer* Identify all of the following 3 solar phenomena that can be caused by a magnetic reconnection event:

- 1) Coronal loop
- 2) Solar flare
- 3) Coronal mass ejection

ANSWER: 2 AND 3 [SC]

### **TOSS-UP**

9. Biology *Multiple Choice* Katherine is studying plants with one cotyledon. Which of the following is NOT a feature of these plants?

- W) Parallel leaf venation
- X) Fibrous root systems
- Y) Scattered vascular bundles
- Z) Flower petals in multiples of four and five

ANSWER: Z) FLOWER PETALS IN MULTIPLES OF FOUR AND FIVE [MS]

### **BONUS**

9. Biology *Short Answer* When being digested by humans, fats are broken down into triglycerides through enzymes called lipases. These triglycerides are then reformed into what lipoprotein complexes before being absorbed by lacteals?

ANSWER: CHYLOMICRONS [MS]

### **TOSS-UP**

10. Physics *Multiple Choice* Maxwell's demon is a paradox in which an intelligent entity sorts a gas into fast particles and slow molecules with a closable door, thus creating a hot and cold reservoir from random motion. This appears to violate what law?

- W) Zeroth law of thermodynamics
- X) First law of thermodynamics
- Y) Second law of thermodynamics
- Z) Third law of thermodynamics

ANSWER: Y) SECOND LAW OF THERMODYNAMICS **[SC]**

### **BONUS**

10. Physics *Short Answer* A bird of mass 2 kg is flying horizontally at a speed of 9 meters per second and accelerating forward at a rate of 20 meters per second squared. What is the instantaneous power the bird must exert to maintain this trajectory?

ANSWER: 360 **[SC]**

### **TOSS-UP**

11. Chemistry *Multiple Choice* Doping a silicon semiconductor with which of the following elements will result in a p-type semiconductor?

- W) Arsenic
- X) Gallium
- Y) Phosphorus
- Z) Sulfur

ANSWER: X) GALLIUM **[YL]**

### **BONUS**

11. Chemistry *Short Answer* If the standard reduction potential of  $\text{Ti}^{3+}$  to  $\text{Ti}^+$  is 1.21 V and the standard reduction potential of  $\text{Ti}^+$  to Ti solid is -0.35 V, what is the standard reduction potential from  $\text{Ti}^{3+}$  to Ti, in volts?

ANSWER: 0.69 **[YL]**

### **TOSS-UP**

12. Math *Short Answer* There are 195 countries in the world with 23 in North America and 12 in South America. Kian picks a country at random; given that it is in the Americas, what is the probability that it is in North America?

ANSWER: 23/35 [EZ]

**BONUS**

12. Math *Short Answer* What is the sum of the areas of the two unique rectangles that have the properties such that their sides have integer lengths, and their areas are equal to their perimeters?

ANSWER: 34 [EZ]

**TOSS-UP**

13. Earth and Space *Short Answer* A large diapir is found in a region of continental crust. As this diapir cools over a long time, what feature will it eventually become?

ANSWER: PLUTON (ACCEPT: BATHOLITH) [SC]

**BONUS**

13. Earth and Space *Short Answer* Order the following four stages in the life of a 1.2 solar mass star from earliest to latest: 1) Red clump 2) Asymptotic giant branch 3) Hayashi track 4) Red giant branch

ANSWER: 3412 [SC]

**TOSS-UP**

14. Biology *Short Answer* Identify all of the following 3 groups of plants that possess microphylls (*MY-cro-fills*):

- 1) Lycophyta
- 2) Bryophyta
- 3) Magnoliophyta

ANSWER: 1 ONLY [KD]

**BONUS**

14. Biology *Multiple Choice* Which of the following animals is most likely to have the largest Loop of Henle length to body length ratio?

- W) Walrus
- X) Camel
- Y) Human
- Z) Howler Monkey

ANSWER: X) CAMEL [MS]

**TOSS-UP**

15. Physics *Short Answer* Given that Saturn is 9 astronomical units away from the Sun, what is the orbital period of Saturn in Earth years, to two significant figures?

ANSWER: 27 [YL]

**BONUS**

15. Physics *Multiple Choice* Which of the following is not an advantage qubits have over regular bits?

- W) They can be entangled with each other
- X) They can have a spectrum of superposed states
- Y) Fewer of them are required for the same computations
- Z) They can be created in many different ways

ANSWER: Z) THEY CAN BE CREATED IN MANY DIFFERENT WAYS [SC]

**TOSS-UP**

16. Chemistry *Short Answer* Arrange the following three elements in order of increasing melting point:

- 1) Carbon
- 2) Bromine
- 3) Gallium

ANSWER: 2, 3, 1 [YL]

**BONUS**

16. Chemistry *Short Answer* How many sigma and pi bonds, respectively, can be found in one molecule of cyclopentadiene [**sy-clo-pen-ta-DIE-ene**]?

ANSWER: 11 SIGMA, 2 PI [YL]

**TOSS-UP**

17. Math *Short Answer* What is the volume of the figure formed by revolving a right triangle with legs of length 5 and 12 about its longer leg?

ANSWER:  $100\pi$  [EZ]

### BONUS

17. Math *Short Answer* Will starts with 5 burger buns and 3 patties. He then buys more buns, which are sold in packs of 7, and patties, which are sold in packs of 10. If Will ends with an equal number of buns and patties, what is the smallest total number of packs he could have bought?

ANSWER: 7 [EZ]

### TOSS-UP

18. Earth and Space *Multiple Choice* Based on Bowen's reaction series, which of the following would you expect to be the main component of sand on a beach that has undergone extensive chemical weathering?

- W) Olivine
- X) Biotite
- Y) Orthoclase feldspar
- Z) Quartz

ANSWER: Z) QUARTZ [KW]

### BONUS

18. Earth and Space *Multiple Choice* Which of the following best describes the ratio of temperatures in the Sun's photosphere, corona, and core, respectively?

- W) 1:10:100
- X) 1:10:1000
- Y) 1:100:1000
- Z) 1:1000:1000

ANSWER: Y) 1:100:1000 [SC]

### TOSS-UP

19. Biology *Short Answer* Identify all of the following 3 proteins that are composed of multiple subunits:

- 1) Insulin
- 2) Myoglobin
- 3) Hemoglobin

ANSWER: 1 AND 3 [KD]

**BONUS**

19. Biology *Multiple Choice* Which of the following sequences is most likely to be cleaved by a restriction endonuclease?

- W) CGCA
- X) ATTT
- Y) CATG
- Z) GCTA

ANSWER: Y) CATG [KD]

**TOSS-UP**

20) Physics *Multiple Choice* Which of the following colors of light has the highest index of refraction in water?

- W) Red
- X) Orange
- Y) Blue
- Z) Violet

ANSWER: Z) VIOLET [YL]

**BONUS**

20. Physics *Short Answer* Arrange the following three particles in order of increasing half life:

- 1) Kaon
- 2) Neutron
- 3) Tau

ANSWER: 3, 1, 2 [SC]

**TOSS-UP**

21. Chemistry *Short Answer* In contrast to addition polymers, what class of polymers, including Nylon and Kevlar, are formed by the joining of monomers with expulsion of a small molecule, commonly water or a hydrogen halide?

ANSWER: CONDENSATION POLYMERS [YL]

### BONUS

21. Chemistry *Short Answer* What principle states that the transition state of a reaction more closely resembles the species, either the product or the reactant, that is closer to it in energy?

ANSWER: HAMMOND POSTULATE [YL]

### TOSS-UP

22. Math *Multiple Choice* Which of the following is the closest to  $\log_3(870) - \log_3(29)$ ?

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

ANSWER: W) 3 [EZ]

### BONUS

22. Math *Short Answer* What is the sum of the cubes of the roots of the polynomial  $x^2 - 4x - 7$ ?

ANSWER: 148 [EZ]

### TOSS-UP

23. Earth and Space *Multiple Choice* Which of the following does NOT contribute to the libration of the Moon?

- W) Inclination of the Moon's orbit
- X) Eccentricity of the Moon's orbit
- Y) Obliquity of the Moon's rotation
- Z) Precession of the Moon's orbit

ANSWER: Z) PRECESSION OF THE MOON'S ORBIT [SC]

### BONUS

23. Earth and Space *Short Answer* Order the following three subtypes of spiral galaxies from least to most spiral arms:

- 1) Grand design
- 2) Flocculent
- 3) Magellanic

ANSWER: 3,1, 2 [SC]

#### TOSS-UP

24. Biology *Multiple Choice* Which of the following neurotransmitters is NOT a monoamine?

- W) Serotonin
- X) Acetylcholine (**a-SEE-tuhl-cole-een**)
- Y) Epinephrine
- Z) Dopamine

ANSWER: X) ACETYLCHOLINE [KW]

#### BONUS

24. Biology *Short Answer* Identify all of the following 3 structures that arise from the metencephalon in humans:

- 1) Cerebral Cortex
- 2) Pons
- 3) Thalamus

ANSWER: 2 ONLY [MS]

#### TOSS-UP

25. Physics *Short Answer* What theorem states that the average potential energy of a system of gravitationally-bound objects is the negative of twice the average kinetic energy of the system?

ANSWER: VIRIAL THEOREM [YL]

#### BONUS

25. Physics *Short Answer* Jason the astronaut can barely resolve two point sources of red light, each with wavelength 700 nanometers. If Jason's pupil diameter is 0.28 millimeters, to one significant figure, what is the angular separation between the two light sources, in radians?

ANSWER: 0.004 [JY]