

### TOSS-UP

1) Chemistry – *Short Answer* What bi-elemental compound has the most ionic character?

ANSWER: CsF (ACCEPT: CESIUM FLUORIDE)

### BONUS

1) Chemistry – *Short Answer* Identify all of the following three elements that can commonly be found in coal: 1) Carbon; 2) Oxygen; 3) Sulfur.

ANSWER: ALL

### **TOSS-UP**

2) Earth and Space – *Short Answer* The Trojan asteroids orbit around the Sun with approximately the same orbital period as what planet?

ANSWER: JUPITER

### **BONUS**

2) Earth and Space – *Short Answer* Identify all of the following three characteristics that are true of all achondrites: 1) They are primarily composed of iron; 2) They are differentiated; 3) They have undergone melting.

ANSWER: 2, 3

### **TOSS-UP**

3) Energy – *Short Answer* Scientists at Brookhaven National Lab are researching how atmospheric reactions can generate solid particulates, which form a homogeneous mixture with the surrounding air. What is the term for this class of colloids?

ANSWER: AEROSOL (ACCEPT: SOLID AEROSOL)

### **BONUS**

3) Energy – *Short Answer* Scientists at Lawrence Berkeley National Lab are studying metals that do not have a defined crystalline structure. What is the adjective for this type of metal?

ANSWER: AMORPHOUS (ACCEPT: GLASSY)

### TOSS-UP

4) Math – *Multiple Choice* Given a figure and its image under a dilation, which of the following can most directly be used to locate the center of the dilation?

- W) Two parallel lines
- X) Two intersecting lines
- Y) One circle and one line
- Z) Two circles

ANSWER: X) TWO INTERSECTING LINES

### BONUS

4) Math – *Short Answer* An infinite geometric sequence has first term  $\frac{5}{8}$  and sum  $\frac{6}{7}$ . In fractional form, what is the common ratio between consecutive terms?

ANSWER:  $\frac{13}{48}$

### TOSS-UP

5) Physics – *Multiple Choice* Which of the following characteristics of water best explains why the flow from a faucet gets narrower as it falls?

W) High density

X) Incompressibility

Y) Cohesion

Z) Surface tension

ANSWER: X) INCOMPRESSIBILITY

### BONUS

5) Physics – *Short Answer* A 500-kilogram boxcar is traveling with an initial speed  $v$  when it collides with a 1500-kilogram cart that is at rest. If the boxcar and the cart stick together after the collision, then, in terms of  $v$ , what is the final speed of the system?

ANSWER:  $v/4$  (ACCEPT:  $(1/4)v$ ,  $0.25v$ )

### TOSS-UP

6) Biology – *Short Answer* In 1979, the World Health Organization declared which infectious disease eradicated?

ANSWER: SMALLPOX (ACCEPT: VARIOLA)

### BONUS

6) Biology – *Multiple Choice* Which of the following is the primary reason for a cell to undergo arrest at the G2-M checkpoint of the cell cycle?

W) Lack of nutrients

X) Incompletely-replicated DNA

Y) Nuclear membrane still intact

Z) Chromosomes not attached to spindle fibers

ANSWER: X) INCOMPLETELY-REPLICATED DNA

### TOSS-UP

7) Chemistry – *Multiple Choice* The organic molecule found in vinegar is an example of what class of organic molecule?

- W) Amine
- X) Hydrocarbon
- Y) Carboxylic acid
- Z) Alcohol

ANSWER: Y) CARBOXYLIC ACID

### BONUS

7) Chemistry – *Multiple Choice* What functional group can be found in acetyl-salicylic acid that is not found in salicylic acid?

- W) Carboxyl
- X) Aryl
- Y) Carbonyl
- Z) Ester

ANSWER: Z) ESTER

### TOSS-UP

8) Earth and Space – *Multiple Choice* At any given moment, which of the following water resources holds the largest fraction of North America's freshwater?

W) Rivers and streams

X) Lakes

Y) Clouds and precipitation

Z) Groundwater

ANSWER: Z) GROUNDWATER

### BONUS

8) Earth and Space – *Short Answer* An observer standing on the island of Bermuda measures easterly winds during a hurricane.

Assuming geostrophic flow, in what cardinal compass direction, relative to the observer, is the hurricane's eye located?

ANSWER: SOUTH



### TOSS-UP

9) Energy – *Multiple Choice* Scientists at Brookhaven National Laboratory are planning to use the High Luminosity Large Hadron Collider to study the Higgs boson. In this context, which of the following best describes the meaning of luminosity?

W) Particle beam energy

X) Rate of photon production

Y) Rate of particle collisions

Z) Radioactivity exposure risk

ANSWER: Y) RATE OF PARTICLE COLLISIONS

### BONUS

9) Energy – *Short Answer* Scientists at Brookhaven National Lab are developing new anodes for lithium-ion batteries. The traditional anodes are made of carbon in what VSEPR hybridization state?

ANSWER:  $sp^2$

### TOSS-UP

10) Math – *Short Answer* There are 25 prime numbers less than 100. How many composite numbers are there among the first 100 positive integers?

ANSWER: 74

### BONUS

10) Math – *Short Answer* According to the rational root theorem, how many different numbers are possible rational roots of the equation  $4x^5 - 5x^4 + 3x^2 + 10 = 0$ ?

ANSWER: 16

### **TOSS-UP**

11) Physics – *Short Answer* Jan travels at 40 kilometers per hour for 45 minutes. In kilometers, what distance does she cover in this time?

ANSWER: 30

### **BONUS**

11) Physics – *Short Answer* Elizabeth is trying to tune her violin. If she doubles the tension of a string, then, to two significant figures, by what factor will the pitch of the fundamental frequency of that string be multiplied?

ANSWER: 1.4

### TOSS-UP

12) Biology – *Multiple Choice* Strawberry plants can often be found with runners or stolons. Which of the following is the primary purpose of these structures?

W) Defense against pathogens

X) Nutrient absorption

Y) Sexual reproduction

Z) Asexual reproduction

ANSWER: Z) ASEXUAL REPRODUCTION

### BONUS

12) Biology – *Short Answer* Identify all of the following three population-limiting factors that are density-independent: 1) Climate; 2) Predation; 3) Local proclivity to wildfire.

ANSWER: 1, 3

### TOSS-UP

13) Chemistry – *Short Answer* What is the chemical formula of the conjugate base of carbonic acid?

ANSWER:  $\text{HCO}_3^-$

### BONUS

13) Chemistry – *Short Answer* What is the oxidation state of chromium in  $\text{K}_2\text{Cr}_2\text{O}_7$ ?

ANSWER: +6 (ACCEPT: 6, 6+)

### TOSS-UP

14) Earth and Space – *Multiple Choice* In millions of years, how long ago are the lunar maria thought to have solidified?

W) 3

X) 30

Y) 300

Z) 3000

ANSWER: Z) 3000

### BONUS

14) Earth and Space – *Short Answer* Giving your answer to the nearest whole degree, what is the angular diameter of the circle traced out by Earth's axial precession?

ANSWER: 47

### TOSS-UP

15) Energy – *Short Answer* Scientists at Lawrence Berkeley National Lab are studying amoebas. Of what domain are amoebas a part?

ANSWER: EUKARYOTA (ACCEPT: EUKARYOTES, EUKARYA)

### BONUS

15) Energy – *Short Answer* Scientists at Pacific Northwest National Lab are studying fluorescent crystals that, when they are in close proximity to a donor chromophore, can transfer energy through dipole-dipole coupling. What is the term for this phenomenon?

ANSWER: FRET (ACCEPT: FORSTER RESONANCE ENERGY TRANSFER, FLUORESCENCE RESONANCE ENERGY TRANSFER)

### TOSS-UP

16) Math – *Short Answer* What is the smallest possible integer edge length, in inches, for a cube so that its surface area is at least one square foot?

ANSWER: 5

### BONUS

16) Math – *Short Answer* What is the minimum number of sides in a regular polygon if its interior angles measure at least 178.3 degrees?

ANSWER: 212



### TOSS-UP

17) Physics – *Multiple Choice* X-ray diffraction is a technique typically used to study the structure of what phase of matter?

W) Plasma

X) Solid

Y) Liquid

Z) Gas

ANSWER: X) SOLID

### BONUS

17) Physics – *Short Answer* A three-meter pipe is closed at one end and open at the other. In meters, what is the wavelength of the lowest-frequency standing wave that could form in this pipe?

ANSWER: 12

### **TOSS-UP**

18) Biology – *Short Answer* What is the term for animals that are most active during the daytime?

ANSWER: DIURNAL

### **BONUS**

18) Biology – *Multiple Choice* Which of the following best describes the purpose of down feathers?

W) Trapping a layer of air to act as insulation

X) Secreting oil

Y) Waterproofing the outer layer of the bird

Z) Providing contouring to make the bird more aerodynamic

ANSWER: W) TRAPPING A LAYER OF AIR TO ACT AS INSULATION