

## TOSS-UP

1) Biology – *Multiple Choice* Which of the following statements about bacterial cell walls is NOT correct?

- W) Gram-positive bacteria have a thick peptidoglycan cell wall
- X) Beta-lactam antibiotics inhibit cell wall synthesis
- Y) Lignin is the primary component of Gram-negative bacterial cell walls
- Z) The outer membrane of Gram-negative bacteria contains lipo-poly-saccharides

ANSWER: Y) LIGNIN IS THE PRIMARY COMPONENT OF GRAM-NEGATIVE BACTERIAL CELL WALLS

## BONUS

1) Biology – *Multiple Choice* Which of the following groups of viruses needs to be in the nucleus of a eukaryotic host to replicate, as opposed to the cytoplasm?

- W) Coronavirus
- X) Orthomyxovirus
- Y) Pico-RNA-virus
- Z) Herpesvirus

ANSWER: Z) HERPESVIRUS

## TOSS-UP

2) Chemistry – *Short Answer* The de Broglie wavelength of a particle is linearly related to its momentum raised to what power?

ANSWER: NEGATIVE ONE

## BONUS

2) Chemistry – *Short Answer* Identify all of the following three statements that are true of the kinetic theory of gases: 1) The gas molecules are constantly moving in random directions with the same speed; 2) The distances between gas molecules are much greater than the size of the molecules; 3) The collisions of molecules with the walls of the container are elastic.

ANSWER: 2, 3

### **TOSS-UP**

3) Earth and Space – *Short Answer* Decompression melting will occur when the solidus of an ascending mass of rock crosses what thermodynamic boundary?

ANSWER: GEOTHERM

### **BONUS**

3) Earth and Space – *Short Answer* The significant drop in ozone over Antarctica, sometimes referred to as an ozone hole, is most pronounced in what Southern hemisphere season?

ANSWER: SPRING

## TOSS-UP

4) Energy – *Short Answer* Scientists at Argonne National Lab are studying a crystal structure named for an orthorhombic calcium titanate mineral. What is the name of this mineral?

ANSWER: PEROVSKITE

## BONUS

4) Energy – *Multiple Choice* Scientists at Argonne National Lab are developing perovskite solar cells. Which of the following is a reason that perovskites are an attractive alternative to silicon for photovoltaic applications?

W) They can achieve higher efficiencies

X) It is easier to make large-area solar cells with perovskites

Y) They use organic dyes, which are generally more stable than silicon

Z) They can be much thicker than silicon-based cells

ANSWER: W) THEY CAN ACHIEVE HIGHER EFFICIENCIES

### TOSS-UP

5) Math – *Short Answer* If  $k$  is a positive integer such that the greatest common divisor of 240 and  $k$  is 15, then, in terms of  $k$ , what is the least common multiple of 240 and  $k$ ?

ANSWER:  $16k$

### BONUS

5) Math – *Short Answer* A Fibonacci-type sequence has fourth term 17 and seventh term 71. What is its ninth term?

ANSWER: 186

### TOSS-UP

- 6) Physics – *Multiple Choice* Which of the following statements regarding the Lorentz force is not true?
- W) It is perpendicular to the magnetic field
  - X) It is proportional to the speed of the charged particle
  - Y) It does no work
  - Z) For an inhomogeneous magnetic field, it can change the speed of the charged particle

ANSWER: Z) FOR AN INHOMOGENEOUS MAGNETIC FIELD, IT CAN CHANGE THE SPEED OF THE CHARGED PARTICLE

### BONUS

- 6) Physics – *Short Answer* A beam of vertically-polarized light passes through a polarization filter oriented at 45 degrees, and then through a horizontal polarization filter. What is the ratio of the intensity of the original beam to that of the beam exiting the horizontal filter?

ANSWER: 4 (ACCEPT: 4 TO 1)

## TOSS-UP

7) Biology – *Multiple Choice* Caspases are apoptosis-promoting enzymes that perform what function?

- W) Catalyze dephosphorylation
- X) Catalyze peptide bond cleavage
- Y) Act as transcription factors
- Z) Act as protein kinases

ANSWER: X) CATALYZE PEPTIDE BOND CLEAVAGE

## BONUS

7) Biology – *Short Answer* Identify all of the following three statements that are true of root pressure in plants: 1) It is primarily responsible for xylem sap movement; 2) It is usually positive; 3) It is highest during the growing season.

ANSWER: 2, 3

## TOSS-UP

8) Chemistry – *Multiple Choice* Chalcogens form salts with a 1:1 stoichiometry with what group of elements?

W) Halogens

X) Alkaline earth metals

Y) Alkali metals

Z) Noble gases

ANSWER: X) ALKALINE EARTH METALS

## BONUS

8) Chemistry – *Short Answer* Identify all of the following three oxoacids that are considered strong acids: 1)  $\text{IO}(\text{OH})_5$ ; 2)  $\text{IOH}$ ; 3)  $\text{NOOH}$ .

ANSWER: NONE

## TOSS-UP

9) Earth and Space – *Multiple Choice* Which of the following is most comparable in mass to the Oort Cloud?

W) The Sun

X) Jupiter

Y) All of the inner planets

Z) Mercury

ANSWER: Y) ALL OF THE INNER PLANETS

## BONUS

9) Earth and Space – *Short Answer* Two large spiral galaxies of near-equal mass merge. Identify all of the following three consequences that will likely occur: 1) A significant number of star collision events; 2) Star formation will significantly increase; 3) The resulting galaxy will be elliptical.

ANSWER: 2, 3

## TOSS-UP

10) Energy – *Short Answer* Scientists supported by the Department of Energy are studying biopolymer liquid crystals that are in a phase in which well-defined layers can slide over one another. What is the term for this liquid crystal phase?

ANSWER: SMECTIC

## BONUS

10) Energy – *Short Answer* Scientists supported by the Department of Energy are studying green algae. Identify all of the following three statements that are true of these organisms: 1) They possess mitochondria; 2) They possess both chlorophyll *a* and *b*; 3) They have no flagella.

ANSWER: 1, 2

### TOSS-UP

11) Math – *Short Answer* What is the derivative with respect to  $x$  of the product of the two binomials  $x + 3$  and  $x - 7$ ?

ANSWER:  $2x - 4$

### BONUS

11) Math – *Short Answer* To the nearest integer, what is the area of a circle that is circumscribed about a right triangle with legs of lengths 1 and 5?

ANSWER: 20

### TOSS-UP

12) Physics – *Short Answer* A uniform disk and a uniform ring each have the same radius and the same mass. What is the ratio of the moment of inertia of the disk to that of the ring?

ANSWER:  $\frac{1}{2}$  (ACCEPT: 0.5, 1 TO 2)

### BONUS

12) Physics – *Short Answer* Given that the rest mass of an electron is 0.5 mega-electron-volts, what is the minimal energy in mega-electron-volts of a photon that can be converted into an electron-positron pair after colliding with another electron?

ANSWER: 1

## TOSS-UP

13) Biology – *Short Answer* Parathyroid hormone is responsible primarily for the regulation of serum levels of what ion?

ANSWER: CALCIUM TWO PLUS (ACCEPT:  $Ca^{2+}$ )

## BONUS

13) Biology – *Short Answer* Identify all of the following three macromolecules in which sulfhydryl groups can be found: 1) Starches; 2) Proteins; 3) Nucleic acids.

ANSWER: 2

### TOSS-UP

14) Chemistry – *Multiple Choice* Which of the following best describes the Bayer process?

- W) Electrolysis of bauxite to produce aluminum
- X) Production of sulfuric acid from hydrogen sulfide
- Y) Purification of alumina from bauxite
- Z) Smelting of copper from copper oxide

ANSWER: Y) PURIFICATION OF ALUMINA FROM BAUXITE

### BONUS

14) Chemistry – *Short Answer* Given that the enthalpy change of water freezing at 0 degrees Celsius and standard pressure is  $-6007$  joules per mole, then, to two significant figures and in joules per mole kelvin, what is the entropy change of this process?

ANSWER:  $-22$

## TOSS-UP

15) Earth and Space – *Multiple Choice* The radiation emitted by T Tauri stars primarily comes from which of the following?

W) Proton-proton chain

X) CNO cycle

Y) Nuclear fission

Z) Kelvin-Helmholtz mechanism

ANSWER: Z) KELVIN-HELMHOLTZ MECHANISM

## BONUS

15) Earth and Space – *Short Answer* Earth's axial precession, axial tilt, and orbital eccentricity all independently influence the amount of incident solar radiation on Earth. These three cycles vary with periods of approximately 25 thousand years, 45 thousand years, and 100 thousand years, respectively. Given these periods, what is the period, in years, of the combined influence of these three cycles on Earth's climate?

ANSWER: 900,000

## TOSS-UP

16) Energy – *Short Answer* Scientists supported by the Department of Energy are studying lightning. Lightning strikes are an example of what phenomenon in which an insulator fails to impede the flow of current?

ANSWER: DIELECTRIC BREAKDOWN (ACCEPT: ELECTRIC BREAKDOWN)

## BONUS

16) Energy – *Short Answer* Scientists at Brookhaven National Lab are studying chalcogens. Identify all of the following three elements that are chalcogens: 1) Tellurium; 2) Selenium; 3) Arsenic.

ANSWER: 1, 2

### TOSS-UP

17) Math – *Short Answer* A plane has a groundspeed of 575 miles per hour. To the nearest second, how long does it take for the plane to travel one mile?

ANSWER: 6

### BONUS

17) Math – *Short Answer* What is the sum of the squares of the first 16 positive integers?

ANSWER: 1496

### TOSS-UP

18) Physics – *Short Answer* A Carnot engine is operating between a hot reservoir at 450 kelvins and a cold reservoir at 200 kelvins. If the engine absorbs 90 joules of heat in the first half of its cycle, then, in joules, how much work does it do in the second half of its cycle?

ANSWER: 50

### BONUS

18) Physics – *Multiple Choice* Which of the following is closest to the escape speed, in meters per second, from the surface of a planet of mass 3 times  $10^{22}$  kilograms and radius 8000 kilometers?

W) 100

X) 300

Y) 500

Z) 700

ANSWER: Z) 700