

BSB ROUND 4

TOSS-UP

1) Chemistry – *Short Answer* Rank the following four elements in terms of increasing electronegativity: 1) Silicon; 2) Nitrogen; 3) Phosphorus; 4) Sulfur.

ANSWER: 1, 3, 4, 2

BONUS

1) Chemistry – *Multiple Choice* Which of the following single atoms is NOT paramagnetic?

- W) Fluorine
- X) Sodium
- Y) Magnesium
- Z) Aluminum

ANSWER: Y) MAGNESIUM

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### **TOSS-UP**

2) Biology – *Short Answer* In a female gametophyte, what structure consists of stigma, style, and ovary?

ANSWER: CARPEL

### **BONUS**

2) Biology – *Multiple Choice* Which of the following is not a necessary component for the CRISPR-Cas9 [**CRISP-er-KAS-nine**] system to function effectively for gene editing?

- W) sgRNA
- X) PAM sequence
- Y) Double-stranded DNA break repair machinery
- Z) Nuclear localization sequence on Cas9 protein

ANSWER: W) sgRNA

## **TOSS-UP**

3) Earth and Space – *Short Answer* Named after a Dutch astronomer, what disc-shaped structure is thought to contain over 1 billion objects and is located outside the orbit of Neptune?

ANSWER: KUIPER BELT

## **BONUS**

3) Earth and Space – *Multiple Choice* Which of the following is a deposit of ice crystals formed when cloud droplets freeze?

- W) Rime
- X) Hail
- Y) Sleet
- Z) Glaze

ANSWER: W) RIME

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TOSS-UP

4) Math – *Short Answer* What is the resultant matrix dimension when you multiply three matrices from left to right with dimensions 2 by 3, 3 by 4, and 4 by 1, respectively?

ANSWER: 2 BY 1

BONUS

4) Math – *Multiple Choice* What is the derivative with respect to x of the function $f(x) = x^2$ times the natural log of \underline{x}^5 ?

- W) $2x$ times the natural log of $\underline{x}^5 + x/5$
- X) $2x$ times the natural log of $\underline{x}^5 + 5x$
- Y) $2x$ times the natural log of $\underline{x}^5 - x/5$
- Z) $2x$ times the natural log of $\underline{x}^5 - 5x$

ANSWER: X) $2x$ TIMES THE NATURAL LOG OF $\underline{x}^5 + 5x$

TOSS-UP

5) Energy – *Multiple Choice* Scientists in the Cohen Lab at UC Berkeley study the effect of volatile organic compounds in the atmosphere. Which of the following is most likely to be relevant to their studies?

- W) Ozone
- X) Polyethylene
- Y) Methane
- Z) Glycogen

ANSWER: Y) METHANE

BONUS

5) Energy – *Short Answer* Scientists in the Arnold Group at UC Berkeley have been synthesizing heavy metal complexes with bridging hydride ligands in order to investigate their bonding. What technique might they use to accurately determine the structure of these complexes?

ANSWER: NEUTRON DIFFRACTION (DO NOT ACCEPT: X-RAY DIFFRACTION)

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## **TOSS-UP**

6) Physics – *Multiple Choice* During an adiabatic process, the internal energy of the gas increases by 1,600 joules. Which of the following statements accurately describes this process?

- W) 1,600 joules of work are done by the gas and the temperature decreases
- X) 1,600 joules of work are done by the gas and the temperature increases
- Y) 1,600 joules of work are done on the gas and the temperature decreases
- Z) 1,600 joules of work are done on the gas and the temperature increases

ANSWER: Z) 1,600 JOULES OF WORK ARE DONE ON THE GAS AND THE TEMPERATURE INCREASES

## **BONUS**

6) Physics – *Short Answer* A circuit consists of two resistors of 2 and 3 ohms in parallel, which are then connected in series to a 1-ohm resistor. If an 11-volt battery is connected to the circuit in series, what is the current in amperes?

ANSWER: 5

## **TOSS-UP**

7) Earth and Space – *Short Answer* The formation of clouds generally requires what tiny bits of particulate matter that help act as surfaces for water to coalesce?

ANSWER: CONDENSATION NUCLEI

## **BONUS**

7) Earth and Space – *Multiple Choice* Radiometric dating is a useful tool for finding the absolute ages of geologic substances. Which of the following radioactive elements is not paired correctly with its stable daughter product?

- W) Uranium and lead
- X) Thorium and lead
- Y) Rubidium and strontium
- Z) Potassium and calcium

ANSWER: Z) POTASSIUM AND CALCIUM

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TOSS-UP

8) Biology – *Multiple Choice* Which of the following acids is glucose broken down into in the first stage of carbohydrate metabolism?

- W) Lactic acid
- X) Citric acid
- Y) Pyruvic acid
- Z) Succinic acid

ANSWER: Y) PYRUVIC ACID

BONUS

8) Biology – *Short Answer* What type of selection occurs when conditions favor individuals at both extremes of a phenotypic range over individuals with intermediate phenotypes?

ANSWER: DISRUPTIVE SELECTION

TOSS-UP

9) Energy – *Short Answer* Researchers in the Herr Lab at UC Berkeley are innovating new technologies to detect dozens of proteins simultaneously without the need to strip and reprobe. This technology would replace what common laboratory technique?

ANSWER: WESTERN BLOT

BONUS

9) Energy – *Short Answer* Scientists at the Sarpong lab at UC Berkeley use various techniques to synthesize natural products. One such technique creates a high-energy three-membered ring with 2 carbons and one oxygen, which is known as what organic functional group?

ANSWER: EPOXIDE

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### **TOSS-UP**

10) Math – *Multiple Choice* Which of the following trigonometric function in degrees is equal to the square root of 3 over 2?

- W) Sine of 30 degrees
- X) Cosine of 60 degrees
- Y) Sine of 120 degrees
- Z) Cosine of 150 degrees

ANSWER: Y) SINE OF 120 DEGREES

### **BONUS**

10) Math – *Short Answer* Find the values for  $a$  and  $b$  for which the following two vectors are parallel:  $ai + 7j + 18k$  and  $8i + 28j + bk$ .

ANSWER:  $a = 2$  AND  $b = 72$

## **TOSS-UP**

11) Chemistry – *Multiple Choice* During an acid-base titration between NaOH and HCl, at what point is the conductivity of the solution at a minimum?

- W) The equivalence point
- X) The half-equivalence point
- Y) At the beginning of the titration
- Z) There is no minimum

ANSWER: W) THE EQUIVALENCE POINT

## **BONUS**

11) Chemistry – *Short Answer* Rank the following three bases in terms of increasing base dissociation constant in water: 1) Ammonia; 2) Potassium hydroxide; 3) Sodium acetate.

ANSWER: 3, 1, 2

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TOSS-UP

12) Physics – *Multiple Choice* An electron is traveling at a constant speed in the $+x$ direction when a uniform magnetic field is applied in the $+y$ direction. In which of the following directions must an electric field be applied so that there is zero net force on the electron?

- W) Positive y
- X) Negative y
- Y) Positive z
- Z) Negative z

ANSWER: Z) NEGATIVE z

BONUS

12) Physics – *Short Answer* A 1-kilogram uniform sphere with radius 0.5 meters is accelerated from rest at time $t = 0$. Given an angular acceleration of 10 radians per second squared, what is its rotational kinetic energy in joules after 2 seconds?

ANSWER: 20

TOSS-UP

13) Biology – *Multiple Choice* Which of the following phyla do octopuses belong to?

- W) Cnidaria [*nye-DAIRY-uh*]
- X) Nematoda
- Y) Annelida
- Z) Mollusca

ANSWER: Z) MOLLUSCA

BONUS

13) Biology – *Short Answer* What coastal biome is characterized by dense, spiny, evergreen shrubs and hot dry summers?

ANSWER: CHAPARRAL

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## **TOSS-UP**

14) Math – *Short Answer* Simplify the expression  $i^{71}$ .

ANSWER:  $-i$

## **BONUS**

14) Math – *Short Answer* Evaluate the integral from 0 to positive infinity of e to the power of  $-x dx$ .

ANSWER: 1

### **TOSS-UP**

15) Earth and Space – *Multiple Choice* Which of the following fault types is classified by the hanging wall moving up relative to the footwall?

- W) Normal fault
- X) Thrust fault
- Y) Reverse fault
- Z) Strike-slip fault

ANSWER: Y) REVERSE FAULT

### **BONUS**

15) Earth and Space – *Short Answer* What is the name of the process in which a section of the Earth’s crust is folded and deformed by lateral compression to form mountains?

ANSWER: OROGENY



### **TOSS-UP**

16) Physics – *Short Answer* In meters per second, what is the magnitude of the velocity of the point on the wheel in contact with the ground if the wheel is rolling at 10 meters per second without slipping?

ANSWER: ZERO

### **BONUS**

16) Physics – *Multiple Choice* A wire has a current of 2 amperes running through it from the bottom to the top of the wire. When viewed from above, what is the direction of the magnetic field around the wire?

- W) Clockwise and parallel to the wire
- X) Counterclockwise and parallel to the wire
- Y) Clockwise and perpendicular to the wire
- Z) Counterclockwise and perpendicular to the wire

ANSWER: Z) COUNTERCLOCKWISE AND PERPENDICULAR TO THE WIRE

## **TOSS-UP**

17) Energy – *Short Answer* Scientists in the Rittle Group at UC Berkeley have been studying how metalloenzymes and their reactive sites are activated using X-ray diffraction methods. What law relates the angle of diffraction to the spacing between lattice planes?

ANSWER: BRAGG'S LAW

## **BONUS**

17) Energy – *Short Answer* Scientists at UC Berkeley's Combustion Analysis Laboratory have been working on reducing the carbon footprint of traditional internal combustion engines. Instead of using traditional PV diagrams, they plotted entropy against what variable in order to visualize thermodynamic processes?

ANSWER: TEMPERATURE

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TOSS-UP

18) Chemistry – *Short Answer* Identify all of the following three ions that are isoelectronic with argon in its ground state: 1) K⁺; 2) Br⁻; 3) Na⁺.

ANSWER: 1 ONLY

BONUS

18) Chemistry – *Multiple Choice* What is the electron geometry of chlorine trifluoride?

- W) Linear
- X) Trigonal planar
- Y) Tetrahedral
- Z) Trigonal bipyramidal

ANSWER: Z) TRIGONAL BIPYRAMIDAL

TOSS-UP

19) Math – *Short Answer* If f of $x = 6x^2 - 3x + 17$, what is f of 4?

ANSWER: 101

BONUS

19) Math – *Short Answer* To the nearest tenth, what is the square root of 56?

ANSWER: 7.5

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**TOSS-UP**

20) Biology – *Multiple Choice* If an animal cell is placed in a solution that is hypotonic to the cell, what will happen to the animal cell?

- W) The cell will shrivel
- X) The cell will burst
- Y) The cell will become flaccid
- Z) The cell will be plasmolyzed

ANSWER: X) THE CELL WILL BURST

**BONUS**

20) Biology – *Multiple Choice* Which of the following amino acids is electrically charged at pH 7?

- W) Glycine
- X) Valine
- Y) Arginine
- Z) Serine

ANSWER: Y) ARGININE

## **TOSS-UP**

21) Earth and Space – *Multiple Choice* Which of the following igneous rocks is mafic?

- W) Gabbro
- X) Andesite
- Y) Diorite
- Z) Granite

ANSWER: W) GABBRO

## **BONUS**

21) Earth and Space – *Multiple Choice* When a fast-moving cold front overtakes a slow-moving warm front and lifts the warm air entirely above the cold air, which of the following atmospheric phenomena is created?

- W) Occluded front
- X) Stationary front
- Y) Warm front
- Z) Polar front

ANSWER: W) OCCLUDED FRONT

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TOSS-UP

22) Chemistry – *Multiple Choice* Which of the following is true regarding electrolytic cells?

- W) Oxidation occurs at the cathode
- X) Cell potential is positive
- Y) Free energy change is negative
- Z) Equilibrium constant is less than one

ANSWER: Z) EQUILIBRIUM CONSTANT IS LESS THAN ONE

BONUS

22) Chemistry – *Short Answer* The rate of effusion of hydrogen gas is 4 times the rate of an unknown gas at the same temperature and pressure. To the nearest integer, what is the molar mass in grams per mole of the unknown gas?

ANSWER: 32

TOSS-UP

23) Physics – *Short Answer* A conducting sphere with a mass of 2 kilograms and a charge of 1 coulomb is initially at rest. What is its speed in meters per second after being accelerated through a 16-volt potential difference?

ANSWER: 4

BONUS

23) Physics – *Short Answer* A nearsighted person has a far point that is 4.2 meters from her eyes. In meters, what focal length must she use in her contact lenses to allow her to focus on distant objects?

ANSWER: -4.2