

## **ROUND 1**

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### **TOSS-UP**

- 1) Earth and Space – *Short Answer* What type of supernova occurs when there is runaway fusion in a secondary white dwarf after enough mass transfer from a giant star?

ANSWER: TYPE IA SUPERNOVA

### **BONUS**

- 1) Earth and Space – *Multiple Choice* Which of the following air masses is most likely to be present above western Washington in February?

- W) Maritime tropical
- X) Maritime polar
- Y) Continental tropical
- Z) Continental polar

ANSWER: X) MARITIME POLAR

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### **TOSS-UP**

- 2) Math – *Short Answer* How many games need to be played in a single-elimination tournament to declare a winner from 16 teams?

ANSWER: 15

### **BONUS**

- 2) Math – *Short Answer* Two concentric circles have radii of 5 and 12. What is the area of the region in between the circles?

ANSWER:  $119\pi$

## **TOSS-UP**

3) Physics – *Short Answer* A car starts accelerating from the top of a 9-meter tall ramp from rest. The ramp makes an angle of 30 degrees with the horizontal. Given that the car accelerates at 1 meter per second squared, how long does it take, in seconds, for the ball to go down the ramp?

ANSWER: 6

## **BONUS**

3) Physics – *Short Answer* A 40-kilogram box is sitting at rest on a 30 degree incline. In newtons, what is the magnitude of the frictional force acting on the block?

ANSWER: 196



## **TOSS-UP**

4) Chemistry – *Multiple Choice* Which of the following is the electron configuration of the  $\text{Mg}^{2+}$  ion?

- W)  $1s^22s^22p^6$
- X)  $1s^22s^22p^63s^1$
- Y)  $1s^22s^22p^63s^2$
- Z)  $1s^22s^22p^63s^23p^6$

ANSWER: W)  $1s^22s^22p^6$

## **BONUS**

4) Chemistry – *Short Answer* Identify all of the following three quantities that are state functions: 1) Volume; 2) Heat; 3) Work.

ANSWER: 1 ONLY

## **TOSS-UP**

5) Biology – *Short Answer* Identify all of the following four cell junctions that can be found between animal cells: 1) Tight junctions; 2) Desmosomes; 3) Gap junctions; 4) Plasmodesmata.

ANSWER: 1, 2 AND 3

## **BONUS**

5) Biology – *Multiple Choice* Which of the following is NOT an organ that may be used by an amphibian to perform gas exchange?

- W) Skin
- X) Lungs
- Y) Gills
- Z) Cloaca

ANSWER: Z) CLOACA

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## **TOSS-UP**

6) Energy – *Short Answer* Scientists at SLAC National Accelerator Lab are researching efficient methods for synthesizing diamonds via the compression of diamondoids, a class of materials extracted from crude oil. Under high pressure, what element is released from diamondoids, leaving the residual carbon?

ANSWER: HYDROGEN

## **BONUS**

6) Energy – *Short Answer* Scientists at Fermilab, Brookhaven National Lab, and Lawrence Berkeley National Lab have designed a niobium-tin quadrupole magnet that sets the record for the highest field strength ever recorded for an accelerator focusing magnet. The niobium-tin alloy is a superconductor that expels magnetic fields via what effect?

ANSWER: MEISSNER EFFECT (ACCEPT: MEISSNER-OCHSENFELD EFFECT)

## **TOSS-UP**

7) Chemistry – *Short Answer* What law of thermodynamics states that the internal energy change of an isolated system is zero?

ANSWER: FIRST LAW OF THERMODYNAMICS

## **BONUS**

7) Chemistry – *Short Answer* A vessel containing 3 moles of H<sub>2</sub> gas is held at pressure of 2 atmospheres and a volume of 9 liters. If another 3 moles of gas are added, and the container is expanded to a volume of 12 liters, what is the final pressure of the vessel, in atmospheres, assuming constant temperature?

ANSWER: 3

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## **TOSS-UP**

8) Biology – *Multiple Choice* Which of the following is NOT characteristic of eudicots?

- W) Vascular bundles arranged in a circle
- X) Taproots
- Y) Reticular leaf venation
- Z) Two cotyledons *[koh-tuh-LEE-duns]*

ANSWER: Y) RETICULAR LEAF VENATION

## **BONUS**

8) Biology – *Short Answer* The nuclear lamina is a dense network important for maintaining the structural integrity of the nucleus. What type of cytoskeletal element composes the majority of the nuclear lamina?

ANSWER: INTERMEDIATE FILAMENT

### **TOSS-UP**

9) Earth and Space – *Short Answer* What is the name of the primary mechanism of helium-4 fusion in medium-mass stars?

ANSWER: TRIPLE-ALPHA PROCESS

### **BONUS**

9) Earth and Space – *Multiple Choice* An air parcel in the Northern Hemisphere subsides and creates a high pressure system at the surface. Which of the following best describes airflow in the system?

- W) Cyclonic, clockwise
- X) Cyclonic counterclockwise
- Y) Anticyclonic, clockwise
- Z) Anticyclonic, counterclockwise

ANSWER: Y) ANTICYCLONIC, CLOCKWISE



### **TOSS-UP**

10) Math – *Short Answer* The point (4, 2) is reflected across the  $y$ -axis and then translated 8 units up. What are the final coordinates of the point?

ANSWER: (-4, 10)

### **BONUS**

10) Math – *Short Answer* Connor's drawer contains 3 green socks, 6 red socks, 9 blue socks, and 2 yellow socks. What is the minimum number of socks Connor needs to pull from his drawer to guarantee that he has at least 1 pair of each color?

ANSWER: 20

## **TOSS-UP**

11) Physics – *Short Answer* A circuit contains a 12-volt battery connected in series with a 3-ohm resistor. What is the power dissipated by the resistor in watts?

ANSWER: 48

## **BONUS**

11) Physics – *Multiple Choice* A 50-kilogram sphere collides head-on in a perfectly elastic collision with a metal plate of mass  $m$ . As the value of  $m$  approaches infinity, which of the following best describes the behavior of the system after the collision?

- W) The sphere will stick to the plate and both objects will move at the sphere's original velocity
- X) The sphere will stop moving and the plate will move at the sphere's original velocity
- Y) The sphere will stick to the plate and stop moving
- Z) The sphere begin traveling in the opposite direction with the same speed

ANSWER: Z) THE SPHERE WILL BEGIN TRAVELING IN THE OPPOSITE DIRECTION WITH THE SAME SPEED

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## **TOSS-UP**

12) Energy – *Multiple Choice* DOE Researchers at Ames Lab have discovered that periodic vibrational motion may stabilize some currently unstable electron states, which can make advanced quantum computing possible. On a macroscopic level, what is the name for this periodic vibrational motion?

- W) Resonance
- X) Damping
- Y) Harmonic oscillation
- Z) Laminar flow

ANSWER: Y) HARMONIC OSCILLATION

## **BONUS**

12) Energy – *Multiple Choice* Researchers at CERN are running the Baryon Antibaryon Symmetry Experiment, or BASE, to look for differences between matter and antimatter. Which of the following particles is a baryon?

- W) Neutrino
- X) Positron
- Y) Electron
- Z) Proton

ANSWER: Z) PROTON

## **TOSS-UP**

13) Physics – *Short Answer* A Carnot engine has a hot reservoir of 102 degrees Celsius and an efficiency of 40%. In degrees Celsius, what is the temperature of the cold reservoir?

ANSWER: -48

## **BONUS**

13) Physics – *Short Answer* A projectile is launched from the ground at a 45 degree angle. If it reaches a maximum height of 23 meters, what is its horizontal range in meters?

ANSWER: 92



## **TOSS-UP**

14) Biology – *Short Answer* What is the largest structure in the nucleus of eukaryotic cells?

ANSWER: NUCLEOLUS

## **BONUS**

14) Biology – *Short Answer* What enzyme participates in both the citric acid cycle and the electron transport chain?

ANSWER: COMPLEX 2 (ACCEPT: SUCCINATE DEHYDROGENASE; SUCCINATE COENZYME-Q)

**TOSS-UP**

15) Math – *Short Answer* What is the area of an isosceles right triangle with a hypotenuse of 6 times the square root of 2?

ANSWER: 18

**BONUS**

15) Math – *Short Answer* What is the greatest common factor of 350 and 518?

ANSWER: 14

**TOSS-UP**

16) Chemistry – *Short Answer* What is the general term for a substance that accelerates a chemical reaction by providing an alternate pathway for the reaction to occur?

ANSWER: CATALYST (DO NOT ACCEPT: ENZYME)

**BONUS**

16) Chemistry – *Short Answer* Rank the following three ions in terms of increasing ionic radius: 1)  $\text{Na}^+$ ; 2)  $\text{Al}^{3+}$ ; 3)  $\text{F}^-$ .

ANSWER: 2, 1, 3

## **TOSS-UP**

17) Earth and Space – *Multiple Choice* Which of the following statements concerning plate tectonics is NOT true?

- W) Slab pull contributes much more driving force than ridge push
- X) In a collision between two oceanic plates, the older one sinks
- Y) Mid-ocean ridges are associated with asthenosphere upwelling
- Z) Continental plates are generally denser than oceanic plates

ANSWER: Z) CONTINENTAL PLATES ARE GENERALLY DENSER THAN OCEANIC PLATES

## **BONUS**

17) Earth and Space – *Short Answer* What oceanic layer is characterized by a rapid vertical change in density?

ANSWER: PYCNOCLINE



## **TOSS-UP**

18) Physics – *Short Answer* The frequency of a photon is directly related to its energy by what physical constant?

ANSWER: PLANCK'S CONSTANT

## **BONUS**

18) Physics – *Short Answer* An ideal Atwood machine has two blocks of masses 3 and 4 kilograms connected by a string on either side of a pulley. In meters per second squared, which of the following is the acceleration of the system?

- W) 0.7
- X) 1.4
- Y) 2.1
- Z) 2.8

ANSWER: X) 1.4

## **TOSS-UP**

19) Biology – *Short Answer* Several types of non-Watson–Crick base pairing may occur during translation due to what phenomenon involving genetic code redundancy?

ANSWER: Wobble

## **BONUS**

19) Biology – *Short Answer* Tracheids and vessel elements are components of what vascular tissue in plants?

ANSWER: XYLEM



## **TOSS-UP**

20) Energy – *Short Answer* Scientists at Pacific Northwest National Lab are working on improving the stability of qubits in quantum computers. Qubits can be represented as a linear combination of two states that are joined by what quantum mechanical principle?

ANSWER: SUPERPOSITION

## **BONUS**

20) Energy – *Multiple Choice* Scientists at Sandia National Lab have developed a prototype for a cheaper device to perform magnetoencephalography. Which of the following best describes the function of magnetoencephalography?

- W) It probes the brain with a magnetic field and measures the rebound
- X) It probes the heart with a magnetic field and measures the rebound
- Y) It detects magnetic fields from the electrical signals in the brain
- Z) It detects magnetic fields from the electrical signals in the heart

ANSWER: Y) IT DETECTS MAGNETIC FIELDS FROM THE ELECTRICAL SIGNALS IN THE BRAIN

## **TOSS-UP**

21) Math – *Multiple Choice* Which of the following polynomials has more than 4 roots?

- W)  $6x^2 + 11x - 17$
- X)  $x^3 - 3x^2 + 1$
- Y)  $4x^4 - 17x + 34$
- Z)  $x^6 - 3$

ANSWER: Z)  $x^6 - 3$

## **BONUS**

21) Math – *Short Answer* A sequence has  $a$  sub 1 = 2,  $a$  sub 2 = 4, and  $a$  sub quantity  $n + 2$  equals 3 times a sub quantity  $n + 1$  minus a sub  $n$  for all positive integers  $n$ . What is  $a$  sub 5?

ANSWER: 68



## **TOSS-UP**

22) Chemistry – *Multiple Choice* Which of the following unit cells has the lowest coordination number?

- W) Simple cubic
- X) Body-centered cubic
- Y) Face-centered cubic
- Z) Base-centered cubic

ANSWER: W) SIMPLE CUBIC

## **BONUS**

22) Chemistry – *Short Answer* The variation of vapor pressure with temperature can be calculated using what equation?

ANSWER: CLAUSIUS-CLAPEYRON EQUATION

### **TOSS-UP**

23) Earth and Space – *Multiple Choice* Which of the following fluvial environments would most likely involve braided stream morphology?

- W) Outwash plain of an alpine glacier
- X) Mid-continent hot desert
- Y) Coastal floodplain
- Z) Uneroded bedrock

ANSWER: W) OUTWASH PLAIN OF AN ALPINE GLACIER

### **BONUS**

23) Earth and Space – *Multiple Choice* Which of the following rocks would most likely function as an aquitard?

- W) Shale
- X) Sandstone
- Y) Arkose
- Z) Limestone

ANSWER: W) SHALE