

ROUND 1

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

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: 119π

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 Mg^{2+} ion?

- W) $1s^2 2s^2 2p^6$
- X) $1s^2 2s^2 2p^6 3s^1$
- Y) $1s^2 2s^2 2p^6 3s^2$
- Z) $1s^2 2s^2 2p^6 3s^2 3p^6$

ANSWER: W) $1s^2 2s^2 2p^6$

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

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 H₂ 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



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 begins traveling in the opposite direction with the same speed

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



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) Na^+ ; 2) Al^{3+} ; 3) 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 $a_{sub n+2}$ equals 3 times $a_{sub n+1}$ 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: CLAUDIUS-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