BSB ROUND 6

TOSS-UP

1) Energy – *Short Answer* Researchers at Lawrence Berkeley National Lab have recently completed working on the Large-Scale Laminar Soil Box facility which will leverage the power of supercomputers in order to simulate what geologic phenomena?

ANSWER: EARTHQUAKES (ACCEPT: SEISMIC WAVES)

BONUS

1) Energy – *Short Answer* Researchers at UC Berkeley's physics department are currently studying particles which have the ability to change flavor while traveling through space. What class of neutral leptons are they studying?

ANSWER: NEUTRINOS

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TOSS-UP

2) Math – *Short Answer* A 30-60-90 triangle has two side lengths of 23 and 46. What is the length of the third side?

ANSWER: 23 TIMES THE SQUARE ROOT OF 3

BONUS

2) Math – *Multiple Choice* In a soccer season, a soccer player has a 79% chance of scoring a penalty assuming that each penalty kick is independent. Which of the following is closest to the probability that the first time they fail is on the fourth penalty kick?

W) 1%
X) 5%
Y) 10%
Z) 20%

ANSWER: Y) 10%
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TOSS-UP

3) Earth and Space – *Short Answer* What layer of a star is defined as the depth at which 50% of light will escape without being scattered?

ANSWER: PHOTOSPHERE

BONUS

3) Earth and Space – *Short Answer* What is the name given to iron-nickel crystals which can be seen when slicing open an iron meteorite?

ANSWER: WIDMANSTÄTTEN PATTERNS (ACCEPT: THOMSON STRUCTURES)

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TOSS-UP

4) Physics – *Multiple Choice* Lenz's law, which states that the direction of the current induced in a conductor by a changing magnetic field is such that the induced current opposes the change in the initial magnetic field, is most analogous to which of the following laws?

W) Newton's first law of motion
X) Newton's third law of motion
Y) First law of thermodynamics
Z) Third law of thermodynamics

ANSWER: X) NEWTON'S THIRD LAW OF MOTION

BONUS

4) Physics – *Short Answer* Imagine a bicycle with hollow cylinders for wheels such that the front and back wheel have the same mass but the front wheel has double the radius. The bicycle is moving forward with the wheels rotating without slipping. What is the ratio of rotational kinetic energy of the front wheel to the back wheel?

ANSWER: ONE TO ONE (ACCEPT: 1)
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TOSS-UP

5) Energy – *Short Answer* Scientists in the Glaunsinger Lab at UC Berkeley are investigating how viruses induce mRNA degradation. What is the term for a bacteriophage DNA that has integrated into the host bacterial chromosome and is created during the lysogenic cycle?

ANSWER: PROPHAGE

BONUS

5) Energy – *Short Answer* The Neumark Group specializes in femtosecond spectroscopy in which an initial laser pulse promotes an electron to a higher energy, and then a second pulse photon-ionizes the electron. The two pulses originate when one pulse is split, and the delay is caused by increasing the path length of one of the pulses. If a delay of 6 femtoseconds is desired, in micrometers, what should the difference in path length be?

ANSWER: 1.8

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TOSS-UP

6) Chemistry – *Short Answer* In proton NMR, how many neighboring hydrogen atoms are required to generate a quartet?

ANSWER: THREE

BONUS

6) Chemistry – *Multiple Choice* Which of the following ions has the smallest radius?

W) Hydride
X) Fluoride
Y) Chloride
Z) Sulfide

ANSWER: X) FLUORIDE
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TOSS-UP

7) Math – *Short Answer* If a standard 6-sided die is rolled five times and the numbers on the top of the die are 1, 3, 3, 6, and 2, then what is the sum of the bottom faces?

ANSWER: 20

BONUS

7) Math – *Short Answer* A particle's velocity is defined by the equation $v(t) = t^3/3 - t^2 - 24t + 17$. At what times t does the particle have zero acceleration?

ANSWER: $t = 6$ AND $t = -4$

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TOSS-UP

8) Earth and Space – *Multiple Choice* Which of the following is not a driving force of metamorphism?

W) Heat
X) Pressure and stress
Y) Lithification of sediments
Z) Chemically active fluids

ANSWER: Y) LITHIFICATION OF SEDIMENTS

BONUS

8) Earth and Space – *Short Answer* Igneous rocks are often classified by the amount of silica they contain. Order the following three rocks from the most felsic to the least: 1) Andesite; 2) Granite; 3) Basalt.

ANSWER: 2, 1, 3
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TOSS-UP

9) Chemistry – *Short Answer* Identify all of the following four molecules that exhibit a net dipole moment: 1) CO; 2) SO_3; 3) N_2H_4; 4) CH_4.

ANSWER: 1 AND 3

BONUS

9) Chemistry – *Multiple Choice* In mass spectrometry, a common occurrence is when peaks come in pairs of similar magnitudes. Which of the following is the most likely cause of this?

W) The peaks are resolved at low temperature
X) There are different isotopes of similar relative abundance
Y) The flow rate is too fast to separate the fragments
Z) The fragments are protonated by the solvent

ANSWER: X) THERE ARE DIFFERENT ISOTOPES OF SIMILAR RELATIVE ABUNDANCE

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TOSS-UP

10) Physics – *Short Answer* In joules, how much energy will a bowling ball lose or gain if it is launched into the atmosphere at a 45 degree angle at 50 meters per second going from the ground to its apex, ignoring air resistance?

ANSWER: ZERO

BONUS

10) Physics – *Multiple Choice* During an isometric process, 225 joules of heat are removed from a trapped gas. Which of the following statements is true regarding this process?

W) The volume of the gas increases
X) The volume of the gas decreases
Y) The temperature of the gas increases
Z) The temperature of the gas decreases

ANSWER: Z) THE TEMPERATURE OF THE GAS DECREASES
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TOSS-UP

11) Earth and Space – *Multiple Choice* A series of non-foliated rocks are produced in a high-temperature and low-pressure environment. Which of the following types of metamorphism could have occurred?

W) Contact metamorphism
X) Hydrothermal metamorphism
Y) Burial metamorphism
Z) Regional metamorphism

ANSWER: W) CONTACT METAMORPHISM

BONUS

11) Earth and Space – *Short Answer* Identify all of the following three statements that may be true regarding a sample of black shale: 1) The sample contains abundant organic matter; 2) The deposition occurred in an oxygen-rich environment; 3) The sample contains a fossil.

ANSWER: 1 AND 3

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TOSS-UP

12) Energy – *Short Answer* Scientists in the Maboudian Lab at UC Berkeley are trying to implement graphite fibers in cement to reduce its carbon footprint. Identify all of the following three statements that are true regarding graphene, or single-layer graphite: 1) It adopts a honeycomb lattice; 2) It consists of sp^3-hybridized carbon atoms; 3) It is more conductive between sheets than within them.

ANSWER: 1 ONLY

BONUS

12) Energy – *Short Answer* Scientists in the Shank Lab work with ultra-fast lasers, which are coherent due to their high-energy and fast pulses. What type of coherence describes the random fluctuations in frequency while maintaining a uniform spatial beam profile?

ANSWER: TEMPORAL
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TOSS-UP

13) Physics – *Short Answer* In volts, what is the induced electromotive force in a circular loop of wire with a bar magnet producing a magnetic field of 0.1 teslas placed at rest perpendicular to the loop at its center?

ANSWER: 0

BONUS

13) Physics – *Short Answer* Two capacitors of equivalent capacitance are placed in series with a 6 microfarad capacitor. Altogether, their equivalent capacitance is 3 microfarads. What is the capacitance, in microfarads, of the first two capacitors?

ANSWER: 12

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TOSS-UP

14) Earth and Space – *Multiple Choice* Which of the following is NOT true regarding hurricanes in the northern hemisphere?

W) Wind flow is counterclockwise
X) Surface pressure is lowest at the center
Y) Strongest winds are aloft, in the jet stream
Z) Air in the center is sinking

ANSWER: Y) STRONGEST WINDS ARE ALOFT, IN THE JET STREAM

BONUS

14) Earth and Space – *Short Answer* Two samples of solid rock, almost identical in appearance, are reacted with dilute hydrochloric acid. One sample fizzes while the other does not react visibly. Given the first sample is limestone, what is the identity of the second sample?

ANSWER: DOLOSTONE (ACCEPT: DOLOMITE, $CaMg(CO_3)_2$)
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TOSS-UP

15) Chemistry – *Multiple Choice* Which combination of conditions would cause the most deviation between ideal and real gases?

W) Low pressure and low temperature
X) Low pressure and high temperature
Y) High pressure and high temperature
Z) High pressure and low temperature

ANSWER: Z) HIGH PRESSURE AND LOW TEMPERATURE

BONUS

15) Chemistry – *Multiple Choice* Assuming rings are planar, which of the following cyclic hydrocarbons has the LEAST ring strain?

W) Cyclopropane
X) Cyclobutane
Y) Cyclopentane
Z) Cyclohexane

ANSWER: Y) CYCLOPENTANE

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TOSS-UP

16) Biology – *Multiple Choice* Which of the following correctly classifies a rattlesnake?

W) Secondary consumers and autotroph
X) Producer and a heterotroph
Y) Primary consumer and a heterotroph
Z) Tertiary consumer and a heterotroph

ANSWER: Z) TERTIARY CONSUMER AND A HETEROTROPH

BONUS

16) Biology – *Short Answer* What is the most abundant immunoglobulin class produced after initial exposure to an antigen?

ANSWER: IgM
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TOSS-UP

17) Math – *Multiple Choice* Which of the following is closest to the area of a triangle with lengths 4, 5, and 7?

W) 5.66
X) 6.93
Y) 9.80
Z) 10.40

ANSWER: Y) 9.80

BONUS

17) Math – *Short Answer* A particle has a 3/4 chance of decaying after some time *t*. Out of 6 total particles, what is the probability that 4 or more particles remain after a time *t* has passed?

ANSWER: 77/2048

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TOSS-UP

18) Energy – *Multiple Choice* Researchers at the Haddad Lab at Lawrence Berkeley National Labs are interested in electrochemical lithium extraction methods from clays to replace current conventional methods. What is the most common current conventional method of lithium extraction?

W) Electrolytic reduction
X) Acid leaching
Y) Evaporation from brine
Z) Sintering and chemical reduction

ANSWER: Y) EVAPORATION FROM BRINE

BONUS

18) Energy – *Short Answer* Scientists in the Schepartz Lab at UC Berkeley use bacteria to create new chemical polymers. If a researcher in this lab wished to choose an amino acid with no enantiomers, identify all of the following three choices that are appropriate: 1) Leucine; 2) Glycine; 3) Cysteine.

ANSWER: 2 ONLY
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TOSS-UP

19) Biology – *Multiple Choice* Which of the following is not one of the three subclasses of mammals that still exist today?

W) Monotremata
X) Boreosphenida
Y) Metatheria
Z) Eutheria

ANSWER: X) BOREOSPHENIDA

BONUS

19) Biology – *Short Answer* What is the class of tetrapods whose members include reptiles, birds, and mammals and can be further divided into synapsids and sauropsids?

ANSWER: AMNIOTES

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TOSS-UP

20) Chemistry – *Short Answer* According to molecular orbital theory, what is the bond order in the CN^+ ion?

ANSWER: 2

BONUS

20) Chemistry – *Multiple Choice* Given a reaction with a nucleophilic reagent and a primary substrate, which of the following reactions is most likely to occur?

W) E1
X) E2
Y) SN1
Z) SN2

ANSWER: Z) SN2
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TOSS-UP

21) Earth and Space – *Multiple Choice* Which of the following is NOT an example of a mineral?

W) Ice
X) Obsidian
Y) Halite
Z) Quartz

ANSWER: X) OBSIDIAN

BONUS

21) Earth and Space – *Short Answer* What term describes a mineral's toughness or its resistance to breaking and deforming?

ANSWER: TENACITY

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TOSS-UP

22) Math – *Short Answer* Two cars are 60 miles apart driving directly towards each other on a straight road at constant speeds of 50 and 30 miles per hour, respectively. How many minutes will it take for the two cars to collide with each other?

ANSWER: 45

BONUS

22) Math – *Short Answer* A high-school club has 8 members. With elections coming up for 4 different positions, two members refuse to serve together. How many different ways can the positions be selected?

ANSWER: 55
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TOSS-UP

23) Physics – *Short Answer* Two point charges are separated by a certain distance *R*. If the magnitudes of both charges is doubled and their separation is also doubled, then what happens to the magnitude of the electric force between these two charges?

ANSWER: REMAINS THE SAME (ACCEPT: NO CHANGE)

BONUS

23) Physics – *Multiple Choice* A certain ideal gas has a specific heat capacity at constant volume of $3R/2$, where R is the gas constant. Which of the following molecules could be the identity of gas?

W) Helium
X) Oxygen
Y) Water
Z) Methane

ANSWER: W) HELIUM