

## BSB ROUND 9

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### TOSS-UP

1) Math – *Short Answer* What is the area of a triangle with side lengths of 13, 14, and 15?

ANSWER: 84

### BONUS

1) Math – *Short Answer* Rounded to the nearest integer, what is the geometric mean of the numbers 8, 29, and 68?

ANSWER: 25

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### TOSS-UP

2) Earth and Space – *Multiple Choice* A lake or pond is known as what type of community?

- W) Pelagic
- X) Benthic
- Y) Lentic
- Z) Lotic

ANSWER: Y) LENTIC

### BONUS

2) Earth and Space – *Multiple Choice* Which of the following properties is used to describe the appearance of a mineral in transmitted light?

- W) Porosity
- X) Opacity
- Y) Translucence
- Z) Diaphaneity

ANSWER: Z) DIAPHANEITY

### TOSS-UP

3) Physics – *Short Answer* A block is initially located at the origin and is confined to the  $x$ - $y$  plane. If the force vector on a block, in newtons, is given by  $3\mathbf{i} - 6\mathbf{j}$ , and the block is moved to the coordinates (6, -5) in meters, what is the total amount of work done on the block in joules?

ANSWER: 48

### BONUS

3) Physics – *Short Answer* A 2-kilogram point mass is attached to a massless 2-meter rod, which is bolted to the ground on the end without the mass. If 32 joules of work are done to rotate the mass at a constant angular acceleration of 2 radians per second squared, what angle, in radians, did the mass sweep through?

ANSWER: 2

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### TOSS-UP

4) Chemistry – *Multiple Choice* Upon adding elemental iodine and sodium hydroxide to an unknown solution with acid workup, a yellow solid was observed. Which of the following functional groups did the solution initially contain?

- W) Primary alcohol
- X) Ketone
- Y) Carboxylic acid
- Z) Aldehyde

ANSWER: X) KETONE

### BONUS

4) Chemistry – *Short Answer* For a reaction  $A \rightarrow B$ , the natural log of the equilibrium constant is graphed versus the reciprocal of temperature in kelvins. If the  $y$ -intercept of this graph is 2, then what is the change in entropy, in joules per mole-kelvin, for this reaction to the nearest tenth?

ANSWER: 16.6

### TOSS-UP

5) Energy – *Short Answer* Scientists at Lawrence Berkeley National Laboratory are studying superconducting magnets to improve the imaging of MRI machines. When a superconductor is cooled past its critical temperature, it expels magnetic fields due to what phenomenon?

ANSWER: MEISSNER EFFECT

### BONUS

5) Energy – *Short Answer* Scientists in the Tilley group use metal-metal bonding to create novel catalysts for C–H bond activation. What type of bond is formed when two metal  $dz^2$ -squared orbitals interact along the  $z$ -axis?

ANSWER: SIGMA BOND

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### TOSS-UP

6) Biology – *Short Answer* What intercellular junction is responsible for preventing fluid from moving across a layer of cells?

ANSWER: TIGHT JUNCTIONS

### BONUS

6) Biology – *Short Answer* Identify all of the following three statements that are true regarding fetal hemoglobin: 1) It is made up of alpha and gamma subunits; 2) It has a higher affinity for oxygen than adult hemoglobin; 3) Reactivating fetal hemoglobin can be used to manage sickle cell disease.

ANSWER: ALL

### TOSS-UP

7) Chemistry – *Multiple Choice* A student wishes to reduce a ketone to a secondary alcohol. Which of the following reagents might she employ?

- W) Sodium dichromate
- X) Ozone
- Y) Sodium borohydride
- Z) Sulfuric acid

ANSWER: Y) SODIUM BOROHYDRIDE

### BONUS

7) Chemistry – *Short Answer* If a series of amino acids in a peptide have negative phi dihedral angles and positive psi dihedral angles, what is the most likely secondary protein structure of this peptide according to the Ramachandran plot?

ANSWER: BETA SHEETS

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### TOSS-UP

8) Earth and Space – *Short Answer* Rank the following four minerals from softest to hardest according to the Mohs hardness scale: 1) Talc; 2) Corundum; 3) Gypsum; 4) Quartz.

ANSWER: 1, 3, 4, 2

### BONUS

8) Earth and Space – *Short Answer* What name is given to a type of mass wasting that involves the gradual downhill movement of soil and regolith, often due to cycles of freezing and thawing?

ANSWER: CREEP

### TOSS-UP

9) Physics – *Short Answer* Identify all of the following three quantities that be zero for a system to be in static equilibrium: 1) Net force; 2) Net torque; 3) Net angular momentum.

ANSWER: ALL

### BONUS

9) Physics – *Short Answer* According to Noether's theorem, translational symmetries give rise to the conservation of what quantity?

ANSWER: LINEAR MOMENTUM (ACCEPT: MOMENTUM)

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### TOSS-UP

10) Math – *Short Answer* What is the derivative of the function  $f(x) = 1$  over the quantity  $\underline{3x^2}$  with respect to  $x$  evaluated at  $x = 3$ ?

ANSWER:  $-2/81$

### BONUS

10) Math – *Short Answer* What is the length of the arc formed between the hour and minute hand at 4:20 for a clock whose radius is one over pi?

ANSWER:  $1/18$

### TOSS-UP

11) Biology – *Short Answer* What is the term for when a cell engulfs a particle by wrapping pseudopodia around it?

ANSWER: PHAGOCYTOSIS

### BONUS

11) Biology – *Short Answer* In order to regulate the transcription of the lac operon, lactose needs to be present in the cell. What does lactose bind to in order to activate transcription of the operon?

ANSWER: LAC REPRESSOR

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### TOSS-UP

12) Energy – *Multiple Choice* Researchers in the Reimer Lab at UC Berkeley are investigating a new class of materials called hydrogen-bonded organic frameworks, which rely on large strings of hydrogen bonding interactions to form stable structures. Which of the following classes of biological molecules might they look to for inspiration?

- W) DNA
- X) Steroids
- Y) Phospholipids
- Z) Amino acids

ANSWER: W) DNA

### BONUS

12) Energy – *Short Answer* Scientists in the Neumark Lab study the dynamics of liquid microjets using time-resolved spectroscopy. As the chamber is under vacuum, there is a relatively high vapor pressure that can interfere with the measurement. Identify all of the following three changes that could be used to reduce the vapor pressure: 1) Adding salt to the jet; 2) Decreasing the temperature of the chamber; 3) Removing nonvolatile impurities.

ANSWER: 1 AND 2

### TOSS-UP

13) Earth and Space – *Short Answer* What is the name of the point at the surface directly above the focus of an earthquake?

ANSWER: EPICENTER

### BONUS

13) Earth and Space – *Short Answer* What fossils consist of limestone mats built up from lime accreting cyanobacteria

ANSWER: STROMATOLITES

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### TOSS-UP

14) Physics – *Short Answer* When forming hadrons, quarks can only be assembled in combinations that have a neutral value for what property?

ANSWER: COLOR CHARGE (ACCEPT: COLOR)

### BONUS

14) Physics – *Short Answer* A point charge of magnitude 24 coulombs is placed at the corner of a cube in a vacuum. In terms of the permittivity of free space, what is the electric flux through one of the faces not in contact with the charge?

ANSWER: ONE OVER THE PERMITTIVITY OF FREE SPACE (ACCEPT: ONE OVER EPSILON NAUGHT)

### TOSS-UP

15) Chemistry – *Multiple Choice* According to Hückel's rule, which of the following numbers of conjugated pi electrons cannot be found in an aromatic molecule?

- W) 10
- X) 14
- Y) 16
- Z) 18

ANSWER: Y) 16

### BONUS

15) Chemistry – *Multiple Choice* Which of the following quantities is NOT used to calculate the lattice enthalpy of sodium fluoride using the Born-Haber cycle?

- W) Electron affinity of fluorine
- X) Enthalpy of vaporization of sodium
- Y) Electronegativity of fluorine
- Z) Ionization energy of sodium

ANSWER: Y) ELECTRONEGATIVITY OF FLUORINE

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### TOSS-UP

16) Biology – *Short Answer* What process during meiosis results in increased genetic diversity by creating chromatids that are a combination of the mother and father?

ANSWER: CROSSING OVER

### BONUS

16) Biology – *Short Answer* Identify **which** of the following three statements that are true regarding enzymes: 1) Enzymes catalyze chemical reactions by making the strongest bonding interaction with the substrate; 2) Enzymes have optimal efficiency at pH of 7; 3) Enzymes use part of the energy of substrate binding.

ANSWER: 3 ONLY



### TOSS-UP

17) Math – *Short Answer* What is the sum of the factors of the number 78?

ANSWER: 168

### BONUS

17) Math – *Short Answer* How many times does the function  $f(x) = \sin \pi x + \sin 2\pi x$  equal zero between the values  $x = 0$  and  $x = 2$ , inclusive?

ANSWER: 5

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### TOSS-UP

18) Energy – *Short Answer* Scientists in the Sarpong Lab at UC Berkeley are focused on developing new mechanisms for total synthesis of various natural products. While investigating the kinetics of a substitution reaction where methanol is reacted with 2-bromo-2-methyl pentane, how much is the reaction rate scaled by if the concentration of methanol is doubled while the concentration of the alkane is halved?

ANSWER: ONE HALF

### BONUS

18) Energy – *Multiple Choice* Scientists in the Chang Lab at UC Berkeley are investigating biosynthetic pathways for noncanonical amino acids, such as for an amino acid with a terminal alkyne side chain. Which of the following functional groups can be reacted with the terminal alkyne in a bioorthogonal reaction?

- W) Azide
- X) Diene
- Y) Nitrosyl
- Z) Allene

ANSWER: W) AZIDE

### TOSS-UP

19) Chemistry – *Short Answer* What is the name of the chemical moiety that distinguishes the nitrogenous bases uracil and thymine?

ANSWER: METHYL GROUP

### BONUS

19) Chemistry – *Multiple Choice* Which of the following metals can act as a sacrificial anode for zinc?

- W) Iron
- X) Gold
- Y) Copper
- Z) Aluminum

ANSWER: Z) ALUMINUM

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### TOSS-UP

20) Biology – *Multiple Choice* During a bottleneck event in a population, which of the following is most likely to occur?

- W) Increase in genetic diversity
- X) Hardy-Weinberg disequilibrium
- Y) Increase in gene flow
- Z) Increase in genetic variation

ANSWER: X) HARDY-WEINBERG DISEQUILIBRIUM

### BONUS

20) Biology – *Short Answer* How many total ATP molecules are required in the Calvin cycle to produce 1 glucose molecule?

ANSWER: 18

### TOSS-UP

21) Earth and Space – *Short Answer* The magnetic field strength of the sun can be measured by the relative splitting of the sun's spectrum. This relies on what effect?

ANSWER: ZEEMAN EFFECT

### BONUS

21) Earth and Space – *Multiple Choice* In which of the following pairs of layers of the atmosphere does temperature increase with altitude?

- W) Stratosphere and mesosphere
- X) Troposphere and thermosphere
- Y) Stratosphere and thermosphere
- Z) Mesosphere and thermosphere

ANSWER: Y) STRATOSPHERE AND THERMOSPHERE

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### TOSS-UP

22) Physics – *Short Answer* Identify all of the following three assumptions that must be made when considering an ideal fluid: 1) Fluids are nonviscous; 2) Fluids are compressible; 3) Fluid flow is irrotational.

ANSWER: 1 AND 3

### BONUS

22) Physics – *Short Answer* In meters, what is the speed of sound in a medium with a bulk modulus of 16 gigapascals and a density of 1 gram per cubic centimeter?

ANSWER: 4000

### TOSS-UP

23) Math – *Multiple Choice* Which of the following is closest to the percent error of a measurement given an experimental value of 250 and an expected value of 450?

- W) 37%
- X) 41%
- Y) 44%
- Z) 47%

ANSWER: Y) 44%

### BONUS

23) Math – *Short Answer* If the second derivative of a function with respect to  $x$  is  $4x^2 + 2x$ , and the original function only has two terms, what is the value of the original function when  $x = 4$ ?

ANSWER: 320/3