

BSB ROUND 10

TOSS-UP

1) Chemistry – *Short Answer* What is the major product formed in the reaction between sodium hydroxide and phenol?

ANSWER: SODIUM PHENOXIDE

BONUS

1) Chemistry – *Short Answer* Identify all of the following three nuclei that are NMR active:
1) Hydrogen-1; 2) Carbon-13; 3) Oxygen-16.

ANSWER: 1 AND 2

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### **TOSS-UP**

2) Earth and Space – *Multiple Choice* Which of the following is a sulfide?

- W) Cinnabar
- X) Rhodochrosite
- Y) Hematite
- Z) Gypsum

ANSWER: W) CINNABAR

### **BONUS**

2) Earth and Space – *Short Answer* Order the following three Milankovich cycles in terms of increasing timescale: 1) Axial tilt; 2) Orbital eccentricity; 3) Axial precession.

ANSWER: 3, 1, 2

**TOSS-UP**

3) Math – *Short Answer* Evaluate the integral from  $x = 0$  to  $10$  of  $3x^2 + 2x + 7$ .

ANSWER: 1170

**BONUS**

3) Math – *Short Answer* Two integers  $a$  and  $b$  are independently selected from the set of integers between  $-5$  and  $5$ , inclusive, with replacement. What is the probability that the quantity  $\underline{a} \text{ plus } b$  cubed equals  $a$  cubed plus  $b$  cubed?

ANSWER: 31/121

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TOSS-UP

4) Physics – *Short Answer* What term is given to the inelastic scattering of X-rays due to charged particles?

ANSWER: COMPTON SCATTERING

BONUS

4) Physics – *Short Answer* A spring-mass system with a damping force is stretched past its equilibrium position and released from rest. Rank the following three damping situations from first to cross through the equilibrium position to last: 1) Underdamped; 2) Overdamped; 3) Critically damped.

ANSWER: 1, 2, 3

TOSS-UP

5) Energy – *Short Answer* Scientists in the Leone Group at UC Berkeley conduct transient spectroscopy requiring ultrafast pulses on the attosecond scale. In a pulse with a given range of wavelengths, there is a minimum pulse length due to what principle?

ANSWER: HEISENBERG'S UNCERTAINTY PRINCIPLE

BONUS

5) Energy – *Multiple Choice* Scientists in the Bustamante Lab at UC Berkeley are specializing in single molecule biophysics, which involves tracking and measuring the activity of individual enzymes in transcription and translation. Which of the following statements are true regarding transcription factors?

- W) Transcription factors only act to activate transcription
- X) Transcription factors can act as both repressors and activators of transcription
- Y) Transcription factors are involved in RNA splicing
- Z) Transcription factors are only involved in the initiation of transcription

ANSWER: X) TRANSCRIPTION FACTORS CAN ACT AS BOTH REPRESSORS AND ACTIVATORS OF TRANSCRIPTION

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## **TOSS-UP**

6) Biology – *Short Answer* What specific type of glycosidic linkage in glycogen is cleaved by glycogen phosphorylase?

ANSWER: ALPHA-1,4 (DO NOT ACCEPT: ALPHA; BETA-1,4)

## **BONUS**

6) Biology – *Multiple Choice* Which of the following complexes of the electron transport chain in cellular respiration does NOT pump protons from the mitochondrial matrix into the intermembrane space?

- W) Complex I
- X) Complex II
- Y) Complex III
- Z) Complex IV

ANSWER: X) COMPLEX II

### **TOSS-UP**

7) Math – *Short Answer* Given a circle with center O and points A, B, C, and D along its circumference such that AC and BD cross the center, what is the value of angle DOC in degrees if angle ABD equals 18 degrees?

ANSWER: 144

### **BONUS**

7) Math – *Short Answer* A mine is randomly placed within a 3-by-3 grid, and a player randomly selects one of the grid tiles to begin the game. What is the probability that the player both does not select the mine nor any adjacent tiles?

ANSWER: 32/81

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TOSS-UP

8) Physics – *Short Answer* Identify all of the following three thermodynamic quantities that are state functions: 1) Gibbs free energy; 2) Helmholtz free energy; 3) Entropy.

ANSWER: ALL

BONUS

8) Physics – *Short Answer* A charged capacitor and inductor are connected at time $t = 0$. In terms of the period T of the resulting oscillations, what is the first later time at which the magnetic flux through the inductor is maximized?

ANSWER: $T/4$

TOSS-UP

9) Biology – *Multiple Choice* Which of the following is NOT a prezygotic barrier?

- W) Mechanical isolation
- X) Temporal isolation
- Y) Behavioral isolation
- Z) Hybrid breakdown

ANSWER: Z) HYBRID BREAKDOWN

BONUS

9) Biology – *Short Answer* How many possible outcomes are there for an independent assortment of 5 unique pairs of chromosomes in a cell?

ANSWER: 32

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**TOSS-UP**

10) Earth and Space – *Short Answer* Order the following three coal types from softest to hardest: 1) Lignite; 2) Anthracite; 3) Bituminous.

ANSWER: 1, 3, 2

**BONUS**

10) Earth and Space – *Short Answer* What glacial depositional features are elongated hills composed of unstratified till that glaciers leave behind as they recede?

ANSWER: DRUMLINS

## **TOSS-UP**

11) Chemistry – *Multiple Choice* A student treats methyl acetate with an excess of phenyl-lithium, followed by the addition of water to the reaction vessel. Which of the following functional groups is he most likely to observe as the major product?

- W) Primary alcohol
- X) Secondary alcohol
- Y) Tertiary alcohol
- Z) Aldehyde

ANSWER: Y) TERTIARY ALCOHOL

## **BONUS**

11) Chemistry – *Short Answer* Rank the following four liquids in terms of increasing normal boiling point: 1) Methanol; 2) Ethanol; 3) Formic acid; 4) Hexanol.

ANSWER: 1, 2, 3, 4

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TOSS-UP

12) Energy – *Short Answer* Scientists in the Chang Lab are studying translational control of gene expression through genome-wide analyses. What site in the large subunit of ribosomal RNA holds the transfer RNA that carries the amino acid that will be added to the growing polypeptide chain?

ANSWER: A SITE (ACCEPT: AMINOACYL SITE)

BONUS

12) Energy – *Short Answer* Scientists in the Williams Lab at UC Berkeley are focused on improving common techniques such as mass spectrometry. Identify all of the following three tactics that a researcher could use to increase the separation between close masses in time-resolved mass spectrometry: 1) Increase the intensity of the electric field; 2) Increase the length of the chamber through which the ion travels; 3) Use a more effective ionization technique.

ANSWER: 1 AND 2

TOSS-UP

13) Biology – *Multiple Choice* Which of the following plant hormones functions in promoting seed germination, controlling apical dominance, and promoting the attraction of mycorrhizal fungi to the root?

- W) Auxins
- X) Ethylene
- Y) Jasmonates
- Z) Strigolactones

ANSWER: Z) STRIGOLACTONES

BONUS

13) Biology – *Multiple Choice* Which of the following is true regarding *Homo sapiens*?

- W) *Homo sapiens* replaced *Homo habilis* in Europe
- X) *Homo sapiens* became extinct about 1 million years ago
- Y) *Homo sapiens* evolved after the Cro-Magnons
- Z) *Homo sapiens* have been Earth's only hominin for the last 24,000 years

ANSWER: Z) HOMO SAPIENS HAVE BEEN EARTH'S ONLY HOMININ FOR THE LAST 24,000 YEARS

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## **TOSS-UP**

14) Earth and Space – *Short Answer* What event in geologic time about 550 million years ago marks the time when most animal phyla first appeared?

ANSWER: CAMBRIAN EXPLOSION

## **BONUS**

14) Earth and Space – *Multiple Choice* What term describes thick deposits of yellowish, fine-grained sediment that form by the accumulation of wind-blown dust?

- W) Fetch
- X) Dune
- Y) Pahoehoe [*puh-HOY-HOY*]
- Z) Loess

ANSWER: Z) LOESS

### **TOSS-UP**

15) Chemistry – *Short Answer* Given the double replacement reaction of mercury(II) fluoride with chromium(II) iodide, what qualitative theory may scientists use to determine if the reactants or products of this reaction are favored?

ANSWER: HARD-SOFT ACID-BASE THEORY (ACCEPT: HSAB)

### **BONUS**

15) Chemistry – *Short Answer* What is the integration ratio between the largest and smallest NMR peaks of 1-bromo-2,2-dimethylpropane?

ANSWER: 9/2

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TOSS-UP

16) Math – *Multiple Choice* Which of the following is equal to the number of values between 1000 and 2023, inclusive, that are neither multiples of 2 nor 3?

- W) 343
- X) 345
- Y) 347
- Z) 349

ANSWER: W) 343

BONUS

16) Math – *Short Answer* The quantity m plus the square root of n times the quantity m minus the square root of n equals 2023. Given that m and n are positive integers, what is the smallest possible value of m plus n ?

ANSWER: 47

TOSS-UP

17) Energy – *Short Answer* Scientists in the Rio Lab are studying epithelial and connective tissues using various microscopic techniques. Which connective tissue contains chondrocytes and a rubbery matrix made up of collagen and proteoglycans?

ANSWER: CARTILAGE

BONUS

17) Energy – *Short Answer* Scientists in the Beatty Lab are investigating immune invasion in mycobacteria. What antibody would be produced in response to exposure to an allergen?

ANSWER: IgE

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## **TOSS-UP**

18) Physics – *Short Answer* A 2-kilogram block experiences a force of 10 newtons to the right, as well as another force of unknown magnitude. If its acceleration equals 3 meters per second squared to the right, what are the magnitude and direction of the unknown force in newtons?

ANSWER: 4 AND LEFT

## **BONUS**

18) Physics – *Multiple Choice* Laplace's equation is used in electrodynamics to find the electric potential under which of the following conditions?

- W) Periodic electric field
- X) Periodic electric charge density
- Y) Zero electric field
- Z) Zero electric charge density

ANSWER: Z) ZERO ELECTRIC CHARGE DENSITY

### **TOSS-UP**

19) Biology – *Short Answer* What is the net number of total NADH molecules produced by 2 molecules of pyruvate in pyruvate oxidation and the citric acid cycle?

ANSWER: 8

### **BONUS**

19) Biology – *Short Answer* Identify all the following three statements that are true of mitosis:

- 1) The nuclear envelope begins to fragment allowing the microtubules to attach to the chromosomes during prometaphase;
- 2) Muscle and nerve cells permanently stay in the G zero phase;
- 3) During cytokinesis, a cleavage furrow forms in plant cells that divides the cytoplasm.

ANSWER: 1 AND 2

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TOSS-UP

20) Chemistry – *Multiple Choice* The electronic transitions of which of the following species cannot be calculated using the Rydberg formula for hydrogen-like elements?

- W) Be^{2+}
- X) B^{4+}
- Y) N^{6+}
- Z) O^{7+}

ANSWER: W) Be^{2+}

BONUS

20) Chemistry – *Short Answer* Compound A decomposes into compounds B and C separately in parallel first-order reactions. The reaction of A forming B has a half-life of 2 seconds, and the reaction of A forming C has a half-life of 4 seconds. What is the overall half-life for the decomposition of A in seconds?

ANSWER: 4/3

TOSS-UP

21) Physics – *Short Answer* Rank the following three materials in terms of increasing thermal conductivity: 1) Lead; 2) Silver; 3) Glass.

ANSWER: 3, 1, 2

BONUS

21) Physics – *Short Answer* To the nearest second, what is the period of small oscillations of a uniform physical pendulum with a mass of 2 kilograms and length of 2.4 meters, given that it is suspended vertically from the ceiling?

ANSWER: 3

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## **TOSS-UP**

22) Earth and Space – *Multiple Choice* At which of the following boundaries is the Mohorovicic discontinuity found?

- W) Outer core and inner core
- X) Mantle and outer core
- Y) Asthenosphere and lithosphere
- Z) Mantle and crust

ANSWER: Z) MANTLE AND CRUST

## **BONUS**

22) Earth and Space – *Short Answer* What is the recessional velocity in kilometers per second of a galaxy that is 50 megaparsecs away from us, assuming a Hubble constant of 70 kilometers per second per megaparsec?

ANSWER: 3500

**TOSS-UP**

23) Math – *Short Answer* What is the slope-intercept form of the tangent line of the function  $f(x) = x^3 - 3x + 5$  at the point (1, 3)?

ANSWER:  $y = 3$

**BONUS**

23) Math – *Short Answer* How many positive integers less than 1000 are equal to 6 times the sum of their digits?

ANSWER: 1