

## BSB ROUND 11

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### **TOSS-UP**

1) Chemistry – *Short Answer* Rank the following three ions in terms of increasing standard reduction potential: 1) Lithium; 2) Sodium; 3) Potassium.

ANSWER: 1, 3, 2

### **BONUS**

1) Chemistry – *Short Answer* Rank the following three carboxylic acid derivatives in terms of increasing reactivity towards nucleophilic substitution: 1) Acyl chloride; 2) Acid anhydride; 3) Carboxylate salt.

ANSWER: 3, 2, 1

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### **TOSS-UP**

2) Energy – *Multiple Choice* Scientists in the Abel group at UC Berkeley have studied various possible polymers and polymer-synthesis reactions. Which of the following would increase the glass transition temperature of a polymer?

- W) Decreasing cross-linking
- X) Cooling the polymer more slowly from its rubbery state
- Y) Changing the species from a homopolymer to a copolymer
- Z) Cooling the polymer below the glass transition temperature

ANSWER: Y) CHANGING THE SPECIES FROM A HOMOPOLYMER TO A COPOLYMER

### **BONUS**

2) Energy – *Short Answer* Researchers in the Peidong Yang Group at UC Berkeley are developing materials that are capable of performing artificial photosynthesis. To strongly absorb light at specific frequencies, scientists often employ transition metal complexes with pi acceptor ligands. These optical transitions most often occur via what charge-transfer band?

ANSWER: METAL–LIGAND CHARGE TRANSFER (ACCEPT: MLCT)

### **TOSS-UP**

3) Earth and Space – *Short Answer* From what direction do trade winds originate in the Northern hemisphere?

ANSWER: NORTHEAST

### **BONUS**

3) Earth and Space – *Multiple Choice* Which of the following parts is a gently sloping, submerged surface that extends from the shoreline toward the deep ocean basin and is considered a flooded extension of the continents?

- W) Slope
- X) Shelf
- Y) Plain
- Z) Rise

ANSWER: X) SHELF



### **TOSS-UP**

4) Math – *Multiple Choice* Which of the following is closest to the area of a 30-60-90 triangle inscribed in a circle of radius 2?

- W) 1.8
- X) 2.2
- Y) 2.8
- Z) 3.5

ANSWER: Z) 3.5

### **BONUS**

4) Math – *Short Answer* Given a clock with radius  $r$  whose hour hand has length  $r$  over 2 and minute hand has length  $r$  over the square root of 2, what is the distance between the tips of the hour and minute hands at 4:30?

ANSWER:  $r/2$

## **TOSS-UP**

5) Physics – *Short Answer* Identify all of the following three particles for which the Pauli exclusion principle is predicted to apply: 1) Neutrino; 2) Proton; 3) Photon.

ANSWER: 1 AND 2

## **BONUS**

5) Physics – *Short Answer* To the nearest tenth, what is the root mean square current in amps of an RLC circuit with a maximum current of 3 amps?

ANSWER: 2.1

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## **TOSS-UP**

6) Biology – *Short Answer* In the Calvin cycle, 1,3-bisphosphoglycerate is an intermediate that is converted into what molecule?

ANSWER: GLYCERALDEHYDE-3-PHOSPHATE (ACCEPT: G3P)

## **BONUS**

6) Biology – *Multiple Choice* Which of the following statements describes the response of rod cells to light stimuli?

- W) Rhodopsin is active in the dark and the rod is depolarized
- X) Rhodopsin is inactive in the light and the rod is depolarized
- Y) Rhodopsin is active in the light and the rod is hyperpolarized
- Z) Rhodopsin is inactive in the dark and the rod is hyperpolarized

ANSWER: Y) RHODOPSIN IS ACTIVE IN THE LIGHT AND THE ROD IS HYPERPOLARIZED

## **TOSS-UP**

7) Earth and Space – *Multiple Choice* Which of the following is a type of transverse surface wave that can only move horizontally and vibrates the ground perpendicularly to its motion?

- W) P-wave
- X) Love wave
- Y) S-wave
- Z) Rayleigh wave

ANSWER: X) LOVE WAVE

## **BONUS**

7) Earth and Space – *Multiple Choice* In what type of sand dune would you expect to find coastal areas covered with vegetation?

- W) Transverse
- X) Barchan
- Y) Parabolic
- Z) Longitudinal

ANSWER: Y) PARABOLIC

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## **TOSS-UP**

8) Physics – *Short Answer* Devices like hard drives and credit cards use ferromagnets to store information over time. What name is given to the phenomenon that allows for ferromagnets to retain history of their previous states?

ANSWER: HYSTERESIS

## **BONUS**

8) Physics – *Short Answer* What property of the strong force causes it to decrease in magnitude as particles get closer together, while increasing in magnitude as they get further apart?

ANSWER: ASYMPTOTIC FREEDOM

### **TOSS-UP**

9) Biology – *Short Answer* Identify all of the following three statements that are true regarding vitamins: 1) Vitamin C is required for blood clotting; 2) Vitamin E is an antioxidant that helps to prevent damage to cell membranes; 3) Vitamin D is water-soluble.

ANSWER: 2 ONLY

### **BONUS**

9) Biology – *Short Answer* Pesticide runoff is absorbed by plankton, which are then consumed by small fish. These fish are then eaten by a shark, leading to a high concentration of the pesticide in the shark’s tissues and leading to toxicity. What is the name of this process?

ANSWER: BIOMAGNIFICATION (DO NOT ACCEPT: BIOACCUMULATION)

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### **TOSS-UP**

10) Chemistry – *Short Answer* Bonding molecular orbitals are created as a result of what type of wave interference?

ANSWER: CONSTRUCTIVE

### **BONUS**

10) Chemistry – *Short Answer* What is the root mean square speed in meters per second of a sample of four particles, each with speeds of 100, 200, 300, and 400 meters per second?

ANSWER: 50 TIMES THE SQUARE ROOT OF 30

## **TOSS-UP**

11) Energy – *Short Answer* Scientists in the Arnold Group at UC Berkeley have discovered new types of bonding in metal-ligand actinide complexes, one of which is a type of delta bond. Identify all of the following pairs of orbitals that can form delta interactions: 1) d and d; 2) d and pi star; 3) d and sigma.

ANSWER: 1 AND 2

## **BONUS**

11) Energy – *Short Answer* Scientists at Lawrence Berkeley National Lab have been trying to replicate early-universe conditions using lasers. Identify all of the following three statements that are true regarding lasers: 1) They involve stimulated emission; 2) They must be in thermal equilibrium; 3) They require population inversion.

ANSWER: 1 AND 3

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## **TOSS-UP**

12) Math – *Short Answer* In the integers mod 13, what is 5 times 5 + 9?

ANSWER: 8

## **BONUS**

12) Math – *Multiple Choice* Assume 70% of teenagers who took a math test studied while the rest did not. Those who did study had a pass rate of 77%, and those who did not had a pass rate of 60%. The probability that a teenager who passed the math test did NOT study for the test is closest to which of the following?

- W) 25%
- X) 30%
- Y) 35%
- Z) 40%

ANSWER: W) 25%

## **TOSS-UP**

13) Chemistry – *Short Answer* A student is investigating a sample of elemental phosphorus. The student finds it to be highly flammable, and upon X-ray diffraction, discovers that it exists as molecules of four tetrahedrally-arranged phosphorus atoms. What allotrope of phosphorus is being investigated?

ANSWER: WHITE PHOSPHORUS

## **BONUS**

13) Chemistry – *Multiple Choice* Which of the following elements has a first ionization energy closest to that of boron?

- W) Beryllium
- X) Carbon
- Y) Aluminum
- Z) Silicon

ANSWER: Z) SILICON

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## **TOSS-UP**

14) Energy – *Short Answer* Scientists in the Long Group study the magnetic properties of metals for applications in quantum computing. What type of magnetism is created when neighboring magnetic moments are opposing but unequal in magnitude?

ANSWER: FERRIMAGNETISM (DO NOT ACCEPT: FERROMAGNETISM)

## **BONUS**

14) Energy – *Multiple Choice* Researchers at UC Berkeley’s Department of Integrative Biology have been studying gluconeogenesis to develop better treatments for traumatic brain injury, or TBI. Which of the following enzymes is NOT involved in the gluconeogenesis pathway?

- W) Pyruvate carboxylase
- X) Phosphofructokinase-1
- Y) Phosphoenolpyruvate carboxykinase
- Z) Fructose-1,6-bisphosphatase

ANSWER: X) PHOSPHOFRUCTOKINASE-1

## **TOSS-UP**

15) Earth and Space – *Multiple Choice* Which of the following volcanic intrusive bodies is a mass of igneous rock near the surface that causes uplift, usually in the shape of a dome?

- W) Batholith
- X) Laccolith
- Y) Dike
- Z) Sill

ANSWER: X) LACCOLITH

## **BONUS**

15) Earth and Space – *Multiple Choice* At which of the following plate boundaries would a volcanic island arc most likely be found?

- W) Oceanic-oceanic divergence
- X) Oceanic-continental divergence
- Y) Oceanic-oceanic convergence
- Z) Oceanic-continental convergence

ANSWER: Y) OCEANIC-OCEANIC CONVERGENCE

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## **TOSS-UP**

16) Biology – *Multiple Choice* In C4 plants, which of the following cell types contains the enzyme PEP carboxylase?

- W) Mesophyll
- X) Bundle sheath
- Y) Collenchyma
- Z) Epidermal guard

ANSWER: W) MESOPHYLL

## **BONUS**

16) Biology – *Short Answer* Identify all of the following three statements that are true regarding the Krebs cycle: 1) NADH is produced during the conversion of alpha-ketoglutarate to succinyl-CoA ; 2) The conversion of citrate to isocitrate is catalyzed by citrate lyase; 3) The conversion of fumarate to malate is catalyzed by fumarase.

ANSWER: 1 AND 3

## **TOSS-UP**

17) Physics – *Multiple Choice* A positive 2-microcoulomb charge is placed along the  $x$ -axis one centimeter to the left of a negative 4-microcoulomb charge. At which of the following locations is the electric field equal to zero?

- W) Left of the positive charge
- X) In between the charges
- Y) Right of the negative charge
- Z) There is no location where the electric field is zero

ANSWER: W) LEFT OF THE POSITIVE CHARGE

## **BONUS**

17) Physics – *Multiple Choice* The exhaust heat of the first Carnot cycle is used to power a second Carnot cycle. The first Carnot cycle has hot and cold reservoirs at 1000 and 500 kelvins, respectively, and the second Carnot cycle has hot and cold reservoirs at 500 and 100 kelvins, respectively. What is the efficiency of the overall system?

- W) 60%
- X) 80%
- Y) 90%
- Z) 95%

ANSWER: Y) 90%

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## **TOSS-UP**

18) Math – *Short Answer* A teacher is buying chocolate bars for her entire class. If Cadburys cost \$2 each, and Toblerones cost \$3 each, how many different combinations of chocolate bars can be purchased for exactly \$50?

ANSWER: 9

## **BONUS**

18) Math – *Short Answer* The average of the five consecutive positive integers starting with 13 is equal to  $x$ . What is the average of the five consecutive positive integers starting with  $x$ ?

ANSWER: 17

## **TOSS-UP**

19) Earth and Space – *Short Answer* What atmospheric boundary is the coldest region in the earth's atmosphere

ANSWER: MESOPAUSE

## **BONUS**

19) Earth and Space – *Short Answer* What is the name of the radiation law that states that a hot solid, liquid, or highly compressed gas emits a continuous spectrum?

ANSWER: KIRCHHOFF'S LAW OF THERMAL RADIATION (ACCEPT: KIRCHOFF'S LAW)

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## **TOSS-UP**

20) Physics – *Multiple Choice* A conducting sphere of radius  $R$  is put inside a hollow conducting spherical shell of radius  $a$ . The sphere has a net charge of  $+Q$ , and the shell has a net charge of  $-Q$ . The potential difference between the inner sphere and outer spherical shell is directly proportional to which of the following?

- W)  $1/a$
- X)  $1/a^2$
- Y)  $1/R$
- Z)  $1/R^2$

ANSWER: Y)  $1/R$

## **BONUS**

20) Physics – *Short Answer* A physicist is studying a three-dimensional electric field that goes to zero as  $x$ ,  $y$ , and  $z$  approach infinity. What theorem states that this electric field can be fully described by its divergence and curl?

ANSWER: HELMHOLTZ THEOREM

## **TOSS-UP**

21) Biology – *Multiple Choice* Which symptom is characteristic of a patient with *Nephrogenic diabetes insipidus*, in which kidneys are unresponsive to ADH hormone?

- W) Decreased levels of plasma ADH
- X) Increased levels of plasma ADH
- Y) Elevated plasma glucose levels
- Z) Dilute urine

ANSWER: Z) DILUTE URINE

## **BONUS**

21) Biology – *Multiple Choice* Which of the following cell types is most likely to respond to the adjuvant component of a vaccine directly?

- W) Neutrophil
- X) B cell
- Y) Dendritic cell
- Z) Epithelial cell

ANSWER: DENDRITIC CELL

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## **TOSS-UP**

22) Chemistry – *Short Answer* The formation of chlorobenzene from benzene, chlorine, and aluminum chloride is over two times faster than the formation of deuterated chloro-benzene from deuterated benzene, chlorine, and aluminum chloride. This phenomenon can be explained by what effect?

ANSWER: KINETIC ISOTOPE EFFECT (ACCEPT: KIE, PRIMARY KIE)

## **BONUS**

22) Chemistry – *Short Answer* Identify all of the following three statements that are true regarding Diels-Alder reactions: 1) *Exo* products are generally formed faster; 2) Water has been found to increase reaction rates; 3) They are regioselective.

ANSWER: 2 AND 3

### **TOSS-UP**

23) Math – *Multiple Choice* Using Stirling’s approximation and the natural log simplification, what is the approximation for the natural log of 100 factorial?

- W) 100 times the natural log of 100
- X) The natural log of 100 minus 100
- Y) 100 times the natural log of 100 plus 100
- Z) 100 times the natural log of 100 minus 100

ANSWER: Z) 100 TIMES THE NATURAL LOG OF 100 MINUS 100

### **BONUS**

23) Math – *Short Answer* What is the total number of palindromic natural numbers below 10,000?

ANSWER: 198