

**TOSS-UP**

- 1) Biology – *Short Answer* In noncyclic electron flow, what is the final electron acceptor of Photosystem 1?

ANSWER: NADP<sup>+</sup>

**BONUS**

- 1) Biology – *Multiple Choice* Which of the following least accurately describes archaea?

- W) Their cell membranes are phospholipid monolayers
- X) Fatty acids in their cell membranes are linked with ester bonds
- Y) They are more tolerant to high salinity than most eubacteria
- Z) Their cell walls contain pseudopeptidoglycan

ANSWER: X) FATTY ACIDS IN THEIR CELL MEMBRANES ARE LINKED WITH ESTER BONDS

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**TOSS-UP**

- 2) Earth and Space – *Short Answer* Which of the following 3 statements is true about Antarctic Bottom Water, or AABW? 1) Temperatures range from -4 to -0.5 degrees C; 2) It is formed from surface water cooling in polynyas and near the ice shelf; 3) Recent climate change and consequent melting of the Antarctic ice sheet has slowed the formation of AABW.

ANSWER: 2, 3

**BONUS**

- 2) Earth and Space – *Short Answer* What is the primary mechanism that removes star forming gas from a galaxy when it moves towards the center of a galaxy cluster?

ANSWER: RAM PRESSURE STRIPPING (ACCEPT: RAM PRESSURE)

### **TOSS-UP**

3) Physics – *Short Answer* A 5 kg box moving at 4 m/s collides inelastically with a stationary 3 kg box. What is the final velocity of the boxes?

ANSWER: 2.5 m/s

### **BONUS**

3) Physics – *Short Answer* A 3 cubic meter block is submerged half in oil and half in water, and is in static equilibrium. If the density of water is  $1000 \text{ kg/m}^3$  and the density of oil is  $800 \text{ kg/m}^3$ , what is the mass of the block?

ANSWER: 2700 kg

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### **TOSS-UP**

4) Math – *Short Answer* A string of 3 letters, each letter being A or B is randomly chosen. What is the probability of having more B's than A's in the string?

ANSWER: 1/2

### **BONUS**

4) Math – *Multiple Choice* Which of the following best describes the Euclidean Algorithm for finding the greatest common divisor of two numbers?

- W) Prime factorize each of the numbers and pick the primes out
- X) Multiply both of the numbers and divide by the least common multiple
- Y) Using remainders by dividing the larger by the smaller and repeating
- Z) Multiply both the numbers and divide by their difference

ANSWER: Y) USING REMAINDERS BY DIVIDING THE LARGER BY THE SMALLER AND REPEATING

### **TOSS-UP**

5) Chemistry – *Short Answer* Which of the following is true about solid solutions? 1) The exsolution of solid solutions forms lamellae that are characterized by differing cation size; 2) The lowest melting of a solid solution is usually near an endmember; 3) The Hume-Rothery rules govern the formation of solid solutions based on similar electronegativities and atomic radii.

ANSWER: 1, 3

### **BONUS**

5) Chemistry – *Short Answer* Which of the following is true about the addition of oxygen to a Grignard reagent? 1) radical intermediates are formed; 2) a magnesium organoperoxide is formed; 3) the halide is removed as an anion

ANSWER: 1, 2



### **TOSS-UP**

6) Biology – *Short Answer* What bond links the phosphates of an ATP molecule?

ANSWER: PHOSPHOANHYDRIDE BONDS

### **BONUS**

6) Biology – *Short Answer* What class of noncoding RNAs are utilized in CRISPR systems to guide the endonuclease complex to the target sequence?

ANSWER: GUIDE RNA (ACCEPT: gRNA)

### **TOSS-UP**

7) Earth and Space – *Multiple Choice* Which of the following igneous structures is a small batholith-like discordant intrusion?

- W) Laccolith
- X) Stock
- Y) Lopolith
- Z) Sphere dike

ANSWER: X) STOCK

### **BONUS**

7) Earth and Space – *Short Answer* Order the following minerals in terms of increasing relative stability at standard temperature and pressure: 1) vermiculite; 2) magnesiowustite; 3) sillimanite; 4) andalusite

ANSWER: 2, 3, 4, 1

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### **TOSS-UP**

8) Physics – *Short Answer* Which fundamental force violates charge parity?

ANSWER: WEAK NUCLEAR FORCE

### **BONUS**

8) Physics – *Short Answer* A hollow, air cored inductor coil consists of 200 turns of copper wire, which produces a magnetic flux of 6 milliwebers when passing a DC current of 10 amps. Calculate the self-inductance of the coil in milli-Henries.

ANSWER: 120 mH

**TOSS-UP**

9) Math – *Short Answer* What is the period of the function  $f(x) = \sin^2(x) * \cos^2(x)$ ?

ANSWER:  $\pi/2$

**BONUS**

9) Math – *Short Answer* What is the area between the curves  $y = x^3$  and  $y = x + 2$  between  $x = 0$  and  $x = 1$ ?

ANSWER: 9/4 (ACCEPT: 2 ¼, 2.25)

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**TOSS-UP**

10) Chemistry – *Multiple Choice* Which of the following cations is the most stable?

- W)  $\text{Al}^+$
- X)  $\text{Ga}^+$
- Y)  $\text{In}^+$
- Z)  $\text{Tl}^+$

ANSWER: Z)  $\text{Tl}^+$

**BONUS**

10) Chemistry – *Short Answer* What important metal oxide is used to oxidize alkenes into *vic* diols, also used as a staining agent in TEM to provide contrast to the image?

ANSWER: OSMIUM TETROXIDE (ACCEPT:  $\text{OsO}_4$ , osmium (VIII) oxide)

### **TOSS-UP**

11) Biology – *Multiple Choice* PIN Proteins in plants are associated with the transport of what major plant hormone?

- W) Auxins
- X) Gibberellins
- Y) Cytokinins
- Z) Ethylene

ANSWER: W) AUXINS

### **BONUS**

11) Biology – *Multiple Choice* The first step of the Calvin cycle, catalyzed by Rubisco, forms what molecule?

- W) 1,5-Bisphosphate
- X) 3-Phosphoglycerate
- Y) 1,3-Bisphosphoglycerate
- Z) Glyceraldehyde 3-Phosphate

ANSWER: X) 3-PHOSPHOGLYCERATE

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### **TOSS-UP**

12) Earth and Space – *Multiple Choice* Which of the following minerals cannot be mined as a source of copper?

- W) Chalcopyrite
- X) Azurite
- Y) Bornite
- Z) Pentlandite

ANSWER: Z) PENTLANDITE

### **BONUS**

12) Earth and Space – *Short Answer* Which of the following statements about important angles in structural geology is true? 1) true dip is always greater than apparent dip; 2) trend is equal to strike if the ground surface is parallel to the horizontal plane; 3) plunge is measured along the limb of a fold

ANSWER: 1, 2, 3 (ACCEPT: ALL)

### **TOSS-UP**

13) Physics – *Short Answer* When a free neutron decays into a proton via beta minus decay, what particle mediates the flavor change from the down quark into an up quark?

ANSWER: W<sup>-</sup> BOSON

### **BONUS**

13) Physics – *Short Answer* A particular planet has mass  $7.0 \times 10^{23}$  kg and a radius of  $2.0 \times 10^6$  m. What is the escape velocity, in meters per second, on this planet? Take G to be  $7 \times 10^{-11}$  Nm<sup>2</sup>kg<sup>-2</sup> (Read as: Newton meters squared per kilogram squared)

ANSWER: 7,000 m/s

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### **TOSS-UP**

14) Math – *Multiple Choice* Which of the following is equivalent to  $\cosh(2x)$ ?

- W)  $\sinh^2(2x)$
- X)  $1 + 2\sinh^2(x)$
- Y)  $2\sinh(x)\cosh(x)$
- Z)  $\sinh^2(x)$

ANSWER: X)  $1 + 2\sinh^2(x)$

### **BONUS**

13) Math – *Short Answer* What is the sum of the values in the matrix that results from the multiplication of a 2 by 3 matrix with all values being 6 and a 3 by 2 matrix with all values being 7?

ANSWER: 126

### **TOSS-UP**

15) Chemistry – *Short Answer* What quantity describes useful work obtained from a closed isothermal and isochoric system?

ANSWER: HELMHOLTZ FREE ENERGY

### **BONUS**

15) Chemistry – *Short Answer* Even as aromatic rings are interrupted by an sp<sup>3</sup> carbon atom, they can still maintain aromaticity through what mechanism, seen in molecules like C<sub>8</sub>H<sub>9</sub><sup>+</sup>?

ANSWER: HOMOAROMATICITY



### **TOSS-UP**

16) Biology – *Multiple Choice* Which of the following gives myelin its characteristic white color?

- W) Water
- X) Proteins
- Y) Phospholipids
- Z) Glycolipids

ANSWER: Z) GLYCOLIPIDS

(Fun fact: the main glycolipid of myelin is galactocerebroside!)

### **BONUS**

16) Biology – *Short Answer* What oval-shaped mechanoreceptor is located in the Stratum basale of the skin and is essential for light touch sensation?

ANSWER: MERKEL CELLS (ACCEPT: MERKEL-RANVIER CELLS, TACTILE EPITHELIAL CELLS)

### **TOSS-UP**

17) Earth and Space – *Multiple Choice* The phase transition of spinel structured ringwoodite into the denser perovskite phases of magnesiowustite and bridgmanite occurs at which of the following depths?

- W) 100 km
- X) 220 km
- Y) 410 km
- Z) 660 km

ANSWER: Z) 660 km

### **BONUS**

17) Earth and Space – *Multiple Choice* In stars above 0.3 solar masses, what is the transition layer between the radiative zone and convective zone, representing significant rotational shear between the two layers?

ANSWER: TACHOCLINE

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### **TOSS-UP**

18) Physics – *Short Answer* An ideal refrigerator is operating between temperatures of 27 degrees celsius and 77 degrees celsius. What is the coefficient of performance of this refrigerator?

ANSWER: 7

### **BONUS**

18) Physics – Short Answer A ball with moment of inertia  $(2/5)mr^2$  rolls down a 30 degree inclined plane. What is its acceleration?

ANSWER:  $3.5 \text{ m/s}^2$

**TOSS-UP**

19) Math – *Short Answer* 5 students are sitting at a round table. How many seatings are possible if rotations are indistinct?

ANSWER: 24

**BONUS**

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

ANSWER: 84

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**TOSS-UP**

20) Chemistry – *Multiple Choice* Which of the following solids has a zincblende structure?

- W) Sodium fluoride
- X) Gallium arsenide
- Y) Caesium chloride
- Z) Silver chloride

ANSWER: X) GALLIUM ARSENIDE

**BONUS**

20) Chemistry – *Short Answer* Assuming there are no rings or triple bonds, how many double bonds are present in the molecule C<sub>12</sub>H<sub>15</sub>O<sub>2</sub>Cl?

ANSWER: 5