

[ROUND NAME GOES HERE]

TOSS-UP

1) Physics – *Short Answer* When unpolarized light strikes a material at a specific angle, the light reflected is perfectly polarized. What law in optics uses the index of refraction of the material to find the measure of this angle?

ANSWER: BREWSTER'S LAW

BONUS

1) Physics – *Short Answer* A wave of light initially passes through a polarizer, then through an analyzer with a transmission axis at an angle of 60 degrees to the polarizer's axis. If the light has an intensity X when incident on the analyzer, what will the intensity of the light be after it passes through the analyzer, in terms of X ?

ANSWER: $X/4$

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**TOSS-UP**

2) Chemistry – *Short Answer* State all of the following four gas laws that relate any of the temperature, volume, or pressure of an ideal gas and who's equations can be used to form the ideal gas law: 1) Charles' Law 2) Graham's Law 3) Gay-Lussac's Law 4) Boyle's Law

ANSWER: 1, 3, 4

**BONUS**

2) Chemistry – *Short Answer* A glass bowl of mass 2.5 kilograms contains a quantity of water of mass 2 kilograms, and both are at a temperature of 15 degrees celsius. Given that the specific heat of glass is  $840 \text{ J/kg}^\circ\text{C}$  and the specific heat of water is  $4186 \text{ J/kg}^\circ\text{C}$ , how much heat input in kilojoules needed to raise the temperature of both the glass bowl and the water to 30 degrees celsius, rounded to the nearest whole number?

ANSWER: 157 KILOJOULES

### TOSS-UP

3) Biology – *Short Answer* How many sister chromatids are contained in a diploid human cell that is undergoing metaphase?

ANSWER: 92

### BONUS

3) Biology – *Short Answer* For each of the following four phenomena, determine whether it occurs more commonly in animal or plant cells.

- I. Lysing when immersed in a hypotonic solution
- II. Plasmolysis when immersed in a hypertonic solution
- III. Formation of a cleavage furrow during cytokinesis
- IV. Presence of centrioles in the cytoplasm

ANSWER: ANIMAL CELL, PLANT CELL, ANIMAL CELL, ANIMAL CELL

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### TOSS-UP

4) Math – *Short Answer* If  $a$  and  $b$  are the zeros of  $f(x) = x^2 + 17x + 20$ , find the value of  $a^2 + b^2$ .

ANSWER: 249

### BONUS

4) Math – *Short Answer* Find the derivative at  $x = 4$  for the function  $f(x) = x^3 + 23x^2 + 56x + 4$ .

ANSWER: 288

### TOSS-UP

5) Earth and Space Science – *Short Answer* Identify, by name or number, all of the following three that are basic laws of radiation: 1) All objects emit radiant energy; 2) Hotter objects radiate more total energy than do colder objects; 3) The hotter the radiating body, the shorter the wavelengths of maximum radiation.

ANSWER: All or I,II,III

### BONUS

5) Earth and Space Science – Multiple Choice Which way do isotherms generally trend?

- W) West to East
- X) East to West
- Y) North to South
- Z) South to North

ANSWER: X) East to West

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### TOSS-UP

6) Physics – *Multiple Choice* Under which of the following conditions would the kinematic equations used to relate position, velocity, and acceleration not apply?

- W) Negative Position
- X) Negative Velocity
- Y) Constant Acceleration
- Z) Changing Acceleration

ANSWER: Z) CHANGING ACCELERATION

### BONUS

6) Physics – *Multiple Choice* A box sits at the top of a frictionless ramp at an angle of 30 degrees and a slope of length 25 meters. If the box begins to slide down the ramp from rest, what will its final velocity be, in meters per second to the nearest tenth, just before it slides off the ramp?

ANSWER: 15.7

### TOSS-UP

7) Chemistry – *Multiple Choice* If an electron has a principal quantum number of 3, which of the following is NOT a possible value for its magnetic quantum number?

- W) -2
- X) 0
- Y) 1
- Z) 3

ANSWER: Z) 3

### BONUS

7) Chemistry – *Multiple Choice* If a certain ion has an electron configuration of  $1s^2 2s^2 2p^6 3s^2 3p^6$ , which of the following could be the identity of the ion?

- W)  $F^+$
- X)  $N^{3-}$
- Y)  $P^{3-}$
- Z)  $Ni^{2+}$

ANSWER: Y)  $P^{3-}$

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### TOSS-UP

8) Biology – *Multiple Choice* At any given point, the majority of cells in the human body are in what cellular phase?

- W)  $G_0$
- X)  $G_1$
- Y)  $G_2$
- Z) M

ANSWER: W)  $G_0$

### BONUS

8) Biology – *Multiple Choice* Which of the following is not an example of apoptosis?

- W) Formation of an embryo's digits through the elimination of interdigital tissue
- X) Reduction of a tadpole's tail as it matures into an adult frog
- Y) Neuron death in Parkinson's disease
- Z) An organism's death due to cancer metastasis

ANSWER: Z) AN ORGANISM'S DEATH DUE TO CANCER METASTASIS

### TOSS-UP

9) Math – *Short Answer* Let P be a point inside equilateral triangle ABC such that  $AB=2$ . Find the sum of the shortest lengths from P to all the sides of ABC

ANSWER:  $\sqrt{3}$

### BONUS

9) Math – *Short Answer* Find the sum of the coefficients of the derivative of  $x^{2020}+x^{2019}+x^{2018}+\dots+x+1$

ANSWER: 2,041,210



### TOSS-UP

10) Earth and Space Science – *Short Answer* Calculate the mixing ratio if the mass of water vapor in a unit of air is 20 grams and the mass of dry air is 1000 grams.

ANSWER: 20

### BONUS

10) Earth and Space Science – *Short Answer* Calculate the relative humidity if the air's actual water-vapor content is 5 grams and the saturation at 25 degrees celsius is 50 grams.

ANSWER: 10%

### TOSS-UP

11) Physics – *Short Answer* For a charge moving with a constant velocity away from a viewer's perspective, in what direction will the magnetic force vector and magnetic field vector point, respectively?

ANSWER: UPWARD AND LEFTWARD

### BONUS

11) Physics – *Short Answer* A car is driving around a circular track of radius 50 meters with a velocity of 6 meters per second. What must be the minimum value, to the nearest hundredth, of the coefficient of friction of the track if the car needs to move without sliding?

ANSWER: 0.07

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### TOSS-UP

12) Biology – *Multiple Choice* Which of the following is not true for plants that undergo crassulacean acid metabolism, also known as CAM plants?

- W) CAM plants close their stomata during the day and open their stomata during the night
- X) CAM plants synthesize and store malic acid inside vacuoles in their cells at night
- Y) CAM plants often have thick leaves and a thick plant cuticle
- Z) CAM plants are most commonly found in humid climates

ANSWER: Z) CAM PLANTS ARE MOST COMMONLY FOUND IN HUMID CLIMATES

### BONUS

12) Biology – *Short Answer* Order the following three colors of light from least to most absorption by chlorophyll *b*.

- I. Blue
- II. Green
- III. Red

ANSWER: II, III, I

### TOSS-UP

13) Chemistry – *Short Answer* What type of reaction occurs when silver nitrate is combined with a solution of sodium chloride to produce the compound silver chloride as one of its products?

ANSWER: PRECIPITATION

### BONUS

13) Chemistry – *Short Answer* Identify the element that has the characteristic of the following given atomic properties: 1) Highest Electron Affinity 2) Highest Electronegativity 3) Lowest Atomic Radius

ANSWER: 1) CHLORINE 2) FLUORINE 3) HELIUM

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### TOSS-UP

14) Math – *Short Answer* What is the largest number that cannot be written as a sum of 99s and 101s?

ANSWER: 9799

### BONUS

14) Math – *Short Answer* Four students got scores of 83, 87, 92, and 98 on a paper. In how many orders can the teacher pass back the papers so that the average score of the papers that have been passed back is always an integer?

ANSWER: 2

### TOSS-UP

15) Earth and Space Science – *Multiple Choice* Which of the following is not a classification for meteorites?

W) Irons

X) Stony-Irons

Y) Chondrites

Z) Stonites

ANSWER: Z) Stonites

### BONUS

15) Earth and Space Science – *Multiple Choice* If the temperature of 1 star is -40 degrees celsius while the other star has a temperature of -40 degrees fahrenheit then how many times greater is the total radiation emitted from 1 star compared to the other star?

W) 16

X) 8

Y) 4

Z) 1

ANSWER: Z) 1

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### TOSS-UP

16) Physics – *Multiple Choice* Which one of the following Maxwell's equations can be used to relate the flow of an electric field through an area to the charge enclosed?

W) Gauss' Law for Magnetism

X) Faraday's Law of Induction

Y) Modified Ampere's Equation

Z) Gauss' Law of Electric Flux

ANSWER: Z) GAUSS' LAW OF ELECTRIC FLUX

### BONUS

16) Physics – *Multiple Choice* A charge of 2 microcoulombs is moving in the positive x direction with a velocity of 5 meters per second, with a magnetic field of strength 3 microteslas oriented at an angle of 30 degrees to the velocity of the charge. What is the magnitude of the magnetic force, in newtons exerted on the test charge?

ANSWER:  $1.5 \times 10^{-11}$



### TOSS-UP

17) Math – *Short Answer* In the GammaZero committee there are 13 men and 5 women. They randomly create a subcommittee called the BetaZero committee consisting of 2 people. What is the probability that there is 1 man and 1 woman on this committee?

ANSWER: 13/21

### BONUS

17) Math – *Short Answer* What is the remainder when  $2016!$  is divided by 2017?

ANSWER: 2016

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### TOSS-UP

18) Chemistry – *Short Answer* What bonds are created by the sideways overlap of p orbitals?

ANSWER: Pi Bonds

### BONUS

18) Chemistry – *Short Answer* When solid, liquid and gas are at equilibrium what is that point called on a phase diagram?

ANSWER: Triple Point

### TOSS-UP

19) Biology – *Short Answer* In which of the following three stages are distinct chromosomes observable with a light microscope?

- I. Interphase
- II. Metaphase
- III. Cytokinesis

ANSWER: II

### BONUS

19) Biology – *Short Answer* Order the following three stages of the cell cycle from shortest to longest duration.

- I. Interphase
- II. Prometaphase
- III. Anaphase

ANSWER: III, II, I



### TOSS-UP

20) Earth and Space Science – *Short Answer* What is it called when the lens acts like a prism and spreads out the colors in the light?

ANSWER: Chromatic Aberration

### BONUS

20) Earth and Space Science – *Question Type* Approximately how many years is one sunspot cycle?

ANSWER: 11

### TOSS-UP

21) Physics – *Multiple Choice* According to the Stefan-Boltzmann Equation, used to find the heat flow due to radiation emitted by an object, the emitted energy of an object per unit time due to radiation is proportional to its temperature raised to what power?

- W) 1
- X) 2
- Y) 4
- Z) 16

ANSWER: Y) 4

### BONUS

21) Physics – *Multiple Choice* The end of a square aluminium rod is placed near a heat source and is at a temperature of 60 degrees celsius. Given that the thermal conductivity of aluminium is  $200 \text{ J/s}\cdot\text{m}\cdot^{\circ}\text{C}$  and the cross sectional area through which heat transfer occurs is  $10 \text{ cm}^2$ , what is the heat flow, in Joules per second to the nearest whole number, to a point on the rod 15 cm away from the end at a temperature of 55 degrees celsius?

- W) 3
- X) 7
- Y) 18
- Z) 30

ANSWER: X) 7



### TOSS-UP

22) Chemistry – Short Answer  $\alpha$ -decay(read as alpha decay) will decrease the mass number by x and the atomic number by y. Find the product of x and y.

ANSWER: 8

### BONUS

22) Chemistry – *Short Answer* What is it called when larger unstable nuclei split into smaller more stable nuclei?

ANSWER: Fission accept Nuclear Fission

### TOSS-UP

- 23) Earth and Space Science – *Multiple Choice* Which of the following was not a part of Gondwana?  
W) South America  
X) India  
Y) Antarctica  
Z) Siberia

ANSWER: Z) Siberia

### BONUS

- 23) Earth and Space Science – *Short Answer* What is the distance that wind has traveled across open water called?

ANSWER: Fetch



### TOSS-UP

- 24) Biology – *Short Answer* Which of the following four invertebrate phyla are characterized by the inclusion of a brain in their nervous systems?

- I. Echinodermata
- II. Annelida
- III. Platyhelminthes
- IV. Tardigrada

ANSWER: II, III, IV

### BONUS

- 24) Biology – *Short Answer* For each of the following three examples, determine whether the response is caused by the sympathetic division or the parasympathetic division of the autonomic nervous system.

- I. Increased glycogen production
- II. Dilation of the pupils
- III. Constriction of the bronchi

ANSWER: PARASYMPATHETIC, SYMPATHETIC, PARASYMPATHETIC



### TOSS-UP

- 25) Math – *Multiple Choice* Which of the following is not a deficient number?

- W) 27
- X) 223

### TOSS-UP

Y) 224

Z) 259

ANSWER: Y) 224

### BONUS

25) Math – *Short Answer* Find all real solutions of  $x^3 - 4x^2 - 4x - 5 = 0$ .

ANSWER: 5