TOSS-UP

1) Physics – *Short Answer* Calculate the equivalent resistance through a system of 2 resistors with resistances of 6 and 12 ohms in parallel.

ANSWER: 4 OHMS

BONUS

1) Physics – *Short Answer* A mass of 10 kilograms traveling 3 meters per second east collides perfectly elastically with a mass of 5 kilograms traveling 4 meters per second north. What is the total kinetic energy of the system following the collision, in joules?

ANSWER: 85 J

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TOSS-UP

2) Chemistry – *Short Answer* By name or number, order the following 4 intermolecular forces from STRONGEST to WEAKEST: 1) dipole-dipole; 2) London dispersion; 3) ion-dipole; 4) hydrogen bonding.

ANSWER: 3, 4, 1, 2

BONUS

2) Chemistry – *Short Answer* By name or number, identify all of the following 3 molecules that exhibit resonance: 1) NO_3; 2) NO_2; 3) CO_3; 4) CO_2

ANSWER: 1, 2, 3
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TOSS-UP

3) Biology – *Multiple Choice* Which of the following is closest to the wavelengths of light absorbed by photosystems 1 and 2, respectively?

W) 680 nm, 680 nm
X) 680 nm, 700 nm
Y) 700 nm, 680 nm
Z) 700 nm, 700 nm

ANSWER: Y) 700 nm, 680 nm

BONUS

3) Biology – *Short Answer* Kary Mullis developed what laboratory technique which repeatedly copies a specific DNA segment?

ANSWER: POLYMERASE CHAIN REACTION (ACCEPT: PCR)

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TOSS-UP

4) Earth and Space – *Short Answer* Which planets have the MOST and LEAST eccentric orbits, respectively?

ANSWER: MERCURY AND VENUS (MUST BE IN THAT ORDER)

BONUS

4) Earth and Space – *Short Answer* What era precedes the most recent era and is when Pangaea started to break up?

ANSWER: MESOZOIC
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TOSS-UP

5) Math – *Short Answer* What is the largest value of x such that $x^2 + 2x + 1$ is less than or equal to 144?

ANSWER: 11

BONUS

5) Math – *Short Answer* Convert 10,000 in base 2020 to base 2019.

ANSWER: ONE-FOUR-SIX-FOUR-ONE (DO NOT ACCEPT: 14,641)

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TOSS-UP

6) Physics – *Short Answer* A mass is being spun horizontally on a frictionless surface at a constant tangential velocity by a massless and unstretchable rod rotating about one end. If the rod doubles in length and the mass maintains its tangential velocity, by what factor is the tension on the rod multiplied?

ANSWER: 0.5

BONUS

6) Physics – *Short Answer* A ball is dropped from a height of 200 meters at the same time that another ball is thrown up from the ground with an initial velocity of 50 meters per second. Giving your answer in seconds to the nearest tenth, how long will it take for the two balls to reach the same height?

ANSWER: 4 (ACCEPT: 4.0)
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TOSS-UP

7) Chemistry – *Multiple Choice* Which of the following elements is most likely to violate the Aufbau principle?

W) Titanium
X) Chromium
Y) Iron
Z) Nickel

ANSWER: X) CHROMIUM

BONUS

7) Chemistry – *Short Answer* How many hydrogens are in 2,4,6-trimethylheptane?

ANSWER: 22

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TOSS-UP

8) Biology – *Short Answer* To what cellular structure does the COPII complex transport proteins?

ANSWER: GOLGI APPARATUS

BONUS

8) Biology – *Short Answer* In a species, red eyes are dominant to white eyes and long wings are dominant to short wings. A male that is heterozygous for both genes mates with a female that is homozygous recessive for both genes. Out of the offspring, there were 9 with red eyes and long wings, 3 with red eyes and short wings, 3 with white eyes and long wings, and 1 with white eyes and short wings. Calculate the recombination frequency, to the nearest percent.

ANSWER: 38%
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TOSS-UP

9) Earth and Space – *Short Answer* What calcium carbonate polymorph has an orthorhombic unit cell?

ANSWER: ARAGONITE

BONUS

9) Earth and Space – *Short Answer* By number, identify all of the following 3 statements that are true of seafloor spreading: 1) seafloor spreading usually occurs at convergent boundaries, 2) the newest seafloor is usually near coastlines, 3) the seafloor doesn't actually spread because it's the landmasses that move.

ANSWER: NONE

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TOSS-UP

10) Math – *Short Answer* Compute the definite integral from 10 to 13 of 2x dx.

ANSWER: 69

BONUS

10) Math – *Short Answer* Compute the sum from n equals 1 to 2020 of the fraction with numerator 1 and denominator $n^2 + n$.

ANSWER: 2020/2021
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TOSS-UP

11) Physics – *Short Answer* The angle between two ideal polarizers is 60^o. By what factor does the intensity of the light passing through the two polarizers multiplied if the angle is changed to 30^o?

ANSWER: 3

BONUS

11) Physics – *Short Answer* Two waves of the same amplitude and period interfere with each other. One of the original waves is t/4 seconds behind the other. What is the ratio between the amplitude of the new wave and the amplitude of the original waves?

ANSWER: 2

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TOSS-UP

12) Chemistry – *Short Answer* What is the formal charge of the nitrogen atom in ammonia?

ANSWER: 0

BONUS

12) Chemistry – *Short Answer* By number, order the following 3 substances from LEAST to GREATEST van't Hoff factor in water: 1) H_2O; 2) HCl; 3) H_3PO_4.

ANSWER: 1, 2, 3
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TOSS-UP

13) Biology – *Short Answer* What positively charged proteins contain many lysine and arginine residues and are where DNA wraps itself?

ANSWER: HISTONES

BONUS

13) Biology – *Short Answer* What was the first multicellular organism to have its entire genome sequenced?

ANSWER: *C. elegans* (ACCEPT: *Caenorhabditis elegans*)

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TOSS-UP

14) Earth and Space – *Multiple Choice* Which of the following statements about the Pleistocene epoch is NOT true?

W) It is contained within the Quaternary period
X) It was the first epoch where humans appeared
Y) The average temperature was much colder than today's average temperatures
Z) Tt was immediately preceded by the Paleocene epoch

ANSWER: Z) IT WAS IMMEDIATELY PRECEDED BY THE PALEOCENE EPOCH

BONUS

14) Earth and Space – *Short Answer* What is the current age, which is hypothesized to have begun with a 200 year drought that killed off some ancient civilizations like Egypt's Old Kingdom?

ANSWER: MEGHALAYAN
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TOSS-UP

15) Math – *Short Answer* By number, identify all of the following 4 statements that are true of the polynomial $x^3 + 3x^2 + 3x + 1$: 1) It is a depressed cubic; 2) It has no multiple roots; 3) It is concave down at $x = 0$; 4) Its third derivative is 0.

ANSWER: NONE

BONUS

15) Math – *Short Answer* Compute the determinant of a 2020 by 2020 matrix with all entries equal to 1.

ANSWER: 0

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TOSS-UP

16) Physics – *Short Answer* Find the velocity of a free-falling object after it has fallen 4.9 meters after being dropped from rest, given that acceleration due to gravity is 9.8 $m \cdot s^{-2}$.

ANSWER: 9.8

BONUS

16) Physics – *Short Answer* Order the following three flavors of quarks from LEAST to MOST massive: 1) Charm; 2) Top; 3) Up.

ANSWER: 3, 1, 2
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TOSS-UP

17) Chemistry – *Short Answer* What is the term for a molecule which has at least one positively charged functional group and one negatively charged functional group, but has an overall charge of zero?

ANSWER: ZWITTERION

BONUS

17) Chemistry – *Short Answer* From smallest to largest binding energy, the photoelectron spectroscopy spectrum of a neutral element has peaks of amplitudes 4 units, 4 units, 8 units. What element is this?

ANSWER: OXYGEN

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TOSS-UP

18) Biology – *Short Answer* Ferredoxins are defined as having what two elements?

ANSWER: IRON AND SULFUR (ACCEPT: SULFUR AND IRON)

BONUS

18) Biology – *Short Answer* The rate limiting step in the Krebs cycle produces alpha-ketoglutarate and CO_2 from what molecule?

ANSWER: OXALOSUCCINATE
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TOSS-UP

19) Earth and Space – *Multiple Choice* During which of the following months is the Cancer constellation most visible from the Northern hemisphere?

W) March
X) June
Y) September
Z) December

ANSWER: W) MARCH

BONUS

19) Earth and Space – *Short Answer* What mineral is the chief source of chromium?

ANSWER: CHROMITE

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TOSS-UP

20) Math – *Short Answer* Compute $e^{0.5i\pi}$.

ANSWER: i

BONUS

20) Math – *Short Answer* Define a sequence such that $a_1 = 20$, $a_2 = 20$, and for all $n > 2$, $a_n = a_{n-1} + a_{n-2}$. What is a_8?

ANSWER: 1280
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