CENTENNIAL AUTUMN SCIENCE TOURNAMENT - ROUND 5

TOSS-UP

1) Earth and Space Science – *Short Answer* By name or number, order the following three forms of aurora from most to least visible in the night sky from the ground: 1) Corona; 2) Arc; 3) Ray.

ANSWER: 1, 3, 2

BONUS

1) Earth and Space Science – *Short Answer* In hours and minutes, what is the length of a tidal day?

ANSWER: 24 HOURS 50 MINUTES

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TOSS-UP

2) Energy – *Short Answer* Researchers at the National Renewable Energy Lab are studying ways to convert solar power into alternating current. This alternating current can be converted to direct current using what device?

ANSWER: RECTIFIER

BONUS

2) Energy – *Multiple Choice* Researchers at the Energy Information Administrations are studying the capacity of solar panels. Which of the following is closest to the energy efficiency rating of commercially used solar panels?

W) 5-10%
X) 10-15%
Y) 15-30%
Z) 30-50%

ANSWER: X) 10-15%
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TOSS-UP

3) Biology – *Multiple Choice* Which of the following is an example of a prion-caused disease?

W) Kuru
X) Gastritis
Y) Achondroplasia
Z) Boils

W) KURU

BONUS

3) Biology – *Short Answer* What was thought to be the original causing agent of hepatitis D, the only known human disease to be caused by a viroid?

ANSWER: DELTA AGENT (ACCEPT HEPATITIS B AGENT)

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TOSS-UP

4) Chemistry – *Multiple Choice* Which of the following solutions will show a positive deviation from Raoult's Law?

W) Chloroform and acetone
X) Water and acetone
Y) Ethanol and acetone
Z) Benzene and acetone

Z) BENZENE AND ACETONE

BONUS

4) Chemistry – *Multiple Choice* Calculate the vapor pressure, in torr to 2 significant figures, of a mixture containing 252 g pentane and 1400 g of hexane, given that pentane and hexane have vapor pressures of 420 torr and 40 torr, respectively.

ANSWER: 120
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TOSS-UP

5) Physics – *Short Answer* A parallel-plate capacitor with capacitance C has square plate areas with A. A dielectric with dielectric constant 0.5 is put between the plates, and the side lengths of the plates are doubled. In terms of C, what is the new capacitance of the capacitor?

ANSWER: 2C

BONUS

5) Physics – *Multiple Choice* A circuit has a battery with voltage V and 2 capacitors in series, one with twice the capacitance of the other. After a long time, how much voltage will be across the higher capacitance capacitor?

W) V/3
X) 2V/3
Y) V
Z) 4V/3

ANSWER: X) 2V/3

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TOSS-UP

6) Math – *Short Answer* Brandon and Isaac each have a bag with 5 marbles: one red, one orange, one yellow, one green, and one blue. Brandon takes a marble and puts it in Isaac's bag. Then, Isaac takes a marble and puts it in Brandon's bag. What is the probability that after this interaction, Brandon and Isaac's bags look the same?

ANSWER: 1/3

BONUS

6) Math – *Short Answer* How many ways are there to rearrange the letters in CAST such that no letter is in its original place?

ANSWER: 9
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TOSS-UP

7) Earth and Space Science – *Short Answer* What fusion process does the Sun use?

ANSWER: PROTON-PROTON CHAIN (ACCEPT: P-P CHAIN)

BONUS

7) Earth and Space Science – *Multiple Choice* Which of the following is NOT true about the CNO cycle?

W) There are multiple CNO cycles
X) Fluorine is part of the CNO cycle
Y) The CNO cycle changes at very high temperatures and pressures
Z) The CNO cycle is exclusive to stars with at least 1.5 solar masses

ANSWER: Z) THE CNO CYCLE IS EXCLUSIVE TO STARS WITH AT LEAST 1.5 SOLAR MASSES

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TOSS-UP

8) Energy – *Short Answer* Researchers at Idaho National Laboratories are studying the feasibility of nuclear energy. What gaseous uranium species is synthesized to enrich uranium isotopes?

Answer: Uranium Hexafluoride (UF6)

BONUS

8) Energy – *Multiple Choice* Researchers at Idaho National Laboratories are studying the enrichment of uranium. What is Uranium's oxidation state in the final step of the uranium leaching process?

W) 0
X) +2
Y) +3
Z) +4

Answer: Z) +4
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TOSS-UP

9) Biology – *Multiple Choice* Which of the following pieces of evidence does not support the endosymbiotic theory?

W) Mitochondria are relatively the same size as modern proteobacteria
X) Mitochondria have 60S ribosomes similar to the ones in prokaryotes
Y) Mitochondria can perform binary fission
Z) Mitochondria are sensitive to the same antibiotics used to target bacteria such as streptomycin

9) ANSWER: X) MITOCHONDRIA HAVE 60S RIBOSOMES SIMILAR TO THE ONES IN PROKARYOTES

BONUS

9) Biology – *Short Answer* What term is used to describe the structures formed by sedimentary rocks and the evolutionary ancestor of chloroplasts?

ANSWER: STROMATOLITES

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TOSS-UP

10) Chemistry – *Short Answer* Pure iron reacts with excess oxygen. What product is formed?

ANSWER: FE2O3 (ACCEPT: FERRIC OXIDE, IRON (III) OXIDE)

BONUS

10) Chemistry – *Short Answer* Chlorine gas is passed into a solution of sodium hydroxide. By name or number, identify all of the following four products that are formed: 1) Water; 2) Chloride; 3) Hypochlorite; 4) Perchlorate.

ANSWER: 1, 2, 3
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TOSS-UP

11) Physics – *Short Answer* On Mars, a ball is thrown downward with a velocity of 5 m/s from a 45 meter tall building. If another ball is thrown upward from the ground with a velocity of 10 m/s, and the acceleration due to gravity on Mars is 3.7 m/s^2, after how much time will the balls collide, in seconds?

ANSWER: 3

BONUS

11) Physics – *Short Answer* There are two systems of vertical springs attached to the ground. In one, three springs are attached in series, and a block is placed on the top spring. In the other, three springs are attached to the ground, and the block is placed on all three. Assuming the springs to be massless, what is the ratio of the distance the block moves in the first system to the distance the block moves in the second system?

ANSWER: 9:1

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TOSS-UP

12) Math – *Multiple Choice* At which of the following x values is there a local minimum for the function $y = x^3 - 12x^2 + 45x + 10$?

W) x = 0
X) x = 2
Y) x = 5
Z) x = 7

ANSWER: Y) X = 5

BONUS

12) Math – *Short Answer* By name or number, identify all of the following 3 statements which are true about integration: 1) A function is continuous over a closed interval if and only if it is integrable over that interval; 2) All differentiable functions are integrable; 3) A continuous function may have a noncontinuous antiderivative.

ANSWER: 2 ONLY

TOSS-UP

13) Energy – *Short Answer* Researchers at Fermilab are building quantum computers. What is the fundamental informational unit used in quantum computers?
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ANSWER: QUBIT

BONUS

13) Energy – *Short Answer* Researchers at Fermilab are also studying applications of quantum computers in cryptography. What algorithm utilizes quantum computers to decipher standard primality-based encryption?

ANSWER: SHOR'S ALGORITHM

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TOSS-UP

14) Earth and Space Science – *Short Answer* What is the minimum sinuosity of a stream?

ANSWER: 1

BONUS

14) Earth and Space Science – *Multiple Choice* Regions that have undergone faulting are most likely to exhibit which of the following kinds of drainage patterns?

W) Dendritic
X) Rectangular
Y) Radial
Z) Centripetal

ANSWER: X) RECTANGULAR
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TOSS-UP

15) Biology – *Short Answer* Which of the following codons to amino acid pairings is incorrect?

W) UUG; Leucine
X) UUU; Tryptophan
Y) GUC; Valine
Z) GGC; Glycine

ANSWER: X) UUU; TRYPTOPHAN

BONUS

15) Biology – *Multiple Choice* Which of the following is not a core histone?

W) H2A
X) H2B
Y) H4
Z) H5

ANSWER: Z) H5

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TOSS-UP

16) Chemistry – *Multiple Choice* Light strikes a piece of sodium metal, causing free electrons to be released. Which of the following could be increased to increase the speed of the electrons?

W) Increase the intensity
X) Increase the amplitude
Y) Increase the wavelength
Z) Increase the frequency

ANSWER: Z) INCREASE THE FREQUENCY

BONUS

16) Chemistry – *Short Answer* Tomas strikes a sample of Sowonium, a metal with a work function of 2 electron volts, with light with wavelength 300 nm, giving off electrons with speed S. What wavelength of light, in nanometers, would Tomas need to strike the Sowonium metal with so that it gave off electrons at a speed of S/2?

ANSWER: 480
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TOSS-UP

17) Physics – *Multiple Choice* An object is gradually inserted into a glass of water, and the depth of the glass is much greater than the height of the object. Which of the following best describes the buoyant force as the block is pushed to the bottom of the glass?

W) As depth increases, buoyant force increases
X) As depth increases, buoyant force decreases
Y) As depth increases, buoyant force increases then decreases
Z) As depth increases, buoyant force increases then stays the same

ANSWER: Z) AS DEPTH INCREASES, BUOYANT FORCE INCREASES THEN STAYS THE SAME

BONUS

17) Physics – *Short Answer* A spherical ball of density p = 0.5 kg/L has a radius of r = 10cm. If the ball is placed on the surface of water and released, what volume of the ball becomes submerged in the water in Liters?

ANSWER: $2\pi/3$

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TOSS-UP

18) Math – *Short Answer* What is the determinant of the 2 x 2 matrix with first row 6,3 and second row -2,1?

ANSWER: 12

BONUS

18) Math – *Short Answer* If M is a 2 x 2 diagonal matrix with the property that det(M) is 6 and trace(M) = 5, then what are the eigenvalues of M?

ANSWER: 2 AND 3
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TOSS-UP

19) Earth and Space Science – *Short Answer* Neutron star mergers, also known as kilonovae, release what low frequency, non-electromagnetic form of radiant energy?

ANSWER: GRAVITATIONAL WAVES

BONUS

19) Earth and Space Science – *Short Answer* LIGO, used to detect gravitational waves, uses what device to measure stretches in spacetime, consisting of a light source, a beam splitter, and two mirrors?

ANSWER: INTERFEROMETER

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TOSS-UP

20) Math – *Multiple Choice* If x is a Mersenne prime, then x(x+1)/2 must necessarily be a:

W) Perfect number
X) Mersenne prime
Y) Multiple of 3
Z) Power of 2

ANSWER: W) PERFECT NUMBER

BONUS

20) Math – *Short Answer* If we define the aliquot sum of a number to be the sum of its proper divisors, so the aliquot sum of 6 is 1 + 2 + 3 = 6, then what is the aliquot sum of 3^{11}, given that 3^{11} equals 177,147?

ANSWER: 88,573
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TOSS-UP

21) Biology – *Short Answer* What class of mollusks have a modified muscular foot so that it is on the same side as their stomach?

ANSWER: GASTROPODA (ACCEPT: SNAILS)

BONUS

21) Biology – *Short Answer* What class of arthropods named for their three lobes went completely extinct during the End-Permian extinction?

ANSWER: TRILOBITA (ACCEPT: TRILOBITES)

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TOSS-UP

22) Chemistry – *Short Answer* By name or number, identify all of the following four elements that, when used to dope silicon, would yield an n-type semiconductor: 1) Lithium; 2) Boron; 3) Aluminum; 4) Antimony.

ANSWER: 1 AND 4

BONUS

22) Chemistry – *Short Answer* By name or number, order the following four elements in increasing order of melting point: 1) Yttrium; 2) Niobium; 3) Molybdenum; 4) Rhodium.

ANSWER: 1, 4, 2, 3
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TOSS-UP

23) Physics – *Multiple Choice* A pendulum swings with period T. If the pendulum is moved to another planet with gravity g/2, and the length of the pendulum is doubled, what is the new period of the pendulum in terms of T?

W) T/2
X) T
Y) $T\sqrt{2}$
Z) 2T

ANSWER: Z) 2T

BONUS

23) Physics – *Short Answer* If a particle has a half-life of 6000 years, if you start with 1 mole of a substance, how much will you have after 9000 years, in moles to 2 significant figures?

ANSWER: 0.35