ROUND 16

TOSS-UP

1) Physics – *Multiple Choice* Poiseuille's Law states that the pressure differential between two ends of a pipe is proportional to what power of the radius of the pipe, all else equal?

W) Radius to the Fourth Power
X) Radius to the First Power
Y) Radius to the Negative First Power
Z) Radius to the Negative Fourth Power

ANSWER: Z) RADIUS TO THE NEGATIVE FOURTH POWER

BONUS

1) Physics – *Short Answer* Structures undergo rotational motion in a differential fashion under what density wave theory?

ANSWER: LIN-SHU DENSITY

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TOSS-UP

2) Energy – *Short Answer* Scientists at SLAC National Accelerator Laboratory are studying how uranium reacts after being leaked into the environment. After being leaked, uranium is reduced to Uranium (IV), which can be found as either a biomass-associated species, or nanoparticles of uraninite. What functional group is the Uranium (IV) typically bound to allowing it to exist as a biomass-associated species?

ANSWER: PHOSPHATE GROUP

BONUS

2) Energy – *Short Answer* What oxidation state is uranium in when it is originally leaked into the environment, which is also uranium's most common oxidation state?

ANSWER: 6+ (ACCEPT URANIUM 6+)
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ROUND 16

TOSS-UP

3) Chemistry – *Multiple Choice* Which of the following is an aromatic amino acid?

W) Cysteine
X) Tyrosine
Y) Proline
Z) Asparagine

ANSWER: X) TYROSINE

BONUS

3) Chemistry – *Short Answer* An amino acid is made up of only C, H, O, and N. If the percent composition of the molecule is 32% carbon, 42.7% oxygen, 18.7% nitrogen, and 6.6% hydrogen, what is the name of this amino acid?

ANSWER: GLYCINE

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TOSS-UP

4) Biology - *Short Answer* What is the term that is caused by a high level of altruism and is known as the highest level of organization of sociality?

ANSWER: EUSOCIALITY

BONUS

4) Biology - *Multiple Choice* Which of the following organisms is NOT known to be eusocial?

W) Bees
X) Wasps
Y) Humans
Z) Naked mole-rats

ANSWER: Y) HUMANS
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ROUND 16

TOSS-UP

5) Math – *Short Answer* Given that the fourth degree polynomial $x^4 - 3x^3 + 2x^2 - x - 1$ has roots $(1 \pm i\sqrt{3})/2$, what is the sum of its real roots?

ANSWER: 2 (Solution: Since the quartic has roots $(1 \pm i\sqrt{3})/2$, it is divisible by the quadratic $(x^2 - x + 1)$, so $(x^2 + ax + b)(x^2 - x + 1) = x^4 - 3x^3 + 2x^2 - x - 1$, and $(a, b) = (-2, 1)$)

BONUS

5) Math – *Short Answer* Given that $cos(\theta) = 0.8$, what is $\frac{cos(3\theta)}{cos(\theta)}$?

ANSWER: -0.44

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TOSS-UP

6) Earth and Space - *Short Answer* Type 1A supernovae play an important role in measuring distance in space because they all have nearly the same luminosity. What is the absolute magnitude of a type 1A supernova?

ANSWER: -19.3

BONUS

6) Earth and Space - *Short Answer* By name or number, list the following 4 events relating to the formation of a type 1A supernova in chronological order: 1) A red giant and a main-sequence star exist in a binary system, 2) A red giant and a white dwarf exist in a binary system, 3) The main-sequence star accretes mass from the red giant, 4) The white dwarf accretes mass from the red giant, 5) The mass of the white dwarf reaches the Chandrasekhar limit.

ANSWER: 1, 3, 2, 4, 5
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ROUND 16

TOSS-UP

7) Energy – *Multiple Choice* Researchers at Lawrence Berkeley National Laboratory are studying how a symbiotic relationship between an archaea and a bacteria affects the production of methane, a greenhouse gas, from hydrogen. Which of the following best explains what types of organisms these archaea and bacteria are?

W) A sulfur reducing archaea, and a methanogen bacteria.
X) A methanogen archaea, and a sulfur reducing bacteria.
Y) A methanogen archaea, and a methanogen bacteria.
Z) A crenarchaeota archaea, and a gram-positive bacteria.

ANSWER: X) A METHANOGEN ARCHAEA, AND A SULFUR REDUCING BACTERIA

BONUS

7) Energy – *Short Answer* What is the specific term for the symbiotic relationship between the methanogen and the sulfur reducing bacteria, which allows them to consume lactate when working together, and is often defined as one organism feeding off the products of another organism?

ANSWER: SYNTROPHY

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TOSS-UP

8) Biology - *Short Answer* What part of the hypothalamus is responsible for controlling the circadian rhythm?

ANSWER: SUPRACHIASMATIC NUCLEUS (ACCEPT SCN)

BONUS

8) Biology - *Multiple Choice* What is the name of the bone which contains a depression that covers the pituitary gland?

W) Ethmoid
X) Mastoid
Y) Sphenoid
Z) Styloid

ANSWER: Y) SPHENOID
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ROUND 16

TOSS-UP

9) Physics – *Short Answer* Quantum harmonic oscillators have constant energy level spacing and have wave functions given by a Gaussian term times what kind of polynomial?

ANSWER: HERMITE POLYNOMIAL

BONUS

9) Physics – *Short Answer* The energy levels of the quantum harmonic oscillator are equal to the reduced planck constant times omega times the quantity n plus what constant?

ANSWER: 0.5 (ACCEPT: ONE-HALF)

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TOSS-UP

10) Chemistry – *Short Answer* To the nearest integer, what is the value of ring strain, in kJ/mol, of cyclohexane in the chair conformation?

ANSWER: 0

BONUS

10) Chemistry – *Short Answer* What is the IUPAC name of iso-octane?

ANSWER: 2, 2, 4 TRIMETHYLPENTANE

TOSS-UP

11) Math – *Short Answer* What is the name for the point in a triangle where the sum of distances from the vertices is minimized?

ANSWER: FERMAT POINT

BONUS

11) Math – *Short Answer* The distances from the vertices of an acute triangle to it's Fermat point are 3, 5, and 5. What is the area of the triangle?
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ANSWER: $\frac{55\sqrt{3}}{4}$

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TOSS-UP

12) Earth and Space - *Multiple Choice* Which of the following best describes a patch reef?

W) a coral reef growing in an irregular pattern found at significantly lower depths than what is standard
X) a coral reef located on a continental shelf growing in a roughly circular pattern
Y) a coral reef that has grown to replace a section of dead or dying reef
Z) an irregular-shaped coral reef growing at faster rates than normal and providing habitat for a larger than expected number of organisms

ANSWER: X) A CORAL REEF LOCATED ON A CONTINENTAL SHELF GROWING IN A ROUGHLY CIRCULAR PATTERN

BONUS

12) Earth and Space - *Short Answer* What is the term for the depth at which coral reef production begins to lag behind island subsidence, often referred to as the threshold for atoll formation?

ANSWER: DARWIN POINT
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ROUND 16

TOSS-UP

13) Biology - *Short Answer* What is the name of the genus of algae which has indistinguishable sporophytes and gametophytes when it goes through alternations of generations?

ANSWER: CLADOPHORA

BONUS

13) Biology - *Short Answer* It is believed that secondary endosymbiosis occurred when red or green algae was engulfed by heterotrophic eukaryotes. What is the name given to the small vestigial nucleus found in some plastids that provides evidence for this theory?

ANSWER: NUCLEOMORPH

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TOSS-UP

14) Energy – *Multiple Choice* Scientists in France were the first to sequence the genes of a polar alga. Their results revealed that the alga have more enzymes involved in lipid metabolism, especially unsaturation of fatty acids. Which of the following best explain how this alga stays warm in the polar temperatures?

W) The higher rate of metabolism in the alga releases more waste heat, keeping the alga warm.
X) The alga stay together in large colonies and use the thermal energy generated from each other to stay warm.
Y) The alga are able to produce fats, keeping them warm.
Z) Temperature has no observable effect on the alga, so there is no reason for them to stay warm.

ANSWER: Y) THE ALGA ARE ABLE TO PRODUCE FATS, KEEPING THEM WARM

BONUS

14) Energy – *Multiple Choice* The polar alga that the scientists analyzed is unique because of its ability to produce fats. Which of the following best explains how this could be beneficial to humans and the environment?

W) The alga can be used to create a substitute for fur, reducing poaching of endangered animals.
X) The fats produced by alga can be used in the production of biodiesel.
Y) The alga can be used as an energy-rich substitute for meat.
Z) The alga can be used for the production of hydrogen gas.
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ANSWER: X) THE FATS PRODUCED BY ALGA CAN BE USED IN THE PRODUCTION OF BIODIESEL

ROUND 16

TOSS-UP

15) Physics – *Short Answer* What theorem can be used to show that the time-averaged kinetic and potential energies for harmonic oscillators are equal?

ANSWER: VIRIAL THEOREM

BONUS

15) Physics – *Multiple Choice* A crystal made entirely of harmonic oscillators will have what values for thermal conductivity, C and thermal expansion, E, respectively?

W) C = 0; E = 0
X) C = 0; E = Infinity
Y) C = Infinity; E = 0
Z) C = Infinity; E = Infinity

ANSWER: Y) C = INFINITY; E = 0

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TOSS-UP

16) Earth and Space - *Multiple Choice* Which of the following is NOT one of the three most common mineral forms calcium carbonate can be found in?

W) calcite
X) aragonite
Y) wolframite
Z) vaterite

ANSWER: Y) WOLFRAMITE

BONUS

16) Earth and Space - *Short Answer* Aragonite is generally only found in recent deposits of calcium carbonate because its geometric configuration is less stable than the hexagonal structure of calcite. What type of crystal system does aragonite have?

ANSWER: ORTHORHOMBIC
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ROUND 16

TOSS-UP

17) Chemistry – *Multiple Choice* Which of the following reactions is most likely to occur without external voltage?

W) $Ca + Ba^{2+} \rightarrow Ca^{2+} + Ba$ (READ C-A plus B-A 2 plus yields C-A two plus, plus B-A)
X) $2Al + 3Sr^{2+} \rightarrow 2Al^{3+} + 3Sr$
Y) $Fe + Co^{2+} \rightarrow Fe^{2+} + Co$
Z) $Cu + Sn^{2+} \rightarrow Cu^{2+} + Sn$

ANSWER: Y) $Fe + Co^{2+} \rightarrow Fe^{2+} + Co$

BONUS

17) Chemistry – *Short Answer* How long, in minutes to the nearest hundred, would a 6.42 amp current need to be running through a solution of calcium nitrate in order to plate 80 grams of calcium?

ANSWER: 1000

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TOSS-UP

18) Math – *Short Answer* Two brothers (brother A and brother B) are playing a game in which brother A goes first. On his turn, a player flips 2 coins, each with probability $\frac{4}{5}$ of coming up heads. If both flips are tails, the brother wins. Otherwise, the other brother takes a turn. The brothers play until someone wins. What is the probability that brother A wins?

ANSWER: $\frac{25}{49}$

BONUS

18) Math – *Short Answer* A coin is flipped till it reaches 2 tails or 2 heads. What is the probability 2 heads are reached before 2 tails if the probability if a head is 2/3?

ANSWER: $\frac{16}{21}$
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ROUND 16

TOSS-UP

19) Chemistry – *Short Answer* What is the name for the process by which alkenes react with iodine and silver acetate in the presence of acetic acid to form cis-diols?

ANSWER: WOODWARD CIS-HYDROXYLATION

BONUS

19) Chemistry – *Short Answer* What is the major product of the reaction of 3-methylbutan-2-ol with hydrochloric acid?

ANSWER: 2-CHLORO-2-METHYLBUTANE

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TOSS-UP

20) Physics – *Multiple Choice* Due to its low atomic mass, what element is nearly transparent to x-ray radiation, which allows it to serve as a "window?"

W) Hydrogen
X) Helium
Y) Beryllium
Z) Carbon

ANSWER: Y) BERYLLIUM

BONUS

20) Physics – *Short Answer* Kelsy drops a small rubber ball from 20 m above the ground, and loses ⅓ of its velocity after each bounce. For example, immediately after the 1st bounce, the ball will have a velocity of 40/3 meters per second. Neglecting air resistance, what is the exact magnitude of the ball's average acceleration during the interval from time t = 0 at 20 meters and the instant after the second bounce?

ANSWER: 8/3 (Solution: $\Delta v = - 0 + v_f = \sqrt{2(10)(20)}$*(⅔)*(⅔) = 20 * 4/9 = 80/9. $\Delta t = t_1 + 2t_2$ where t_1 is the time to fall from a height 20 m and t_2 is the time to fall from however high the ball goes after the second bounce, d. $20 = ½ (10)(t_1)^2$, so $t_1 = 2$. $d = 20 * (⅔)^2$ by the conservation of energy, so $d = 80/9 = ½ (10)(t_2)^2$ and $t_2 = 4/3$. $\Delta t = 2 + 4/3 = 10/3$)
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ROUND 16

TOSS-UP

21) Earth and Space - *Multiple Choice* Soil particles often join together to form clumps called peds that can be categorized into four or five general structures. Which of the following is NOT a common type of structure peds can form?

W) platy
X) tabular
Y) granular
Z) prismatic

ANSWER: X) TABULAR

BONUS

21) Earth and Space - *Multiple Choice* What term is given to the layers of soil that plant roots and other life are restrained to?

W) solum
X) topsoil
Y) regolith
Z) horizon vitae

ANSWER: W) SOLUM

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TOSS-UP

22) Biology - *Short Answer* A man catches on fire and the front of his right arm and the front of both of his legs are burned. Using the Rule of Nines, what percent of his body is burned?

ANSWER: 22.5 PERCENT

BONUS

22) Biology - *Multiple Choice* What is the name of the canals that connect lacunae together?

W) Haversian
X) Volkmann's
Y) Canaliculi
Z) Trabeculae
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ANSWER: Y) CANALICULI

ROUND 16

TOSS-UP

23) Math – *Short Answer* What is the minimum slope of the graph of tan x?

ANSWER: 1

BONUS

23) Math – *Multiple Choice* What is the minimum value of 3 sin x + 4 cos x + y + 1/y, where x and y are both real and y is positive?

W) -1
X) -2
Y) -3
Z) -4

ANSWER: Y) -3