ROUND 15

TOSS-UP

1) Physics – *Short Answer* What state can be represented by disconnected bubbles on a Feynman diagram?

ANSWER: VACUUM

BONUS

1) Physics – *Short Answer* Vacuum birefringence occurs when charged particles become perturbed due to interactions with what entities?

ANSWER: ELECTRIC AND MAGNETIC FIELDS

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TOSS-UP

2) Energy – *Short Answer* Researchers at Lawrence Berkeley National Laboratory are studying peptoids and their ability to form nanosheets, which opens up new possibilities for them to be used in medical, sensing, and other fields. Peptoids differ from peptides in that the side chain is attached to what instead of the α-carbon?

ANSWER: THE NITROGEN OF THE PEPTIDE BACKBONE

BONUS

2) Energy – *Short Answer* These researchers studied the details of the molecular structure of a peptoid nanosheet using a technique known as solid-state nuclear magnetic resonance (NMR) spectroscopy. An interaction commonly found in solid-state NMR is known as chemical shift anisotropy, and is induced by what?

ANSWER: THE ELECTRON CLOUD AROUND THE NUCLEUS
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ROUND 15

TOSS-UP

3) 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

3) Chemistry – *Short Answer* Order the following energy conformations of butane from highest to lowest: 1) Synperiplanar, 2) Antiperiplanar, 3) Eclipsed, 4) Gauche

ANSWER: 1, 3, 4, 2

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TOSS-UP

4) Biology - *Short Answer* What is the minimum number of amino acids needed to form an alpha helix?

ANSWER: 4

BONUS

4) Biology - *Short Answer* By name or number, order the following 3 types of DNA by increasing width: 1) Z-DNA, 2) A-DNA, 3) B-DNA.

ANSWER: 1, 3, 2
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ROUND 15

TOSS-UP

5) Math – *Short Answer* The roots of the polynomial f(x) = x5-8x4+2x3-3x2+x-12 are a, b, c, d, and e. A new polynomial g(x) has roots a - 1, b - 1, c - 1, d - 1, and e - 1. What is the product of roots of g(x)?

W) 4
X) 9
X) 14
Z) 19

ANSWER: 19

BONUS

5) Math – *Short Answer* In triangle ABC, AB has side length 4 and BC has side length 7. A cevian is drawn from B intersecting side AC at point D such that AD = 3 and DC = 5. What is the length of the cevian BD in simplest radical form?

ANSWER: $\frac{\sqrt{214}}{4}$

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TOSS-UP

6) Earth and Space - *Short Answer* What is the term for mountain ridges that "stick" through an ice sheet or ice cap, creating valley glaciers when the ice expands past them?

ANSWER: NUNATAKS

BONUS

6) Earth and Space - *Multiple Choice* Which of the following is true of a Piedmont glacier?

W) a Piedmont glacier is a glacier made of an exceptionally large chunk of ice generated by an icefall
X) Piedmont glaciers are a subcategory of glaciers found in warmer temperatures than what is normally expected
Y) a Piedmont glacier is a glacier that has "spilled" out onto a flat surface, sometimes joining with other glaciers to form one body
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Z) a Piedmont glacier is any glacier that has a significant number of moraines, especially of the englacial kind, creating a dirt-streaked appearance

ANSWER: Y) A PIEDMONT GLACIER IS A GLACIER THAT HAS “SPILLED” OUT ONTO A FLAT SURFACE, SOMETIMES JOINING WITH OTHER GLACIERS TO FORM ONE BODY

ROUND 15

TOSS-UP

7) Energy – *Multiple Choice* Researchers in California are understanding how a community of microorganisms derived from sediment from ANAS are cleaning up groundwater contaminations. Which of the following chemicals are these microorganisms breaking down, which is a pervasive groundwater pollutant often used by industries as cleansers?

W) Potassium Chloride
X) Trichloroethane
Y) Dichloromethane
Z) Bromochloromethane

ANSWER: X) TRICHLOROETHANE

BONUS

7) Energy – *Multiple Choice* Which of the following is the name of the genus of the microorganism that was used in this research to break down the trichloroethane?

W) Bordetella
X) Dehalococcoides
Y) Staphylococcus
Z) Agrobacterium

ANSWER: X) DEHALOCOCCOIDES

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TOSS-UP

8) Biology - *Short Answer* What is the term given to when a plant has a cluster of flowers rather than a solitary flower?

ANSWER: INFLORESCENCE

BONUS

8) Biology - *Multiple Choice* Which of the following is NOT an example of an elongated inflorescence with a central axis?

W) Corymb
X) Panicle
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Y) Raceme
Z) Spike

ANSWER: W) CORYMB

ROUND 15

TOSS-UP

9) Physics – *Multiple Choice* What types of fundamental interactions exhibit conservation of strangeness?

W) Gravitational Force and Strong Force
X) Strong Force and Electromagnetic Force
Y) Electromagnetic Force and Weak Force
Z) Weak Force and Gravitational Force

ANSWER: X) STRONG FORCE AND ELECTROMAGNETIC FORCE

BONUS

9) Physics – *Short Answer* What is the term for a baryon that does not contain top, bottom, or charm quarks, but does contain at least one strange quark?

ANSWER: HYPERON

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TOSS-UP

10) Chemistry – *Short Answer* Besides single covalent bonds, what other type of bond is present in diborane?

ANSWER: 3-CENTER 2-ELECTRON BOND (ACCEPT BANANA BOND)

BONUS

10) Chemistry – *Short Answer* Order the three functional groups in increasing wavenumber of IR absorption: 1) Alkane, 2) Alcohol, 3) Carboxyl

ANSWER: 3, 1, 2

TOSS-UP
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ROUND 15

11) Math – *Short Answer* If the dot product of two vectors is 16 while the cross product is $< 3, 4, 5 >$, what is the tangent of the smallest angle between the two vectors in simplest radical form?

ANSWER: $\frac{5\sqrt{2}}{16}$

BONUS

11) Math – *Short Answer* What is the magnitude of the vector projection of the vector $< 3, 9, 2 >$ onto the vector $< 2, -4, 9 >$ in simplest radical form?

ANSWER: $\frac{12\sqrt{101}}{101}$

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TOSS-UP

12) Earth and Space - *Multiple Choice* Which of the following is true of a forearc basin?

W) a basin formed when a glacier retreats and leaves behind a large depression in the ground
X) a man-made feature dug out in order to determine the composition and quality of soil and other sediment lying beneath the surface of the crus
Y) a basin that forms when a period of upwarping fractures and weakens the crust and a later period of downwarping pushes the rock and sediment into a depression
Z) a basin that forms when sediments start to collect between the accretionary wedge of a subducting plate and a continental island arc, forming a relatively smooth and stratified layer

ANSWER: Z) A BASIN THAT FORMS WHEN SEDIMENTS START TO COLLECT BETWEEN THE ACCRETIONARY WEDGE OF A SUBDUCTING PLATE AND A CONTINENTAL ISLAND ARC, FORMING A RELATIVELY SMOOTH AND STRATIFIED LAYER

BONUS

12) Earth and Space - *Short Answer* Cordilleran-type orogeny often creates mountainous features that rim oceans when seafloor spreading carries and accretes pieces of crust to the edges of continents. What is the name for these features?

ANSWER: TERRANES
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ROUND 15

TOSS-UP

13) Biology - *Short Answer* What type of hallucination might people experience during the transitional stage from wakefulness to light sleep?

ANSWER: HYPNAGOGIC

BONUS

13) Biology - *Multiple Choice* Which neural measure uses a head coil to record magnetic fields from the brain's natural electrical currents?

W) EEG
X) MEG
Y) MRI
Z)fMRI

ANSWER: X) MEG

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TOSS-UP

14) Energy – *Short Answer* Researchers are studying how the photosynthetic microbe *Nostoc* forms differentiated filaments. What is the specific name for these differentiated filaments, which allow some cells to perform photosynthesis while others can specialize in nitrogen fixation?

ANSWER: HETEROCYSTS

BONUS

14) Energy – *Short Answer* By name or number, identify all of the following 4 choices that are traits of heterocysts: 1) production of nitrogenase, 2) contains 3 additional cell walls, 3) degradation of Photosystem 1, 4) degradation of Photosystem 2.

ANSWER: 1, 2, 4 (ACCEPT ALL BUT 3)
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ROUND 15

TOSS-UP

15) Physics – *Multiple Choice* What is the rate of change of ideal mechanical advantage of a frictionless inclined plane with an angle of inclination theta at theta equals 45°?

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

ANSWER: Z) $-\sqrt{2}$

BONUS

15) Physics – *Short Answer* A car of mass m = 1000 kg is travelling along a curve banked at $\Theta = 30°$. The car is taking a turn with a radius of curvature R = 50 m. If the car successfully turns on a hot day with temperature T = 35° C and with a frictional force F = 2000 N, find the exact normal force between the car and the curve given g = 10 m/s^2.

ANSWER: $6000\sqrt{3}$ (Solution: The car experiences three forces, a normal force perpendicular to the curve, the gravitational force directly downward, and a frictional force down the curve. The net vertical force on the car must be equal to 0 so $F_n \cos \Theta + F_f \sin \Theta = mg$, and $F_n = (mg - F \sin \Theta)/\cos\Theta$)

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TOSS-UP

16) Earth and Space - *Short Answer* Found by NASA's Spitzer Space Telescope, the recent discovery of what allotrope of carbon opens up the theory that life on Earth could have originated from outer-space?

ANSWER: FULLERENES (ACCEPT: BUCKMINSTERFULLERENES or BUCKYBALLS)

BONUS

16) Earth and Space - *Multiple Choice* The first indication that the moon Phobos will be destroyed in the next 30 to 50 million years and possibly form a planetary ring around Mars is which of the following?

W) grooves forming on the surface of Phobos
X) craters slowly beginning to flatten out
Y) Phobos' orbital radius gradually becoming larger
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Z) more asteroids and other space material colliding with Phobos

ANSWER: W) GROOVES FORMING ON THE SURFACE OF PHOBOS

ROUND 15

TOSS-UP

17) Chemistry – *Short Answer* What term describes a mixture of two enantiomers in equal amounts that does not rotate plane polarized light?

ANSWER: RACEMIC

BONUS

17) Chemistry – *Short Answer* What are the products of the reaction of methenium with water?

ANSWER: METHANOL AND HYDRONIUM (ACCEPT CH_3OH AND H_3O^+)

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TOSS-UP

18) Math – *Multiple Choice* All the mass of a triangle resides in its three vertices. What is the center of mass of the triangle if the vertices (0, 0), (0, 1), and (1, 0) have weights of 2, 3, and 4 respectively?

W) (4/9, 1/3)
X) (1/3, 4/9)
Y) (2/9, 4/9)
Z) (2/9, 1/3)

ANSWER: W) (4/9, 1/3)

BONUS

18) Math – *Short Answer* The trapezoid ABCD has its mass uniformly distributed throughout the shape's area. What is the y-coordinate of its center of mass if A is at (6, 0), B is at (-6, 0), C is at (-1, 5) and D is at (1, 5)?

ANSWER: $6 - 3\sqrt{2}$
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ROUND 15

TOSS-UP

19) Chemistry – *Multiple Choice* Which of the following is not a characteristic of aromatic molecules?

W) Delocalized conjugated pi system
X) Coplanar structure
Y) Cyclic shape
Z) Number of delocalized pi electrons is a multiple of 4

ANSWER: Z) NUMBER OF DELOCALIZED PI ELECTRONS IS A MULTIPLE OF 4

BONUS

19) Chemistry – *Short Answer* What is the process by which a carboxylic acid is heated with an alcohol in the presence of a strong acid such as sulfuric acid?

ANSWER: FISCHER ESTERIFICATION

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TOSS-UP

20) Physics – *Multiple Choice* The fine structure constant can be expressed exactly with which combination of physical units divided or multiplied together possibly with a combination of multiplication and division and possibly using small integers?

W) Charge of an electron, permittivity of free space, and π
X) Permeability of free space, Von Klitzing Constant, and speed of light
Y) Charge of an electron, vacuum impedance, and reduced planck constant
Z) Coulomb Constant, planck constant, and π

ANSWER: X) PERMEABILITY OF FREE SPACE, VON KLITZING CONSTANT, AND SPEED OF LIGHT

BONUS

20) Physics – *Short Answer* What correspondence principle did quantum theorists find between string theory and quantum field theory in the late 1990s?

ANSWER: AdS/CFT CORRESPONDENCE (ACCEPT: MALDACENA DUALITY)
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ROUND 15

TOSS-UP

21) Earth and Space - *Short Answer* Trans-neptunian objects are classified into two groups, one of which consists of bodies with very eccentric, non-circular orbits. What is the name of this group?

ANSWER: SCATTERED DISC OBJECTS

BONUS

21) Earth and Space - *Short Answer* The first of its kind to be classified, Chiron is a small icy body with an unstable orbit between Saturn and Uranus. To what group of objects does Chiron belong to?

ANSWER: CENTAURS

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TOSS-UP

22) Biology - *Multiple Choice* What type of joint allows no movement under normal conditions?

W) Synovial
X) Cartilaginous
Y) Amphiarthrosis
Z) Synarthrosis

ANSWER: Z) SYNARTHROSIS

BONUS

22) Biology - *Short Answer* Build up of uric acid in the big toe is the biggest indicator of what condition?

ANSWER: GOUTY ARTHRITIS
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ROUND 15

TOSS-UP

23) Math – *Short Answer* Zach has four friends: friend 1, friend 2, friend 3, and friend 4. He also has 24 doughnuts. Assuming the doughnuts are indistinguishable and that friend x must get at least x doughnuts (for example, friend 3 must get at least 3 doughnuts), how many ways are there for Zach to distribute the doughnuts to his friends (assuming Zach doesn't want any)?

ANSWER: 680

BONUS

23) Math – *Short Answer* Marc wants to walk up 8 stairs. Being the athletic person he is, he can either cover 1, 2, or 3 stairs with one step. How many ways are there for him to walk up the stairs? For example, one way is to walk up the stairs is 3 steps, then 1 step, then 2 steps, then 2 steps.

ANSWER: 81