

ROUND ROBIN – ROUND 15

TOSS-UP

1) Earth & Space – *Short Answer* As red giant stars evolve, they undergo a rapid runaway reaction when they begin to fuse what element in the core?

ANSWER: HELIUM

BONUS

1) Earth & Space – *Multiple Choice* The highest-albedo asteroids primarily belong to what asteroid class?

- W) S
- X) X
- Y) M
- Z) C

ANSWER: W) S

TOSS-UP

2) Math – *Multiple Choice* Let f of x be a continuous and differentiable function on the closed interval from 4 to 8. Which of the following could be the x -value guaranteed by the mean value theorem for this situation?

- W) 4
- X) 7
- Y) 10
- Z) 13

ANSWER: X) 7

BONUS

2) Math – *Short Answer* Consider an infinite geometric series with sum equal to $13/3$ and first term $7/5$. What is the value of the common ratio r for this series?

ANSWER: 44/65

TOSS-UP

3) Chemistry – *Short Answer* What theory of chemical kinetics states that molecules must come into contact with each other to react?

ANSWER: COLLISION THEORY

BONUS

3) Chemistry – *Short Answer* Identify all of the following three properties that are typically exhibited by network solids, but not atomic solids: 1) They are soft; 2) They have high conductivity; 3) They have high melting points.

ANSWER: 3

TOSS-UP

4) Physics – *Short Answer* A photon can lose energy in matter via Compton scattering. If a photon is sufficiently high in energy, what process will occur instead?

ANSWER: PAIR PRODUCTION

BONUS

4) Physics – *Short Answer* A musical instrument is made from a 2-meter tube that is open on one end and closed at the other. In meters, what is the wavelength of the first overtone of this instrument?

ANSWER: 8/3 (ACCEPT: 2 2/3)

TOSS-UP

5) Biology – *Multiple Choice* Which of the following best describes what will occur to a tadpole if it is fed pieces of a thyroid gland?

- W) It will be unable to undergo metamorphosis
- X) It will immediately undergo metamorphosis
- Y) It will begin to suffer from adrenal *[Ah-DREE-null]* insufficiency
- Z) It will suffer iodine poisoning

ANSWER: X) IT WILL IMMEDIATELY UNDERGO METAMORPHOSIS

BONUS

5) Biology – *Multiple Choice* Which of the following groups of protists is most closely related to plants?

- W) Dinoflagellates *[DYE-no-FLAJ-ill-ates]*
- X) Unikonts *[YOU-nih-konts]*
- Y) Diatoms
- Z) Red algae

ANSWER: Z) RED ALGAE

TOSS-UP

6) Energy – *Short Answer* Pacific Northwest National Lab scientists are studying atmospheric aerosols. Some of the particles in these aerosols serve as substrates for cloud formation. What is the term for these particles?

ANSWER: CONDENSATION NUCLEI (ACCEPT: CLOUD SEEDS)

BONUS

6) Energy – *Short Answer* Researchers at Fermilab are working with CERN to detect long-lived particles in the Large Hadron Collider. One potential source of these particles is the decay of what particle, whose field is thought to give mass to other particles?

ANSWER: HIGGS BOSON (ACCEPT: HIGGS PARTICLE, HIGGS; DO NOT ACCEPT: GOD PARTICLE)

TOSS-UP

7) Earth & Space – *Short Answer* What atmospheric gas was NOT a significant component of Earth's atmosphere until about 2.4 billion years ago?

ANSWER: OXYGEN (ACCEPT: DIOXYGEN, O₂)

BONUS

7) Earth & Space – *Short Answer* What mass extinction event led to the most significant percentage decrease in global diversity?

ANSWER: PERMIAN (ACCEPT: END-PERMIAN, PERMIAN-TRIASSIC, PERMO-TRIASSIC)

TOSS-UP

8) Biology – *Multiple Choice* The triple response in a growing seedling is typically triggered by which of the following stresses?

- W) Mechanical contact
- X) Excessive flooding
- Y) Drought
- Z) Excessive salt

ANSWER: W) MECHANICAL CONTACT

BONUS

8) Biology – *Short Answer* Identify all of the following three developments that are analogous features between bats and birds: 1) Flight; 2) Amnion [*AM-nee-awnj*]; 3) Endothermy [*EN-doh-thermee*].

ANSWER: 1, 3

TOSS-UP

9) Energy – *Multiple Choice* Department of Energy-supported scientists are using DNA as a molecular wire to transport electrons between organic molecules. What specific moieties [**MOY-eh-teez**] in the DNA exchange the electrons in these reactions?

- W) Phosphoesters [*faws-fo-ES-turs*]
- X) Deoxyribose [*dee-oxee-RYE-bose*] sugars
- Y) Nucleobases
- Z) Ribose sugars

ANSWER: Y) NUCLEOBASES

BONUS

9) Energy – *Short Answer* The Department of Energy supports scientists studying the high thermal conductivity of boron arsenide. This high thermal conductivity is due to heat transmission within boron arsenide being mediated by quantized collective vibrations in its crystal structure. This is an example of what quasiparticle [**KWAH-zye-particle**]?

ANSWER: PHONON (DO NOT ACCEPT: PHOTON)

TOSS-UP

10) Math – *Multiple Choice* In the conversion of the rectangular coordinates $(-5, 3)$ to polar coordinates, to the nearest degree, what is the measure of the angle?

- W) 121
- X) 149
- Y) 301
- Z) 329

ANSWER: X) 149

BONUS

10) Math – *Short Answer* What are the coordinates of the image of the point $(5, 6)$ when it is rotated about the point $(1, 3)$ by 90 degrees counterclockwise?

ANSWER: $(-2, 7)$ (ACCEPT: $x = -2$ AND $y = 7$)

TOSS-UP

11) Physics – *Short Answer* The voltage of an RLC circuit is analogous to the position of a damped harmonic oscillator. Continuing this analogy, what aspect of the RLC circuit is most analogous to the mass of the harmonic oscillator?

ANSWER: INDUCTANCE

BONUS

11) Physics – *Short Answer* A point charge of one coulomb is enclosed in a shell-like spherical conductor with a radius of four meters. In SI base units, what is the product of the permittivity [*purr-mih-TIV-it-ee*] of free space with the electric flux through the conductor?

ANSWER: ONE (ACCEPT: 1 COULOMB)

TOSS-UP

12) Chemistry – *Short Answer* Identify all of the following three species that have increasing solubility in water with increasing temperature: 1) Carbon dioxide; 2) Sucrose; 3) Silver nitrate.

ANSWER: 2, 3

BONUS

12) Chemistry – *Multiple Choice* Melissa is attempting to dissolve a solid in water to form a solution. After vigorous agitation, she can no longer visibly see particles of solid. Which of the following steps should she take next to determine if the solid has completely dissolved?

- W) If she sees no visible particles, the solid has dissolved completely
- X) She should shine a beam of light through the sample
- Y) She should determine if the freezing point of the sample has changed
- Z) She should measure the vapor pressure of the sample

ANSWER: X) SHE SHOULD SHINE A BEAM OF LIGHT THROUGH THE SAMPLE

TOSS-UP

13) Biology – *Short Answer* In eukaryotic DNA, what named sequence is located 25 nucleotides upstream of the transcription start site in the core promoter region?

ANSWER: TATA BOX (ACCEPT: GOLDBERG-HOGNESS BOX)

BONUS

13) Biology – *Short Answer* Identify all of the following three substances whose reabsorption is increased in the kidneys in response to aldosterone [*al-DOSS-ter-own*]: 1) Sodium; 2) Potassium; 3) Water.

ANSWER: 1, 3

TOSS-UP

14) Physics – *Short Answer* Consider an infinitely long line of uniformly dense charge, which has an electric field strength of E at a certain distance R from the line. In terms of E , what is the electric field strength at a distance $3R$ from the line?

ANSWER: $E/3$ (ACCEPT: $1/3 E$)

BONUS

14) Physics – *Short Answer* An electric dipole is placed in a uniform electric field. Identify all of the following three statements that are always true: 1) There is no net electric force on the dipole; 2) There is no net torque [*tork*] on the dipole; 3) The dipole has minimum electrical potential energy when the dipole moment is parallel to the electric field.

ANSWER: 1, 3

TOSS-UP

15) Energy – *Multiple Choice* Brookhaven National Lab researchers are using electron diffraction to image structural details of crystalline materials. Which of the following is closest to the ratio of the wavelength of these electrons to that of x-rays used in x-ray diffraction?

- W) 100,000
- X) 1,000
- Y) 10
- Z) 0.1

ANSWER: Z) 0.1

BONUS

15) Energy – *Short Answer* Fermilab researchers are developing computational techniques to model the interactions of various quantum particles. One of the first theoretical considerations they made is to use an operator that is the sum of the kinetic and potential energies of all the particles in their system. What is the name of this operator?

ANSWER: HAMILTONIAN

TOSS-UP

16) Chemistry – *Multiple Choice* Which of the following best explains why the atomic radius of the lanthanide [*LAN-tha-nide*] elements decreases significantly going across the period from lanthanum [*LAN-tha-num*] to lutetium [*loo-TEE-shum*]?

- W) Shielding decreases leading to a greater effective nuclear charge
- X) 5d orbitals start to fill, decreasing shielding
- Y) Extra neutrons stabilize the smaller atomic radii
- Z) 4f orbitals are diffuse, so effective nuclear charge increases relative to shielding

ANSWER: Z) 4F ORBITALS ARE DIFFUSE, SO EFFECTIVE NUCLEAR CHARGE INCREASES RELATIVE TO SHIELDING

BONUS

16) Chemistry – *Multiple Choice* Which of the following is correct concerning VSEPR [*VESS-pur*] geometries?

- W) Trigonal bipyramidal [*bye-peer-ah-MID-ul*] complexes have four ligands
- X) Methane molecules have a carbon atom with an sp² hybridization [*HIGH-brih-dye-ZAY-shun*]
- Y) See-saw compounds have one central atom lone pair
- Z) The triiodide [*try-EYE-oh-died*] ion adopts a bent geometry

ANSWER: Y) SEE-SAW COMPOUNDS HAVE ONE CENTRAL ATOM LONE PAIR

TOSS-UP

17) Math – *Short Answer* The point $(-7, 6)$ is reflected across the x -axis and the resulting point is then translated 2 units left. What are the coordinates of the final image point?

ANSWER: $(-9, -6)$ (ACCEPT: $x = -9$ AND $y = -6$)

BONUS

17) Math – *Short Answer* In a circle with radius 4, to the nearest integer, what is the area of a circular segment defined by an arc of 90 degrees?

ANSWER: 5

TOSS-UP

18) Earth & Space – *Multiple Choice* Cepheid **[SEF-ee-id]** variables are useful as standard candles because their luminosity is proportional to which of the following?

- W) Their period of oscillation
- X) Their mass
- Y) Their temperature
- Z) Their age

ANSWER: W) THEIR PERIOD OF OSCILLATION

BONUS

18) Earth & Space – *Short Answer* Identify all of the following three layers of the Sun's atmosphere that are typically only seen in visible light during a solar eclipse: 1) Photosphere; 2) Chromosphere; 3) Corona.

ANSWER: 2, 3

TOSS-UP

19) Physics – *Short Answer* Euler defined precession as a process that represents a rotation around the external z -axis of a rotating body. What process that results in swaying of the axis of rotation during precession is defined as representing a change in the second Euler angle?

ANSWER: NUTATION (ACCEPT: FREE NUTATION)

BONUS

19) Physics – *Short Answer* A fire engine has a siren that wails at a frequency of 2000 hertz. It drives toward you at 17 meters per second, while you are pulled over to let it pass. Later, you drive towards the fire engine at 17 meters per second, while it is parked. To the nearest hertz, what is the absolute difference between the frequencies you hear in these two circumstances?

ANSWER: 5

TOSS-UP

20) Math – *Short Answer* What is the integer part of the log base 6 of 2020?

ANSWER: 4

BONUS

20) Math – *Short Answer* What is the volume of the solid obtained by rotating about the y -axis the first-quadrant region bounded by $y = x - x^3$ and $y = 0$?

ANSWER: $4\pi/15$ (ACCEPT: $(4/15)\pi$)

TOSS-UP

21) Biology – *Short Answer* ACTH and FSH are examples of what type of hormones that exclusively target other endocrine tissues?

ANSWER: TROPIC (DO NOT ACCEPT: TROPHIC)

BONUS

21) Biology – *Short Answer* A particular Next-Generation Sequencing technique works through detecting flashes of light that are enzyme-atically generated when a correct nucleotide is added. This happens because the addition of each nucleotide releases what high-energy ion?

ANSWER: PYROPHOSPHATE (ACCEPT: DIPHOSPHATE, PPi)

TOSS-UP

22) Chemistry – *Multiple Choice* Which of the following substances has the most spontaneous reduction half-reaction?

- W) Fluorine
- X) Oxygen
- Y) Iodine
- Z) Sulfur

ANSWER: W) FLUORINE

BONUS

22) Chemistry – *Short Answer* Rank the following three substances in order of increasing melting point: 1) Sucrose; 2) Table salt; 3) Water.

ANSWER: 3, 1, 2

TOSS-UP

23) Earth & Space – *Short Answer* Conchoidal [**kon-KOI-dal**], fibrous, and splintery are all examples of what structural property of minerals?

ANSWER: FRACTURE

BONUS

23) Earth & Space – *Short Answer* A seismic wave denoted as PKP is detected following a seismic event. The K in PKP denotes that this wave has traveled through what layer of the Earth's interior?

ANSWER: OUTER CORE (DO NOT ACCEPT: CORE)