LOST ROUND 7

TOSS-UP

1) Earth and Space – *Multiple Choice* Via which of the following methods does helioseismology measure the vibration modes of the Sun?

W) Babcock model predictions
X) Doppler shifts
Y) Occultations of planets
Z) Interferometry with multiple wavelength telescopes

ANSWER: X) DOPPLER SHIFTS

BONUS

1) Earth and Space – *Short Answer* Identify all of the following three statements which are true concerning climate proxies which are true: 1) High ^{16}O ***[o-16]*** to ^{18}O ***[o-18]*** ratios indicate periods of glaciation; 2) Varves can contain pollen; 3) Oxygen in ocean cores can come from foraminifera.

ANSWER: 2 AND 3

TOSS-UP

2) Physics – *Multiple Choice* Which of the following state functions is a conjugate variable of temperature?

W) Pressure
X) Volume
Y) Entropy
Z) Enthalpy

ANSWER: Y) ENTROPY

BONUS

2) Physics – *Short Answer* To the nearest tenth and in electron volts, what is the potential energy of an electron in the second excited state of a hydrogen atom if the binding energy of an electron in the hydrogen ground-state is -13.6 electron volts?

ANSWER: -1.5

TOSS-UP

3) Math – *Short Answer* Connor is searching for coconuts. If on day 1, he finds 1 coconut, and on each subsequent day, he finds one more coconut than he did on the previous day, on what day will he find his 1001st coconut?

ANSWER: 45

BONUS

3) Math – *Short Answer* Consider the polynomial equation $x^{99} - x + 1 = 0$. Compute the sum of the 100th powers of all the roots of the polynomial.

ANSWER: 0

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TOSS-UP

4) Energy – *Short Answer* Scientists at FermiLab discovered a particle known as the "odderon" in the Tevatron collider, which are composed of three gluons. What is the color charge of an odderon?

ANSWER: COLORLESS (ACCEPT: 0, NEUTRAL)

BONUS

4) Energy – *Short Answer* Scientists at Ames National Lab created a new carbon-based catalyst for organic reduction reactions that uses nitrogen atoms placed closely with one another to create a thermodynamically unstable surface. Identify all of the following three statements that are true about this catalyst: 1) It is metastable; 2) It is an example of a phase transfer catalyst; 3) It can be used to deprotect silyl ethers under basic conditions.

ANSWER: 1 ONLY
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TOSS-UP

5) Biology – *Short Answer* When the tip links of the stereocilia in the ear are stretched a certain way, they activate the mechanically gated channels for which ion?

ANSWER: K^+ (ACCEPT: POTASSIUM)

BONUS

5) Biology – *Short Answer* Identify all of the following three statements that are true of the chloroplast respiratory chain: 1) Proton are pumped into the stroma by cytochrome b_6f; 2) Plastocyanin carries electrons between photosystem II and photosystem I; 3) $NADP^+$ Reductase is not involved in cyclic electron flow.

ANSWER: 2 AND 3

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TOSS-UP

6) Chemistry – *Multiple Choice* Which of the following statements is NOT true about the hydroboration oxidation of propene?

W) The hydroboration step is thermodynamically favored by higher temperatures
X) The major product is from an anti-Markovnikov addition
Y) The oxidation step requires basic conditions
Z) The dominant stereochemistry of the product is syn

ANSWER: W) THE HYDROBORATION STEP IS THERMODYNAMICALLY FAVORED BY HIGHER TEMPERATURES

BONUS

6) Chemistry – *Short Answer* In the unit cell structure of calcium fluoride, the calcium cations adopt a face centered cubic arrangement while the fluoride anions adopt a simple cubic arrangement. What percent of the tetrahedral interstitial sites are occupied?

ANSWER: 100%
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TOSS-UP

7) Earth and Space – *Multiple Choice* As one ascends from the photosphere, how does the temperature change with respect to altitude?

W) Increases then decreases
X) Decreases then increases
Y) Increases only
Z) Decreases only

ANSWER: X) DECREASES THEN INCREASES

BONUS

7) Earth and Space – *Multiple Choice* Pallasites are formed from large meteors which have broken up. In which of the following areas would one expect to find the characteristic olivine in the nickel - iron matrix?

W) Crust - mantle boundary
X) Inside the mantle
Y) Core - mantle boundary
Z) Inside the core

ANSWER: Y) CORE - MANTLE BOUNDARY

TOSS-UP

8) Physics – *Short Answer* What theorem for electrical circuits states that any linear circuit consisting of resistors and voltage sources can be reduced to an equivalent circuit with a single resistor and voltage source?

ANSWER: THEVENIN'S THEOREM

BONUS

8) Physics – *Short Answer* Identify all of the following three physical symmetries that are discrete: 1) Lattice; 2) Time; 3) Parity.

ANSWER: 1 AND 3

TOSS-UP

9) Math – *Short Answer* How many positive base 5 numerals contain a strictly increasing sequence of digits?

ANSWER: 15

BONUS

9) Math – *Short Answer* Four planes can divide three dimensional space into at most how many non-overlapping regions?

ANSWER: 15

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TOSS-UP

10) Energy – *Multiple Choice* Scientists at Brookhaven National Lab used lanthanide-binding tags to image proteins at the level of a cell membrane. If they were targeting the insulin response elements, which bind to the insulin receptor, which of the following amino acids would they find in abundance due to their self phosphorylating nature?

W) Serine
X) Tyrosine
Y) Histidine
Z) Threonine

ANSWER: X) TYROSINE

BONUS

10) Energy – *Short Answer* Scientists at Brookhaven National Lab found a protein that was completely complementary to its substrate. Identify all of the following three statements that are likely true about this protein: 1) This protein stabilizes the substrate; 2) This protein could be a catalyst; 3) The K_d of this protein is very large.

ANSWER: 1 ONLY
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TOSS-UP

11) Biology – *Short Answer* Which canal in the middle ear allows for equilibrium of pressure between the atmosphere and the middle ear?

ANSWER: EUSTACHIAN TUBE

BONUS

11) Biology – *Multiple Choice* Which of the following adaptations was crucial for the development from single celled organisms to multicellular organisms in animals?

W) The advent of cadherin attachment proteins to anchor and connect different cells together
X) The advent of the pentose phosphate pathway to coordinate cells based on energy signals
Y) The advent of meiotic cell division to introduce cellular diversity and preventing Muller's ratchet
Z) The advent of cephalization to coordinate sensory information into a nervous system

ANSWER: W) THE ADVENT OF CADHERIN ATTACHMENT PROTEINS TO ANCHOR AND CONNECT DIFFERENT CELLS TOGETHER

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TOSS-UP

12) Chemistry – *Short Answer* What is the strongest possible acid in pure hydrofluoric acid?

ANSWER: H_2F^+

BONUS

12) Chemistry – *Short Answer* Given that the formation of methane clathrates occurs at or below 4 degrees celsius at atmospheric pressure, identify all of the following three thermodynamic quantities that increase as a result of the formation of methane clathrates at STP: 1) Enthalpy; 2) Entropy; 3) Gibbs free energy.

ANSWER: NONE
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TOSS-UP

13) Earth and Space – *Short Answer:* An orbital resonance with the moon Mimas causes which orbital division in Saturn's rings?

ANSWER: CASSINI

BONUS

13) Earth and Space – *Short Answer* An energy E is received by an observer from a black body. The black body then doubles in both temperature and distance from the observer. In terms of E, what is the new energy received from the black body?

ANSWER: 4E

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TOSS-UP

14) Physics – *Short Answer* What type of emergent phenomena describes the electron spins as a quantized wave within a crystal lattice?

ANSWER: MAGNON

BONUS

14) Physics – *Short Answer* An equilateral triangle is placed parallel to the horizontal such that a frictionless massless pulley lies at its top vertex. Two blocks of masses 2 and 3 kilograms are connected on adjacent sides of the triangle using a massless rope through the pulley. In terms of the acceleration due to gravity *g*, what is the magnitude of the acceleration of the 2 kilogram block if there is no friction between the triangle's sides and the blocks?

ANSWER: $\frac{g\sqrt{3}}{10}$
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TOSS-UP

15) Math – *Multiple Choice* Which of the following values of x is NOT in the domain of the function $f(x) = \sqrt{x^2 + 4x - 5}$ ***[f of x equals the square root of the quantity x squared plus four x minus five]***?

W) -7
X) -6
Y) -5
Z) -4

ANSWER: Z) -4

BONUS

15) Math – *Short Answer* How many positive three digit integers have the property that the first digit is equal to the sum of the remaining two digits?

ANSWER: 54

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TOSS-UP

16) Energy – *Short Answer* Scientists at Argonne National Lab are using the Advanced Light Source to study the movement of lithium ions through aqueous electrolytes in lithium-ion batteries. What model can be used to characterize the dynamics of the non-ideal dilute solution present in the lithium-ion battery?

ANSWER: DEBYE HUCKEL

BONUS

16) Energy – *Short Answer* Scientists at Fermi National Lab are using the annihilation of quarks with anti-quarks to study the asymmetry of the proton structure. Identify all of the following three particles that can be produced by the annihilation of an up quark and an anti-up quark: 1) Muon; 2) Muon neutrino; 3) Photon.

ANSWER: 1 AND 2
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TOSS-UP

17) Biology – *Short Answer* Which enzyme, present in rods and cones, is responsible for the decyclization of cGMP to GMP?

ANSWER: cGMP PHOSPHODIESTERASE

BONUS

17) Biology – *Short Answer* Identify all of the following three protists that had an early ancestral secondary endosymbiosis with red algae: 1) Stramenopiles; 2) Apicomplexans; 3) Cercozoans.

ANSWER: 1 AND 2

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TOSS-UP

18) Chemistry – *Multiple Choice* Which of the following, when added to a solution of $FePO_4$, will significantly increase its solubility?

W) KSCN
X) $KMnO_4$
Y) KI
Z) KBr

ANSWER: W) KSCN

BONUS

18) Chemistry – *Multiple Choice* Propyne is treated with aqueous acid in the presence of mercuric sulfate. An IR spectrum is collected over the course of the reaction. Which of the following describes the change in the IR spectrum as the reaction progresses?

W) Peak at 1100 inverse cm replaced by a peak at 1700 inverse cm
X) Peak at 1100 inverse cm replaced by a peak at 3600 inverse cm
Y) Peak at 2100 inverse cm replaced by a peak at 1700 inverse cm
Z) Peak at 2100 inverse cm replaced by a peak at 3600 inverse cm

ANSWER: Y) PEAK AT 2100 INVERSE CM REPLACED BY A PEAK AT 1700 INVERSE CM
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TOSS-UP

19) Earth and Space – *Short Answer* Identify all of the following three statements which are true during positive phases of El Nino Southern Oscillation: 1) Thermocline depth increases in East Pacific; 2) Coastal upwelling off western South America; 3) Stronger equatorial countercurrent.

ANSWER: 1 AND 3

BONUS

19) Earth and Space – *Short Answer* Order the following three soil orders in order of INCREASING amount of weathering: 1) Ultisols; 2) Mollisols; 3) Aridisols.

ANSWER: 3, 2, 1

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TOSS-UP

20) Physics – *Multiple Choice* Which of the following best describes how the electric field varies in a spherical insulator with charge q with constant charge density?

W) $1/r$ as r is less than the radius of the sphere, $1/r^2$ as r is more than the radius of the sphere
X) 1/r^2 as r is less than the radius of the sphere, $1/r^3$ as r is more than the radius of the sphere
Y) r as r is less than the radius of the sphere, $1/r^2$ as r is more than the radius of the sphere
Z) r as r is less than the radius of the sphere, $1/r$ as r is more than the radius of the sphere

ANSWER: Y) R AS R IS LESS THAN THE RADIUS OF THE SPHERE, $1/R^2$ AS R IS MORE THAN THE RADIUS OF THE SPHERE

BONUS

20) Physics – *Short Answer* Identify all of the following quantities that when increased, will increase the mean momentum density of an electromagnetic wave: 1) Frequency; 2) Wavelength; 3) Intensity.

ANSWER: 3 ONLY
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TOSS-UP

21) Math – *Short Answer* Two sides of a triangle have lengths of 6 and 12. What should be the length of the third side in order to maximize the area of the triangle?

ANSWER: $6\sqrt{5}$

BONUS

21) Math – *Short Answer* How many ordered pairs of integers (x, y) satisfy the equation $x^y = y^2$ ***[x to the power of y equals y squared]***?

ANSWER: 6

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TOSS-UP

22) Energy – *Multiple Choice* Scientists at Pacific Northwest National Laboratory are studying how the Zika virus hijacks lipid metabolism within the brain. What group of lipids, found in high concentrations around myelin sheaths, were these researchers analyzing?

W) Cardiolipins
X) Sphingolipids
Y) Ether lipids
Z) Triacylglycerols

ANSWER: X) SPHINGOLIPIDS

BONUS

22) Energy – *Short Answer* Scientists at Brookhaven National Lab studied exotic antimatter pairs formed near the start of the universe, and confirmed the value of the Hagedorn temperature, a point at which hadronic matter is theoretically unstable. Identify all of the following three particles that are considered hadrons: 1) Tetraquark; 2) Alpha particle; 3) Tau.

ANSWER: 1 AND 2
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TOSS-UP

23) Biology – *Short Answer* In Huntington's disease, the quantity of CAG repeats increases after every generation due to polymerase slippage. This results in an earlier onset of symptoms after every generation known as what phenomena?

ANSWER: ANTICIPATION

BONUS

23) Biology – *Short Answer* Identify all of the following three statements concerning the kidney that are true: 1) NKCC Channels are found exclusively in the descending loop of Henle; 2) Juxtamedullary nephrons are more common than medullary nephrons; 3) It is responsible for the first hydroxylation of Vitamin D.

ANSWER: NONE

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TOSS-UP

24) Chemistry – *Short Answer* Order the following three sodium oxygen compounds in increasing stability at STP: 1) Sodium oxide; 2) Sodium peroxide; 3) Sodium superoxide.

ANSWER: 3, 1, 2

BONUS

24) Chemistry – *Short Answer* Identify all of the following three statements that are true about the first excited state of a three dimensional cubic box containing electrons: 1) It has a degeneracy of 3; 2) It has three times the energy of the ground-state; 3) The energy of the first-excited state would increase if muons replaced electrons in the box.

ANSWER: 1 ONLY

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TOSS-UP

25) Earth and Space – *Short Answer* Order the following three minerals in order of increasing metamorphic grade: 1) Sillimanite 2) Staurolite 3) Chlorite.

ANSWER: 3, 2, 1

BONUS

25) Earth and Space – *Short Answer* Identify all of the following four planets that have rings that are primarily composed of dust and can forward scatter light: 1) Jupiter; 2) Uranus; 3) Saturn; 4) Neptune.

ANSWER: 1 AND 4