ROUND 13

TOSS-UP

1) Physics – *Short Answer* The shell theorem applies to forces which have magnitudes proportional to what power of distance?

ANSWER: -2 (ACCEPT: INVERSE-SQUARE LAW)

BONUS

1) Physics – *Multiple Choice* The Rayleigh form of what phenomenon explains why the daytime sky is blue?

W) Photoelectric effect
X) Scattering
Y) Dispersion
Z) Diffraction

ANSWER: X) SCATTERING

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TOSS-UP

2) Energy – *Multiple Choice* Research at Jefferson National Laboratory has determined the weak charge of a proton, a measure of the strength of the weak force on an object. Which of the following are the three bosons that carry the weak force?

W) W, Z^+, Z^-
X) W, Z, Z^-
Y) W^+, W^-, Z
Z) W^+, W, Z

ANSWER: Y) W^+, W^-, Z

BONUS

2) Energy – *Short Answer* To measure the weak charge of a proton, the scientists at Jefferson National Lab scientists bombarded liquid hydrogen with an intense beam of highly polarized electrons. The high polarization of the beam influences the quantum spin of the electrons. In a highly polarized beam, the spin of most particles in the beam will be in what direction or directions relative to the beam direction?

ANSWER: PARALLEL TO THE BEAM DIRECTION AND ANTIPARALLEL TO THE BEAM DIRECTION (ACCEPT: PARALLEL AND ANTIPARALLEL)
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ROUND 13

TOSS-UP

3) Chemistry – *Multiple Choice* Which of the following polyprotic acids has three pKa values?

W) Arsenic acid
X) Ascorbic acid
Y) Carbonic acid
Z) Acetic acid

ANSWER: W) ARSENIC ACID

BONUS

3) Chemistry – *Short Answer* Rank the three hydrogen atoms in terms of increasing pKa: 1) Hydrogen atom in water; 2) Hydrogen atom of hydroxyl group in phenol ; 3) Hydrogen atom in propan-2-one

ANSWER: 2, 1, 3

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TOSS-UP

4) Biology - *Multiple Choice* Which of the following acts as a main source of amino acids for human infants, and is located in milk?

W) Ovalbumin
X) Insulin
Y) Keratin
Z) Casein

ANSWER: Z) CASEIN

BONUS

4) Biology - *Multiple Choice* Which of the following BEST explains the purpose of performing the indole test on a bacterium?

W) It determines whether the bacteria can produce tyrosine by the deamination of indole.
X) It determines whether the bacteria can produce indole by the deamination of tryptophan.
Y) It determines whether the cell membrane of the bacteria contains indole.
Z) It determines whether the bacteria is an obligate anaerobe.
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ANSWER: X) IT DETERMINES WHETHER THE BACTERIA CAN PRODUCE INDOLE BY THE DEAMINATION OF TRYPTOPHAN

ROUND 13

TOSS-UP

5) Math – *Short Answer* For 10 miles a car goes at 3 meters/minute, and for another 10 miles the car goes at 5 meters/minute. What is the average speed of the car over the entire 20 miles?

ANSWER: 15/4 (ACCEPT: 3.75)

BONUS

5) Math – *Short Answer* What is the harmonic mean between the numbers 2, 3, and 4 in simplified form?

ANSWER: 36/13

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TOSS-UP

6) Earth and Space - *Short Answer* What is the term for the time it takes the Moon to cycle through all of its phases exactly once, also known as a lunar month?

ANSWER: SYNODIC MONTH

BONUS

6) Earth and Space - *Multiple Choice* Which of the following is true regarding mean solar days and sidereal days?

W) a sidereal day is defined as the time interval from 12:00 AM one day to 12:00 AM the next
X) a mean solar day is approximately 2 minutes shorter than a sidereal day
Y) a mean solar day is approximately 4 minutes longer than a sidereal day
Z) a mean solar day is defined as the time it takes for the Earth to complete a full rotation around its axis

ANSWER: Y) A MEAN SOLAR DAY IS APPROXIMATELY 4 MINUTES LONGER THAN A SIDEREAL DAY
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ROUND 13

TOSS-UP

7) Energy – *Short Answer* Recent research at Lawrence Berkeley National Laboratory has been focused on measuring the weight of superheavy elements. What is the term for these elements that directly follow the actinides with atomic numbers from 104 to 120.

ANSWER: TRANSACTINIDES

BONUS

7) Energy – *Multiple Choice* The process for discovering new Transactinides over the past couple decades has been to fuse together actinide isotopes. Which of the following is a common isotope of an actinide?

W) Neodymium - 265
X) Mendelevium - 280
Y) Ytterbium - 235
Z) Thorium - 232

ANSWER: Z) THORIUM - 232

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TOSS-UP

8) Biology - *Short Answer* What is the name for the walls in hyphae that separate individual cells?

ANSWER: SEPTA (ACCEPT SEPTUM)

BONUS

8) Biology - *Short Answer* What is the name given to fungi that lack septa, due to their repeated division of cells without cytokinesis?

ANSWER: COENOCYTIC
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ROUND 13

TOSS-UP

9) Physics – *Short Answer* The magnetic moment of an electron can be written in terms of what physical constant, named after Bohr?

ANSWER: BOHR MAGNETON

BONUS

9) Physics – *Short Answer* By name or number, identify all of the following 4 interactions which is a possible interaction the charm quark may have with another, possibly identical particle? 1) Gravitational, 2) Weak, 3) Strong, 4) Electromagnetic?

ANSWER: ALL

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TOSS-UP

10) Chemistry – *Short Answer* What is the maximum number of orbitals allowed when l [L] equals 6?

ANSWER: 13

BONUS

10) Chemistry – *Short Answer* In the following three ions, what are the highest energy sublevels, respectively, that contain electrons: 1) Cu^{+}, 2) Sn^{4+}, 3) N^{3-} ?

ANSWER: 1) 3d, 2) 4d, 3) 2p

TOSS-UP

11) Math – *Multiple Choice* A triangle with which of the following side lengths is obtuse?
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W) 3, 4, 7
X) 2, 3, 4
Y) 7, 23, 24
Z) 4, 6, 7

ANSWER: X) 2, 3, 4

BONUS

11) Math – *Short Answer* What is the circumradius of a triangle with sides of length 5, 6, and 9?

ANSWER: Z) $27\sqrt{2}/8$

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TOSS-UP

12) Earth and Space - *Short Answer* What type of hydrothermal vent is generally found away from mid-ocean ridges and emits fluids with high pH?

ANSWER: WHITE SMOKER

BONUS

12) Earth and Space - *Short Answer* What term is used to describe the fluid coming from hydrothermal vents that exists as both a gas and a liquid?

ANSWER: SUPERCRITICAL
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ROUND 13

TOSS-UP

13) Biology - *Short Answer* What is the name of the type of cell in sponges that uses pseudopodia to travel across the mesohyl?

ANSWER: AMOEBOCYTES

BONUS

13) Biology - *Multiple Choice* Which of the following is used by amoebocytes in sponges to produce the flexible fibers in sponges?

W) Calcium carbonate
X) Spongin
Y) Silica
Z) Keratin

ANSWER: X) SPONGIN

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TOSS-UP

14) Energy – *Short Answer* An international team of researchers using the SLAC's Linac Coherent Light Source X-ray laser have captured the most complete and highest-resolution images to date of Photosystem II at work, showing all four intermediate states that produce the oxygen we breathe. In the light-absorption process of photosystem II, energy is passed from pigment to pigment, until reaching the center of the reaction. From there, energy is transferred to what pigment type in order to increase an electron's energy level?

ANSWER: P680 (ACCEPT:PHOTOSYSTEM II PRIMARY DONOR)

BONUS

14) Energy – *Multiple Choice* More than 2 billion years ago, tiny organisms on Earth started photosynthesizing. Chloroplasts are organelles responsible for this process in plants. The theory that chloroplasts are endosymbionts can best be justified by which of the following?

W) Chloroplasts contain a membrane
X) Chloroplasts are relatively stationary within the cytosol
Y) Chloroplasts contain circular DNA
Z) Chloroplasts carry out individual functions

ANSWER: Y) CHLOROPLASTS CONTAIN CIRCULAR DNA
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ROUND 13

TOSS-UP

15) Physics – *Multiple Choice* Which of the following is true about the gravitational interactions between photons and other particles?

W) Photons cannot interact gravitationally with any other particle
X) Photons can interact gravitationally only with bosons
Y) Photons can interact gravitationally only with gluons
Z) Photons can interact gravitationally with any particle

ANSWER: Z) PHOTONS CAN INTERACT GRAVITATIONALLY WITH ANY OTHER PARTICLE

BONUS

15) Physics – *Short Answer* A wave passes through a polarizing filter with the direction of propagation of the wave at an angle of 30° with the plane of the filter. The final intensity of the wave will be what fraction of the initial intensity of the wave?

ANSWER: 3/4

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TOSS-UP

16) Earth and Space - *Multiple Choice* Which of the following scientists was a major supporter of uniformitarianism and would later be known as the father of modern geology?
W) Alfred Wegner
X) Georges Cuvier
Y) James Hutton
Z) Will Smith

ANSWER: Y) JAMES HUTTON

BONUS

16) Earth and Space - *Short Answer* By name or number, identify all of the following 4 events that occurred during the Jurassic Period: 1) Most iron banded formations were created, 2) Pangaea formed, 3) The salinity of the ocean increased at a rapid rate, 4) Birds first appeared.

ANSWER: NONE

TOSS-UP
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ROUND 13

17) Chemistry – *Short Answer* Identify the oxidizing agent and the reducing agent, respectively, for the following reaction: $CuSO_4 + 2Zn \rightarrow 2ZnSO_4 + Cu$

ANSWER: OXIDIZING AGENT - Cu^{2+}, REDUCING AGENT - Zn

BONUS

17) Chemistry – *Multiple Choice* Which of the following occurs when a dilute solution of ammonia is added to a solution containing nickel(II) ions?

W) $Ni(NH_2)_2$ precipitates
X) $Ni(OH)_2$ precipitates
Y) The solution turns from clear to blue
Z) Hydrogen gas is given off

ANSWER: X) $Ni(OH)_2$ PRECIPITATES

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TOSS-UP

18) Math – *Short Answer* Evaluate: 7^{140} mod 139 (READ 7 to the 140 mod 139).

ANSWER: 49

BONUS

18) Math – *Short Answer* What is the least possible length of the common external tangent between two coplanar circles that do not intersect with radii 3 and 5 in simplest radical form?

ANSWER: $2\sqrt{15}$
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ROUND 13

TOSS-UP

19) Chemistry – *Multiple Choice* How many isomers exist for a compound with formula C_6H_{14}?

W) 3
X) 5
Y) 7
Z) 9

ANSWER: X) 5

BONUS

19) Chemistry – *Short Answer* An SN1 reaction is performed by reacting sodium bromide with (S)-2-chlorobutane, and generates a 1 molar mixture of 65% (S)-2-bromobutane and 35% (R)-2-bromobutane. If the optical rotation of the solution was 6.9°, what is the optical rotation of pure (S)- 2-bromobutane, to the nearest degree?

ANSWER: 23

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TOSS-UP

20) Physics – *Multiple Choice* Two blocks of clay, Block A and Block B, are moving in the same direction with different speeds when they collide and stick together. Which of the following quantities has the same value before and after the collision?

W) Block A's momentum
X) Block B's momentum
Y) The sum of Block A and Block B's kinetic energies
Z) The sum of Block A and Block B's momentum

ANSWER: Z) THE SUM OF BLOCK A AND BLOCK B'S MOMENTUM

BONUS

20) Physics – *Short Answer* To the nearest ten meters per second how far will a sound wave travel in 3 seconds in still air at a temperature of 20 degrees Celsius?

ANSWER: 1030
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ROUND 13

TOSS-UP

21) Earth and Space - *Short Answer* What is the term for the rate at which the temperature of the atmosphere changes with regard to altitude?

ANSWER: ENVIRONMENTAL LAPSE RATE (DO NOT ACCEPT: ADIABATIC LAPSE RATE)

BONUS

21) Earth and Space - *Multiple Choice* Which of the following best describes conditional instability in the atmosphere?

W) conditional instability occurs when both saturated and unsaturated air parcels are stable in the atmosphere at elevations higher than 2000 meters but are unstable at elevations lower than 2000 meters
X) conditional instability occurs when saturated air parcels are stable in the atmosphere but unsaturated air parcels are unstable
Y) conditional instability occurs when both saturated and unsaturated air parcels are unstable in the atmosphere at elevations higher than 2000 meters but stable at elevations lower than 2000 meters
Z) conditional instability occurs when saturated air parcels are unstable in the atmosphere but unsaturated air parcels are stable

ANSWER: Z) CONDITIONAL INSTABILITY OCCURS WHEN SATURATED AIR PARCELS ARE UNSTABLE IN THE ATMOSPHERE BUT UNSATURATED AIR PARCELS ARE STABLE

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TOSS-UP

22) Biology - *Multiple Choice* Which of the following phylums contains methanogens?

W) Nanoarchaeota
X) Korarchaeota
Y) Crenarchaeota
Z) Euryarchaeota

ANSWER: Z) EURYARCHAEOTA

BONUS
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22) Biology - *Short Answer* By name or number, identify all of the following species of bacteria that are gram-negative: 1) E. Coli, 2) Actinomyces neuii, 3) Bordetella pertussis, 4) Clostridium tetani.

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

ROUND 13

TOSS-UP

23) Math – *Multiple Choice* If 5 consecutive integers from 1 to 100 inclusive are selected, what is the probability exactly 1 of them is divisible by six?

W) 1/2
X) 3/4
Y) 5/6
Z) 1

ANSWER: Y) ⅚

BONUS

23) Math – *Short Answer* How many common tangents do the graphs of $(x + 2)^2 + (y - 3)^2 = 16$, and $(x - 4)^2 + (y - 11)^2 = 36$ have?

ANSWER: 3