SBL FALL ROUND 13

TOSS-UP

1) Chemistry – *Short Answer* [2] Rank the following three ions in terms of increasing size: 1) Na^{+}; 2) K^{+}; 3) Mg^{2+}.

ANSWER: 3, 1, 2 [CK]

BONUS

1) Chemistry – *Short Answer* [3] Identify all of the following three statements that are true regarding 3p orbitals: 1) They possess a nodal plane; 2) They possess a radial node; 3) They are generally involved in more efficient pi bonding than 2p orbitals.

ANSWER: 1 AND 2 [CK]

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TOSS-UP

2) Biology – *Short Answer* [2] What term is given to the ability of the brain to change when given different stimuli?

ANSWER: NEUROPLASTICITY (ACCEPT: PLASTICITY) [SF]

BONUS

2) Biology – *Short Answer* [3] Identify all of the following four plant hormones that promote growth: 1) Abscisic acid; 2) Gibberellins; 3) Auxins; 4) Cytokinins.

ANSWER: 2, 3, 4 [SF]
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TOSS-UP

3) Earth and Space – *Short Answer* [2] What type of galaxy is commonly thought of as an intermediate between spiral galaxies and elliptical galaxies and are denoted as S0 in the Hubble classification scheme?

ANSWER: LENTICULAR [YL]

BONUS

3) Earth and Space – *Multiple Choice* [3] Which of the following statements best describes the dominant formation mechanism of precipitation in cold clouds?

W) Supercooled water droplets merge due to electrostatic forces and eventually fall after reaching a critical mass
X) Ice crystals merge due to electrostatic forces and eventually fall after reaching a critical mass
Y) Water vapor diffuses from above supercooled water droplets to ice crystals, which fall after reaching a critical mass
Z) Water vapor diffuses from above ice crystals to supercooled water droplets, which fall after reaching a critical mass

ANSWER: Y) WATER VAPOR DIFFUSES FROM ABOVE SUPERCOOLED WATER DROPLETS TO ICE CRYSTALS, WHICH FALL AFTER REACHING A CRITICAL MASS [YL]

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TOSS-UP

4) Math – *Short Answer* [4] What is the slope of the directrix of the parabola $y = 2x^2 + 3$?

ANSWER: 0 [CT]

BONUS

4) Math – *Short Answer* [5] What is the largest 3-digit integer n such that n choose 2 is divisible by 32?

ANSWER: 961 [CT]
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TOSS-UP

5) Energy – *Multiple Choice* [5] Scientists at Brookhaven National Lab are studying halide perovskites and their use in photovoltaic applications. Which of the following compounds is a halide perovskite commonly used in PV systems?

W) Magnesium bromide
X) Methylammonium lead trichloride
Y) Calcium titanite
Z) Lead (IV) fluoride

ANSWER: X) METHYLAMMONIUM LEAD TRICHLORIDE [YL]

BONUS

5) Energy – *Short Answer* [2] Researchers at Idaho National Lab are studying the *in situ* imaging of boehmite suspended in liquid using a scanning electron microscope to understand how the particles aggregate after forming a colloid. The backscattering of electrons produced by the microscope was found to produce results in accordance with what effect that describes the scattering of light in a colloid?

ANSWER: TYNDALL EFFECT [SF]

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TOSS-UP

6) Physics – *Short Answer* [6] In two rotating systems that are mirror images of each other, the angular momentum vectors for each system are not true mirror images because one vector has a reversed direction compared to the other. What is the term for this kind of vector?

ANSWER: PSEUDOVECTOR [CT]

BONUS

6) Physics – *Short Answer* [3] A 9000 kg block is traveling through empty space at 15 m/s when it collides perfectly elastically with a 1 kg block initially at rest. If the collision is head-on, to the nearest m/s, what is the final speed of the 1 kg block?

ANSWER: 30 [CT]
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TOSS-UP

7) Earth and Space – *Short Answer* [3] Olivine exists as a continuous solid solution between forsterite and fayalite. These two endmembers are silicates of which two metals?

ANSWER: IRON AND MAGNESIUM (ACCEPT: FE AND MG) [YL]

BONUS

7) Earth and Space – *Short Answer* [3] What specific type of pyroclastic flow is characteristically incandescent and flows as a dense, hot cloud of volcanic gases?

ANSWER: NUÉE ARDENTE [YL]

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TOSS-UP

8) Biology – *Multiple Choice* [4] In which of the following portions of the kidney is most glucose reabsorbed in a non diabetic patient?

W) Proximal convoluted tubule
X) Loop of Henle
Y) Distal convoluted tubule
Z) Collecting duct

ANSWER: W) PROXIMAL CONVOLUTED TUBULE [SF]

BONUS

8) Biology – *Short Answer* [4] Identify all of the following 3 vitamins that are water soluble: 1) Pyridoxine; 2) Tocopherol; 3) Cholecalciferol.

ANSWER: 1 ONLY [SF]
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TOSS-UP

9) Energy – *Multiple Choice* [2] Scientists at Los Alamos National Lab are studying the decay modes of various nuclei. Which of the following decay modes would a nucleus of plutonium-242 most likely undergo?

W) Alpha decay
X) Beta plus decay
Y) Beta minus decay
Z) Gamma decay

ANSWER: W) ALPHA DECAY [CT]

BONUS

9) Energy – *Short Answer* [3] Researchers at Princeton Plasma Physics Lab are modeling the range of quantum entanglement of fermions by using asymmetric square matrices. These matrices are asymmetric because they do not remain constant after what function has been applied to them?

ANSWER: TRANSPOSE (ACCEPT: TRANSPOSITION) [CT]

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TOSS-UP

10) Math – *Short Answer* [6] Identify all of the following 3 functions that do NOT have an elementary antiderivative with respect to x: 1) e to the power of $-x^2$, 2) sine of x over x, 3) e to the power of $-x$.

ANSWER: 1 AND 2 [CT]

BONUS

10) Math – *Short Answer* [6] What is the sum of the squares of the roots of the cubic polynomial $f(x) = x^3 + 10x^2 - 7x + 10$?

ANSWER: 114 [CT]
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TOSS-UP

11) Chemistry – *Short Answer* [3] When the solvation of copper cations is studied, it is found that the electrostatic potential energy of the interaction is dependent on the distance between the copper ions and water ligands to what power?

ANSWER: –2 [CK]

BONUS

11) Chemistry – *Short Answer* [5] Given only the temperature of a sample of gas, identify all of the following three properties that could be uniquely determined: 1) Root mean square speed; 2) Average kinetic energy; 3) Collision frequency.

ANSWER: 2 ONLY [CK]

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TOSS-UP

12) Physics – *Multiple Choice* [4] Which of the following quantities does a galvanometer measure?

W) Voltage
X) Current
Y) Resistance
Z) Magnetic field

ANSWER: X) CURRENT [DK]

BONUS

12) Physics – *Short Answer* [4] 1 kg of water vapor at 101 °C is mixed with 1 kg of ice at -1 °C in an insulated container at a pressure of 1 atmosphere, and the system comes to thermal equilibrium. In degrees Celsius, what is the final temperature of the mixture?

ANSWER: 100 [DK]
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TOSS-UP

13) Biology – *Short Answer* [5] Since ATP is an allosteric modulator of myosin and actin binding, the lack of ATP causes rigidity in muscles especially during brain death. What term is given to this phenomenon?

ANSWER: RIGOR MORTIS

BONUS

13) Biology – *Short Answer* [2] What cross linked organic polymer that stains red in plant tissue is essential in the sturdiness of sclerenchyma tissue and is found in abundance in tracheids?

ANSWER: LIGNIN [SF]

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TOSS-UP

14) Math – *Short Answer* [5] What is the surface area of a cylinder with a radius of 5 and a height of 12?

ANSWER: 170π [CT]

BONUS

14) Math – *Short Answer* [4] How many integers between 10 and 10 thousand, inclusive, are palindromes?

ANSWER: 189 [CT]
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TOSS-UP

15) Earth and Space – *Short Answer* [5] Rank the following three atmospheric circulation cells in terms of increasing maximum height: 1) Polar cell; 2) Ferrel cell; 3) Hadley cell.

ANSWER: 1, 2, 3 [YL]

BONUS

15) Earth and Space – *Short Answer* [5] Galactic collision often produces thin elongated regions of dust and gas that support large outbursts of star formation, which are a result of gravitational forces from interacting galaxies. What is the term for these thin elongated regions?

ANSWER: TIDAL TAILS [SF i think]

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TOSS-UP

16) Physics – *Multiple Choice* [4] A boy is standing on the outer edge of a frictionless merry-go-round spinning clockwise at constant angular velocity omega. As viewed from above, the boy is on the eastern side of the merry-go-round. If he throws a ball radially inward, in what direction will it be deflected by the Coriolis force?

W) North
X) East
Y) South
Z) West

ANSWER: Y) SOUTH [RB]

BONUS

16) Physics – *Short Answer* [3] A 5 kg block is tied to the ceiling with a string. Alice ties another string to the block and pulls it horizontally such that the first string makes a 60 degree angle with the vertical. What is the new tension in the first string?

ANSWER: 98 N [CT]
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TOSS-UP

17) Energy – *Short Answer* [4] Researchers at Lawrence Berkeley National Lab are using Earth's magnetic field in order to conduct NMR experiments. Order the following 3 hydrogens in terms of increasing chemical shift in a proton-NMR experiment: 1) Benzylic hydrogen; 2) Aldehyde hydrogen; 3) Alkyl hydrogen.

ANSWER: 3, 1, 2 [CT]

BONUS

17) Energy – *Short Answer* [6] Scientists at Pacific Northwest National Lab are involved in the development of the ICLASS ***[eye-class]*** climate model, which incorporates radiative forcings from cloud cover and aerosols. Identify all of the following three large-scale changes to the Earth system that generally increase surface temperatures: 1) Formation of more high altitude clouds; 2) Formation of more low altitude clouds; 3) Increasing surface albedo.

ANSWER: 1 ONLY [YL]

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TOSS-UP

18) Chemistry – *Short Answer* [4] Identify all of the following 3 quantities for which fluorine has the greatest value of all the elements: 1) Electronegativity; 2) Electron affinity; 3) Standard reduction potential.

ANSWER: 1 AND 3 [CK]

BONUS

18) Chemistry – *Short Answer* [3] Rank the following 3 normalized orbitals from least to greatest value of their radial wavefunctions at the origin: 1) 1s; 2) 2s; 3) 2p.

ANSWER: 3, 2, 1 [CK]
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TOSS-UP

19) Math – *Short Answer* [2] There are 100 students in a school, and everyone takes band or art or both. If there are 60 total students in band and 20 students in both, how many total students are in art?

ANSWER: 60 [CT]

BONUS

19) Math – *Short Answer* [7] An isosceles trapezoid has a shorter base of 1, and the interior angles adjacent to that base are 120 degrees each. Given that the trapezoid has an incircle, what is the length of the longer base?

ANSWER: 3 [CT]

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TOSS-UP

20) Biology – *Short Answer* [6] The enzyme urate oxidase may be found in the highest abundance in which organelle?

ANSWER: PEROXISOME [SF]

BONUS

20) Biology – *Short Answer* [5] Identify all of the following 3 statements that are true of Sanger sequencing: 1) It can only sequence DNA and not RNA; 2) It requires a heat resistant polymerase; 3) It requires gel electrophoresis.

ANSWER: 3 ONLY [SF]
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TOSS-UP

21) Earth and Space – *Short Answer* [5] What is the term given to an active galactic nucleus with a relativistic jet pointed directly at Earth?

ANSWER: BLAZAR [YL]

BONUS

21) Earth and Space – *Short Answer* [4] Rank the following three solar system bodies in terms of increasing volume: 1) Mercury; 2) Ganymede; 3) Ceres.

ANSWER: 3, 1, 2 [YL]

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TOSS-UP

22) Chemistry – *Multiple Choice* [7] Novel molecular dynamics studies of protein structure have revealed that the contribution of hydrogen bonding to alpha helix stability has historically been vastly overstated. The study showed that the true greatest proportion of free energy relief is the interaction between strand-adjacent carbonyl groups. Which of the following molecular orbital interactions accounts for this phenomenon?

W) Nonbonding to sigma star
X) Nonbonding to pi star
Y) Pi to sigma star
Z) Sigma to pi star

ANSWER: X) NONBONDING TO PI STAR [RB]

BONUS

22) Chemistry – *Multiple Choice* [7] During which of the following steps of the Heck reaction cycle does carbon-carbon π bond cleavage occur?

W) Migratory insertion
X) Beta hydride elimination
Y) Oxidative insertion
Z) Reductive elimination

ANSWER: W) MIGRATORY INSERTION [RB]
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TOSS-UP

23) Physics – *Short Answer* [4] A man is standing near a loudspeaker and observes a loudness of 100 decibels. If the loudspeaker suddenly doubles in intensity, to the nearest decibel, what is the new observed loudness?

ANSWER: 103 [CT]

BONUS

23) Physics – *Short Answer* [5] A particle is spontaneously produced and travels at 0.6c before spontaneously decaying 8 seconds later relative to an observer on Earth. In seconds, how long was the particle's lifetime in its own frame of reference?

ANSWER: 6.4 [CT]