SBL FALL ROUND 14

TOSS-UP

1) Math – *Short Answer* How many people need to be in a room to ensure that there are at least 3 people born in the same month of the year?

ANSWER: 25

BONUS

1) Math – *Short Answer* Alice and Bob each choose a distinct diagonal of a regular pentagon. What is the probability that they choose diagonals of the same length?

ANSWER: 1

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TOSS-UP

2) Biology – *Short Answer* Ridings has debilitating senioritis and thus whenever he hears the word ‘essay’, he immediately reacts by performing a series of unlearned actions. What is this behavior called?

ANSWER: FIXED ACTION PATTERN (ACCEPT: FAP)

BONUS

2) Biology – *Short Answer* Identify all of the following three amino acids that are aromatic: 1) Tyrosine; 2) Phenylalanine; 3) Alanine.

ANSWER: 1 AND 2
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TOSS-UP

3) Energy – *Multiple Choice* Researchers at Argonne National Lab have been using optimization to apply artificial intelligence to quantum computing. When optimizing a univariate function over a given domain, which of the following sets of numbers must be tested?

W) Critical points
X) Horizontal asymptotes
Y) Roots
Z) Inflection points

ANSWER: W) CRITICAL POINTS

BONUS

3) Energy – *Short Answer* Scientists at Lawrence Berkeley National Lab have been investigating new ways to remove heavy metals from industrial waste products. Most heavy metal removal involves the binding of polydentate ligands in what phenomenon?

ANSWER: CHELATION

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TOSS-UP

4) Chemistry – *Multiple Choice* Which of the following reactions is most likely to perfectly obey second order kinetics?

W) Photolysis of chlorine to yield two Cl radicals
X) Combustion of methane in excess oxygen
Y) Decomposition of potassium chlorate upon heating
Z) Formation of norbornene from ethene and 1,3-cyclopentadiene

ANSWER: Z) FORMATION OF NORBORNENE FROM ETHENE AND 1,3-CYCLOPENTADIENE

BONUS

4) Chemistry – *Multiple Choice* Sodium hydroxide is reacted with 2-bromopropane at high temperature. Which of the following molecules is likely to be the major product of this reaction?

W) 2-propanol
X) 2-propanone
Y) Propene
Z) Propanoic acid

ANSWER: Y) PROPENE

TOSS-UP
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5) Physics – *Short Answer* Torque is defined as the time derivative of what quantity?

ANSWER: ANGULAR MOMENTUM

BONUS

5) Physics – *Short Answer* In terms of the ideal gas constant R, what is the heat capacity at constant volume of an ideal monatomic gas at room temperature?

ANSWER: 3R/2

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TOSS-UP

6) Earth and Space – *Multiple Choice* Which of the following masses is closest to the lower mass limit of a main sequence star in solar masses?

W) 0.08
X) 0.16
Y) 0.5
Z) 0.75

ANSWER: W) 0.08

BONUS

6) Earth and Space – *Multiple Choice* When working in the field, Jay finds a fossil replaced by pyrite. Which of the following best describes the likely environment of fossilization?

W) Oxygen rich deep marine
X) Oxygen rich river bed
Y) Anoxic deep marine
Z) Anoxic river bed

ANSWER: Y) ANOXIC DEEP MARINE
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TOSS-UP

7) Biology – *Short Answer* How many germ layers does a sea star have?

ANSWER: 3

BONUS

7) Biology – *Short Answer* The infundibulum connects the hypothalamus to which endocrine gland in the human body?

ANSWER: POSTERIOR PITUITARY (ACCEPT: PITUITARY GLAND)

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TOSS-UP

8) Earth and Space – *Short Answer* What type of precipitation is characterized by falling supercooled water that crystallizes upon impact?

ANSWER: FREEZING RAIN

BONUS

8) Earth and Space – *Short Answer* Identify all of the following three changes, if considered alone, that will raise the eustatic sea level: 1) Increase in total ocean mass; 2) Increase in mean ocean density; 3) Increase in sedimentation rate.

ANSWER: 1 AND 3
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TOSS-UP

9) Energy – *Short Answer* Scientists at Lawrence Berkeley National Lab have been using methods developed in particle physics to increase the effectiveness of quantum computing. In quantum computing, what term is given to the basic unit of quantum information?

ANSWER: QUBIT

BONUS

9) Energy – *Short Answer* Researchers at Los Alamos National Lab are investigating the dynamics behind the Nice ***[neese]*** model, which proposes the outward migration of Saturn and Jupiter from the inner disk of the early solar system. The Nice model provides an explanation for which period of intense cratering occurring roughly four billion years ago?

ANSWER: LATE HEAVY BOMBARDMENT

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TOSS-UP

10) Math – *Multiple Choice* An acute triangle has two sides of length 5 and 12. Which of the following could be the length of the third side?

W) 8
X) 10
Y) 12
Z) 14

ANSWER: Y) 12

BONUS

10) Math – *Short Answer* What is the 2020th smallest positive integer that is not divisible by 3?

ANSWER: 3029
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TOSS-UP

11) Chemistry – *Short Answer* To one significant figure, what is the pH of a 1 molar solution of a weak acid with a pKa of 4?

ANSWER: 2

BONUS

11) Chemistry – *Short Answer* How many isomers exist for the coordination complex formed between magnesium 2+ and EDTA?

ANSWER: 2

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TOSS-UP

12) Physics – *Multiple Choice* In an RC circuit, which of the following best describes the potential difference across the resistor as the capacitor is charged?

W) Exponentially approaching zero
X) Exponentially approaching a nonzero constant
Y) Quadratically approaching zero
Z) Quadratically approaching a nonzero constant

ANSWER: W) EXPONENTIALLY APPROACHING ZERO

BONUS

12) Physics – *Short Answer* What function is defined as the difference between the kinetic and potential energies for a system?

ANSWER: LAGRANGIAN
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TOSS-UP

13) Biology – *Short Answer* Adenylyl cyclase is a signaling enzyme that converts what molecule into cyclic AMP?

ANSWER: ATP

BONUS

13) Biology – *Short Answer* Identify all of the following three clades that contain protostomes: 1) Annelida; 2) Ecdysozoans; 3) Tetrapods.

ANSWER: 1 AND 2

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TOSS-UP

14) Earth and Space – *Short Answer* What is the name given to alternating light and dark bands of dust found on glaciers that reflect seasonal variations of flow velocity?

ANSWER: OGIVES

BONUS

14) Earth and Space – *Multiple Choice* Which of the following best describes the solidus in igneous petrology?

W) The line in a phase diagram above which a mineral starts to melt
X) The line in a phase diagram above which a mineral completely melts
Y) A point in a phase diagram at which a mineral completely melts
Z) A region in a phase diagram within which the mineral is completely solid

ANSWER: W) THE LINE IN A PHASE DIAGRAM ABOVE WHICH A MINERAL STARTS TO MELT
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TOSS-UP

15) Math – *Short Answer* If $x + y = 7$, $y + z = 11$, and $z + x = 10$, what is $x + y + z$?

ANSWER: 14

BONUS

15) Math – *Short Answer* The digits 1, 2, 1, and 2 can be arranged to form 6 different 4-digit integers. What is the sum of these 6 integers?

ANSWER: 9999

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TOSS-UP

16) Chemistry – *Short Answer* Ketones, aldehydes, and esters are all reactive because they contain what functional group?

ANSWER: CARBONYL

BONUS

16) Chemistry – *Short Answer* What is the name of the temperature at which antiferromagnetic materials lose their microscopic order and become paramagnetic?

ANSWER: NÉEL TEMPERATURE
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TOSS-UP

17) Physics – *Short Answer* Ampere's law states that the curl of the magnetic field is equal to the current density times what constant?

ANSWER: VACUUM PERMEABILITY (ACCEPT: PERMEABILITY OF FREE SPACE; DO NOT ACCEPT: MAGNETIC PERMEABILITY)

BONUS

17) Physics – *Short Answer* Identify all of the following three quantities that are required to experimentally calculate Earth's gravitational acceleration using a uniform physical pendulum: 1) Length of pendulum; 2) Mass of pendulum; 3) Period of oscillation.

ANSWER: 1 AND 3

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TOSS-UP

18) Math – *Short Answer* What is the curvature of a circle with radius 4?

ANSWER: 1/4

BONUS

18) Math – *Short Answer* If x, y, and z are positive integers with $xy = 2021$, what is the smallest possible value of yz such that y is not uniquely determined?

ANSWER: 43
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TOSS-UP

19) Energy – *Short Answer* Researchers at Argonne National Lab are investigating new ways to convert nitrate into ammonia. This is particularly difficult because it requires the transfer of how many electrons per molecule of nitrate?

ANSWER: 8

BONUS

19) Energy – *Short Answer* Scientists at Idaho National Lab have been developing new methods for the production of X-rays for applications in medicine. Currently, many X-rays are produced by the deceleration of electrons as they approach atomic nuclei, producing what specific type of radiation?

ANSWER: BREMSSTRAHLUNG (ACCEPT: BRAKING RADIATION)

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TOSS-UP

20) Biology – *Short Answer* What is the term for the type of body cavity possessed by rotifers and nematodes that refers to a body cavity not derived from mesoderm?

ANSWER: PSEUDOCOELOM

BONUS

20) Biology – *Short Answer* What general term is used to describe the asexual reproduction of plants occuring without fertilization?

ANSWER: APOMIXIS
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TOSS-UP

21) Earth and Space – *Short Answer* The inverse of the Hubble constant is approximately equal to what cosmological quantity?

ANSWER: AGE OF THE UNIVERSE

BONUS

21) Earth and Space – *Short Answer* Identify all of the following three mechanisms that are thought to have generated Earth's internal heat: 1) Decay of radioactive isotopes; 2) Friction from planetary differentiation; 3) Moon-forming impact with Theia.

ANSWER: ALL

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TOSS-UP

22) Physics – *Short Answer* Identify all of the following three particles that have zero electric charge: 1) Photon; 2) Gluon; 3) Muon.

ANSWER: 1 AND 2

BONUS

22) Physics – *Short Answer* An apparatus consists of two identical bulbs separated by a stopcock. Initially, the stopcock is closed, and 3 gas molecules are added to each bulb. Alice opens the stopcock and leaves the system for some time. How many times as likely are the molecules to be evenly split between the bulbs than they are to all be in the left bulb?

ANSWER: 20
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TOSS-UP

23) Chemistry – *Short Answer* What is the term for the process by which chemical reactions emit light?

ANSWER: CHEMILUMINESCENCE

BONUS

23) Chemistry – *Short Answer* Which allotrope of phosphorus has a standard enthalpy of formation of zero?

ANSWER: WHITE PHOSPHORUS