



Competitive Division Double Elimination 5

TOSS-UP

1) BIOLOGY *Multiple Choice* Phoenixes require colder temperatures than a savannah and more precipitation than a shrubland. Which of the following biomes would not be appropriate for phoenixes?

- W) Temperate grassland
- X) Taiga
- Y) Temperate deciduous forest
- Z) Temperate rainforest

ANSWER: W) TEMPERATE GRASSLAND [GKD]

BONUS

1) BIOLOGY *Short Answer* Identify all of the following three statements that are true about boundaries between biomes:

- 1) Predation rates are typically lower on the boundaries between biomes than in the interior of biomes
- 2) The boundary between biomes can harbor more species diversity than the communities on either side of the boundary
- 3) Riparian [*rih-PAIR-ee-en*] zones are ecotones

ANSWER: 2 AND 3 [GKD]

TOSS-UP

- 2) CHEMISTRY *Short Answer* What is the point group of CO₂?

ANSWER: D_{∞h} / **D infinity h** [DC]

BONUS

- 2) CHEMISTRY *Short Answer* A refrigerator brings a material at 57 °C to 2 °C. Calculate the coefficient of performance for this refrigerator.

ANSWER: 5 [DC]

TOSS-UP

- 3) EARTH AND SPACE *Short Answer* Like rivers, oceanic currents often meander, and said meanders can eventually become cut off. When this happens, a warm-core ring and a cold-core ring are formed. By name or number, identify all of the following three statements that are true about these structures:

- 1) Cold core rings can strengthen hurricanes
- 2) Warm core rings produced by the Gulf stream are often reabsorbed by the same current
- 3) Cold core rings are more easily detected by satellites than warm core rings

ANSWER: 2 ONLY [EB]

BONUS

- 3) EARTH AND SPACE *Short Answer* By name or number, identify all of the following conditions that could lead to the production of amphiboles:

- 1) Contact metamorphism of dolomitic limestone
- 2) Alteration of pyroxene
- 3) Low-temperature, high-pressure metamorphism of gabbro

ANSWER: ALL [EB]

TOSS-UP

- 4) MATH *Short Answer* Emmy speaks 20 languages¹, including English and Spanish. You only speak English and Spanish. Emmy comes in very tired, speaking a mix of two random languages she knows. What is the probability you understand at least one of those languages?

ANSWER: 37/190 [MD]

BONUS

- 4) MATH *Multiple Choice* Arnesh is forcing Emmy and Edward to do a titration lab. He will give them 3 tries to stop it at the perfect time, or else he will give them an F in the class. Emmy and Edward's probability of stopping the titration follows the distribution of the 8th row of Pascal's triangle, where they are guaranteed to stop within 4 drops of the correct point, and the most likely outcome is they succeed at the trial. What is the probability that Emmy and Edward fail, to the nearest tenth?

- W) 0.2
- X) 0.4
- Y) 0.6
- Z) 0.8

Answer: X) .4 [MD]

¹ Rounded to the nearest ten to make the problem easier, though as of public release on 7/13/2022, it's probably now pretty close to accurate

TOSS-UP

- 5) PHYSICS *Short Answer* What vector describes how energy moves in an electromagnetic field?

ANSWER: POYNTING VECTOR [AC]

BONUS

- 5) PHYSICS *Short Answer* Lightning strikes a tower. It then strikes another place. An infinitely resourceful alien tries to find a reference frame in which an observer would observe the two lightning strikes to occur at the same spatial location. However, he cannot do so without breaking the laws of physics. Name all of the following that could represent the relationship between the two lightning strikes.

- 1) Timelike
- 2) Spacelike
- 3) Lightlike

ANSWER: 2 AND 3 [AC]

TOSS-UP

- 6) ENERGY *Short Answer* Davidson HS A team members are studying methods in computational chemistry. One such method involves dynamically simulating the movements of atoms and molecules using Newtonian mechanics. While computationally expensive, these simulations can provide useful insight into the interactions between large and small molecules and are therefore frequently employed in drug design as a biophysical tool. What is this method called?

ANSWER: MOLECULAR DYNAMICS (ACCEPT: MD) [DC]

BONUS

- 6) ENERGY *Short Answer* Davidson MS A team members are studying ensembles. In a canonical ensemble, what is the most important parameter for determining the probability distribution of different microstates?

ANSWER: TEMPERATURE [GKD]

TOSS-UP

- 7) BIOLOGY *Short Answer* The outer membrane of Gram-negative bacteria is characterized by the presence of what class of molecule that acts as an endotoxin?

ANSWER: LIPOPOLYSACCHARIDES (ACCEPT: LPS) [GKD]

BONUS

- 7) BIOLOGY *Short Answer* Derek is studying hemoglobin and myoglobin and places a small sample of each protein into two tubes, but he forgets to label the tubes. Identify all of the following three observations that would lead him to conclude that the contents of one of the tubes is myoglobin and not hemoglobin:

- 1) A Hill plot constructed with the contents of the tube has a slope of 1
- 2) The contents of the tube have a lower K_d than the contents of the other tube
- 3) An oxygen dissociation curve constructed with the contents of the tube has a hyperbolic shape

ANSWER: ALL [GKD]

TOSS-UP

- 8) CHEMISTRY *Short Answer* What is the name of the compound produced by the combination of an iron(II) cation with two cyclopentadienyl anions?

ANSWER: FERROCENE [DC]

BONUS

- 8) CHEMISTRY *Short Answer* In electron transfer reactions, upon reaching a certain threshold, reaction rate has a negative correlation with spontaneity of the reaction. Which theory explains why this is so?

ANSWER: MARCUS THEORY [DC]

TOSS-UP

- 9) EARTH AND SPACE *Short Answer* What type of zoning is characterized by fluctuating anorthite concentrations in a sample of plagioclase, leading to concentric bands of varying properties..

ANSWER: OSCILLATORY ZONING (DO NOT ACCEPT: REVERSE ZONING) [EB]

BONUS

- 9) EARTH AND SPACE *Short Answer* By name or number, order the following three families of asteroids in order of decreasing perihelion distance:

- 1) Aten
- 2) Centaur
- 3) Vulcanoid

ANSWER: 2, 1, 3 (ACCEPT: CENTAUR, VULCANOID, ATEN) [EB]

TOSS-UP

- 10) MATH *Short Answer* The variance of a set S is 6. The elements of S are multiplied by 4 and then increased by 9, creating a new set T. What is the variance of T?

ANSWER: 96 [AKa]

BONUS

- 10) MATH *Short Answer* How many ordered pairs (a,b) of positive integers are there such that 41 is the largest positive integer not expressible as $ax+by$ for some non-negative integers x and y?

ANSWER: 8 [AKa]

TOSS-UP

11) PHYSICS *Short Answer* Which of the following is true about the Poincare recurrence theorem?

- W) Every initial phase of a system must return to itself infinite times
- X) No system that returns to its initial state can be chaotic
- Y) A bounded region in physical space where energy is conserved always corresponds to a finite region in phase space
- Z) All parts of the phase volume have the same recurrence time

ANSWER: Y) A BOUNDED REGION IN PHYSICAL SPACE WHERE ENERGY IS CONSERVED ALWAYS CORRESPONDS TO A FINITE REGION IN PHASE SPACE [AC]

BONUS

11) PHYSICS *Multiple Choice* Which of the following situations would be least effectively analyzed using Rankine-Hugoniot jump conditions?

- W) Supernova shockwave
- X) Perturbations parallel to a long tube of foam
- Y) Pressurized water exploding out of a nozzle
- Z) Subsonic gunpowder deflagration

ANSWER: Y) PRESSURIZED WATER EXPLODING OUT OF A NOZZLE [AC]

TOSS-UP

12) EARTH AND SPACE *Multiple Choice* Davidson HS A Team members are studying PSR B1957+20 [*p-s-r b-one-nine-five-seven-plus-two-zero*], a tidally locked binary system consisting of a brown dwarf and a pulsar nicknamed the “black widow pulsar.” Which of the following best describes what will happen to this system in the future?

- W) Due to its greater mass, the pulsar will accrete mass from the brown dwarf
- X) Due to tidal dragging, the two bodies are in a decaying orbit and will eventually collide
- Y) The radiation from the pulsar will ionize nearby gas clouds, eventually obscuring the system from view
- Z) Radiation from the pulsar will eventually strip the brown dwarf of all its gas

ANSWER: Z) RADIATION FROM THE PULSAR WILL EVENTUALLY STRIP THE BROWN DWARF OF ALL ITS GAS [EB]

BONUS

12) EARTH AND SPACE *Short Answer* Davidson HS A Team members are studying the Messinian Salinity Crisis, a period of time in the late Miocene where the Mediterranean Sea dried up due to closing of the strait of Gibraltar. By name or number, order the following three minerals from the last to the first to precipitate from evaporating seawater:

- 1) Calcite
- 2) Halite
- 3) Sylvite

ANSWER: 3, 2, 1 (ACCEPT: SYLVITE, HALITE CALCITE) [EB]

TOSS-UP

13) BIOLOGY *Multiple Choice* In response to high sodium chloride concentrations in the distal convoluted tubule, macula densa [**MACK-you-luh DEN-suh**] cells release adenosine, which binds to receptors on which of the following?

- W) Peritubular capillary
- X) Vasa recta
- Y) Afferent arteriole
- Z) Glomerulus [**glom-yur-ROO-lus**]

ANSWER: Y) AFFERENT ARTERIOLE [GKD]

BONUS

13) BIOLOGY *Short Answer* Identify all of the following three regions you would expect to find chondrocytes in the long bones of a 12-year-old boy:

- 1) Epiphysis [**eh-PIFF-ih-sis**]
- 2) Diaphysis [**die-AF-ih-sis**]
- 3) Metaphysis [**met-AF-ih-sis**]

ANSWER: 3 ONLY (ACCEPT: METAPHYSIS) [GKD]

TOSS-UP

14) CHEMISTRY - *Short Answer* Suppose that you have two chambers A and B, each with identical volume but filled with a different kind of gas molecule. When these two gasses are mixed isothermally into a third chamber C, which has the same volume as A and B, what is the resultant entropy? Give your answer to the two nearest significant figures.

ANSWER: 0 [DC]

BONUS

14) CHEMISTRY *Short Answer* Assume that you have 12 molecules and two chambers, A and B. There are two orientations to consider: state 1 where chambers A and B have 6 molecules each and state 2 where one of chamber A or B has 8 molecules and the other has 4 molecules. Calculate the absolute difference of microstates between state 1 and state 2.

ANSWER: 66 [DC]

TOSS-UP

- 15) EARTH AND SPACE *Short Answer* What is the adjective used to describe magma that becomes increasingly silica-rich as it cools?

ANSWER: THOLEIITIC [*tho-lee-IH-tic*] [EB]

BONUS

- 15) EARTH AND SPACE *Short Answer* By name or number, identify all of the three statements about dwarf novae, also known as U Geminorum variables that are true:

- 1) Dwarf novae are thought to be caused by fusion of hydrogen accreted onto the white dwarf from a companion star
- 2) The companion star mass is accreted from is smaller in a U Geminorum pair than a classical nova pair
- 3) During outbursts, mass transfer through the white dwarf's accretion disk is faster than the rate of accretion

ANSWER: 2 AND 3 [EB]

TOSS-UP

- 16) MATH *Short Answer* What is the sum of the coefficients of the expansion of $(2x-5y+5)^6$?

ANSWER: 64 [AKa]

BONUS

- 16) MATH *Short Answer* Find the determinant of the four by four matrix with first row eight, seven, three, six; second row zero, five, nine, seven; third row zero, zero, nine, three; and fourth row zero, zero, zero, eleven.

ANSWER: 3960 [EB]

TOSS-UP

17) PHYSICS *Short Answer* The properties of a plasma can be investigated by poking an electrode with varying potential into it, a device known as what?

ANSWER: LANGMUIR PROBE [AC]

BONUS

11) PHYSICS *Short Answer* Dielectric breakdown occurs in a gas when the magnitude of the electric field is high enough for a stray electron to ionize other atoms, and the resulting electrons are accelerated enough for this process to happen again in a positive feedback loop known as what?

ANSWER: ELECTRON AVALANCHE (ACCEPT: TOWNSEND DISCHARGE) [AC]

TOSS-UP

18) ENERGY *Short Answer* Davidson HS B Team members are studying conic sections. What is the area of the shape defined by the equation $4x^2+8x+9y^2+6y=31$?

ANSWER: 6π [AKa]

BONUS

18) ENERGY *Short Answer* Davidson HS A Team members are studying the SNARE complex. When syntaxin, VAMP, and SNAP-25 associate after calcium binds to synaptotagmin, they form what rope-like structural motif that functions like a pulley to pull the vesicle towards the plasma membrane?

ANSWER: COILED-COIL [GKD]

TOSS-UP

19) BIOLOGY *Short Answer* The formation of Barr bodies is mediated by what long non-coding RNA that coats the X chromosomes destined to be inactivated, promoting histone methylation and deacetylation?

ANSWER: XIST (DO NOT ACCEPT: TSIX) [GKD]

BONUS

19) BIOLOGY *Short Answer* While tending to his mother's plants, Griffin notices two of them appear to have mineral deficiencies. While he doesn't particularly care if the plants live, he decides to investigate in case mineral deficiencies show up on USABO opens again. The first plant shows chlorosis between the veins of young leaves, and when he adds manganese to the soil, the plant's growth does not improve. The older leaves of the second plant have purple tips, but the young leaves look healthy. What two elements are deficient in these plants?

ANSWER: IRON AND PHOSPHORUS [GKD]

TOSS-UP

20) CHEMISTRY *Short Answer* What is the minimum amount of intensive variables required to describe any equation of state?

ANSWER: THREE [DC]

BONUS

20) CHEMISTRY *Short Answer* While molecules are classically said to exhibit either covalent, ionic, or metallic bonding, many molecules have bonds that would be best described as intermediate. One visual representation of bonding types involves placing covalent, ionic, and metallic on the three vertices of a triangle and graphing compounds on the triangle. What is this diagram called?

ANSWER: VAN ARKEL-KETELAAR TRIANGLE (ACCEPT: VAN ARKEL TRIANGLE, KETELAAR TRIANGLE) [GKD]

TOSS-UP

21) EARTH & SPACE *Multiple Choice* What is the name for the class of pre-main-sequence stars that undergo short but highly dramatic fluctuations in magnitude and spectral type?

- W) SX Phoenicis
- X) FU Orionis
- Y) RV Tauri
- Z) U Geminorum

ANSWER: X) FU ORIONIS [EB]

BONUS

21) EARTH AND SPACE *Short Answer* Taking the absolute magnitude of the sun to be +4.7 and the apparent magnitude of star A to be +7.3, how far away, in kiloparsecs to one significant figure, is star A if it is determined to be ten times more luminous than the sun?

Abs 2.2

ANSWER: 0.1 [EB]

TOSS-UP

22) MATH *Short Answer* How many integer values of x and y satisfy $xy + 27x + 11y = 3$?

ANSWER: 36 [MD]

BONUS

22) MATH *Multiple Choice* Which of the following is the largest?

- W) e
- X) Square root of 6
- Y) Pi times 0.6
- Z) 32/11

ANSWER: Z) 32/11 [MD]

TOSS-UP

23) PHYSICS *Multiple Choice* Which of the following is the result when a particle state is superimposed on itself?

- W) It constructively interferes
- X) It destructively interferes
- Y) It doubles the uncertainty in measurement
- Z) No change

ANSWER: Z) NO CHANGE [AC]

BONUS

23) PHYSICS *Short Answer* A non-rotating black hole with mass M has a Schwarzschild radius of R . This black hole then eats some gas from its binary partner, increasing its mass by $3M$. What is the photon sphere radius of the new black hole in terms of the Schwarzschild radius of the original black hole R ?

ANSWER: $6R$ [AC]