2025 Bay Area Science-Estimathon Duel

Double Elimination

Question Set 3

Questions will begin on the next page.

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*E&S = Earth and Space, Est = Estimation.

TOSS-UP

1) **Y-Risk – *Multiple Choice*** Scientists at Argonne National Laboratory are studying qubits [*read as: cue-bits*] and quantum computing. In order for a quantum computer to function, its qubits must be protected from noise in order to maintain superposition and well-defined phase relations. These qubits are said to be in which of the following states?

W) Coherent
X) Linked
Y) Measureable
Z) Supersymmetrical

ANSWER: W) COHERENT [QG]

BONUS

1) **Y-Risk – *Short Answer*** Argonne National Laboratory Researchers are studying the coherence of qubits. By name or number, list all of the following four disturbances that could cause qubits to decohere:

1. Temperature fluctuations
2. Electromagnetic radiation
3. Mechanical vibrations
4. Particle collisions

ANSWER: ALL [QG]

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TOSS-UP

2) **Biology – *Short Answer*** What enzyme catalyzes the interconversion of carbon dioxide and water with protons and bicarbonate?

ANSWER: CARBONIC ANHYDRASE [AG]

BONUS

2) **Biology – *Short Answer*** Carbonic anhydrase plays an important role in regulating blood pH and CO_2. What effect, triggered by the conversion of CO_2 into hydrogen and bicarbonate, is responsible for decreased affinity of hemoglobin for oxygen in environments with high CO_2 or low pH?

ANSWER: BOHR SHIFT [EP]

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TOSS-UP

3) **Chemistry – *Multiple Choice*** Alex is titrating H_3PO_4 with sodium hydroxide. Given that K_{a1} for H_3PO_4 is approximately $6.9 \cdot 10^{-3}$, and K_{a2} for H_3PO_4 is approximately $6.2 \cdot 10^{-8}$, which of the following indicators would be best for detecting the first equivalence point?

W) Crystal violet
X) Phenolphthalein
Y) Methyl red
Z) Cresol red

ANSWER: Y) METHYL RED [QG]

BONUS

3) **Chemistry – *Short Answer*** By name or number, arrange the following four molecules in increasing bond angle.

1. NH_3
2. PH_3
3. AsH_3
4. H_2O

ANSWER: 3, 2, 1, 4 [AG]

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TOSS-UP

4) **Physics – *Multiple Choice*** A co-axial cable has two different layers of wiring, each concentric and with equal currents flowing in opposite directions. This is done to ensure what quantity, according to Ampere's law, remains 0 on the outside of the cable?

W) Magnetic Field
X) Electric Field
Y) Voltage
Z) Charge

ANSWER: W) MAGNETIC FIELD [MR]

BONUS

4) **Physics – *Multiple Choice*** In a real co-axial cable, the magnetic field can still sometimes be non-zero on the outside, even when the wire is perfectly assembled and the currents flowing in opposite directions have equal magnitudes. Which of the following is the most likely explanation for this behavior?

W) The dielectric between the inner and outer conductor shields some of the inner current's magnetic field
X) The inner and outer conductors are made out of different metals
Y) The dielectric constant of the insulating material becomes non-uniform at high temperatures
Z) High frequency alternating currents cause the current to become unevenly distributed

ANSWER: Z) HIGH FREQUENCY ALTERNATING CURRENTS CAUSE THE CURRENT TO BECOME UNEVENLY DISTRIBUTED [MR]

TOSS-UP

5) **Math – *Short Answer*** While researching more questions about pear juice, Max prompts Wolfram Alpha to draw a "pear curve." Wolfram Alpha tells him that a pear can be drawn with an eighth degree algebraic closed curve. What is the simplest example of an algebraic, closed curve in the real 2D plane?

ANSWER: CIRCLE [MR]

BONUS

5) **Math – *Short Answer*** Max has an upcoming AP Stats test, and he wants to optimize his grade to effort ratio. The effort he has to exert to study as a function of time can be modeled as $t + 1$ and his score on the test as a function of time spent studying is $100 - 50e^{-t}$ [read as: 100 minus 50 e to the negative t], where t is non-negative and in hours. To the nearest hour, find the amount of time Max should spend studying in order to maximize his grade to effort ratio.

ANSWER: 0 [MR]

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TOSS-UP

6) **Earth and Space – *Short Answer*** By name or number, order the following three laws by increasing exponent degree for temperature in their most common forms:

1. Stefan-Boltzmann Law
2. Wein's [*wine's*] Law
3. Rayleigh-Jeans Law

ANSWER: 2, 3, 1 [MR]

BONUS

6) **Earth and Space – *Multiple Choice*** Hornfels are metamorphic rocks formed when magma intrudes into sedimentary rock layers. Which of the following types of metamorphism is responsible for creating hornfels?

W) Hydrothermal
X) Contact
Y) Shock
Z) Dynamic

ANSWER: X) CONTACT [AG]

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TOSS-UP

7) **Biology – *Short Answer*** Arjun is an ascomycotic fungus. As he approaches fruition, how many ascospores would be found in each of Arjun's asci?

ANSWER: EIGHT [AG]

BONUS

7) **Biology – *Short Answer*** What type of ascomycetes, unlike Arjun, typically do not produce asci, instead relying on mating based on the recognition of opposite mating types?

ANSWER: YEASTS (accept TRUE YEASTS or SACCHAROMYCETES and similar phyla[1]) [EP]

[1] Accept phyla that begin with "saccharo". If unsure whether a phylum stated by the other team exists, cross-checking with a question judge is recommended.

TOSS-UP

8) **Physics – *Short Answer*** How many of the four fundamental forces are non-conservative?

ANSWER: 0 [MR]

BONUS

8) **Physics – *Short Answer*** Quinn is building an RC circuit. He plans to connect a 5-volt battery to two 20-microfarad capacitors and one 20-kiloohm resistor in series. However, he accidentally swaps out one of the 20-microfarad capacitors for a 20-kiloohm resistor, altering the time constant of the circuit. In seconds, what is the difference between the time constants of the circuit Quinn actually made and what he was trying to make?

ANSWER: 0.6 [QG]

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TOSS-UP

9) **Earth and Space – *Short Answer*** What narrow, diagonally sloped region on the HR diagram contains several classes of closely related pulsating variable stars?

ANSWER: INSTABILITY STRIP [MR]

BONUS

9) **Earth and Space – *Multiple Choice*** Max is in English and learning about Chekov's gun, the idea that anything described in a setting will eventually be plot-relevant. He makes a text to world connection to the clathrate gun hypothesis, which caused rapid global warming and cooling in the quaternary time period. Which gas, trapped in ice, was primarily responsible for this cycle?

W) CO_2
X) CO
Y) CH_4
Z) C_2H_6

ANSWER: Y) CH_4 [AG]

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TOSS-UP

10) **Math – *Multiple Choice*** Which of the following conditions guarantees that the columns of an m by n matrix will span R^m [read as: R of m]?

W) There is a pivot position in every row
X) There is a pivot position in every column
Y) The determinant of the matrix is 0
Z) The columns of the matrix are linearly independent

ANSWER: W) THERE IS A PIVOT POSITION IN EVERY ROW [QG]

BONUS

10) **Math – *Short Answer*** (Note to moderator: read matrix entries slowly) Calculate the result of the following matrix multiplication: The matrix with rows (-2, 3, 1); (0, 4, 0); (-1, 1, 2) times the matrix with rows (1, 1); (0, 3); (4, -2).

ANSWER: (2, 5); (0, 12); (7, -2) [QG]

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TOSS-UP

11) **Y-Risk – *Multiple Choice*** According to legend, a group of scientists at Bell Labs once tracked the building of a suspension bridge through a window in the building. First, the two towers were built, and the suspension cable was hung over the towers. As the main deck was being laid, what kind of transformation would the scientists see in the shape of the suspension cable as it began to bear the weight of the bridge?

W) Parabolic to catenary
X) Catenary to parabolic
Y) Parabolic to half sinusoid
Z) Half sinusoid to parabolic

ANSWER: X) CATENARY TO PARABOLIC [MR]

BONUS

11) **Y-Risk – *Short Answer*** To "bridge" the gap between the previous physics and upcoming chemistry question, Max decides to make a bridge out of superglue. What is the term for the bonds that link superglue polymers together when it sets?

ANSWER: CROSS-LINKS [WC]

TOSS-UP

12) **Chemistry – *Short Answer*** In the reaction between 1-propanol and acetic acid in acidic condition, what is the major product?

ANSWER: PROPYL ACETATE (accept PROPYL ETHANOATE or ETHYL PROPYL ESTER) [AG]

BONUS

12) **Chemistry – *Short Answer*** While studying for AP Chem, Max is getting PTSD from AIME. He sees that the ratio of pi to sigma bonds in benzene can be written in the form m/n [read as: m over n] where m and n are relatively prime positive integers. What is m + n?

ANSWER: 5 [MR]

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TOSS-UP

13) **Math – *Multiple Choice*** Which of the following numbers is irrational but not transcendental?

W) π
X) Natural log of 2
Y) Square root of 2
Z) e

ANSWER: Y) SQUARE ROOT OF 2 [QG]

BONUS

13) **Math – *Short Answer*** By name or number, identify all of the following four geometric constructions that are possible when considering spherical, non-Eulcidean geometry:

1. Diverging parallel lines
2. Converging parallel lines
3. Equilateral, right triangles
4. Triangles with 361° as the sum of their angles

ANSWER: 2, 3, AND 4 [MR]

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TOSS-UP

14) **Y-Risk – *Multiple Choice*** Which of the following would NOT be considered a divide and conquer algorithm?

W) Binary search
X) Quicksort
Y) Fast fourier transform
Z) Selection sort

ANSWER: Z) SELECTION SORT [QG]

BONUS

14) **Y-Risk – *Short Answer*** Benzene is added to a solution of concentrated nitric and sulfuric acids. By name or number, order the following three dinitro products that are produced by this scheme:

1. Ortho-dinitrobenzene
2. Meta-dinitrobenzene
3. Para-dinitrobenzene

ANSWER: 2, 3, 1 [AG]

TOSS-UP

15) **Biology – *Short Answer*** Alex trips over a bird. Upon further examination, he realizes that it is a sleeping nightjar. What state of reduced physiological activity, characterized by lowered metabolism and body temperature, is exhibited by animals such as nightjars?

ANSWER: TORPOR (do not accept HIBERNATION) [EP]

BONUS

15) **Biology – *Short Answer*** By name or number, select all of the following three examples of reduced physical activity that are examples of torpor.

1. Aestivation
2. Brumation
3. Hibernation

ANSWER: ALL [AG]

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TOSS-UP

16) **Earth and Space – *Short Answer*** White dwarfs are able to live for extremely long times, up to possibly trillions of years. However, even they are hypothesized to eventually cool sufficiently to stop emitting light, resulting in what theoretical stellar remnant?

ANSWER: BLACK DWARFS [MR]

BONUS

16) **Earth and Space – *Multiple Choice*** Dark nebulae produce no visible light of their own, so they cannot be seen directly. What is the primary method by which dark nebulae are detected?

W) Observing in the infrared range
X) Observing in the microwave range
Y) Observing dark nebulae blocking light from background stars
Z) Observing the gravitational influence of dark nebulae on surrounding matter

ANSWER: Y) OBSERVING DARK NEBULAE BLOCKING LIGHT FROM BACKGROUND STARS [MR]

TOSS-UP

17) **Physics – *Multiple Choice*** A thermally insulated chamber contains a vacuum and is connected to the outside by a small valve. The valve is opened until the air inside the chamber reaches atmospheric pressure, then it's closed. If the temperature of the air outside the chamber was T, what is the temperature of the air now inside the chamber?

W) Less than T
X) Greater than T
Y) Equal to T
Z) Not enough information to tell

ANSWER: X) GREATER THAN T [MR]

BONUS

17) **Physics – *Short Answer*** By name or number, list all of the following three statements that could describe a visible light photon:

1. Emitted in the Lyman series
2. Wavelength of 900 nm
3. Produced by a 500 Kelvin blackbody

ANSWER: NONE [QG]

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TOSS-UP

18) **Chemistry – *Short Answer*** What is the bond order between oxygens of the superoxide anion, O_2^- [read as: O two one minus]?

ANSWER: 1.5 [AG]

BONUS

18) **Chemistry – *Multiple Choice*** Tin (IV) chloride forms readily while lead (IV) chloride does not. Which of the following justifications most accurately explains this phenomenon?

W) Tin (IV) is more electronegative than Lead (IV), thus it can attract chloride ions more effectively
X) Lead (IV) 6s electrons orbit at speeds at which relativistic effects must be considered, meaning they are less able to bond
Y) The bond length of Pb to Cl in Lead (IV) Chloride is too long and weak to exist
Z) Lead (IV) Chloride requires interactions between antibonding molecular orbitals, thus formation of Lead (II) Chloride is favored

ANSWER: X) LEAD 6S ELECTRONS ORBIT AT SPEEDS AT WHICH RELATIVISTIC EFFECTS MUST BE CONSIDER, MEANING THEY ARE LESS ABLE TO BOND [AG]

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TOSS-UP

19) **Biology – *Multiple Choice*** Max is a bear in a cornfield. He notices that the leaves of his corn plants exhibit stunted growth, and older leaves on the plants appear red or purple. Which of the following minerals should Max apply to his corn to alleviate deficiency symptoms?

W) Nitrogen
X) Magnesium
Y) Potassium
Z) Phosphorus

ANSWER: Z) PHOSPHORUS [EP]

BONUS

19) **Biology – *Multiple Choice*** Max is still a bear in a cornfield. After months of carefully watering, weeding, and balancing soil nutrients, his corn is now ready for harvest. Noting that each corn kernel is formed from a single flower, what type of fruit is Max's corn classified as?

W) Simple fruit
X) Aggregate fruit
Y) Multiple fruit
Z) Accessory fruit

ANSWER: W) SIMPLE FRUIT [EP]

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TOSS-UP

20) **Math – *Short Answer*** Answering with an angle in radians, what are the polar coordinates for the point with Cartesian coordinates $(4, -4\sqrt{3})$?

ANSWER: $(8, 5\pi/3)$ [QG]

BONUS

20) **Math – *Short Answer*** Express $\frac{-5+i}{5+12i}$ [read as: the fraction with numerator negative 5 plus i and denominator 5 plus 12 i] in standard a + bi form.

ANSWER: -1/13 + 5/13 i [QG]

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TOSS-UP

21) **Physics – *Short Answer*** What central set of partial differential equations in fluid dynamics describe the motion of viscous fluids?

ANSWER: NAVIER-STOKES EQUATIONS [MR]

BONUS

21) **Physics – *Short Answer*** In what subfield of fluid dynamics are the Navier-Stokes equations coupled with Maxwell's equations to describe the behavior of electrically conducting fluids?

ANSWER: MAGNETOHYDRODYNAMICS (accept HYDROMAGNETICS) [MR]

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TOSS-UP

22) **Chemistry – *Multiple Choice*** Which of the following energetic quantities is generally negative?

W) Bond dissociation enthalpy
X) Enthalpy of ionization
Y) Lattice enthalpy
Z) Enthalpy of formation

ANSWER: Z) ENTHALPY OF FORMATION [AG]

BONUS

22) **Chemistry – *Multiple Choice*** Which of the following best describes the effect of an increase in temperature on the conductance of a metallic conductor and a semiconductor, respectively?

W) Decreases, increases
X) Increases, decreases
Y) Constant, increases
Z) Constant, decreases

ANSWER: W) DECREASES, INCREASES [AG + QG]

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TOSS-UP

23) **Earth and Space – *Short Answer*** Soil is produced over hundreds of thousands of years by a combination of weathering, erosion, and biological activity. What general term describes this synthesis of topsoil?

ANSWER: PEDOGENESIS [AG]

BONUS

23) **Earth and Space – *Short Answer*** Rank the following three materials in order of increasing cation exchange capacity.

1. Sand
2. Organic humus
3. Weathered mica

ANSWER: 1, 3, 2 [AG]

TOSS-UP (30 seconds)

24) **Estimation – *Short Answer*** Warren tries contacting aliens by blasting "Beam me up, Scotty" from his computer at full volume. If there were, theoretically, an alien civilization on a planet orbiting Alpha Centauri with advanced enough tools to pick up this particular signal, estimate the order of magnitude of the absolute value of the decibel level it would hear "Beam me up, Scotty" at.

ANSWER: 3 [MR]

End of Questions.

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