2025 Bay Area Science-Estimathon Duel

Double Elimination

Question Set 4

Questions will begin on the next page.

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

TOSS-UP

1) **Math – *Multiple Choice*** What is the value of (6^7 + 8! + 8^7) [read as: open parentheses 6 to the 7th power plus 8 factorial plus 8 to the 7th power close parentheses] mod 7?

W) 0
X) 1
Y) 4
Z) 6

ANSWER: W) 0 [QG]

BONUS

1) **Math – *Short Answer*** Evaluate the infinite sum with terms 3^n/n!, where n goes from 0 to infinity.

ANSWER: e^3 [AG]

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TOSS-UP

2) **Biology – *Short Answer*** Alex is studying the classification of bugs. Which of the following four insects are considered true bugs?

1. Butterflies
2. Bees
3. Cicadas
4. Stink bugs

ANSWER: 3 AND 4 (accept CICADAS AND STINK BUGS) [EP]

BONUS

2) **Biology – *Multiple Choice*** True bugs, including cicadas and stink bugs, belong to which large insect order consisting of over 80,000 species?

W) Diptera [read as: DIE-tera]
X) Hemiptera [read as: HEMI-tera]
Y) Hymenoptera [read as: hy-MEN-o-tera]
Z) Coleoptera [read as: CO-leo-tera]

ANSWER: HEMIPTERA [EP]

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TOSS-UP

3) **Chemistry – *Short Answer*** A spectrochemical series lists ligands based on ligand field strength. By name or number, order the following four ligands from weakest to strongest ligand field strength:

1. NO_2^-
2. H_2O
3. CO
4. Cl^-

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

BONUS

3) **Chemistry – *Short Answer*** A transition metal ion is bonded to six ligands in an octahedral geometry. As a result of crystal field splitting, the normally degenerate d orbitals of the central metal ion split into two sets: two of the five d orbitals are higher energy, while three of the five d orbitals are lower energy. Name the two d orbitals that are higher energy.

ANSWER: d_x^2-y^2 AND d_z^2 (order irrelevant, accept equivalents) [QG]

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TOSS-UP

4) **Physics – *Multiple Choice*** What term in Einstein's Field Equations represents the vacuum energy density, whose positive value drives the accelerated expansion of the universe?

W) Riemann curvature tensor
X) Metric tensor
Y) Cosmological constant
Z) Energy-momentum tensor

ANSWER: Y) COSMOLOGICAL CONSTANT [MR]

BONUS

4) **Physics – *Short Answer*** A particle has wave function: $\Psi(x,t) = Ae^{-\frac{x^2}{2}}$ [read as: phi of x and t equals A times e to the negative x squared over 2]. Find the value of A by normalizing the wavefunction.

ANSWER: $\pi^{-1/4}$[MR]

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TOSS-UP

5) **Y-Risk – *Short Answer*** In regions of high elevation, especially the Andes Mountains, sheet ice and glaciers will occasionally form penitentes, or vertically oriented blades of ice. These features are a result of differential ablation with the dew point being subzero. What phase transition is associated with penitentes?

ANSWER: SUBLIMATION [AG]

BONUS

5) **Y-Risk – *Multiple Choice*** Which of the following describes the main difference between training models with a small batch size compared to a large batch size?

W) Smaller batch sizes use less computing power than large batch sizes per training epoch
X) Smaller batch sizes lead to noisier gradient descent compared to larger batch sizes
Y) Using smaller batch sizes leads to worse performing models compared to larger batch sizes
Z) Smaller batch sizes increases the likelihood that the model gets stuck in local minima during training

ANSWER: X) SMALLER BATCH SIZES LEAD TO NOISIER GRADIENT DESCENT COMPARED TO LARGER BATCH SIZES [WC]

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TOSS-UP

6) **Earth and Space – *Multiple Choice*** Alex has a mystery mineral that displays strong birefringence. Which of the following crystal structure groups would this mineral likely NOT belong to?

W) Trigonal
X) Monoclinic
Y) Hexagonal
Z) Isometric

ANSWER: Z) ISOMETRIC [AG]

BONUS

6) **Earth and Space – *Short Answer*** What theory explains the persistence of spiral arms in galaxies as regions of higher density that stars and gas move through, rather than as fixed arrangements of specific stars?

ANSWER: SPIRAL DENSITY WAVE THEORY [MR]

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TOSS-UP

7) **Chemistry – *Multiple Choice*** Which of the following hydrocarbons is the strongest acid?

W) 1-hexyne (“one hex-why-ne”)
X) 1-hexene (“one hex-een”)
Y) 1,5-hexadiene (“one five hexa-di-een”)
Z) hexane (“hex-ain”)

ANSWER: W) 1-HEXYNE [AG]

BONUS

7) **Chemistry – *Multiple Choice*** Which of the following materials has a recorded negative enthalpy of fusion?

W) Benzene
X) Argon
Y) Oxygen
Z) Helium

ANSWER: Z) HELIUM [AG]

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TOSS-UP

8) **Y-Risk – *Short Answer*** Alex asks Warren to check the time. Unfortunately, Warren positions his watch so that sunlight perfectly reflects off the flat, shiny watch face and blinds him. If the watch face had been rough instead of smooth, the sunlight would have scattered in many directions rather than reflecting directly into his eyes due to what optical phenomenon?

Answer: DIFFUSE REFLECTION [MR]

BONUS

8) **Y-Risk – *Multiple Choice*** Warren experiences a blind spot in his eyes for several hours after getting flashed. What cells in the eye, typically reacting slower than their counterparts, are responsible for this blind spot, and by what process do they recover?

W) Rods, depolarization
X) Rods, hyperpolarization
Y) Cones, depolarization
Z) Cones, hyperpolarization

ANSWER: W) RODS, DEPOLARIZATION [EP]

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TOSS-UP

9) **Physics – *Short Answer*** Max is experimenting with incandescence by heating up a cylindrical tungsten coil, which can be approximated as a blackbody. If he increases the temperature of the coil from 3000 to 4000 kevlin and triples its surface area, then by what factor does its power output increase?

ANSWER: 256/27 [QG]

BONUS

9) **Physics – *Short Answer*** Fermi gases, composed of non-interacting fermions at low temperatures, are essential for understanding phenomena like superconductivity and superfluidity. What is the analogous counterpart to a Fermi gas, composed of non-interacting bosons at low temperatures?

ANSWER: BOSE GAS (do not accept BOSE-EINSTEIN CONDESATE) [MR]

TOSS-UP

10) **Biology – *Short Answer*** Arjun high-fives a cactus. The cactus, unsurprisingly, has spines. The spines of cacti are modified forms of what plant organ?

ANSWER: LEAVES [EP]

BONUS

10) **Biology – *Short Answer*** By name or number, identify all of the following functions that may be performed by leaves or parts of leaves in certain plants:

1. Defense against herbivores
2. Attraction of pollinators
3. Reproduction
4. Underground nutrient storage

ANSWER: ALL [EP]

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TOSS-UP

11) **Earth and Space – *Multiple Choice*** Earth's penitentes are only found under very specific conditions. However, on Pluto, penitentes hundreds of meters tall have been found, theorized to instead be deposited seasonally from its atmosphere. What would Pluto's penitentes likely be made of?

W) Methane
X) Ammonia
Y) Water
Z) Carbon dioxide

ANSWER: W) METHANE [AG]

BONUS

11) **Earth and Space – *Short Answer*** By name or number, order the following three regions of the mantle by increasing P wave velocity.

1. Lower mantle
2. Transition zone
3. Upper mantle

ANSWER: 3, 2, 1 [AG]

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TOSS-UP

12) **Math – *Short Answer*** What is the term for the first term of an ordered pair, which, along with the ordinate, defines a unique position on the Cartesian coordinate plane?

ANSWER: ABSCISSA [AG]

BONUS

12) **Math – *Short Answer*** **(Note to moderator: read entire question very slowly)** The point (5,6) is transformed in the following sequence of steps: 1) It is reflected across the line y=2x+1; 2) It is translated 9 units down; 3) It is translated 4 units to the right; 4) It is reflected across the x-axis; 5) The magnitude of its y-coordinate multiplied by 6. What are the new coordinates of this point?

ANSWER: (5, 6) [MR]

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TOSS-UP

13) **Chemistry – *Short Answer*** What is the lowest unoccupied molecular orbital in a molecule of F_2?

ANSWER: 2 SIGMA STAR [AG]

BONUS

13) **Chemistry – *Short Answer*** A dihaloalkane is placed into a mass spectrometer and displays three peaks of M, M+2, and M+4 at a ratio of 9 : 6 : 1. What is the identity of the halogen in this compound?

ANSWER: CHLORINE [AG]

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TOSS-UP

14) **Physics – *Multiple Choice*** Symmetry is pretty nice. Which of the following conservation laws are guaranteed by Noether's Theorem due to temporal translation symmetry?

W) Conservation of linear momentum
X) Conservation of electric charge
Y) Conservation of angular momentum
Z) Conservation of energy

ANSWER: Z) CONSERVATION OF ENERGY [MR]

BONUS

14) **Physics – *Short Answer*** Speaking of conservation of energy, what is the qualitative law that states that an induced current will flow in the direction that opposes the change in magnetic flux that caused it, ensuring that energy is conserved?

ANSWER: LENZ'S LAW [MR]

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TOSS-UP

15) **Y-Risk – *Short Answer*** Max is exploring the generalization of the factorial, the gamma function. What is the value of the gamma function evaluated at one half?

ANSWER: $\sqrt{\pi}$ [AG]

BONUS

15) **Y-Risk – *Short Answer*** Max is examining the wave nature of light and performs a double slit diffraction experiment. He shines light with a wavelength of 600 nanometers through double slits onto a detector located 5 meters behind the slits and observes an interference pattern. If the distance between the slits is 3 centimeters, then, in meters, what is the distance between the central fringe and first order bright fringes, to one significant figure?

ANSWER: $1 \cdot 10^{-4}$ (accept 0.0001) [QG]

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TOSS-UP

16) **Math – *Short Answer*** By name or number, list all of the following three series that converge:

1. The sum from n=1 to infinity of (1-n)/square root of n
2. The sum from n=1 to infinity of 1/n!
3. The sum from n=1 to infinity of log(n)/n

ANSWER: 2 ONLY [QG]

BONUS

16) **Math – *Short Answer*** By name or number, identify all of the following tests that yield no information when applied to the harmonic series:

1. Divergence Test
2. Integral Test
3. Root Test

ANSWER: 1 AND 3 [QG]

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TOSS-UP

17) **Earth and Space – *Short Answer*** What is the term for the weather modification technique, sometimes used in drought-prone areas, that involves the spraying of small particles into clouds to encourage condensation and precipitation?

ANSWER: CLOUD SEEDING [EP]

BONUS

17) **Earth and Space – *Short Answer*** Cloud seeding was once used in an unsuccessful attempt by the US government to weaken tropical cyclones. While the project had initially positive results, the weakening of seeded hurricanes was later determined to be unrelated to seeding. What natural process, present in strong tropical cyclones, involves the coalescence of outer rainbands into a secondary eyewall, depleting the main eyewall of necessary moisture and inducing weakening?

ANSWER: EYEWALL REPLACEMENT CYCLE [EP]

TOSS-UP

18) **Biology – *Short Answer*** Seals and other marine mammals can dive to extreme depths and remain there for hours. What protein, found in the muscles of these organisms, stores large amounts of oxygen to ensure muscle function without an immediate air supply?

ANSWER: MYOGLOBIN [EP]

BONUS

18) **Biology – *Short Answer*** By name or number, identify all of the following four statements which are true about myoglobin:

1. In mammals, myoglobin is not present in large amounts in the bloodstream.
2. Both hemoglobin and myoglobin have distinctive quaternary structures.
3. Hemoglobin has four oxygen-binding sites, while myoglobin has six, accounting for its better oxygen-carrying ability.
4. The presence of heme pigments in myoglobin contributes to the color of many red meats.

ANSWER: 1 AND 4 [EP]

TOSS-UP

19) **Chemistry – *Short Answer*** For an electron in a spherical one-dimensional well with l = 0, to what power is Planck's constant raised when calculating energy?

ANSWER: 2 [AG + MR]

BONUS

19) **Chemistry – *Multiple Choice*** Let the energy required to excite an electron in a one-electron system from the n=2 sublevel to the n=4 sublevel be E. In terms of E, what is the energy required to excite an electron of the same system from the n=1 sublevel to the n=2 sublevel?

W) E
X) 4E
Y) 9E
Z) 16E

ANSWER: X) 4E [AG + MR]

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TOSS-UP

20) **Earth and Space – *Short Answer*** What is the name of the collection of methods used to measure distances to celestial objects, so named due to each method, or "rung," building upon another to provide an accurate measurement?

ANSWER: COSMIC DISTANCE LADDER [WC]

BONUS

20) **Earth and Space – *Short Answer*** By name or number, list the following four measurement methods on the cosmic distance ladder from shortest range to longest range:

1. Variable stars
2. Stellar parallax
3. Standard candles
4. Spectroscopic parallax

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

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TOSS-UP

21) **Math – *Multiple Choice*** The Science Bowl team decides to make a variation of Jeopardy. Their game has six categories each with four questions, worth 100, 200, 300, and 400 points. Additionally, a Daily Double randomly replaces one question and allows a contestant to double their total score instead of gaining a set number of additional points. Somehow, Advaith Avadhanam returns to SHS and proceeds to sweep the game by answering every question. What is the maximum possible score he could obtain?

W) 10400
X) 11600
Y) 11800
Z) 12000

ANSWER: Y) 11800 [QG]

BONUS

21) **Math – *Short Answer*** Quinn is playing a variation of the Monty Hall game. In this version, there are 7 doors, 2 of which have prizes behind them. He first has to choose one door at random. Then, the host will open one empty door and offer him the chance to switch his choice, such that he chooses one of the five remaining doors at random. If Quinn plays optimally, what are the odds he chooses a door with a prize?

ANSWER: 12/35 [QG]

TOSS-UP

22) **Biology – *Multiple Choice*** Which of the following classes of compounds would likely NOT activate a toll-like receptor?

W) Heat shock proteins
X) Peptidoglycans (“pep-tide-o-gly-cans”)
Y) Unmethylated CpG oligonucleotides
Z) SNARE proteins

ANSWER: Z) SNARE PROTEINS [AG]

BONUS

22) **Biology – *Short Answer*** What triskelon-shaped protein mediates endocytosis by forming a "pit" shaped depression by coating vesicles and then buds inwards by the action of dynamin?

ANSWER: CLATHRIN [AG]

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TOSS-UP

23) **Physics – *Multiple Choice*** Quinn is pondering the motion of objects and finding their jounce given functions for their position over time. Which of the following functions for position over time represents motion in which jounce is positive?

W) s(t) = -ln(t)
X) s(t) = t^3 + t^2
Y) s(t) = -2^(-t)
Z) s(t) = sqrt(1-t)

ANSWER: W) s(t) = -ln(t) [QG]

BONUS

23) **Physics – *Multiple Choice*** Max constructs a simple RL circuit consisting of a 12 volt battery, a 12 ohm resistor, a 3 henry inductor, and an open switch. He closes the switch at time t = 0 seconds. Which of the following is closest to the time t, in seconds, at which the current in his circuit is 0.6 amps?

W) 0.1
X) 0.2
Y) 0.3
Z) 0.4

ANSWER: X) 0.2 [QG]

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TOSS-UP (30 seconds)

24) **Estimation – *Short Answer*** Sagittarius B2 is a giant molecular cloud of dust quite close to the center of the Milky Way, containing an abundance of ethyl alcohol. Estimate, to the nearest order of magnitude, the amount of martinis you could make if you could extract all the ethyl alcohol from Sagittarius B2.

ANSWER: 11 [MR]

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End of Questions.