2025 Bay Area Science-Estimathon Duel

Round Robin

Question Set 3

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

TOSS-UP

1) **Physics – *Short Answer*** Ethan is observing the Canada geese which reside on the SHS lawns. One day, he notices that the pitch and frequency of honks decreases once the geese fly by. What effect is responsible for this behavior?

ANSWER: DOPPLER EFFECT [EP]

BONUS

1) **Physics – *Short Answer*** Warren is looking at an X-ray spectrum of an active galaxy. He sees an emission peak at 1003 picometers, but knows that the peak he should be observing if the galaxy wasn't moving relative to him should be 1000 picometers. In scientific notation, to one significant figure, and in meters per second, what is the recessional speed of the galaxy Warren is observing?

ANSWER: $9 \cdot 10^5$ [MR]

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TOSS-UP

2) **Biology – *Short Answer*** What biological model, first proposed by Singer and Nicholson in 1972, describes the cell membrane as an elastic lipid bilayer with interspersed membrane components?

ANSWER: FLUID MOSAIC MODEL (accept FLUID MOSAIC) [EP]

BONUS

2) **Biology – *Short Answer*** By name or number, identify all of the following four molecules that are NOT considered part of the fluid mosaic model:

1. Phospholipids
2. Carbohydrates
3. Cholesterol
4. Proteins

ANSWER: NONE [EP]

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TOSS-UP

3) **Chemistry – *Multiple Choice*** Which of the following represents the units for the rate constant of a zeroth order reaction?

W) M*s [read as: molar times seconds]
X) M/s [read as: molar over seconds]
Y) 1/s [read as: one over seconds]
Z) 1/(M * s) [read: one over quantity molar times seconds]

ANSWER: X) M/s [QG]

BONUS

3) **Chemistry – *Multiple Choice*** The beta minus decay of Cobalt-60 results in the formation of which of the following isotopes?

W) Iron-60
X) Nickel-60
Y) Copper-60
Z) Zinc-60

ANSWER: X) NICKEL-60 [QG]

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TOSS-UP

4) **Math – *Short Answer*** What is the smallest integer x that satisfies the following:$|4x + 6| < 14$ [read as: the absolute value of the quantity open parentheses four x plus six close parentheses is less than fourteen]?

ANSWER: -4 [WC]

BONUS

4) **Math – *Multiple Choice*** Which of the following is true about the graph $y = |x|$ [read as: y equals the absolute value of x]?

W) Continuous over all real numbers, differentiable over all real numbers
X) Continuous over all real numbers, differentiable over all real numbers except at x=0
Y) Continuous over all real numbers except at x=0, differentiable over all real numbers
Z) Continuous over all real numbers except at x=0, differentiable over all real numbers except at x=0

ANSWER: X) CONTINUOUS OVER ALL REAL NUMBERS, DIFFERENTIABLE OVER ALL REAL NUMBERS EXCEPT AT x=0 [WC]

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TOSS-UP

5) **Biology – *Short Answer*** Arjun to amplify his DNA for an experiment to measure the X-ray scattering of DNA. What laboratory technique would he use to achieve this, which involves repeated heating and cooling cycles?

ANSWER: PCR (accept POLYMERASE CHAIN REACTION) [AG]

BONUS

5) **Biology – *Short Answer*** Arjun is now performing PCR. By name or number, place the following three stages of PCR in the order they occur:

1. Extension
2. Denaturation
3. Annealing

ANSWER: 2, 3, 1 [AG]

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TOSS-UP

6) **Y-Risk – *Multiple Choice*** Saratoga High School students continue their tour of Europe by learning about the Copenhagen interpretation. Which of the following best describes the Copenhagen interpretation?

W) Properties of a quantum system are relative to the observer, so different observers may assign different states to the same system
X) The universe splits into parallel worlds for every quantum observation that is made
Y) A quantum system is described by a superposition of possible states until it is measured, which is when the wavefunction collapses into a definite state
Z) Particles have definite positions and are guided by a deterministic hidden variable

ANSWER: Y) A QUANTUM SYSTEM IS DESCRIBED BY A SUPERPOSITION OF POSSIBLE STATES UNTIL IT IS MEASURED, WHICH IS WHEN THE WAVEFUNCTION COLLAPSES INTO A DEFINITE STATE [MR]

BONUS

6) **Y-Risk – *Short Answer*** SHS Science Bowl team members hop on a VC to play Terraria at 2am on a Sunday night. They plan to fight a boss that has 20,000 base health on singleplayer and scales by a factor of 1.5 for each additional player online. If Max, Warren, Quinn, Alex, and Arjun are fighting the boss together, how much health will the boss have?

ANSWER: 101,250 [WC]

TOSS-UP

7) **Earth and Space – *Short Answer*** In the early 20th century, astronomers estimated the Milky Way's diameter to be 10 kiloparsecs, a third of its actual value. This error came from the presence of what medium, which often obscures light in the visible range for astronomers?

ANSWER: INTERSTELLAR DUST (accept COSMIC DUST or DUST) [MR]

BONUS

7) **Earth and Space – *Multiple Choice*** Which of the following best describes the galactic halo of the Milky Way?

W) A roughly spherical area around the galactic center with large amounts of star formation throughout
X) A roughly spherical area around the galactic center with metal-poor stars in irregular orbits
Y) A flat disk offset from the galactic center with large amounts of star formation throughout
Z) A flat disk offset from the galactic center with metal-poor stars in irregular orbits

ANSWER: X) A ROUGHLY SPHERICAL AREA AROUND THE GALACTIC CENTER WITH METAL-POOR STARS IN IRREGULAR ORBITS [WC]

TOSS-UP

8) **Chemistry – *Short Answer*** What commercial process works by combining nitrogen gas and hydrogen gas in a 1:3 ratio over an iron catalyst to synthesize ammonia?

ANSWER: HABER PROCESS (accept HABER-BOSCH PROCESS) [AG]

BONUS

8) **Chemistry – *Short Answer*** By name or number, identify all of the following three molecules that would display an overall dipole moment:

1. NH_3
2. CH_3CH_2OH
3. CCl_4

ANSWER: 1, 2 [AG]

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TOSS-UP

9) **Biology – *Short Answer*** The body's endocrine system is responsible for regulating several hormonal feedback loops. By name or number, identify all of the following four feedback loops that are controlled by the endocrine system:

1. Thermal regulation
2. Sleep-wake cycles
3. Fight-or-flight response
4. Blood pressure regulation

ANSWER: ALL [EP]

BONUS

9) **Biology – *Multiple Choice*** Regulating appetite is another important function of the endocrine system. Which of the following hormones is NOT a part of the body's appetite control system?

W) Leptin
X) Serotonin
Y) Peptide YY
Z) Ghrelin

ANSWER: X) SEROTONIN [EP]

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TOSS-UP

10) **Chemistry – *Short Answer*** What concept states that in an atom, no two electrons may have the same set of quantum numbers?

ANSWER: PAULI EXCLUSION PRINCIPLE [AG]

BONUS

10) **Chemistry – *Multiple Choice*** Which of the following chemicals would have the greatest vapor pressure at room temperature?

W) Methanol
X) Water
Y) Isopropyl alcohol
Z) tert-butyl alcohol

ANSWER: W) METHANOL [AG]

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TOSS-UP

11) **Math – *Short Answer*** By name or number, identify all of the following three mathematical constants that are often defined in terms of a ratio:

1. π [read as: pi]
2. e
3. φ [read as: phi]

ANSWER: 1 AND 3 [MR]

BONUS

11) **Math – *Short Answer*** What is the value of x-coordinate that satisfies the Mean Value Theorem for the function $f(x) = x^2$ [read as: f of x equals x squared] on the open interval from 0 to 6?

ANSWER: 3 [WC]

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TOSS-UP

12) **Earth and Space – *Multiple Choice*** On a weather map, which of the following front types would be drawn with a purple line containing both triangles and semicircles on the same side?

W) Warm front
X) Cold front
Y) Stationary front
Z) Occluded front

ANSWER: Z) OCCLUDED FRONT [AG]

BONUS

12) **Earth and Space – *Short Answer*** Geologists have a sometimes unfortunate habit of licking rocks to identify their properties. Which of the following minerals, after many licks, would most likely cause adverse effects in an unlucky geologist?

W) Halite
X) Cinnabar
Y) Komatiite
Z) Gneiss

ANSWER: X) CINNABAR [AG]

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TOSS-UP

13) **Physics – *Short Answer*** Joe leaves his 200-gram scoop of ice cream at 0 degrees Celsius outside on a warm day. Assuming the heat of fusion for ice cream is the same as that of water, 334 joules per gram, how much energy, to the nearest kilojoule, is required to completely melt Joe's ice cream?

ANSWER: 67 [MR]

BONUS

13) **Physics – *Multiple Choice*** Two capacitors of capacitance 4 and 6 microfarads are placed in parallel. They are then placed in series with a 5 ohm resistor and a 10 volt battery. What is the magnitude of the charge, in microcoulombs, on the plate of the 4 microfarad capacitor after a long time?

W) 20
X) 40
Y) 60
Z) 80

ANSWER: X) 40 [WC]

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TOSS-UP

14) **Y-Risk – *Short Answer*** What training method for neural networks traverses the cost function through repeatedly calculating gradients and taking steps in the opposite direction in order to reach a local minimum?

ANSWER: GRADIENT DESCENT [WC]

BONUS

14) **Y-Risk – *Short Answer*** Quinn and Warren have successfully taken all of the images that they will use as training data. What data structure are the images represented as when they are used for training?

ANSWER: TENSORS (do not accept MATRICES) [WC]

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TOSS-UP

15) **Earth and Space – *Multiple Choice*** A hydroelectric dam has been constructed along a narrow mountain stream. This will surely affect the trout population. How will the local water table respond in front and behind the dam?

W) Rises, raises
X) Rises, lowers
Y) Lowers, rises
Z) Lowers, lowers

ANSWER: Y) LOWERS, RISES [AG]

BONUS

15) **Earth and Space – *Short Answer*** In a Type Ia supernova *[read as: type one-A]*, a white dwarf siphons material from its binary companion until it becomes massive enough to reignite, triggering an explosion which releases energy. What is the name for this critical mass, typically approximated to 1.44 solar masses?

ANSWER: CHANDRASEKHAR LIMIT (accept CHANDRASEKHAR MASS) [EP]

TOSS-UP

16) **Math – *Multiple Choice*** What is the period of the function $y = 10\ cos\ (4\pi x + 5) + 6$ [read as: y equals 10 cosine of, open parenthesis, 4 pi x plus 5, close parenthesis, plus 6]?

W) 4π
X) π/2
Y) 4
Z) ½

ANSWER: Z) ½ [WC]

BONUS

16) **Math – *Short Answer*** If $f(x) = sin^2\ x + cos\ x$ [read as: f of x equals sine squared of x plus cosine of x] and $g(x) = 15x^2 + 2x - 30$ [read as: g of x equals 15 x squared plus 2 x minus 30], what is the value of $g(f(\pi/2))$ [read as: g of f of pi over 2]?

ANSWER: -13 [WC]

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TOSS-UP

17) **Biology – *Short Answer*** Oh no! Arjun has broken into hives after eating a suspiciously nut-shaped nut. Which neurotransmitter is likely responsible for his allergic reaction?

ANSWER: HISTAMINE [EC + EP]

BONUS

17) **Biology – *Short Answer*** Arjun is rushed into the hospital, where doctors successfully treat his allergies. However, he has been traumatized by the experience and screams in pain whenever he sees a nut-shaped object. In a behavioral context, what is the role of nut-shaped objects in Arjun's reaction?

ANSWER: SIGN STIMULUS (accept CONDITIONED STIMULUS, KEY STIMULUS) [EP]

BASED
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TOSS-UP

18) **Physics – *Multiple Choice*** The magnitude and direction of the electric field 2 meters above an infinite plate of uniform charge is 5 volts per meter upward. Which of the following is the magnitude, in volts per meter, and direction of the electric field 1 meter below the plate?

W) 20, downward
X) 5, downward
Y) 20, upward
Z) 5, upward

ANSWER: X) 5, DOWNWARD [QG]

BONUS

18) **Physics – *Multiple Choice*** A capacitor with capacitance C is charged in a circuit containing a battery with emf [*E-M-F*] V. If a second identical battery and a resistor of resistance R is added to the circuit, in terms of C and V, what is the charge on the capacitor after a long time?

W) CV
X) CV/2
Y) 2CV
Z) Can't be determined with the information given

ANSWER: Y) 2CV [WC]

TOSS-UP

19) **Y-Risk – *Short Answer*** While having dinner in Boston, Max orders something he's never tried before: pear juice. He finds that the tiny bottle he orders has a whole 60 grams of sugar, but decides that it is not enough. He starts adding even more sugar until there is so much inside the bottle that no more dissolves in the juice. What is the term for this kind of solution?

ANSWER: SATURATED [MR]

BONUS

19) **Y-Risk – *Multiple Choice*** From the precipitate, Max somehow manages to recover an entire pear. He notices that while cutting the pear, its texture is gritty due to small, hard particles. What category of plant cells are these particles made of?

W) Collenchyma
X) Parenchyma
Y) Sclerenchyma
Z) Phytochyma

ANSWER: Y) SCLERENCHYMA [AG + MR]

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TOSS-UP

20) **Earth and Space – *Multiple Choice*** Which layer of the atmosphere contains the jet stream?

W) Troposphere
X) Stratosphere
Y) Mesosphere
Z) Thermosphere

ANSWER: W) TROPOSPHERE [QG]

BONUS

20) **Earth and Space – *Short Answer*** What layer of the sun is situated directly above the photosphere and usually has a temperature between 4000 to 8000 kelvin?

ANSWER: CHROMOSPHERE [AG]

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TOSS-UP

21) **Math – *Short Answer*** Bessie the Cow is trying her hoof out with a new contest, the USACOw. The contest consists of 5 problems, each equally weighted towards her final score. Additionally, each problem is made up of several test cases, each contributing equally to the final score of the problem. If Bessie ends the contest with 2 out of 5 test cases for the first three problems and none for the rest, what percent of the points did she manage to earn in the contest?

ANSWER: 24 [WC]

BONUS

21) **Math – *Short Answer*** Elsie the Cow is also trying out the USACOw. So far, she has scored 4 out of 5 test cases on the first problem, 2 out of 5 on the second and third problem, and 3 out of 10 on the fourth problem. Determined to prove that she is better, Elsie wants to score at least 50% overall in the contest. Given that the last problem is out of 20 test cases, how many must she score? Remember that each problem is equally weighted towards her final score, and is made up of several test cases, each contributing equally to the final score of the problem.

ANSWER: 12 [WC]

TOSS-UP

22) **Chemistry – *Multiple Choice*** Which of the following four laws of thermodynamics governs the principle of maximum entropy, or that all reactions act solely to increase universal entropy?

W) Zeroth Law of Thermodynamics
X) First Law of Thermodynamics
Y) Second Law of Thermodynamics
Z) Third Law of Thermodynamics

ANSWER: Y) SECOND LAW OF THERMODYNAMICS [AG]

BONUS

22) **Chemistry – *Multiple Choice*** A solution has a hydroxide ion concentration of $2 \cdot 10^{-4}$ [read as: two times ten to the negative four]. To one significant figure, what is the pH of this solution?

W) 3
X) 4
Y) 10
Z) 11

ANSWER: Y) 10 [AG]

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TOSS-UP

23) **Physics – *Short Answer*** Given that sunlight hits the surface of a particular beach on a clear day with a power of 1000 watts per square meter, what is the wattage, to the nearest hundred watts, absorbed by an average sunbather, approximated as a rectangle with length 1.8 meters and width 0.5 meters?

ANSWER: 900 [MR]

BONUS

23) **Physics – *Short Answer*** A 5 kilogram block is placed at the top of a ramp with an incline of 30 degrees. It slides without friction down the ramp to the ground, where it immediately collides elastically with a 5 kilogram ball initially at rest. If the kinetic energy of the ball after the collision is 98 joules, what is the length of the ramp in meters?

ANSWER: 4 [QG]

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TOSS-UP (30 seconds)

24) **Estimation – *Short Answer*** Let Avocado's number be the average number of atoms in a single Hass avocado. Estimate the order of magnitude of Avocado's number.

ANSWER: 25 [MR]

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End of Questions.