2025 Bay Area Science-Estimathon Duel

Double Elimination

Question Set 2

Questions will begin on the next page.

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

TOSS-UP

1) **Physics – *Short Answer*** A uniform disk with kinetic energy E rotates with a constant angular velocity on the axis normal to the plane of the disk that runs through the center. If the same disk now rotates at the same angular velocity about an axis still normal to the plane of the disk, but now going through the edge of the disk, what is its kinetic energy, in terms of E?

ANSWER: 3E [MR]

BONUS

1) **Physics – *Multiple Choice*** For small heights, wind speed is usually proportional to height above the ground. Alex builds two wind turbines that convert a constant fraction of available kinetic energy into electricity. If the first one is 8 meters tall and produces 10 kilowatts of power, how much power, in kilowatts, would be produced by his second turbine, which is 24 meters tall?

W) 10
X) 30
Y) 90
Z) 270

ANSWER: Z) 270 [MR]

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TOSS-UP

2) **Biology – *Short Answer*** In meiosis, one diploid cell divides into four haploid cells to produce gametes. This process involves the separation and distribution of chromosomes, as well as crossing over. What abnormal phenomenon, which occurs during cell division, can result in abnormal chromosome number due to failed chromosomal separation?

ANSWER: NONDISJUNCTION [EP]

BONUS

2) **Biology – *Multiple Choice*** A child is diagnosed with trisomy 21, or Down syndrome. Karyotype analysis shows that the extra chromosome 21 is identical to one of the mother's chromosome 21s along its entire length, with no evidence of recombination. From which parent and during which meiotic division did nondisjunction most likely occur?

W) Father, meiosis 1
X) Father, meiosis 2
Y) Mother, meiosis 1
Z) Mother, meiosis 2

ANSWER: Z) MOTHER, MEIOSIS 2 [AK]

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TOSS-UP

3) **Math – *Short Answer*** Every day, Max and Warren play For The Win in the SHS student center. Max's scores create a normal distribution with mean 13 and standard deviation 4, while Warren's scores create a normal distribution with mean 8 and standard deviation 3. To the nearest percent, what is the probability that, in a single game, Warren beats Max?

ANSWER: 16% [MR]

BONUS

3) **Math – *Multiple Choice*** Which of the following is true of the Weierstrass function?

W) It is continuous everywhere but differentiable nowhere
X) It is continuous at every rational number and discontinuous at every irrational number
Y) It converges non-uniformly
Z) It monotonically increases over the real numbers

ANSWER: W) IT IS CONTINUOUS EVERYWHERE BUT DIFFERENTIABLE NOWHERE [MR]

TOSS-UP

4) **Y-Risk – *Short Answer*** Alex is an oil company executive who is conducting research on purification of crude oil. Commercially, crude oil is split into constituents through heating and letting vapor rise through tall condensing towers in what separatory technique?

ANSWER: FRACTIONAL DISTILLATION (Accept: Distillation) [AG]

BONUS

4) **Y-Risk – *Short Answer*** By name or number, indicate which of the following three algorithms are correctly matched with their appropriate application.

1. Binary search and finding an element in any list
2. Depth first search and traversing a graph to find connected components
3. Prim's algorithm and finding a minimum spanning tree

ANSWER: 2 AND 3 [WC]

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TOSS-UP

5) **Chemistry – *Multiple Choice*** Bredt's rule states that a double bond cannot exist at which of the following locations?

W) Allylic to an alkyne (read: "alk-INE")
X) Vinylic to an alkene (read: "alk-ENE")
Y) At a bridgehead carbon
Z) Coordinated to a metal cation

ANSWER: Y) AT A BRIDGEHEAD CARBON [AG]

BONUS

5) **Chemistry – *Short Answer*** Polystyrene is a polymer made up of repeating styrene units. Due to the large size of the phenyl groups, a molecule of polystyrene will rotate to place phenyl groups on alternating "sides" of the backbone to minimize steric effects. What is the tacticity of this polystyrene molecule?

ANSWER: SYNDIOTACTIC (ACCEPT: SYNTACTIC) [AG]

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TOSS-UP

6) **Earth and Space – *Short Answer*** What kind of fault, chiefly responsible for the Basin and Range topography of the American Southwest, is a variant of a normal fault known for its curved shape that flattens with depth?

ANSWER: LISTRIC FAULT [AG]

BONUS

6) **Earth and Space – *Multiple Choice*** What type of supernova is characterized by the presence of helium but no hydrogen or silicon in its emission spectrum?

W) Type Ia
X) Type Ib
Y) Type Ic
Z) Type II

ANSWER: X) TYPE Ib [MR]

TOSS-UP

7) **Biology – *Multiple Choice*** Which of the following sets of sedimentation coefficients corresponds to those of the small and large units of a eukaryotic ribosome, respectively?

W) 20S, 40S
X) 30S, 50S
Y) 40S, 60S
Z) 50S, 70S

ANSWER: Y) 40S, 60S [AG]

BONUS

7) **Biology – *Multiple Choice*** Which of the following best describes the composition of a eukaryotic ribosome?

W) Protein only
X) Mostly protein, with small amounts of RNA
Y) Approximately equal amounts of protein and RNA
Z) Mostly RNA, with small amounts of protein

ANSWER: Y) APPROXIMATELY EQUAL AMOUNTS OF PROTEIN AND RNA [EP]

TOSS-UP

8) **Chemistry – *Multiple Choice*** A chemist hypothesizes that the reaction 2NO2 +F2 --> 2NO2F occurs in the following two elementary steps:
1. NO2 + F2 -> NO2F + F (slow) NO2 plus F2 yields NO2F plus a fluorine radical comma slow
2. NO2 + F -> NO2F (fast) no2 plus a fluorine radical yields NO2F comma fast
Which of the following best describes the overall reaction according to this mechanism?

W) Zeroth order in NO2, first order in F2
X) Zeroth order in NO2, second order in F2
Y) First order in NO2, first order in F2
Z) First order in NO2, second order in F2

ANSWER: Y) FIRST ORDER IN NO2, FIRST ORDER IN F2 [QG]

BONUS

8) **Chemistry – *Multiple Choice*** A reaction is performed at 500 Kelvin and is observed to have a rate constant of k=2.0, as well as an activation energy of 8.3 kJ. Assuming this reaction obeys the Arrhenius equation, which of the following is the closest to the value of k if the reaction were repeated at 1000 Kelvin?

W) 2.8
X) 3.3
Y) 4.0
Z) 5.4

ANSWER: Z) 5.4 [QG]

TOSS-UP

9) **Y-Risk – *Multiple Choice*** Students at Saratoga High School are taking a field trip to Fermi National Accelerator Laboratory, also known as Fermilab. Which of the following fundamental particles was NOT discovered at Fermilab?

W) Bottom quark
X) W plus minus boson
Y) Z boson
Z) Higgs boson

ANSWER: Z) HIGGS BOSON [MR]

BONUS

9) **Y-Risk – *Multiple Choice*** Warren is training a neural network. Which of the following best describes the relationship between training time and model accuracy given a small training dataset?

W) Increases logistically
X) Increases linearly
Y) Increases, then decreases
Z) Increases, then sinusoidal

ANSWER: Y) INCREASES, THEN DECREASES [WC + QG]

TOSS-UP

10) **Math – *Short Answer*** What is the fractional form of the recurring decimal number 0.240240... repeating?

ANSWER: 80/333 [QG]

BONUS

10) **Math – *Short Answer*** By name or number, list all of the following four sets that are countably infinite in size:

1. Irrational numbers
2. Rational numbers
3. Real numbers
4. Prime numbers

ANSWER: 2 AND 4 [QG]

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TOSS-UP

11) **Earth and Space – *Short Answer*** One might think that when observing a star, all points on the visible disk of the star would be equally bright. What optical effect leads the edge of the disk to actually appearing dimmer than the central regions?

ANSWER: LIMB DARKENING [MR]

BONUS

11) **Earth and Space – *Multiple Choice*** The darkened edges of the disk are unsurprisingly called "limbs." What is the primary reason limb darkening in a star occurs?

W) The star's core is hotter than its outer layers, causing a brightness gradient across the disk
X) Light from the star's limbs passes through denser, cooler atmospheric layers, reducing its intensity
Y) The star's magnetic field is stronger at the limbs, scattering light and reducing brightness
Z) Gravitational lensing bends light more at the star's edges, making them appear dimmer

ANSWER: X) LIGHT FROM THE STAR'S LIMBS PASSES THROUGH DENSER, COOLER ATMOSPHERIC LAYERS, REDUCING ITS INTENSITY [MR]

TOSS-UP

12) **Physics – *Multiple Choice*** Which of the following quarks has a negative charge?

W) Strange
X) Up
Y) Charm
Z) Top

ANSWER: W) STRANGE [QG]

BONUS

12) **Physics – *Short Answer*** Max is watching the Groundhog Day movie, where the main character, Phil, is stuck in a localized time loop that resets the world back to the way it was the previous day every 24 hours except for Phil's memory. By name or number, indicate all of the following four laws of physics this violates:

1. Constancy of the speed of light
2. Causality
3. Equivalence principle
4. Second Law of Thermodynamics

ANSWER: 2 AND 4 [MR]

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TOSS-UP

13) **Chemistry – *Multiple Choice*** Which of the following mixtures would exhibit a negative deviation from Raoult's Law?

W) Methanol and water
X) Benzene and toluene
Y) THF and hexane
Z) Acetone and DMSO

ANSWER: X) BENZENE AND TOLUENE [AG]

BONUS

13) **Chemistry – *Short Answer*** What is the degree of unsaturation of cubane, a cycloalkane visualized by placing a carbon at every vertex of a cube and attaching a hydrogen to each?

ANSWER: 5 [AG]

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TOSS-UP

14) **Biology – *Short Answer*** What immunological marker, present on nearly all nucleated cells, is notable for its ability to present antigen fragments to complementary receptors on CD8+ T cells, helping with the identification and elimination of cancer?

ANSWER: MHC 1 (accept MHC CLASS 1) [EP]

BONUS

14) **Biology – *Short Answer*** Occasionally, cancer cells can evade detection by T cells through reduced or nonexistent MHC 1 expression. However, these cancer cells can still be detected by what other type of immune cell, which acts in a natural immune response directed at "non-self" targets?

ANSWER: NATURAL KILLER CELL (accept NK CELL) [EC]

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TOSS-UP

15) **Math – *Multiple Choice*** Max and Warren are playing leapfrog. Max makes the first jump, covering 6 meters. Warren follows by jumping 4 meters, and Max then jumps another 8/3 meters. They continue alternating, making each jump ⅔ of the length of the last jump. If they continue jumping for a very long time, how far, in meters, will Warren have jumped in total?

W) 18
X) 12
Y) 10.8
Z) 7.2

ANSWER: Z) 7.2 [MR]

BONUS

15) **Math – *Short Answer*** Max and Warren continue their leapfrog shenanigans. Max again starts by jumping 6 meters, but now Warren makes a jump 3/2 meters long, followed by Max jumping ⅔ meters, with every nth jump being $6/n^2$ [read as: six over n squared] meters long, which they will also continue for a very long time. Expressing your answer in exact form, combined, how far will the two of them jump?

ANSWER: π^2 [MR]

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TOSS-UP

16) **Earth and Space – *Multiple Choice*** Suevite (sue-ee-vites), tektites (tech-tites), and shocked quartz found in a roughly circular region are evidence of what event?

W) Meteorite impact
X) Volcanic eruption
Y) Tsunami
Z) Alien invasion

ANSWER: W) METEORITE IMPACT [AG]

BONUS

16) **Earth and Space – *Short Answer*** By name or number, identify all of the following four metrics of a river that increase as the river flows from headwaters to mouth:

1. Channel slope
2. Channel width
3. Discharge
4. Flow velocity

ANSWER: 2, 3, AND 4 [AG]

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TOSS-UP

17) **Y-Risk – *Multiple Choice*** Students at Saratoga High School are researching the Mariana Trench. They find out that if you treat water as incompressible, then pressure increases linearly with depth, giving a pressure of about 101 megapascals at the bottom of the trench. By approximately what factor is this pressure greater than sea-level atmospheric pressure?

W) 10
X) 100
Y) 1000
Z) 10000

ANSWER: Y) 1000 [MR]

BONUS

17) **Y-Risk – *Multiple Choice*** Turns out, the Mariana Trench is so deep that the effect of water being compressible has a measurable effect on the pressure at the bottom, increasing exponentially, instead of linearly, with depth. Which of the following percentages is closest to the percent difference between the pressure calculated at the bottom when water is assumed to be incompressible versus compressible?

W) 3%
X) 30%
Y) 300%
Z) 3000%

ANSWER: W) 3% [MR]

TOSS-UP

18) **Physics – *Short Answer*** While parabolic mirrors perfectly reflect rays parallel to the principal axis to their focal point, spherical mirrors do not, which results in blurred images. What is the name of this phenomenon?

ANSWER: SPHERICAL ABERRATION [QG]

BONUS

18) **Physics – *Short Answer*** A 20 liter container holds 3 moles of helium gas at 2000 Kelvin. To two significant figures, what is the internal energy of the gas in kilojoules?

ANSWER: 75 [QG]

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TOSS-UP

19) **Math – *Multiple Choice*** Warren rolls a fair 20-sided die and pulls one card from a standard deck of 52 playing cards. What are the odds that he rolls a prime number and pulls a face card?

W) 6/65
X) 8/65
Y) 3/26
Z) 2/13

ANSWER: W) 6/65 [QG]

BONUS

19) **Math – *Short Answer*** Warren shuffles a deck of 52 playing cards, and then pulls the top three cards from the deck. What is the probability that the colors of the cards he pulls will be red, black, red, in that order?

ANSWER: 13/102 [QG]

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TOSS-UP

20) **Chemistry – Short Answer** (Note To Moderator: Answer order is not required here.) What are the two distinct bond angles in a molecule of PF_5?

ANSWER: 120 AND 90 DEGREES [AG]

BONUS

20) **Chemistry – *Multiple Choice*** What is the VSEPR molecular geometry of nickel tetracarbonyl, $Ni(CO)_4$?

W) Tetrahedral
X) Seesaw
Y) Octahedral
Z) Square planar

ANSWER: W) TETRAHEDRAL [AG]

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TOSS-UP

21) **Biology – *Short Answer*** Ethan is a neuronal nucleus. By name or number, order the following three parts of a neuron by increasing distance from Ethan:

1. Axon hillock
2. Axon terminal
3. Myelin sheath

ANSWER: 1, 3, 2 [AG]

BONUS

21) **Biology – *Multiple Choice*** Ethan is now a full neuron. As a result, he requires a sufficient amount of dopamine to function. Which of the following amino acids is used to produce dopamine?

W) Tryptophan
X) Lysine
Y) Aspartic acid
Z) Tyrosine

ANSWER: Z) TYROSINE [AG]

TOSS-UP

22) **Physics – *Short Answer*** On Earth, tidal forces are created by the Moon's difference in gravitational pull on opposite sides of the planet. If the distance between the Earth and Moon was halved, by what factor would the tidal force from the Moon be increased by?

ANSWER: 8 [MR]

BONUS

22) **Physics – *Multiple Choice*** What kind of diagram is commonly used in general relativity to represent causal [*caw-sual*] spacetime?

W) Minkowski diagram
X) Argand diagram
Y) Einstein diagram
Z) Penrose diagram

ANSWER: Z) PENROSE DIAGRAM [MR]

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TOSS-UP

23) **Earth and Space – *Multiple Choice*** Which of the following types of stars is typically used to estimate the distance to nearby galaxies?

W) Cepheid [*seh-fee-uhd*] variables
X) White dwarfs
Y) Red supergiants
Z) RR Lyrae *[lie-ra]* variables

ANSWER: W) CEPHEID VARIABLES [WC + MR]

BONUS

23) **Earth and Space – *Multiple Choice*** While scrolling on zoom.earth, Ethan notices a weather system in the northern hemisphere with rotational winds spinning clockwise. What would he classify this system as, and what is its associated weather and pressure?

W) Anticyclone, fair weather and high pressure.
X) Anticyclone, fair weather and low pressure.
Y) Cyclone, stormy weather and high pressure.
Z) Cyclone, stormy weather and low pressure.

ANSWER: W) ANTICYCLONE, FAIR WEATHER AND HIGH PRESSURE [AG]

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TOSS-UP (30 seconds)

24) **Estimation – *Short Answer*** The Scoville scale is a system designed to measure the spiciness of chilli peppers. Estimate the order of magnitude of the scoville rating of handheld pepper spray.

ANSWER: 6 [EP]

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End of Questions.