2025 Bay Area Science-Estimathon Duel

Double Elimination

Question Set 5

Questions will begin on the next page.

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Quick Navigation:

1. E&S	2. Chemistry	3. Math	4. Physics	5. Biology	6. Y-Risk
7. Chemistry	8. E&S	9. Biology	10. Math	11. Physics	12. Y-Risk
13. Biology	14. Physics	15. E&S	16. Math	17. Chemistry	18. Y-Risk
19. E&S	20. Biology	21. Chemistry	22. Math	23. Physics	24. Est

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

TOSS-UP

1) **Earth and Space – *Short Answer*** What geologically active moon orbits in retrograde to its host planet, exhibits large-scale cryovolcanism, and has a characteristic "cantaloupe terrain"?

ANSWER: TRITON [EP]

BONUS

1) **Earth and Space – *Multiple Choice*** Triton's unusual size and orbit, as well as its young surface features, suggest that it was not formed in a typical fashion. Which of the following is the currently accepted theory for the formation of Triton?

W) Planetary capture of a Kuiper Belt object
X) Accretion of debris from the break-up of a previous, larger moon
Y) A recent merger of several smaller moons
Z) Coalescence of debris after a Neptunian impact, similar to the Earth's moon

ANSWER: W) PLANETARY CAPTURE OF A KUIPER BELT OBJECT [EP]

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TOSS-UP

2) **Chemistry – *Short Answer*** By name or number, identify all of the following three common laboratory reagents that are NOT primary standards:

1. NaOH
2. HCl
3. $KMnO_4$

ANSWER: ALL [AG]

BONUS

2) **Chemistry – *Short Answer*** Similarly to Plutonian penitentes, carbon nanotubes can also be synthesized by seeding a host polycarbonate and allowing carbon vapor to deposit in a tube structure. This method, as opposed to the "top-down" technique, is known as what process?

ANSWER: "BOTTOM-UP" [AG]

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TOSS-UP

3) **Math – *Multiple Choice*** What is the limit as x approaches zero from the positive side in the expression $ln\ (\frac{1}{x}) \cdot sin\ (\sqrt{x})$?

W) 0
X) 1
Y) Negative infinity
Z) Does not exist

ANSWER: W) 0 [QG]

BONUS

3) **Math – *Short Answer*** What is the limit as (x,y) approaches (0,0) of the function $f(x) = \frac{x+y}{\sqrt{(x+y+9)}-3}$ [read as: f of x equals the fraction with numerator x plus y and denominator square root of open parenthesis x plus y plus 9 close parenthesis minus 3?

ANSWER: 6 [QG]

TOSS-UP

4) **Physics – *Multiple Choice*** Wave functions are said to live in what kind of space, which mathematicians pedantically call L^2 (a,b) [read as: L two of a comma b]?

W) Probability Space
X) Metric Space
Y) Hilbert Space
Z) Euclidean Space

ANSWER: Y) HILBERT SPACE [MR]

BONUS

4) **Physics – *Multiple Choice*** A thin spherical shell with a uniform non-zero surface charge density spins with a constant angular speed about one of its diameters. Which of the following is an accurate, qualitative description of the magnetic field on the inside and outside of the shell, respectively?

W) Zero on the inside; like the magnetic field of a finite piece of current-carrying wire on the outside
X) Zero on the inside; like the magnetic field of a dipole on the outside
Y) Uniform, but not zero, on the inside; like the magnetic field of a finite piece of current-carrying wire on the outside
Z) Uniform, but not zero, on the inside; like the magnetic field of a dipole on the outside

ANSWER: Z) UNIFORM, BUT NOT ZERO, ON THE INSIDE; LIKE THE MAGNETIC FIELD OF A DIPOLE ON THE OUTSIDE [MR]

TOSS-UP

5) **Biology – *Multiple Choice*** Which of the following best describes the eyes of an individual with astigmatism?

W) A single fovea centralis
X) An elliptical iris
Y) An elliptical cornea
Z) A concave macula lutea

ANSWER: Y) AN ELLIPTICAL CORNEA [AK]

BONUS

5) **Biology – *Multiple Choice*** Oh no! Max drank too much water and needs to avoid hyponatremia. Which of the following could help him with his predicament?

W) Aquaporin inhibitors
X) Increased secretion of ANP
Y) Increased secretion of angiotensin II
Z) Oxalate ion supplements

ANSWER: X) INCREASED SECRETION OF ANP [AG]

TOSS-UP

6) **Y-Risk – *Multiple Choice*** In chemical formulae, which two gases compose syngas, a starting point for the industrial production of many organic compounds?

W) CH_4 and H_2O
X) CO_2 and H_2O
Y) CO and H_2
Z) CH_4 and O_2

ANSWER: Y) CO AND H_2 [AG]

BONUS

6) **Y-Risk – *Short Answer*** One limitation of a queue is that objects can only be added to the back and removed from the front. What other, more flexible data structure allows the removal and addition of objects at both ends?

ANSWER: DEQUE (accept DOUBLE-ENDED QUEUE) [QG]

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TOSS-UP

7) **Chemistry – *Short Answer*** Alex is dissecting his TV and has extracted the liquid crystals from his display, putting them under a very powerful microscope. Order the following three mesophases he may encounter by increasing entropy:

1. Smectic
2. Cholesteric
3. Nematic

ANSWER: 1, 3, 2 [AG]

BONUS

7) **Chemistry – *Multiple Choice*** A new allotrope of nitrogen, N6, has been discovered. The structure of N6 resembles two azide radicals being joined together, and is thus very unstable. Researchers isolated N6 by freezing it within solid argon at 10K, then using which of the following techniques to confirm its existence?

W) NMR
X) IR spectroscopy
Y) UV VIS spectroscopy
Z) Atomic force microscopy

ANSWER: X) IR SPECTROSCOPY [AG]

TOSS-UP

8) **Earth and Space – *Multiple Choice*** In what layer of Earth's atmosphere is the Brewer-Dobson circulation located?

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

ANSWER: X) STRATOSPHERE [AG]

BONUS

8) **Earth and Space – *Short Answer*** During the last glacial maximum, large ice sheets covered most of the Earth and volcanism beneath the sheets resulted in steep but flat confined structures that could not become cone-shaped due to the ice. These landforms, which resemble buttes, are known by what name?

ANSWER: TUYAS (accept TUYA VOLCANO) [AG]

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TOSS-UP

9) **Biology – *Multiple Choice*** By name or number, identify all of the following organisms that are considered algae:

1. Dinoflagellates
2. Zooflagellates
3. Cyanobacteria
4. Rhodophytes

ANSWER: 1 AND 4 (accept DINOFLAGELLATES AND RHODOPHYTES) [EP]

BONUS

9) **Biology – *Short Answer*** Dinoflagellates are abundant in seawater, and can occasionally explode in population size. What is the term for harmful algal blooms, often caused by dinoflagellates, generalized by the color of the organisms involved?

ANSWER: RED TIDES [EP]

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TOSS-UP

10) **Math – *Short Answer*** A function is an object that maps values to other values. What is the name for the mathematical object that maps functions to values?

ANSWER: FUNCTIONAL (Accept FUNCTIONAL OPERATOR) [MR]

BONUS

10) **Math – *Short Answer*** By name or number, list all of the four following mathematical entities that could be functionals:

1. Tensors
2. Heaviside function
3. Dirac delta function
4. Definite integrals

ANSWER: 3 AND 4 [MR]

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TOSS-UP

11) **Physics – *Multiple Choice*** Which of the following isotopes has a mass defect of 0?

W) Hydrogen-1
X) Helium-4
Y) Carbon-12
Z) Neon-20

ANSWER: W) HYDROGEN-1 [QG]

BONUS

11) **Physics – *Multiple Choice*** In two-dimensional projectile motion with no air resistance, a particle is launched from a fixed point at a constant speed but variable angle. What curve forms the boundary of the region of all points the particle can reach?

W) Parabola
X) Circle
Y) Ellipse
Z) Hyperbola

ANSWER: W) PARABOLA [MR]

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TOSS-UP

12) **Y-Risk – *Short Answer*** By name or number, order the following three classifications of neutrons by increasing energy:

1. Thermal
2. Cold
3. Resonance

ANSWER: 2, 1, 3 [AG]

BONUS

12) **Y-Risk – *Short Answer*** In nuclear reactor engineering, an iodine pit refers to the accumulation of iodine-135, which absorbs neutrons to form xenon-135. Due to having a very large neutron cross section, xenon-135 is a powerful absorber of thermal neutrons, which deprives fission reactors of free neutrons required to sustain fission. For this reason, xenon-135 is known as what type of substance?

ANSWER: REACTOR POISON (accept reasonable answers containing POISON) [AG]

TOSS-UP

13) **Biology – *Multiple Choice*** Fungi may be a fun guy, but his spores are serious. In most fungi, sexual reproduction involves the fusion of cytoplasms without immediate nuclear fusion. What is the term for this intermediate stage?
W) Dikaryotic
X) Plasmogamy
Y) Karyogamy
Z) Syngamy
ANSWER: X) PLASMOGAMY [AK]

BONUS

13) **Biology – *Multiple Choice*** Fungi is no longer a fun guy. He is looking into the connections between acetylglucosamines ("acetyl-glu-cos-amines") in chitin. What kind of glycosidic ("gly-co-sid-ic") linkage is found in chitin?

W) α-1,4 (alpha one four)
X) β-1,4 (beta one four)
Y) γ 1,4 (gamma one four)
Z) α-1,3 (alpha one three)

ANSWER: X) β-1,4 [AG]
.

TOSS-UP

14) **Physics – *Short Answer*** What is the vector, which is the cross product of the electric field vector, E, and the magnetizing field vector, H, that represents the direction and rate of electromagnetic energy transfer?

ANSWER: POYNTING VECTOR [QG]

BONUS

14) **Physics – *Short Answer*** A resistor of resistance R is placed on each edge of a regular tetrahedron. In terms of R, what is the equivalent resistance between any two of the vertices of this tetrahedron?

ANSWER: R/2 [MR]

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TOSS-UP

15) **Earth and Space – *Multiple Choice*** Which of the following INCORRECTLY describes katabatic and anabatic winds?

W) Katabatic winds act downhill, while anabatic winds act uphill
X) Katabatic winds can lead to temperature inversion, while anabatic winds cannot
Y) Katabatic winds are active during the late afternoon and early evening, while anabatic winds are strongest during the pre-dawn hours
Z) Both katabatic and anabatic winds can act to remove and replace polluted air trapped in valleys

ANSWER: Y) KATABATIC WINDS ARE ACTIVE DURING THE LATE AFTERNOON AND EARLY EVENING, WHILE ANABATIC WINDS ARE STRONGEST DURING THE PRE-DAWN HOURS [AG]

BONUS

15) **Earth and Space – *Short Answer*** Arjun is looking for sunken ships in the Bermuda Triangle where he observes long strands of algae on the surface oriented parallel to the wind. This formation consists of paired counter-rotating vortices that trap buoyant objects on the surface. What is the name of this phenomenon?

ANSWER: LANGMUIR CIRCULATION [AG]

TOSS-UP

16) **Math – *Multiple Choice*** What is the equation for the tangent line to $y = x\ sin\ x$ at $x = \pi$?

W) $y = -\pi x + \pi^2$
X) $y = \pi x - \pi^2$
Y) $y = -x + \pi$
Z) $y = x - \pi$

ANSWER: W) $y = -\pi x + \pi^2$ [QG]

BONUS

16) **Math – *Short Answer*** Knuth's up arrow notation offers a compact way to denote operations like exponentiation and tetration. What is the value of 2 double up arrow 4?

ANSWER: 65536 [QG]

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TOSS-UP

17) **Chemistry – *Short Answer*** Max is calculating reaction rates with deuterated alkanes in the lab, and finds that the deuterated counterparts tend to react significantly slower. What is the name of this effect?

ANSWER: KINETIC ISOTOPE EFFECT [AG]

BONUS

17) **Chemistry – *Short Answer*** By name or number, order the following three functional groups by increasing absorption wavenumber.

1. Aldehyde C=O stretch
2. Alcohol O-H stretch
3. Alkyne C=C stretch

ANSWER: 1, 3, 2 [AG]

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TOSS-UP

18) **Y-Risk – *Multiple Choice*** Some of the elements required for RSA encryption are two large prime numbers and an encryption exponent. If we call the primes p and q, and we call the encryption exponent e, which of the following describes the information shared in the public key?

W) The quantities p and q
X) The quantities p, q, and e [read p [pause] q and e]
Y) The quantity pq
Z) The quantities pq and e

ANSWER: Z) THE QUANTITIES PQ AND E [QG]

BONUS

18) **Y-Risk – *Short Answer*** One important value for RSA encryption is the value of the encryption exponent e. A common value used for e is the fourth fermat number. What is this value?

ANSWER: 65537 [QG]

TOSS-UP

19) **Earth and Space – *Short Answer*** What is the term used to describe large, gaseous exoplanets which have an extremely high surface temperature due to their proximity to their host star?

ANSWER: HOT JUPITERS [EP]

BONUS

19) **Earth and Space – *Short Answer*** What is the term used to describe low density "hot Jupiter" exoplanets which orbit especially close to their star, and, as a result, have their atmosphere expand significantly due to internal heating?

ANSWER: PUFFY PLANETS (accept HOT SATURNS) [EP]

TOSS-UP

20) **Biology – *Multiple Choice*** Arjun is an aspiring neuroscientist. He is studying the functions of various regions of the cortex. Which of the following regions of the cortex is incorrectly matched with its function?

W) Broca's area, speaking and hearing
X) Wernicke's area (“wer-nick-e”), language processing and comprehension
Y) Arcuate fasciculus (“arc-you-ate fasci-cu-lus”), connecting Broca's area to Wernicke's area
Z) Precentral gyrus, involuntary muscle contraction

ANSWER: Z) PRECENTRAL GYRUS, INVOLUNTARY MUSCLE CONTRACTION [AG]

BONUS

20) **Biology – *Multiple Choice*** Alex is performing an autopsy. He suspects the patient died of strychnine poisoning, a neurotoxin that blocks inhibitory glycine receptors in the spinal cord. Which of the following findings would best support his hypothesis?

W) Loss of anterior horn motor neurons and flaccid paralysis of skeletal muscle
X) Rhabdomyolysis (“rhab-do-myo-lysis”) with widespread muscle breakdown and vertebral fractures from severe spasms
Y) Markedly increased bronchial secretions and pulmonary edema
Z) Descending symmetric paralysis with preservation of sensory neurons

ANSWER: X) RHABDOMYOLYSIS WITH WIDESPREAD MUSCLE BREAKDOWN AND VERTEBRAL FRACTURES FROM SEVERE SPASMS [AK]

TOSS-UP

21) **Chemistry – *Short Answer*** Calculate the number of radial and angular nodes in an orbital with n = 4 and l = 2.

ANSWER: 1 RADIAL NODE, 2 ANGULAR NODES. [AG] radial nodes is n-l-1, not angular nodes. total = n-1.

BONUS

21) **Chemistry – *Short Answer*** By name or number, order the following five spectral lines by increasing wavelength of emitted light:

1. Balmer series
2. Lyman series
3. Brackett series
4. Pfund series
5. Paschen series

ANSWER: 2, 1, 5, 3, 4 [AG]

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TOSS-UP

22) **Math – *Short Answer*** Max is riding in a taxi around downtown New York. He notices that the block system of the city is similar to a geometry where, instead of treating distance the usual Euclidean way, distance is defined as the sum of the absolute differences of the assigned Cartesian coordinates between two points. What is the name for this type of geometry?

ANSWER: TAXICAB METRIC (accept MANHATTAN METRIC, TAXICAB GEOMETRY, and MANHATTAN GEOMETRY) [MR]

BONUS

22) **Math – *Short Answer*** If $f'(x) = floor(x)$, then what is $f(7.5) - f(2.5)$?

ANSWER: 22.5 [QG]

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TOSS-UP

23) **Physics – *Multiple Choice*** When heavy atomic nuclei are bombarded with high energy particles, such as protons from a particle accelerator, free neutrons are ejected from the host atom through which of the following processes?

W) Psuedo-fission
X) Neutron spallation
Y) Nuclear stripping
Z) Seaborg process

ANSWER: X) NEUTRON SPALLATION [MR]

BONUS

23) **Physics – *Short Answer*** A child ties a 5 kilogram mass to the end of an ideal massless string with length 4 meters. Then, they begin to swing the mass in a circle. The circle is in a plane that is 60 degrees to the horizontal. If the mass reaches a velocity of 10 meters per second at the bottom of the circle, then, to two significant figures, what is the tension in the string at the bottom of the circle in newtons?

ANSWER: 170 [QG]

TOSS-UP (30 seconds)

24) **Estimation – *Short Answer*** Neutrinos from cosmic rays are known for being pretty fast. If such a neutrino raced against a photon in a one year drag race, estimate the order of magnitude of the distance this neutrino would lose to the photon by in meters.

ANSWER: -2 [MR]

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End of Questions.