



## **DOUBLE ELIMINATION 3**

---

### **TOSS-UP**

1) X-Risk - *Multiple Choice* What behavior is exhibited by an AI that displays inner misalignment?

- W) It will maximize a reward function that is bad for humanity
- X) It will not maximize the reward function that it is trained on
- Y) It will appear to satisfy human values, but will end up not doing so
- Z) It will become less safe as it becomes more powerful

ANSWER: X) It will not maximize the reward function that it is trained on

### **BONUS**

1) X-Risk - *Short Answer* In what classification method is the category chosen based on the categories of a specified number of points closest to the point being classified, by some distance metric?

ANSWER: k-nearest neighbors (ACCEPT: KNN)

## **TOSS-UP**

- 2) Math - *Short Answer* How many ordered pairs of non-negative integers  $(a, b)$  [a comma b] satisfy  $24a! = b!$  [24 a factorial equals b factorial]?

ANSWER: 3

## **BONUS**

- 2) Math - *Short Answer* What are the coordinates of the two foci for the ellipse with equation  $16x^2 + 25y^2 - 100 = 0$ ?

ANSWER:  $(3/2, 0)$  and  $(-3/2, 0)$

## **TOSS-UP**

3) Chemistry - *Short Answer* What is the ratio of the number of rotational modes of diatomic oxygen to the number of vibrational modes of diatomic oxygen?

ANSWER: 2

## **BONUS**

3) Chemistry - *Multiple Choice* Which particle interaction has the greatest minimum energy in a graph of potential energy versus distance of separation?

- W) Lithium cation and fluoride anion
- X) Sodium cation and chloride anion
- Y) Helium atom and helium atom
- Z) Argon atom and argon atom

ANSWER: Y) Helium atom and helium atom

## **TOSS-UP**

- 4) Earth and Space - *Short Answer* By name or number, identify all of the following processes that may naturally produce a type of glass: 1) Lightning; 2) Subglacial eruption; 3) Submarine eruption.

ANSWER: All

## **BONUS**

- 4) Earth and Space - *Multiple Choice* Within the first 10 kilometers of Earth's crust, what relationship best describes the strength of rock with increasing depth?

- W) Linearly decreasing
- X) Linearly increasing
- Y) Exponential decay
- Z) Exponentially increasing

ANSWER: X) Linearly increasing

## **TOSS-UP**

5) Biology - *Short Answer* The phospholipids in the plasma membrane of archaea [ar-KEE-uh] contain what type of linkage between the hydrophobic head and hydrophilic tail?

ANSWER: Ether linkage

## **BONUS**

5) Biology - *Short Answer* Identify all of the following three statements that are true regarding microtubules: 1) Taxol causes the stabilization of microtubules; 2) ATP is bound to the beta subunit of tubulin; 3) Kinesin [kuh-NEE-sin] moves towards the plus end of microtubules.

ANSWER: 1 and 3

## **TOSS-UP**

6) Physics - *Multiple Choice* A quark's wavefunction is composed of spatial, color, and spin components. Under the condition that a fermion wavefunction is wholly anti-symmetric under particle exchange, the spin component of the wavefunction must be of what type if the spatial component is symmetric?

- W) Symmetric
- X) Anti-symmetric
- Y) Neither symmetric or anti-symmetric
- Z) Either symmetric or anti-symmetric

ANSWER: Z) Either symmetric or anti-symmetric

## **BONUS**

6) Physics - *Short Answer* Identify all of the following three statements that correctly compare an ideal double pendulum and a three body orbit: 1) The double pendulum cannot reach stability while the three body orbit can; 2) Both systems are dynamically chaotic; 3) Both can have uncoupled equations of motion.

ANSWER: 1 and 2

## **TOSS-UP**

7) X-Risk - *Short Answer* Cyanide is a toxin that has the potential for use in bioterrorism. Cyanide works by inhibiting the oxidation of what hemeprotein in the mitochondrial inner membrane?

ANSWER: Cytochrome C (ACCEPT: Cytochrome A3)

## **BONUS**

7) X-Risk - *Multiple Choice* The Deep Blue chess computer implemented which algorithm, an improvement on the minimax algorithm that allows for branches of the search tree to be eliminated?

- W) A\* [A star] search
- X) SSS\* [SSS star]
- Y) Alpha-beta pruning
- Z) Zero-window search

ANSWER: Y) Alpha-beta pruning

## **TOSS-UP**

8) Math - *Short Answer* What is the absolute difference between  $x$  and  $y$  given that  $x^2 + y^2 = 80$  and  $x + y = 12$ ?

ANSWER: 4

## **BONUS**

8) Math - *Short Answer* A committee of 5 people is to be chosen from a group of 10 people, including 3 men and 7 women. What is the probability that the committee has more women than men, if the choice is made completely uniformly randomly?

ANSWER: 11/12

## **TOSS-UP**

9) Chemistry - *Multiple Choice* Which of the following molecular orbitals displays cylindrical symmetry?

- W) Sigma bonding molecular orbital
- X) Sigma antibonding molecular orbital
- Y) Pi bonding molecular orbital
- Z) Pi antibonding molecular orbital

ANSWER: W) Sigma bonding molecular orbital

## **BONUS**

9) Chemistry - *Multiple Choice* When a crystal lattice of N sulfur monoxide molecules is cooled to absolute zero, which of the following functions describes the dependence of the residual entropy on N?

- W) N
- X)  $\log N$
- Y)  $N^2$
- Z)  $2^N$

ANSWER: W) N

## **TOSS-UP**

10) Earth and Space - *Short Answer* Because of frame dragging, neutron star crusts can accumulate tension over time, and can undergo sudden corrections that result in a lower energy state. What are these events known as?

ANSWER: Starquake

## **BONUS**

10) Earth and Space - *Short Answer* The Fermi bubbles above and below the plane of the Milky Way provide evidence that our galaxy might have recently been what type of active galaxy?

ANSWER: Seyfert [SAY-furt] galaxy

## **TOSS-UP**

11) Biology - *Short Answer* The crystallin lens of human eyes can accumulate deposits of protein and cloud up the lens as a person ages. What disorder does this likely cause?

ANSWER: Cataract

## **BONUS**

11) Biology - *Short Answer* Identify all of the following three actions that are functions of cholecystokinin [kol-uh-sis-toh-KY-nin]: 1) Inhibits stomach acid secretion; 2) Inhibits gallbladder contraction; 3) Contracts sphincter of Oddi [ODD-ee].

ANSWER: 1 only

## **TOSS-UP**

12) Physics - *Short Answer* A spring with spring constant  $k$  is connected to a block. If there are  $N$  number of springs with spring constants  $N \times k$  that are added in series with the first spring, what is the effective spring constant of the system?

ANSWER:  $\frac{k}{2}$

## **BONUS**

12) Physics - *Multiple Choice* How much energy, in joules, is stored in a 0.6 millihenry inductor when a 30 amp current flows through it?

- W) 0.21
- X) 0.24
- Y) 0.27
- Z) 0.30

ANSWER: Y) 0.27

## **TOSS-UP**

13) X-Risk - *Short Answer* ChatGPT uses supervised learning and what other learning technique to fine-tune its large language models, in which the agent is trained to take actions to maximize cumulative reward?

ANSWER: Reinforcement learning

## **BONUS**

13) X-Risk - *Short Answer* Which unsupervised learning algorithm partitions observations into clusters based on which cluster's mean each point is closest to?

ANSWER: k-means clustering

## **TOSS-UP**

14) Math - *Short Answer* Leonhard draws an infinite snowman by drawing a circle with radius 1, then drawing a circle with radius 1/2 tangent to it, then a circle with radius 1/3 tangent to the previous circle, continuing on infinitely, such that no two circles of the snowman ever intersect. What is the area of Leonhard's infinite snowman?

ANSWER:  $\frac{\pi^3}{6}$

## **BONUS**

14) Math - *Multiple Choice* Peter wants to solve the integral from 0 to 1 of  $\sqrt{1-x^2}dx$  by substituting  $x = \sin(u)$  and  $dx = \cos(u)du$ . Which of the following should be the bounds of the new integral?

- W) 0 to  $\pi/4$
- X) 0 to  $\pi/2$
- Y) 0 to  $\pi$
- Z) 0 to  $2\pi$

ANSWER: X) 0 to  $\pi/2$

## **TOSS-UP**

15) Chemistry - *Short Answer* What is the molecular geometry of the central xenon atom in the ion xenon trichloride one minus?

ANSWER: T-shaped

## **BONUS**

15) Chemistry - *Short Answer* For a reaction obeying the Arrhenius [ur-RAIN-ee-is] model at temperature T, which of the following three graphs of the rate constant k will produce a straight line? 1) k against e to the T; 2) Inverse of log k against T; 3) Log k against inverse of T.

ANSWER: 3 only

## **TOSS-UP**

16) Earth and Space - *Multiple Choice* Which of the following iron bearing minerals is the least iron rich by weight?

- W) Pyrite
- X) Chalcopyrite [cal-co-PY-rite]
- Y) Hematite
- Z) Magnetite

ANSWER: X) Chalcopyrite

## **BONUS**

16) Earth and Space - *Multiple Choice* Which of the following rock has a granitic composition but lacks quartz?

- W) Diorite
- X) Gabbro
- Y) Syenite [SY-uh-nite]
- Z) Pyroxenite [py-ROX-uh-nite]

ANSWER: Y) Syenite

## **TOSS-UP**

17) Biology - *Multiple Choice* What are the presynaptic and postsynaptic neurotransmitters, respectively, released in the sympathetic nervous system?

- W) Acetylcholine, acetylcholine
- X) Acetylcholine, norepinephrine
- Y) Norepinephrine, acetylcholine
- Z) Norepinephrine, norepinephrine

ANSWER: X) Acetylcholine, norepinephrine

## **BONUS**

17) Biology - *Short Answer* You run isoelectric focusing on a solution of three amino acids. Assuming that as the amino acids migrate, the pH increases, order the following three amino acids in increasing distance traveled: 1) Aspartate [as-PAR-tate]; 2) Arginine [AR-juh-neen]; 3) Alanine.

ANSWER: 1, 3, 2

## **TOSS-UP**

18) Physics - *Short Answer* The Lagrange point L1 appears as a saddle point in the gravitational potential between two celestial bodies. An object placed at L1 would be experiencing what type of stability in its motion?

ANSWER: Metastability (ACCEPT: Metastable)

## **BONUS**

18) Physics - *Short Answer* Order the following three elements from lowest to highest Curie temperature: 1) Cobalt; 2) Iron; 3) Nickel.

ANSWER: 3, 2, 1

## **TOSS-UP**

19) X-Risk - *Multiple Choice* Which of the following is a Markov process unable to model?

- W) Events happening in continuous time
- X) Events happening at random
- Y) Events with a continuous state space
- Z) Events depending on states before the current one

ANSWER: Z) Events depending on states before the current one

## **BONUS**

19) X-Risk - *Multiple Choice* In 2012, virologist Ron Fouchier published findings from controversial gain-of-function research indicating that he had discovered a viral mutation that could do what?

- W) Transmit avian influenza between mammals
- X) Transmit cowpox between humans
- Y) Increase the lethality of mousepox
- Z) Increase the infectiousness of measles

ANSWER: W) Transmit avian influenza between mammals

## **TOSS-UP**

20) Math - *Short Answer* What is the value of the sum from  $n = 0$  to infinity of the alternating series  $\frac{(-\pi)^n}{n!}$  [the quantity negative pi to the n all over n factorial]?

ANSWER:  $e^{-\pi}$

## **BONUS**

20) Math - *Short Answer* Trapezoid  $ABCD$  has point  $A$  at  $(0,0)$  [zero comma zero], point  $B$  at  $(5,8)$ , point  $C$  at  $(9,8)$ , and point  $D$  at  $(16,0)$ . A line passing through the origin intersects  $CD$  at point  $E$  such that triangle  $ADE$  has half of the area of trapezoid  $ABCD$ . What is the  $x$ -coordinate of point  $E$ ?

ANSWER: 93/8

## **TOSS-UP**

21) Chemistry - *Short Answer* The long timescale of phosphorescence is caused by an electronic transition forbidden by quantum mechanics. What intrinsic property of the excited electron changes during this forbidden transition?

ANSWER: Spin

## **BONUS**

21) Chemistry - *Short Answer* Order the following three molecules in terms of increasing chemical shift in an H1 NMR spectrum: 1) Benzene; 2) Ethyne [ETH-ine]; 3) Formaldehyde.

ANSWER: 2, 1, 3

## **TOSS-UP**

22) Earth and Space - *Multiple Choice* The Kappa mechanism is responsible for the pulsation of which of the following variable stars?

- W) T Tauri stars
- X) Luminous blue variables
- Y) RR Lyrae variables
- Z) Semiregular variables

ANSWER: Y) RR Lyrae variables

## **BONUS**

22) Earth and Space - *Multiple Choice* Kilonovae produce elements through what process, which makes them isotopically distinct from supernovae?

- W) r-process
- X) s-process
- Y) rp-process
- Z) p-process

ANSWER: W) r-process

## **TOSS-UP**

23) Biology - *Short Answer* The closure of the Venus flytrap after being touched is mediated by which motor organs of the plant?

ANSWER: Pulvini

## **BONUS**

23) Biology - *Multiple Choice* The causative agent of ebola belongs to which of the following families of viruses?

- W) Picornavirus
- X) Orthomyxovirus
- Y) Flivirus
- Z) Reovirus

ANSWER: Y) Flivirus

## **TOSS-UP**

24) Physics - *Short Answer* Pions are responsible for mediating the residual form of which fundamental nuclear force?

ANSWER: Strong nuclear (ACCEPT: Strong)

## **BONUS**

24) Physics - *Short Answer* [read carefully] How many times more likely is a particle to be found in the second state than the first state if a wavefunction of the particle is given by  $\frac{1}{A^2} \left[ \frac{1}{2} \Psi_1 + \frac{\sqrt{3}}{2} \Psi_2 \right]$  [1 over A squared times the quantity one half psi one plus root 3 over two times psi two] where  $\frac{1}{A^2}$  is the normalization constant?

ANSWER: 3