

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 heme protein 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 π

Z) 0 to 2π

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) Filiovirus
- Z) Reovirus

ANSWER: Y) Filiovirus

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 $\frac{1}{A^2}[\frac{1}{2}\Psi_1 + \frac{\sqrt{3}}{2}\Psi_2]$ [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