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)

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)

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

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

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

- 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

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

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

- 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

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

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

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

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

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 $\pi/2$

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

- 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

- 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

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

- 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

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

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 [ETHine]; 3) Formaldehyde.

ANSWER: 2, 1, 3

- 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

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) Fliovirus
- Z) Reovirus

ANSWER: Y) Fliovirus

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