Double Elimination 6

TOSS-UP

1) Energy (ML Eng) – *Multiple Choice* Which of the following is true of data augmentation for image classification?
W) Image operations in data augmentation are lossless
X) Data Augmentation increases overfitting due to repeated use of the same data
Y) Gaussian Blur increases noise in an image
Z) Data augmentation often occurs during training instead of during preprocessing
ANSWER: Z) Data augmentation often occurs during training instead of during preprocessing

BONUS

1) Energy (ML Triv) – *Short Answer* Identify all of the following that are true about generative adversarial networks:
1) The training loop is equivalent to a two-player min-max game
2) The goal of the generator is to have the discriminator output 0 to all of its generated inputs
3) Generator training requires sampling noise from some noise prior
4) Discriminator training requires sampling noise from some noise prior
ANSWER: 1, 3, 4

TOSS-UP

2) Physics (Thermo) – *Short Answer* What quantity in statistical mechanics is defined as the sum over all possible states of the Boltzmann factor?
ANSWER: The partition function

BONUS

2) Physics (EM) – *Short Answer* An electric dipole is formed by placing two opposite charges of magnitude 0.5 coulombs and mass 1 milligram 0.4 centimeters apart. An uniform electric field of magnitude 500 newtons per coulomb is then applied pointing perpendicular to the line connecting the charges. The dipole is rotated slightly, and begins to oscillate. Find the frequency of oscillation in hertz in scientific notation to one significant figure.
ANSWER: $5 * 10^5$ hertz

TOSS-UP

3) Math – *Multiple Choice* Frogs have a peculiar anatomy. They have an intestinal track from their mouth to their anus, and two external nostrils that connect into their mouth cavity. Assuming these are all of their holes, what is the Euler characteristic of a frog?
W. 2
X. 0
Y. -2
Z. -4
ANSWER: Z

BONUS

3) Math – *Short Answer* Identify all of the 3 statements about the Dirichlet function that are false, which is defined as equal to 1 if x is rational and equal to 0 if x is irrational.
1) It is discontinuous everywhere.
2) It is Riemann Integrable over the real numbers.
3) It is Lebesgue Integrable over the real numbers.
ANSWER: 2

TOSS-UP

4) Chemistry – *Short Answer* What reaction occurs when an acyl azide is decomposed to form an isocyanate?
ANSWER: Curtius Rearrangement

BONUS

4) Chemistry – *Short Answer* Which of the following three proposed steps are a common synthetic step following a Curtius Rearrangement?
1) Reaction with a primary alcohol to form an isolable carbamate
2) Reaction with water to form an isolable carbamic acid
3) Reaction with an amine to form an isolable urea derivative
ANSWER: 1) and 3)

TOSS-UP

5) Biology – *Multiple Choice* Which of the following best explains what happens to the rate of myosine phosphorylation and dephosphorylation respectively just as voltage gated Ca^{2+} channels open in a smooth muscle cell?
W) Increases, decreases
X) Increases, stays the same
Y) Decreases, increases
Z) Decreases, stays the same
ANSWER: X) Increases, stays the same

BONUS

5) Biology – *Short Answer* Identify all of the following three characteristics that could be found in peripheral proteins on the noncytosolic side of the plasma membrane:
1) The presence of a GPI anchor at the C-terminus after posttranslational modification
2) Attachment to the plasma membrane through the insertion of an amphiphilic alpha helix
3) Disulfide bridges stabilizing the protein structure
ANSWER: 1 and 3

TOSS-UP

6) Earth and Space – *Multiple Choice* Brewer-Dobson circulation refers to the Rossby wave-driven global circulation occurring in what layer of the atmosphere?
W) Troposphere
X) Stratosphere
Y) Mesosphere
Z) Ionosphere
ANSWER: X) Stratosphere

BONUS

6) Earth and Space – *Multiple Choice* Which of the following minerals or groups of minerals is dominant in syenite?
W) Quartz
X) Alkali feldspars
Y) Plagioclase feldspars
Z) Feldspathoids
ANSWER: X) Alkali feldspars

TOSS-UP

7) Biology – *Short Answer* Identify all of the following four enzymes that would induce double stranded breaks in DNA:
1) DNA polymerase III
2) RNA polymerase II
3) Topoisomerase I
4) Topoisomerase II

ANSWER: 4 only

BONUS

7) Biology – *Short Answer* Identify all of the following 4 amino acids that can be produced by the Shikimate pathway:
1) alanine
2) histidine
3) phenylalanine
4) tyrosine

ANSWER: 3, 4

TOSS-UP

8) Physics (EM) – *Multiple Choice* An insulating spherical shell of radius R with surface charge density s is set spinning with angular frequency w. The net dipole moment of the shell is proportional to what power of the radius?
W. 1
X. 2
Y. 3
Z. 4
ANSWER: Z

BONUS

8) Physics (Modern) – *Multiple Choice* A minus kaon and a neutron collide. A neutral xi baryon is produced, along with two other particles. Which of the following pairs of particles could be produced?
W. Neutral Kaon and Plus Pion
X. Neutral Kaon and Minus Pion
Y. Delta-0 baryon and proton
Z. Delta-0 baryon and antiproton
ANSWER: X

TOSS-UP

9) Chemistry – *Short Answer* It's heterocycle time! Identify the molecular formula of oxazole.

ANSWER: C_3H_3NO (or equivalent)

BONUS

9) Chemistry – *Visual Bonus* On the top are shown three different murexes and the colors of dye extracted from their mucus. On the bottom is the primary pigment that gives the dyes its color. Answer the following three questions regarding these specimens.
1) What is the common name for the dye produced from these gastropods?
2) Identify the primary reason why this compound is colored.
3) Removing the two bromine groups produces a much more commercially produced dye. What is its common name?

ANSWER: 1. TYRIAN PURPLE, 2. CONJUGATED SYSTEM or CONJUGATION, 3. INDIGO

TOSS-UP

10) Earth and Space – *Multiple Choice* Andalusite is most commonly associated with which of the following metamorphic facies?
W) Granulite
X) Hornfels
Y) Sanidinite
Z) Zeolite

ANSWER: X) Hornfels

BONUS

10) Earth and Space – *Multiple Choice* Two water masses have the same density but different temperatures and salinities. If the two water masses fully mixed together, how would the density of the new water mass compare to the water masses' original densities?
W) Slightly higher
X) Slightly lower
Y) Exactly the same
Z) Cannot be determined

ANSWER: W) Slightly higher

TOSS-UP

11) Math – *Short Answer* What theorem states that the cardinality of a power set of a set is always greater than the cardinality of that set?

ANSWER: Cantor's Cardinality Theorem

BONUS

11) Math – *Short Answer* Two frogs, George and Harold, both begin at the origin. Each frog chooses a random direction uniformly and independently and jumps a distance of one unit in that direction. Find the expected value of the distance between the two frogs.

ANSWER: 4 OVER PI

TOSS-UP

12) Energy (ML Eng) – *Multiple Choice* Which of the following best describes the purpose of training an autoencoder before training a model?

W) The autoencoder allows for quicker training time
X) The autoencoder allows for construction of efficient latent space representations
Y) The autoencoder reduces the frequency of gradient explosion
Z) The autoencoder standardizes the data

ANSWER: X) The autoencoder allows for construction of efficient latent space representations

BONUS

12) Energy (Sci Chem) – *Short Answer* What method in computational chemistry gets the exchange energy splittings of asymptotically degenerate energy states in molecular systems by computing polarized single-particle wave functions?

ANSWER: Holstein–Herring method

TOSS-UP

13) Physics (Mech) – *Multiple Choice* In the hopes of testing a new method of bacterial growth, William sets a petri dish on the equator of a spinning sphere of homogenous rock in a vacuum and rotates it with constant angular velocity less than that of the rock's about an axis normal to the dish's plane and through its center. In the frame where the disk is stationary and not spinning, which of the following best describes the regions where a fluid in the disk is at equilibrium?
W. Nowhere
X. A thin radius of the disk
Y. A thin diameter of the disk
Z. Two thin radii of the disk
ANSWER: Z

BONUS

13) Physics (Mech) – *Long Bonus* Consider a cylindrical bubble of radius 5 meters, height 8 meters, and surface tension 2 newtons/meter
1) What equation gives the difference in pressure between the inside and outside of the bubble?
2) If the bubble is in a vacuum, filled with one mole of an ideal gas, what is the temperature of this gas to the nearest 10 kelvin?
ANSWER: 1) Young-Laplace 2) 60 K

TOSS-UP

14) Biology – *Short Answer* What is the name of the external layer of an angiosperm pollen cell?

ANSWER: EXINE

BONUS

14) Biology – *Short Answer* Identify all of the following three amino acid sequence oligomers that would be cleaved by chymotrypsin. (Spell out each answer choice letter by letter.)

1) H-A-R-P-Y
2) S-I-R-E-N
3) S-C-Y-L-L-A

ANSWER: 2 ONLY

TOSS-UP

15) Chemistry – *Multiple Choice* Which of the following are NOT true of coordination numbers?
W) Coordination number 1 commonly occurs for complexes in the solid phase
X) Tetrahedral and Square planar complexes often correspond to a coordination number of 4
Y) The most common coordination number is 6
Z) Coordination number 8 only exists in ionic lattices
ANSWER: W

BONUS

15) Chemistry – *Short Answer* Which of the following 3 statements about the chemical potential are true?
1) The chemical potential is equivalent to the helmholtz free energy per molecule
2) Stoichiometric coefficients are inversely proportional to the chemical potential
3) On a pressure-temperature graph, phase coexistence occurs along lines of constant chemical potential
ANSWER: 2,3

TOSS-UP

16) Math – *Short Answer* Nine lily pads, arranged in a line from left to right are labeled 1 through 9. Clark, a frog, is currently at lilypad 5. When Clark jumps, he will either go left or right, with a $\frac{1}{3}$ chance of going left and a $\frac{2}{3}$ chance of going right. After 4 jumps, what is the probability that he has landed on lilypad 7?
ANSWER: 32/81

BONUS

16) Math – *Short Answer* McNair has ten coins each of pennies, nickels, dimes, and quarters. How many nonzero quantities of money can he make using some or all of the coins?
ANSWER: 410

TOSS-UP

17) Earth and Space – *Short Answer* Pluto's moon Charon, as well as various other solar system bodies, has a reddish-brown tint near its poles. What group of organic compounds is responsible for this color?

ANSWER: Tholins

BONUS

17) Earth and Space – *Short Answer* Identify all of the following three quantities that are nonzero for axions:

1) Charge
2) Mass
3) Spin

ANSWER: 2 only

TOSS-UP

18) Chemistry – *Multiple Choice* Edwin plots the reaction rate of different types of metal catalysts against their heat of adsorption. Which of the following best describes the trend he observers in reaction rate as heat of adsorption increases?

W) Increases
X) Decreases
Y) Increases then Decreases
Z) Decreases then Increases

ANSWER: Y) Increases then Decreases

BONUS

18) Chemistry – *Short Answer* Which of the following are true of the madelung constant?

1) It represents the potential energy of an ion in a lattice
2) It is generated from an alternating series
3) It is greater for a face-centered cubic lattice than for a body-centered cubic lattice

ANSWER: 1 and 2

TOSS-UP

19) Earth and Space – *Multiple Choice* A Strömgren sphere is a particular example of which of the following objects?
W) Bok globule
X) Herbig-Haro object
Y) H-two region
Z) Supernova remnant
ANSWER: Y) H-two region

BONUS

19) Earth and Space – *Multiple Choice* Which of the following best describes how the ratio of normal matter to dark matter changes with increasing distance from the center of a galaxy?
W) Uniformly increases
X) Uniformly decreases
Y) Increases, then decreases
Z) Decreases, then increases
ANSWER: X) Uniformly decreases

TOSS-UP

20) Math – *Short Answer* Clark the frog realizes that the total amount of lily pads he has over time follows the function t cubed plus 4 times t squared plus 16 times t plus 64. How many lily pads did Clark gain from t = 1 to t = 4??
ANSWER: 171

BONUS

20) Earth and Space – *Multiple Choice* Clark the frog has become very interested in the possible ways he can hop across his 13 lily pads. He can jump any odd number of lily pads at a time from 1 to 13. How many ways are there for him to jump across the 13 pads?
ANSWER: 144

TOSS-UP

21) Physics – *Multiple Choice* The weak decay of which of the following best shows CP violation?
W) Pions
X) B Mesons
Y) K Mesons
Z) Electrons
ANSWER: X) B Mesons

BONUS

21) Physics – *Short Answer* A photon gas is initially at volume 1 m^3 and temperature 30 K. The gas then adiabatically expands. If the final temperature is 15 K, what is the final volume of the gas?
ANSWER: 8 m^3

TOSS-UP

22) Physics – *Short Answer* What data structure, consisting of a collection of trees where the key of each child is always greater than or equal to the key of the parent, is used in priority queue operations?
ANSWER: Fibonacci heap

BONUS

22) Energy – *Short Answer* What algorithm in computational biology uses dynamic programming to align a general sequence by constructing a grid with the first sequence as the column and the second as the rows?
ANSWER: Needleman–Wunsch algorithm

TOSS-UP

23) Physics – *Short Answer* A circular plasmid has 210 base pairs but its most stable orientation in space has a writhe of negative 5. Which of the following is CLOSEST to the superhelix density of this plasmid?
W) -4
X) -0.25
Y) +0.25
Z) +4
ANSWER: X) -0.25

BONUS

23) Energy – *Short Answer* Nucleobases typically join together using Watson-Crick base pairing. What alternate base pairing occurs when two purine bases are rotated 180 degrees and occurs in G tetrads?
ANSWER: HOOGSTEEN