Double Elimination 1

TOSS-UP

1) Biology – *Multiple Choice* A container is divided into two compartments, A and B, by a membrane permeable to only water. Adding which of the following to compartment A would lead to the greatest decrease in its solute potential?
W) 1.5 molar NaCl
X) 2.0 molar $MgCl_2$
Y) 3.5 molar $C_6H_{12}O_6$
Z) 1.0 molar $Al_2(SO_4)_3$
ANSWER: X) 2.0 molar $MgCl_2$ [EH]

BONUS

1) Biology – *Short Answer* What molecular biology technique uses fluorescent nucleic acid probes that hybridize to their complementary sequences?
ANSWER: FISH, fluorescence in situ hybridization

TOSS-UP

2) Math – *Short Answer* Which one of Euclid's original postulates, when not used, leads to non-euclidean geometries?
ANSWER: Answer: Parallel Postulate (Accept: Euclid's 5th Postulate)

BONUS

2) Math – *Short Answer* Find the hundreds digit of 11 to the power of 2024.
ANSWER: 8

TOSS-UP

3) Physics (Modern) – *Short Answer* The energy of a 1D particle in a box is proportional to what power of the length of the box?

ANSWER: -2

BONUS

3) Physics (Mech) – *Multiple Choice* A sprinkler is designed such that it shoots a uniform amount of water at equal velocity from all angles. Given that there is linear air drag with coefficient b=0.5, after a long time, which of the following describes the change in the area density of the water on the ground as you move radially outward from the center to the edge of the water spot formed?

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

ANSWER: W)

TOSS-UP

4) Earth and Space – *Short Answer* What is the term for a geologic structure where the strata have a uniform dip in the same direction and approximately the same angle?

ANSWER: Monocline

BONUS

4) Earth and Space – *Short Answer* What term describes a volcano that erupts only once across its lifetime?

ANSWER: Monogenetic

TOSS-UP

5) Energy – *Multiple Choice* Which of the following best describes the benefit of a prefix sum array?
W) It allows for O(n) queries after an O(1) preprocessing step
X) It allows for O(log n) queries after an O(n) preprocessing step
Y) It allows for O(1) queries after an O(n) preprocessing step
Z) It allows for O(1) queries after an O(n^2) preprocessing step
ANSWER: Y) It allows for O(1) queries after an O(n) preprocessing step

BONUS

5) Energy – *Short Answer* Akhil is performing an amortized analysis on an algorithm. Which of the following is true about his results?
1) The big O time complexity can be less than the amortized time complexity
2) If he finds the time complexity for processing an entire sequence to be O($n^2 \log n$), the time complexity for a single element is O(log n)
3) He would find the time complexity of appending to a dynamic array to be O(1)
ANSWER: 2,3

TOSS-UP

6) Chemistry – *Short Answer* Rank the following four gases in terms of increasing a parameter values for the Van Der Waals equation at STP.
1) SO_2
2) H_2
3) NH_3
4) CH_4
ANSWER: 2, 4, 1, 3

BONUS

6) Chemistry – *Short Answer* McNair is analyzing a compound with chemical formula C6H14N2O2. Which of the following four sets of functional groups could be present in the compound?
1) One aromatic ring and one ether group
2) One hydroxyl group and one nitro group
3) One ester group and two amino groups
4) One carbon-carbon double bond and one carbon-carbon triple bond
ANSWER: 0

TOSS-UP

7) Biology – *Short Answer* Ryan is looking at a leaf cross-section under the microscope. He sees some elongated directly green cells under the waxy cuticle. What is the name for these cells?

ANSWER: Palisade Mesophyll

BONUS

7) Biology – *Short Answer* What structure in the root endodermis of plants contains suberin, allowing for better control of the transportation of water and inorganic salts between the cortex and vascular bundle?

ANSWER: Casparian Strip

TOSS-UP

8) Earth and Space – *Short Answer* When a star starts burning hydrogen in its core, it begins its life on the main sequence of the HR diagram. What is the name given to the point where the star first appears on the main sequence?

ANSWER: Zero Age Main Sequence (ACCEPT: ZAMS)

BONUS

8) Earth and Space – *Short Answer* Identify all of the following 3 statements that are true regarding star clusters:

1) Globular clusters generally contain younger stars than open stars
2) Stars in an open cluster are strongly gravitationally bound
3) Open clusters are typically found in the disk of a galaxy.

ANSWER: 3 only

TOSS-UP

9) Math – *Multiple Choice* Find the integral of $\cos^2(x)$ from $x = 0$ to $x = 2\pi$.
W) $\frac{\pi}{4}$
X) $\frac{\pi}{2}$
Y) π
Z) 2π
ANSWER: Y) π

BONUS

9) Math – *Short Answer* How many ways are there to color each of the faces of a cube black or red if rotations and reflections of one coloring are considered the same?
ANSWER: 10

TOSS-UP

10) Physics (Mech) – *Multiple Choice* Akhil has written down the equation of motion for a ball traveling through the air with air resistance proportional to velocity. Which of the following methods could be used to best approximate the velocity of the ball?
W) Newton's
X) Euler's
Y) Runge-Kutta
Z) Dulong-Petit
ANSWER: Y) Runge-Kutta

BONUS

10) Physics (Mech) – *Short Answer* William is playing with balls. They are attached to springs in series, constrained to move in a circle. He finds that for certain arrangements of the system, all balls oscillate with the same frequency and constant phase difference. What is the general term for these states of a system?
ANSWER: Normal Modes

TOSS-UP

11) Chemistry – *Short Answer* What type of strain is the main source of energy difference in the various conformers of propane?

ANSWER: Torsional strain

BONUS

11) Chemistry – *Short Answer* Rank the following three conformations of butane in order of increasing energy.

1) Anti
2) Gauche
3) Eclipsed

ANSWER: 1, 2, 3

TOSS-UP

12) Physics (Thermo) – *Short Answer* Consider a hypothetical gas confined to a square box in 2D space where the particles are effectively nonvibrating point masses that move around in the box. What is the adiabatic index of this gas?

ANSWER: 2

BONUS

12) Physics (EM) – *Multiple Choice* An RLC circuit has resistance 8 ohms, capacitance 10 farads, and inductance 20 henries. Which of the following graphs best describes the current in the system as a function of time?

W) Sinusoidal
X) Exponentially decaying
Y) Sinusoidal and exponentially decaying
Z) Constant

ANSWER: X) Exponentially decaying

TOSS-UP

13) Earth and Space – *Short Answer* If the dry adiabatic lapse rate is less than the atmospheric lapse rate, but the wet adiabatic lapse rate is greater than the atmospheric lapse rate, what atmospheric condition is occurring?

ANSWER: Conditional instability

BONUS

13) Earth and Space – *Multiple Choice* In order for a surface low to gain in intensity, which of the following needs to occur at the higher latitudes?

W) Convergence
X) Divergence
Y) Absolute geostrophic flow
Z) Conditional geostrophic flow

ANSWER: X) Divergence

TOSS-UP

14) Energy – *Short Answer* In reinforcement learning, what is the term for the strategy the agent uses to take its actions?

ANSWER: Policy

BONUS

14) Energy – *Multiple Choice* Which of the following statements about random walks in space is NOT true?

W) A random walk in 1D space can be represented by a Markov chain
X) The path traced out by a random walk in 2 or greater dimensional space is self-similar
Y) In 2 or greater dimensional space, the expected distance from the origin is 0
Z) Random walks can model an ideal polymer chain

ANSWER: Y) In 2 or greater dimensional space, the expected distance from the origin is 0

TOSS-UP

15) Math – *Multiple Choice* Which of the following operations, when applied to two 5x1 vectors, will produce a 5x5 matrix?
W) Cross Product
X) Triple Product
Y) Inner Product
Z) Outer Product
ANSWER: Z) Outer Product

BONUS

15) Math – *Short Answer* What is the sum of the values of $(n+1)(n+2)$ for n from 1 to 100?
ANSWER: 353700

TOSS-UP

16) Chemistry – *Multiple Choice* Which of the following solvents would be most effective in carrying out the reaction from tert-butyl bromide to tert-butyl methoxide?
W) methanol
X) water
Y) DMSO
Z) DMF
ANSWER: W) methanol

BONUS

16) Chemistry – *Multiple Choice* Which d orbital has cylindrical symmetry?
W) d_{xy}
X) d_{yz}
Y) $d_{x^2-y^2}$
Z) d_{z^2}
ANSWER: Z) d_{z^2}

TOSS-UP

17) Biology – *Short Answer* What plant hormone, whose precursor is produced around plant infection sites, activates a signal pathway that primes plant defense systems to respond to an infection?

ANSWER: Salicylic acid

BONUS

17) Biology – *Multiple Choice* William is a naked mole rat. He has a piece of food that will save his starving grandnephew Conrad if given to him. However, William's son, Nairit, is also hungry, and has a certain percent chance of dying if not given the food. Under the theory of inclusive fitness, which of the following is closest to the minimum percent chance of Nairit's death for William to give him the food?

W) 6%
X) 13%
Y) 25%
Z) 50%

ANSWER: Y) 25%

TOSS-UP

18) Physics (Thermo) – *Short Answer* What quantity represents the partial derivative of internal energy in terms of entropy?

ANSWER: Temperature

BONUS

18) Physics (EM) – *Short Answer* What is the total energy stored in a two-inductor system made up of two solenoids of inductances 3 Henries and mutual inductance 2 Henries both with current 2 Amperes, if their magnetic fields point in the same direction?

ANSWER: 20 Joules

TOSS-UP

19) Math – *Short Answer* Find the remainder when 6^{53} is divided by 53.
ANSWER: 6

BONUS

19) Math – *Short Answer* A square pyramid and cone are constructed pointing in opposite directions such that the cone's base is inscribed in the pyramid's base. If the pyramid and cone have the same volume, what is the ratio of the height of the pyramid to that of the cone?
ANSWER: $\frac{\pi}{4}$

TOSS-UP

20) Earth and Space – *Short Answer* Order the following locations of a meandering stream by increasing stream velocity:
1) Thalweg
2) Point Bar
3) Cut Bank
ANSWER: 2, 3, 1

BONUS

20) Earth and Space – *Short Answer* When a pre-main sequence star is too cold to fuse hydrogen in its core, gravity begins to contract the core of the star, which leads to an increase in pressure and temperature at the core. The increase in temperature allows for the star to begin fusing hydrogen. What is the name given to this mechanism?
ANSWER: Kelvin-Helmholtz Mechanism

TOSS-UP

21) Chemistry – *Short Answer* What is the reaction order in the nucleophile in an SN1 reaction?

ANSWER: 0

BONUS

21) Chemistry – *Short Answer* A gas in a closed container has root mean square speed v. More of the same gas is added to the container such that the density doubles while the pressure stays the same. What is the new root mean square speed of the gas?

ANSWER: $\sqrt{2}v$

TOSS-UP

22) Energy – *Short Answer* Computational Neuroscientists often have to use brain imaging data. Identify all of the following four which are true about imaging techniques.

1) Magnetoencephalography uses SQUIDs to measure small changes in the brain's magnetic field
2) Diffusion tensor imaging allows for visualization of the functional connectivity of the brain
3) Polysomnography uses a combination of MRI data and eye movement data
4) PET scans use radiopharmaceuticals to visualize biochemical changes in the brain

ANSWER: 1,4

BONUS

22) Energy – *Multiple Choice* You notice while training a fully connected neural network that your testing loss is much lower than your training loss. Which of the following modifications could best fix this issue?

W) Increasing the learning rate of the optimizer
X) Increasing the proportion of data that is zeroed in dropout
Y) Adding another hidden layer
Z) Decreasing the learning rate of the optimizer

ANSWER: X) Increasing the proportion of data that is zeroed in dropout

TOSS-UP

23) Biology – *Short Answer* What form of DNA repair mechanism involves recognizing and repairing bulky, helix-distorting DNA lesions, such as thymine dimers, by excising a section of the DNA strand that contains the damage?

ANSWER: Nucleotide excision repair (NER)

BONUS

23) Biology – *Multiple Choice* Which of the following diseases is caused by a deficiency in one or more components of the nucleotide excision repair pathway, leading to extreme sensitivity to ultraviolet light and a high risk of skin cancer?

W) Cockayne syndrome
X) Xeroderma pigmentosum
Y) Bloom syndrome
Z) Eczema

ANSWER: X) Xeroderma pigmentosum