Double Elimination 3

TOSS-UP

1) Physics (Modern) – *Short Answer* What is the degeneracy of the n=4 quantum level?

ANSWER: 32

BONUS

1) Physics (Thermo) – *Short Answer* A sphere with nonzero emissivity of radius 500 meters orbits around a very massive blackbody of radius $5*10^5$ meters at a distance of $2*10^{10}$ meters away. The blackbody it is orbiting has a constant temperature of 400 K. After a very long time, what is the temperature of the sphere in Kelvin to one significant figure?

ANSWER: 300 Kelvin

TOSS-UP

2) Energy (Misc) – *Short Answer* Consider a four-sided die that will roll the numbers 1-4 with equal probability. What is the Shannon entropy of this system in bits?

ANSWER: 2

BONUS

2) 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: 3 only

TOSS-UP

3) Earth and Space – *Short Answer* By name or number, identify all of the following 3 statements that are true concerning alfisols: 1) They are found in association with coniferous forests; 2) They are relatively immature; 3) They contain elevated levels of aluminum and iron

ANSWER: 3 only

BONUS

3) Earth and Space – *Short Answer* An olivine crystal has an iron rich core and a magnesium rich rim, which is indicative that the temperature increased drastically from influxes of hot magma. What kind of zoning will likely occur from this mechanism?

ANSWER: Reverse zoning

TOSS-UP

4) Biology – *Multiple Choice* Which of the following characteristics would most likely not be present in a xerophyte?

W) High number of trichomes
X) Photosynthesis being carried out primarily in stems
Y) Taproots that extend far underground
Z) Rubisco as the primary enzyme for initial carbon fixation

ANSWER: Z) Rubisco as the primary enzyme for carbon fixation

BONUS

4) Biology – *Multiple Choice* Which of the following muscles is an example of smooth muscle?

W) Biceps brachii
X) Heart muscle
Y) Intestinal wall muscle
Z) Deltoid

ANSWER: Y) Intestinal wall muscle

TOSS-UP

5) Math – *Short Answer* What is log base 2 of 6 times log base 3 of 8 times log base 36 of 81?

ANSWER: 6

BONUS

5) Math – *Short Answer* A probability density function has a domain from 0 to infinity and is defined by the function e to the power of the quantity c times x, where c is a constant. What is the value of c?

ANSWER: -1

TOSS-UP

6) Chemistry – *Short Answer* Identify all of the following three statements that are TRUE regarding alkynes.

1) It is generally easier to deprotonate alkynes than alkenes.
2)Treating an alkyne with liquid sodium and ammonia will result in a trans alkene.
3)Hydrating an alkyne will result in a ketone.

ANSWER: 1,2, 3

BONUS

6) Chemistry – *Short Answer* Identify all of the following four reagents that, when added to an alkene, will produce an epoxide group.

1) m-CPBA
2) osmium tetroxide
3) silver oxide
4) ozone followed by DMS

ANSWER: 1,3

TOSS-UP

7) Biology – *Multiple Choice* In the Calvin cycle, which molecule is regenerated to allow the cycle to continue?
W) 3-phosphoglycerate
X) Ribulose bisphosphate
Y) Glyceraldehyde 3-phosphate
Z) NADPH
ANSWER: X) Ribulose bisphosphate

BONUS

7) Biology – *Short Answer* Given that ln(2) = 0.7 and ln(5)=1.6, find the Shannon's diversity index of a local ecosystem consisting of 5 lilies, 2 frogs, 2 TearBears , and 1 palm tree?
ANSWER: 5

TOSS-UP

8) Earth and Space – *Short Answer* What emission line in the radio wavelength is used to observe clouds of interstellar gas of neutral hydrogen?
ANSWER: 21 cm

BONUS

8) Earth and Space – *Short Answer* By name or number, order the following 3 isotopes by increasing ignition temperature of fusion: 1) Deuterium; 2) Protium; 3) Lithium
ANSWER: 3 1 2

TOSS-UP

9) Physics – *Multiple Choice* After finding the philosopher's stone, Andrey built a factory to produce and then cut sheets of gold. A rectangular stamp cuts the gold into bars to be sold . If the sheet of gold is carried by a conveyor belt moving at 0.5c, what issue might Andrey find with his factory?
W) The gold bars are stretched parallel to the belt's movement
X) The gold bars are squashed parallel to the belt's movement
Y) The gold bars are stretched both parallel and transverse to the belt's movement
Z) There is no issue
ANSWER: W

BONUS

9) Physics (EM) – *Short Answer* Earnshaw's Theorem arises from the fact that all critical points of the electric potential field in free space are what type of point?
ANSWER: Saddle Point

TOSS-UP

10) Chemistry – *Short Answer* Identify all elements present in a strand of pure nylon.
ANSWER: CARBON, HYDROGEN, NITROGEN, OXYGEN

BONUS

10) Chemistry – *Short Answer* Identify the organometallic hydride compound that is used to reduce esters to aldehydes and nitriles to imines.
ANSWER: DIISOBUTYLALUMINUM HYDRIDE or DIBAL-H

TOSS-UP

11) Math – *Short Answer* What is the sum of the factors of 48?
ANSWER: 124

BONUS

11) Math – *Short Answer* Circles A and B, with radii 100 and 144 respectively, are externally tangent to each other. Line m is externally tangent to circles A and B such that both circles are on the same side of m. Define a circle C such that C is externally tangent to A, B, and m. Find the radius of circle C.
ANSWER: 3600 OVER 121

TOSS-UP

12) Earth and Space – *Multiple Choice* Which of the following is not a polymorph of potassium feldspar?
W) Orthoclase
X) Sanidine
Y) Microcline
Z) Sillimanite
ANSWER: Z

BONUS

12) Earth and Space – *Short Answer* Order the following 4 minerals from first to last to decay chemically; 1) Quartz; 2) Olivine, 3) Pyroxene 4) Amphibole
ANSWER: 2 3 4 1

TOSS-UP

13) Chemistry – *Short Answer* In infrared spectroscopy, a very broad peak near 3300 inverse centimeters indicates the presence of what functional group?

ANSWER: Alcohol (accept hydroxyl)

BONUS

13) Chemistry – *Multiple Choice* After doing an SN1 reaction with a levorotatory substrate, you shine a laser through the product. What is most likely to happen to the plane of the laser light?

W) It doesn't get significantly rotated
X) It gets rotated clockwise
Y) It gets rotated counterclockwise
Z) It gets rotated 180 degrees

ANSWER: W) It doesn't get significantly rotated

TOSS-UP

14) Energy (ML Triv) – *Multiple Choice* Which of the following is NOT true about momentum in gradient descent?

W) Momentum uses an exponentially weighted average of previous gradients
X) Momentum allows for more stochasticity in gradient descent
Y) Momentum helps prevent the descent process from settling in local minima
Z) Momentum typically provides greater performance on unconstrained optimization problems

ANSWER: X) Momentum allows for more stochasticity in gradient descent

BONUS

14) Energy (Classical) – *Multiple Choice* When a heap is used to implement a max priority queue, which of the following is NOT true regarding max priority queue trees and binary search trees?

W) They are both binary
X) The insert operation takes O(log(n)) time for both trees
Y) Priority queues self balance while binary search trees do not
Z) Finding the largest element takes O(n) for both trees

ANSWER: Z) Finding the largest element takes O(n) for both trees

TOSS-UP

15) Math – *Short Answer* The famous Basel problem is the sum of the reciprocals of the perfect squares starting from 1. The Basel Problem is obtained when what positive integer is plugged into the Riemann Zeta function?

ANSWER: 2

BONUS

15) Math – *Short Answer* 3 real numbers are chosen from random and uniformly from 0 to 1. What is the probability that the largest number is greater than the sum of the other two numbers?

ANSWER: 1/4

TOSS-UP

16) Chemistry – *Short Answer* Rank the following three bonds in order of increasing bond strength.

1) Carbon-carbon bond in benzene
2) Carbon-oxygen bond in carbon monoxide
3) Carbon-nitrogen bond in cyanide ion

ANSWER: 1, 3, 2

BONUS

16) Chemistry – *Short Answer* Rank the following three species in order of increasing molar Gibbs free energies of formation.

1) Ethane
2) Propane
3) Ethene

ANSWER: 2, 1, 3

TOSS-UP

17) Earth and Space – *Multiple Choice* The ergosphere around a black hole is characterized by which of the following phenomena?
W) Frame dragging
X) Hawking radiation
Y) Synchrotron radiation
Z) Urca process
ANSWER: W) Frame dragging

BONUS

17) Earth and Space – *Short Answer* By name or number, order the following 4 epochs of the early Universe in chronological order: 1) Photon epoch; 2) Quark epoch; 3) Planck epoch 4) Electroweak epoch
ANSWER: 3 4 2 1

TOSS-UP

18) Biology – *Short Answer* 2-Mercaptoethanol is commonly used in SDS-PAGE to break what type of interaction?
ANSWER: Disulfide, disulfide bridge, SS-bridgepage

BONUS

18) Biology – *Multiple Choice* Acorn worms belong to what phylum whose members have gill slits and a dorsal nerve cord?
W) Echinodermata
X) Acoela
Y) Ophiuroidea
Z) Hemichordata
ANSWER: Z

TOSS-UP

19) Physics (Modern) – *Short Answer* Which of the following are commonly accepted candidates for dark matter? 1) Sterile Neutrinos 2) GRINCHes 3) WIMPs 4) Gravitons 5) MACHOs

ANSWER: 1 3 5

BONUS

19) Physics (EM) – *Short Answer* A small spherical cavity is drilled inside of a nonconducting charged sphere of uniform charge density. To what power of the distance from the center of the cavity is the electric field inside proportional to?

ANSWER: 0

TOSS-UP

20) Energy (Misc) – *Short Answer* Which of the following are true of cellular automata?
1)Class 4 cellular automata are capable of universal computation
2) In John Conway's game of life, a 3x3 square is stable
3) If a cellular automaton is reversible, its time-reversed behavior can also be considered a cellular automaton

ANSWER: 1,3

BONUS

20) Energy (Sci Bio) – *Short Answer* Biology Researchers often use UMAP for dimensionality reduction. What other algorithm for dimensionality reduction uses a gaussian distribution to find the similarity between objects in an N-dimensional space?

ANSWER: t-SNE or "t-distributed stochastic neighbor embedding"

TOSS-UP

21) Biology – *Short Answer* In the xylem, pits connect neighboring tracheids to allow water to migrate laterally. Identify all of the following three polymers that can be found composing these pits: 1) Cellulose; 2) Lignin; 3) Suberin.

ANSWER: 1 only

BONUS

21) Biology – *Short Answer* Identify all of the following 3 cells that you would expect to find in fibrocartilage: 1) fibroblasts, 2) chondroblasts, 3) chondrocytes

ANSWER: 1 and 3

TOSS-UP

22) Physics – *Short Answer* What mathematical object, often thought of as "the square root of a vector," is used to represent the polarization of light?

ANSWER: Spinor

BONUS

22) Physics – *Multiple Choice* A tank is made by removing the base from two cones of radius 2 meters and height 5 meters, filling them both with incompressible fluid at pressure 4.5 pascals, and sealing them to form a new convex polyhedron. What is the total force exerted by the fluid on the outside of the tank, in newtons to two significant figures?

ANSWER: 110 Newtons

TOSS-UP

23) Math – *Multiple Choice* A pyramid with a regular polygon of side length 1 for its base has a lateral height of 2. If the pyramid's surface area is 18 plus three square root three, how many sides does the base have?
W) 6
X) 9
Y) 12
Z) 15
ANSWER: Y) 12

BONUS

23) Math – *Short Answer* How many unique nondegenerate triangles can be made from a lattice grid with 12 points arranged in a 3 by 4 pattern, where each vertex of the triangle is a different point on the lattice?
ANSWER: 200