BASH

Double Elimination 5

TOSS-UP

1. Energy *Multiple Choice* Students at Amador Valley are emulating Dora the Explorer. Which of the following exploration strategies selects actions proportionally to a softmax of estimated Q-values?

W) ε-greedy **[EPSILON-GREEDY]**
X) Boltzmann exploration
Y) Upper confidence bound
Z) Thompson sampling

ANSWER: X) BOLTZMANN EXPLORATION

BONUS

1. Energy *Short Answer* Students at Montgomery Blair are studying new distributions in Statistics class. In the hypergeometric distribution with population size 5 and 4 objects, what is the probability mass function when you have 3 draws and 2 successes?

ANSWER: 3/5

TOSS-UP

2. Earth and Space *Multiple Choice* Dora the Explorer is rafting around the North Atlantic gyre. She's searching for her missing pet monkey, so time is of the essence. Which of the following currents should she expect to sail the fastest on?

W) Gulf Stream
X) North Atlantic Drift
Y) Canary Current
Z) North Equatorial Current

ANSWER: W) GULF STREAM

BONUS

2. Earth and Space *Short Answer* Loess is often deposited at the terminus of a glacier by what kind of wind, which is characterized by cold, dense air at high altitudes flowing down a slope due to its own weight?

ANSWER: KATABATIC

TOSS-UP

3. Chemistry *Multiple Choice* Which of the following alkyl bromides cannot be converted into a Wittig reagent via reaction with triphenylphosphine and a strong base?

W) n-butyl bromide

X) iso-butyl bromide

Y) sec-butyl bromide

Z) tert-butyl bromide

ANSWER: Z) TERT-BUTYL BROMIDE

BONUS

3. Chemistry Multiple Choice When getting ready to eat his sample of gallium, Advai notices that it melts in his hand. Which of the following best explains why gallium melts at such a low temperature?

W) Gallium has an anomalously low atomic radius due to d-block contraction

X) Gallium has an unusually disordered solid crystal state

Y) Gallium forms covalent dimers in the solid state that interact poorly with each other

Z) Gallium's single p electron is easily ionized, causing charge repulsion in the solid state

ANSWER: Y) GALLIUM FORMS COVALENT DIMERS IN THE SOLID STATE THAT INTERACT POORLY WITH EACH OTHER

TOSS-UP

4. Physics *Short Answer* Evan is trying to make stable configurations of point charges in free space, but he is failing miserably. What theorem explains why no stable configuration of point charges can exist?

ANSWER: EARNSHAW'S THEOREM

BONUS

4. Physics *Multiple Choice* A point charge is placed equidistant between two grounded conducting plates. How many image charges must be added to model the system?

W) 1

X) 2

Y) 4

Z) Infinite

ANSWER: Z) INFINITE

TOSS-UP

5. Math *Short Answer* How many surjective maps are there from a set with 4 elements to a set with 2 elements?

ANSWER: 14

BONUS

5. Math *Short Answer* Edwin is counting the children in his basement. He tries to put them in groups of n for each n between 2 and 10 inclusive, and he finds that n - 1 people are always left over. If the number of children in his basement is as small as possible satisfying these conditions, if he tries to put them in groups of 11, how many people will be left over?

ANSWER: 0

TOSS-UP

6. Biology *Multiple Choice* Which of the following is the main reason why DNA evolved to contain thymine instead of uracil?

W) Uracil cannot form stable hydrogen bonds in a double helix
X) Cytosine deamination to uracil can be more easily recognized as a mutation
Y) Thymine can be more easily excised from the helix by DNA mismatch repair
Z) The difference in composition between DNA and RNA can allow the small ribosomal subunit to more easily identify RNA during translation

ANSWER: X) CYTOSINE DEAMINATION TO URACIL CAN BE MORE EASILY RECOGNIZED AS A MUTATION

BONUS

6. Biology *Multiple Choice* A limb bud in a chicken undergoes abnormal development where the resultant wing has more digits. Which of the following best describes what went wrong in the wing?

W) Increased activity of ZPA in the anterior region of the limb
X) Increased activity of AER in the anterior region of the limb
Y) Increased activity of ZPA in the posterior region of the limb
Z) Increased activity of AER in the posterior region of the limb

ANSWER: W) INCREASED ACTIVITY OF ZPA IN THE ANTERIOR REGION OF THE LIMB

TOSS-UP

7. Earth and Space *Multiple Choice* As a one-solar mass protostar becomes a main sequence star, in what direction does it move along the HR diagram?

W) Up and to the left

X) Up and to the right

Y) Down and to the left

Z) Down and to the right

ANSWER: Y) DOWN AND TO THE LEFT

BONUS

7. Earth and Space *Short Answer* A spaceship is orbiting around a star in an elliptical orbit with an eccentricity of ⅔. If the speed of the spaceship at perigee is 150 kilometers per second, then in kilometers per second, what is the speed of the spaceship at apogee?

ANSWER: 30 [YL]

TOSS-UP

8. Chemistry *Short Answer* What aromatic compound is created when anisole, also known as methoxybenzene, is treated with excess hydrochloric acid and heat?

ANSWER: PHENOL

BONUS

8. Chemistry *Multiple Choice* Excess Grignard reagent is added to a reaction vessel with a certain compound in a diethyl ether solvent. Then, an acidic workup is done on the products of that reaction. If a ketone is formed as a result of this series of reactions, which of the following functional groups could the original compound possess?

W) Ester

X) Anhydride

Y) Acid chloride

Z) Nitrile

ANSWER: Z) NITRILE

TOSS-UP

9. Physics *Short Answer* Local hidden-variable theories were initially introduced to attempt to explain quantum phenomena. However, these theories were eventually disproven by what inequality, which demonstrated the conflict between local realism and quantum mechanics?

ANSWER: BELL'S INEQUALITY (ACCEPT: BELL'S THEOREM)

BONUS

9. Physics Short Answer A ball is dropped from rest off of a cliff. 2 seconds later, a second ball is thrown downwards at 25 meters per second. Neglecting air resistance and taking g as 10 meters per second squared, then in seconds, how long will it take for the second ball to reach the first ball from the time the second ball was thrown downwards?

ANSWER: 4

TOSS-UP

10. Math *Short Answer* The hyperbolic cosine of a real number is 5/3. What is the largest possible value of the real number, expressed in simplest form?

ANSWER: ln(3) [RG]

BONUS

10. Math *Short Answer* Kian the ant and Edwin the gopher are both trying to travel between two opposing corners in a cube. Kian is forced to travel along the surface while Edwin can travel through the cube. If they both travel at 1 meter per second and it takes Kian 10 more seconds to complete the journey, then to the nearest meter, what is the side length of the cube? Assume both Kian and Edwin travel optimally.

ANSWER: 20

TOSS-UP

11. Biology *Multiple Choice* Which of the following proteins does not rely on a phosphorylated intermediate conformation to function?

W) Sodium-potassium pump

X) Insulin receptor

Y) Epinephrine receptor

Z) Maturation-promoting factor

ANSWER: Y) EPINEPHRINE RECEPTOR

BONUS

11. Biology *Multiple Choice* Which of the following temperature regulation strategies is the rarest?

W) Endothermic homeotherm

X) Endothermic poikilotherm

Y) Ectothermic homeotherm

Z) Ectothermic poikilotherm

ANSWER: X) ENDOTHERMIC POIKILOTHERM

TOSS-UP

12. Energy *Multiple Choice* Students at Montgomery Blair are performing radical reactions with peroxides, specifically the anti-Markovnikov addition of HBr. In this reaction, the double bond of alkene participates in which of the following radical steps?

W) Halogen abstraction

X) Hydrogen abstraction

Y) Addition

Z) Coupling

ANSWER: Y) ADDITION

BONUS

12. Synergy *Short Answer* The Titius-Bode law states that the orbital radius of solar system planets in astronomical units is 0.4 + k times 2^n, for some constant k and where n equals 0 for Venus and increments by 1 for each additional planet. According to the Titius-Bode law, what is the sum of the orbital radii of every planet that contains metallic hydrogen?

ANSWER: 15.2

TOSS-UP

13. Earth and Space *Multiple Choice* Which of the following describes the effect of a La Nina event on the strength of the Walker circulation and the strength of trade winds respectively?

W) Strengthen, strengthen

X) Strengthen, weaken

Y) Weaken, strengthen

Z) Weaken, weaken

ANSWER: W) STRENGTHEN, STRENGTHEN

BONUS

13. Earth and Space *Short Answer* Identify all of the following three comparisons between the center of a pluton and its chilled margins that are true:

1) Chilled margins tend to be coarser-grained

2) Chilled margins tend to be more felsic

3) Chilled margins are usually darker in color

ANSWER: 3 ONLY

TOSS-UP

14. Chemistry *Short Answer* Identify all of the following three molecules that can be analyzed using microwave spectroscopy:

1) NH_3

2) CO_2

3) XeF_4

ANSWER: 1 ONLY

BONUS

14. Chemistry *Short Answer* Katherine is using permanganate to oxidize iron (II) ions to iron (III). She uses 1 mole of permanganate in each of two solutions, one of pH 2 and another of pH 7. What is the ratio of the number of moles of iron (III) ions produced in the first solution to those produced in the second solution?

ANSWER: 5/3

TOSS-UP

15. Physics *Multiple Choice* Kian is building a suspension bridge. He starts with a cable, which is attached to two horizontal structures and hangs under its own weight. He then adds vertical suspension cables to support the bridge below. As more suspension cables are added, which of the following best describes how the shape of the cable changes?

W) Catenary to parabola
X) Parabola to catenary
Y) Catenary to hyperbola
Z) Hyperbola to catenary

ANSWER: W) CATENARY TO PARABOLA

BONUS

15. Physics *Multiple Choice* Which of the following changes would change the intensity of a sound wave by the greatest factor?

W) Tripling the frequency of the wave
X) Tripling the density of the wave
Y) Doubling the amplitude of the wave
Z) Doubling the speed of the wave

ANSWER: W) TRIPLING THE FREQUENCY OF THE WAVE

TOSS-UP

16. Math *Short Answer* Two triangles have one side of length 5 and one side of length 7. The first triangle has an angle of 60 degrees between the two sides while the second triangle has an angle of 120 degrees between the two sides. What is the absolute difference in the square of the third side length for the two triangles?

ANSWER: 70

BONUS

16. Math *Short Answer* Cards are drawn one by one from a standard 52 card deck. What is the expected number of cards drawn until two aces are drawn?

ANSWER: 106/5

TOSS-UP

17. Biology *Short Answer* After being secreted by adipose tissues, leptin travels through the bloodstream to the brain where it acts to increase satiety through its inhibition of what hormone secreted by the hypothalamus?

ANSWER: NEUROPEPTIDE Y

BONUS

17. Biology *Short Answer* Genes A and B are found 20 map units apart on the same chromosome. Both genes have two alleles: one dominant and one recessive. Two individuals with the same genotype have maternal chromosomes with the A and b **[READ: big A and little b]** alleles and paternal chromosomes with the a and B **[READ: little a and big B]** alleles. If the two individuals are crossed, what is the probability that they will get an offspring with Ab **[READ: big A little b]** on one chromosome and ab **[READ: little a little b]** on the other?

ANSWER: 0.08

TOSS-UP

18. Earth and Space *Short Answer* Particles in the Cassini Division have a 2 to 1 orbital resonance with which of Saturn's moons?

ANSWER: MIMAS

BONUS

18. Earth and Space *Short Answer* If the redshift of a distant galaxy is 3, then as a fraction in terms of the speed of light c, what is the recessional velocity of the galaxy?

ANSWER: 15c/17

TOSS-UP

19. Chemistry *Multiple Choice* In which of the following quantum mechanical models would microwave radiation most likely be able to excite the ground state to an excited state?

W) Quantum harmonic oscillator

X) Rigid rotor

Y) Particle in a box

Z) Particle in a ring

ANSWER: X) RIGID ROTOR

BONUS

19. Chemistry Short Answer What is the name given to the class of dienes that contain an sp-hybridized carbon atom?

ANSWER: ALLENE (ACCEPT: CUMULATED DIENE)

TOSS-UP

20. Physics *Short Answer* Rohan sends a complex signal to Evan. What technique should Evan use to decompose the signal into analyzable sinusoidal functions?

ANSWER: FOURIER TRANSFORM

BONUS

20. Physics *Multiple Choice* The Ives-Stillwell experiment utilized the transverse Doppler effect to prove which of the following properties?

W) Huygen's principle

X) Time dilation

Y) Particle-wave duality

Z) Quantum entanglement

ANSWER: X) TIME DILATION

TOSS-UP

21. Math *Short Answer* Tetris the cat is on a trip on the n-dimensional plane! Each second, he takes a random step in one of the n directions uniformly at random of unit length. If he starts at the origin, which is his home, what is the smallest integer value of n for which he is expected to never come back home again?

ANSWER: 3

BONUS

21. Math *Short Answer* A random permutation of the first 1000 positive integers is chosen. To one significant figure, what is the probability it has exactly two fixed points?

ANSWER: 0.2

TOSS-UP

22. Biology *Multiple Choice* Nondisjunction happens in meiosis I for the sex chromosomes. In which of the following would there be offspring without any aneuploidy disorders?

W) Platypuses

X) Grasshoppers

Y) Fruit flies

Z) Chickens

ANSWER: X) GRASSHOPPERS

BONUS

22. Biology *Short Answer* Identify all of the following three structures in bryophytes that would be in the sporophyte stage of their life cycle:

1) Peristome

2) Protonema

3) Brood bodies

ANSWER: 1 ONLY

TOSS-UP

23. Energy *Short Answer* Students at Amador Valley are looking at animals, plants, and both at the same time. Specifically, they are comparing the C4 pathway of photosynthesis with the Krebs cycle. Identify all of the following three compounds which serve as intermediates in both pathways:

1) Succinate
2) Malate
3) Oxaloacetate

ANSWER: 2 AND 3

BONUS

23. Synergy *Short Answer* What property of analytes in solution is the reason why the graph of a cyclic voltammetry experiment is a loop instead of a one-to-one function?

ANSWER: HYSTERESIS
