



## DOUBLE ELIMINATION 5

---

### TOSS-UP

1) X-Risk - *Multiple Choice* Scientists are studying new methods to bring nuclear fusion onto the grid as a reliable energy source. What is the term for the method of fusion which involves heating and compressing a fuel target, typically a pellet containing deuterium and tritium?

- W) Thermonuclear fusion
- X) Inertial confinement fusion
- Y) Inertial electrostatic confinement
- Z) Muon-catalyzed fusion

ANSWER: X) Inertial confinement fusion

### BONUS

1) X-Risk - *Multiple Choice* Which of the following failures in reasoning would NOT cause a multi-stage probabilistic reasoning process to underestimate a probability?

- W) Multiplying unconditional probabilities as if they were conditional probabilities
- X) Assigning excessive confidence to representative-sounding events
- Y) Neglecting the possibility of reaching stages outside of an existing model
- Z) Biasing probability assessments towards 50%

ANSWER: X) Assigning excessive confidence to representative-sounding events

## TOSS-UP

2) Math - *Short Answer* In the Fibonacci sequence, what is the ratio of odd to even numbers in the first 90 values?

ANSWER: 2 to 1 (ACCEPT: 2)

## BONUS

2) Math - *Short Answer* Suppose the residents in a city live in four neighborhoods, A, B, C, and D, and they work in three different types of occupations, white collar, blue collar, or no collar. If one were to perform a chi-squared test on the null hypothesis that each person's neighborhood of residence is independent of the person's occupational classification, how many degrees of freedom should be used?

ANSWER: 6

### TOSS-UP

3) Chemistry - *Short Answer* What quantity represents the maximum amount of useful work that can be extracted from a system under isothermal conditions?

ANSWER: Helmholtz free energy

### BONUS

3) Chemistry - *Multiple Choice* Which of the following is the product of the reaction between nitrobenzene and nitronium tetrafluoroborate?

W) Nitrobenzene

X) 1,2-dinitrobenzene

Y) 1,3-dinitrobenzene

Z) 1,4-dinitrobenzene

ANSWER: Y) 1,3-dinitrobenzene

### TOSS-UP

4) Earth and Space - *Multiple Choice* What type of fault accommodates a fault block undergoing rotational motion?

- W) Thrust
- X) Dip-slip
- Y) Oblique
- Z) Listric

ANSWER: Z) Listric

### BONUS

4) Earth and Space - *Short Answer* Identify all of the following four properties that are expected to increase as a river gradient decreases: 1) Sinuosity; 2) Discharge; 3) Channel depth; 4) Turbulence.

ANSWER: 1, 2, and 3

## TOSS-UP

5) Biology - *Multiple Choice* In which of the following places would you most likely find inosine?

- W) Viral ssRNA
- X) rRNA
- Y) tRNA
- Z) snRNA

ANSWER: Y) tRNA

## BONUS

5) Biology - *Multiple Choice* Molybdenum is an important micronutrient in plants required for which of the following processes?

- W) Carbohydrate Translocation
- X) Nitrogen metabolism
- Y) Calvin cycle
- Z) Cellulose synthesis

ANSWER: X) Nitrogen metabolism

## TOSS-UP

6) Physics - *Short Answer* What term is used to describe the dependence of the state of a system on its history, is often associated with irreversible thermodynamic change and where dissipation is a common side effect?

ANSWER: Hysteresis

## BONUS

6) Physics - *Multiple Choice* Which of the following would not be expected to be produced following a charged sigma baryon decay?

- W) Baryons
- X) Charged meson
- Y) Neutral meson
- Z) Photon

ANSWER: Z) Photon

## TOSS-UP

7) X-Risk - *Short Answer* Which term, originating from the term in set theory for a set with only one member, is used to refer to an AI system that is able to exert total decision-making influence over the entire world?

ANSWER: Singleton

## BONUS

7) X-Risk - *Multiple Choice* The problem of understanding an AI system's world model when it exists in the world it is modeling is referred to by what name?

W) Solomonoff induction

X) Embedded agency

Y) Agent foundations

Z) Anti-induction

ANSWER: X) Embedded agency



### TOSS-UP

8) Math - *Short Answer* What is the 10th derivative of  $x$  times  $e^x$  at  $x = 0$ ?

ANSWER: 10

### BONUS

8) Math - *Short Answer* How many pairs of positive integers  $(a, b)$  [a comma b] satisfy  $a^2 - b^2 = 2023$ ?

ANSWER: 3

### TOSS-UP

9) Chemistry - *Multiple Choice* Which of the following organic compounds would react most rapidly with thiols?

W) Ethene

X) Formaldehyde

Y) 1,3 butadiene

Z) Methyl prop-2-enoate

ANSWER: X) Formaldehyde

### BONUS

9) Chemistry - *Short Answer* Identify all of the following three changes to a model for a conjugated hydrocarbon chain that would increase the theoretical wavelength of absorption: 1) Increasing the length of the chain; 2) Increasing the effective mass of an electron; 3) Increasing the density of electrons trapped in the chain.

ANSWER: 1 and 2

## TOSS-UP

10) Earth and Space - *Multiple Choice* Which of the following best describes why eyewall replacement cycles occur in a hurricane?

- W) Drier air in the outer bands provides less moisture
- X) Interruptions of the warm core by the strength of the eyewall
- Y) Outer rainbands remove angular momentum from the inner eyewall
- Z) Eddy formation in the eye

ANSWER: Y) Outer rainbands remove angular momentum from the inner eyewall

## BONUS

10) Earth and Space - *Multiple Choice* Which of the following properties of an active galactic nucleus is least likely to affect the broadening of observed absorption lines?

- W) Black hole mass
- X) Black hole spin
- Y) Gas energy state
- Z) Gas ionization rate

ANSWER: Z) Gas ionization rate

## TOSS-UP

11) Biology - *Multiple Choice* Which of the following is not an intermediate filament protein?

- W) Vimentin
- X) Keratin
- Y) Lamin
- Z) Elastin

ANSWER: Z) Elastin

## BONUS

11) Biology - *Multiple Choice* Which of the following vertebrates has an incomplete septum in its heart?

- W) Birds
- X) Alligators
- Y) Crocodiles
- Z) Snakes

ANSWER: Z) Snakes

## TOSS-UP

12) Physics - *Short Answer* What hypothetical type of neutrino is postulated to be the right-handed counterpart of ordinary neutrinos, and is a possible candidate for dark matter?

ANSWER: Sterile neutrinos

## BONUS

12) Physics - *Short Answer* In a spherical well of radius  $R$ , one can use the following wavefunction:  $\Psi(r) = Ae^{-\frac{irk}{5}}$  [psi of r equals A e to the quantity negative i r k over 5], where  $A$  is the normalization constant and  $k$  is the wavevector magnitude. Compute the value of  $A$  in terms of  $R$ .

ANSWER:  $\sqrt{\frac{3}{R^3}}$

## TOSS-UP

13) X-Risk - *Multiple Choice* Which of the following populations is most ideal for performing cluster sampling?

W) Homogenous population within clusters, heterogeneous population between clusters

X) Heterogeneous population within clusters, homogenous population between clusters

Y) Heterogeneous population within and between clusters

Z) Homogenous population within and between clusters

ANSWER: X) Heterogeneous population within clusters, homogenous population between clusters

## BONUS

13) X-Risk - *Short Answer* What term describes the problem in which a fixed limited set of resources must be allocated between competing choices that maximizes their expected gain, when each choice's properties are only partially known at the time of allocation and may become better understood as time passes or by allocating resources to the choice?

ANSWER: Multi-armed bandit problem

### TOSS-UP

14) Math - *Short Answer* How many subsets of a set  $S$  with all the perfect squares between 1 and 100 inclusive satisfy the property that the pair-wise addition of distinct elements in the subset is never divisible by 4?

ANSWER: 192

### BONUS

14) Math - *Short Answer* Right triangle  $ABC$  has legs of length 20 and 48. What is the inradius of triangle  $ABC$ ?

ANSWER: 8

### TOSS-UP

15) Chemistry - *Short Answer* In silicon-29 NMR, what compound is used as the standard to calibrate chemical shifts to zero parts per million?

ANSWER: Tetramethylsilane (ACCEPT: TMS)

### BONUS

15) Chemistry - *Short Answer* The energy of an electron trapped in a potential well analogous to a hydrogen-like atom scales linearly with what power of the atom's atomic number by Moseley's law?

ANSWER: 2



## TOSS-UP

16) Earth and Space - *Multiple Choice* A cut-off low generally develops from what atmospheric phenomenon?

- W) Post-tropical cyclone
- X) Atmospheric trough
- Y) Atmospheric ridge
- Z) Thermal advection

ANSWER: X) Atmospheric trough

## BONUS

16) Earth and Space - *Multiple Choice* Which of the following processes introduces tensional stresses at convergent boundaries?

- W) Slab rollback
- X) Subduction
- Y) Slab breakoff
- Z) Accretion

ANSWER: W) Slab rollback

## TOSS-UP

17) Biology - *Short Answer* What enzyme derived from the P1 bacteriophage carries out site-specific recombination events on Lox sequences?

ANSWER: Cre [KREE] recombinase

## BONUS

17) Biology - *Short Answer* What form of DNA is predominately found in regions of negative supercoiling?

ANSWER: Z form

## TOSS-UP

18) Physics - *Multiple Choice* According to Euler's equations, which of the following will occur when rotating a tennis racket about its second principal axis, in the absence of torques?

- W) The axis of rotation will precess
- X) Any perturbation to the rotation will grow
- Y) Any perturbation to the rotation will be suppressed
- Z) Any perturbation to the rotation will remain

ANSWER: X) Any perturbation to the rotation will grow

## BONUS

18) Physics - *Multiple Choice* Which of the following most accurately describes the position of the Fermi level in n-type semiconductors?

- W) Between the acceptor levels and the valence band
- X) Between the acceptor levels and the conduction band
- Y) Between the donor levels and the valence band
- Z) Between the donor levels and the conduction band

ANSWER: Z) Between the donor levels and the conduction band

## TOSS-UP

19) X-Risk - *Multiple Choice* One of the leading causes of death in the world right now is Malaria, which is caused by the apicomplexan Plasmodium Falciparum. Which of the following serves as the vector for this parasite?

- W) Aedes mosquitos
- X) Anopheles mosquitos
- Y) Ixodes ticks
- Z) Xenopsylla fleas

ANSWER: X) Anopheles mosquitos

## BONUS

19) X-Risk - *Multiple Choice* What is considered the fundamental problem in inverse reinforcement learning?

- W) Observing enough behavior to create a reward function can be expensive
- X) Reward functions from IRL are not human-interpretable
- Y) IRL will be outperformed by RLHF except on sufficiently simple data
- Z) Observed behavior may be optimal in many different reward functions

ANSWER: Z) Observed behavior may be optimal in many different reward functions

### TOSS-UP

20) Math - *Multiple Choice* There exist unique one digit integers  $A$  and  $B$  such that the product of  $A$  and  $B$  has units digit  $A$ . Assuming  $A$  does not equal 0, which of the following is the only possible even value of  $B$ ?

W) 2

X) 4

Y) 6

Z) 8

ANSWER: Y) 6

### BONUS

20) Math - *Short Answer* On a  $5 \times 6$  grid of points, how many rectangles are there that have integer side lengths and all corners on gridpoints?

ANSWER: 150

### TOSS-UP

21) Chemistry - *Multiple Choice* The reaction of aryl [AIR-ul] diazonium [di-uh-ZOHN-ee-um] salts with cuprous halides follows which of the following types of reaction mechanisms?

W) Nucleophilic

X) Ionic

Y) Radical

Z) Pericyclic

ANSWER: Y) Radical

### BONUS

21) Chemistry - *Short Answer* Order the following three organic species by increasing frequency of the carbonyl [CAR-buh-nul] vibrational stretching mode: 1) Acylium cation; 2) Acetate anion; 3) Acetic acid.

ANSWER: 2, 3, 1

## TOSS-UP

22) Earth and Space - *Multiple Choice* The precession of the moon's orbit, tracked by the regression of its orbital nodes, has a period of approximately how many years?

W) 11 years

X) 19 years

Y) 27 years

Z) 35 years

ANSWER: X) 19 years

## BONUS

22) Earth and Space - *Short Answer* The specific intensity of an object that has the blackbody function as its source function will be proportional to what power of its distance if the line of sight is clear of obstruction?

ANSWER: 0

### TOSS-UP

23) Biology - *Short Answer* What isotope is commonly bound to glucose for detection by positron emission tomography?

ANSWER: Fluorine-18

### BONUS

23) Biology - *Multiple Choice* An enzyme is said to follow Michaelis-Menten kinetics if which of the following is true?

W)  $V_0$  is parabolically dependent on S

X)  $V_0$  is linearly dependent on S

Y)  $V_0$  is exponentially dependent on S

Z)  $V_0$  is hyperbolically dependent on S

ANSWER: Z)  $V_0$  is hyperbolically dependent on S



### TOSS-UP

24) Physics - *Multiple Choice* Which of the following is true of the Poynting vector inside a conductor in a magnetic field?

- W) It points radially inward
- X) It points radially outward
- Y) It points angularly
- Z) It is zero

ANSWER: Z) It is zero

### BONUS

24) Physics - *Multiple Choice* Assuming that the gyromagnetic ratio for fluorine-19 is equal to 40.05 megahertz per tesla, then in seconds, which of the following is closest to the length of a Larmor precession cycle for a fluorine atom in the presence of a 4 tesla magnetic field?

- W)  $10^{-7}$
- X)  $10^{-8}$
- Y)  $10^{-9}$
- Z)  $10^{-10}$

ANSWER: X)  $10^{-8}$