



## DOUBLE ELIMINATION 10

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### TOSS-UP

1) X-Risk - *Multiple Choice* Which of the following traits of a disease presents the most significant obstacle to eradication?

- W) Inaccurate vaccination records
- X) Asymptomatic transmission
- Y) Animal vectors
- Z) Animal reservoirs

ANSWER: Z) Animal reservoirs

### BONUS

1) X-Risk - *Multiple Choice* Data augmentation is sometimes used to artificially increase the size of data sets for a machine learning model. Which technique is not commonly used as data augmentation for an image recognition model?

- W) Adding noise to images
- X) Rotating images
- Y) Cropping images
- Z) Downscaling images

ANSWER: Z) Downscaling images

### TOSS-UP

2) Math - *Short Answer* Identify all of the following three algebraic combinations that are in an indeterminate form: 1)  $0/0$ , 2)  $0 \cdot \infty$ , 3)  $0^\infty$ .

ANSWER: 1 and 2

### BONUS

2) Math - *Short Answer* A triangle has side lengths 5, 12, and 13. Squares are constructed on each side of the triangle, and the endpoints of the squares are connected to form a convex hexagon. What is the area of this hexagon?

ANSWER: 458

### TOSS-UP

3) Chemistry - *Multiple Choice* Which of the following elements necessarily will have a magic number of one of its nucleons?

W) Beryllium

X) Carbon

Y) Oxygen

Z) Neon

ANSWER: Y) Oxygen

### BONUS

3) Chemistry - *Short Answer* Nathan mixes 50 milliliters of a 0.1 molar solution of hydrochloric acid with 50 milliliters of a 0.2 molar solution of sodium hydroxide. He measures the temperature change of the resulting reaction as  $T$ . In terms of  $T$ , what is the temperature change caused by the reaction when Nathan mixes 125 milliliters of a 0.1 molar solution of hydrochloric acid with 75 milliliters of a 0.2 molar solution of sodium hydroxide?

ANSWER:  $\frac{5}{4}T$  (ACCEPT:  $1.25T$ )

### TOSS-UP

4) Earth and Space - *Multiple Choice* Which of the following rocks has the lowest quartz concentration?

- W) Granite
- X) Diorite
- Y) Syenite
- Z) Quartzite

ANSWER: Y) Syenite

### BONUS

4) Earth and Space - *Short Answer* The formation of a tornado is preceded by the formation of what rotating column of vertical air within supercell thunderstorms?

ANSWER: Mesocyclone

### TOSS-UP

5) Biology - *Multiple Choice* Phosphofructokinase is inhibited by ATP in a non-competitive way. Based on this knowledge, how would ATP affect the  $V_{max}$  and  $K_m$  of phosphofructokinase, respectively?

W) Increase; unchanged

X) Unchanged; increase

Y) Decrease; unchanged

Z) Unchanged; decrease

ANSWER: Y) Decrease; unchanged

### BONUS

5) Biology - *Short Answer* Nicholas is crossing beavers of small and large brain sizes. Two genes control brain size, and a beaver only has a big brain if neither gene is recessive. Nicholas crosses a true breeding large brain beaver with a true breeding small brain beaver, then crosses their progeny together. What is the expected phenotypic ratio of the F<sub>2</sub> generation?

ANSWER: 9:7 (ACCEPT: 7:9)

### TOSS-UP

6) Physics - *Short Answer* Paramagnetic materials, such as oxygen, tend to align with applied magnetic fields and thus have a positive value of what dimensionless quantity that describes a material's ability to become magnetized?

ANSWER: Magnetic susceptibility

### BONUS

6) Physics - *Short Answer* Identify all of the following three materials that could be used to image excitons: 1) Photovoltaic cell; 2) High-temperature superconductor; 3) Helium superfluid.

ANSWER: 1 only

### TOSS-UP

7) X-Risk - *Multiple Choice* The pigeonhole principle makes which of the following types of cryptographic attacks possible?

- W) Birthday attack
- X) Frequency analysis
- Y) Length extension attack
- Z) Known plaintext attack

ANSWER: W) Birthday attack

### BONUS

7) X-Risk - *Multiple Choice* The technique of "passaging" a pathogenic virus through non-human cell cultures is used in manufacturing what type of vaccine?

- W) Attenuated vaccine
- X) Inactivated vaccine
- Y) Viral vector vaccine
- Z) Subunit vaccine

ANSWER: W) Attenuated vaccine



### TOSS-UP

8) Math - *Multiple Choice* Dan is playing a game in which he draws cards labeled between 1 and 100, inclusive. He is given ten draws and wins 5 for each card above 67 he draws. What type of probability distribution best describes Derek's game?

W) Normal

X) Geometric

Y) Hypergeometric

Z) Binomial

ANSWER: Y) Hypergeometric

### BONUS

8) Math - *Short Answer* What is the factorization of the cubic polynomial  $x^3 + 5x^2 - 2x - 24$ ?

ANSWER:  $(x - 2)(x + 3)(x + 4)$

### TOSS-UP

9) Chemistry - *Multiple Choice* Which of the following ligands has the strongest field effect?

W) Ammonia

X) Water

Y) Fluoride

Z) Cyanide

ANSWER: Z) Cyanide

### BONUS

9) Chemistry - *Short Answer* Order the following three ligands by increasing field strength: 1)  $\text{CN}^-$ ; 2)  $\text{F}^-$ ; 3)  $\text{NH}_3$ .

ANSWER: 2, 3, 1

## TOSS-UP

10) Earth and Space - *Multiple Choice* Which of the following describes the constraint on the Universe's mean energy density needed for flat geometry?

- W) Not related to critical density
- X) Less than critical density
- Y) Greater than critical density
- Z) Equal to critical density

ANSWER: Z) Equal to critical density

## BONUS

10) Earth and Space - *Short Answer* A special telescope of radius  $r$  can somehow collect photons at a rate of  $r^3$  within an annulus of inner radius 1 and outer radius 2. If a normal telescope with the same dimensions collects photons proportional to its area instead, what is the ratio of the numbers of photons collected from the special telescope to the normal telescope within the annulus?

ANSWER: 124/75

### TOSS-UP

11) Biology - *Short Answer* Parthenogenesis [par-the-no-JEN-uh-sis] is analogous to what process in plants?

ANSWER: Apomixis [ap-oh-MIX-is]

### BONUS

11) Biology - *Short Answer* Identify all of the following three systems that would be nonfunctional in a person possessing nonfunctional cilia: 1) Balance; 2) Cell migration; 3) Digestive.

ANSWER: All

### TOSS-UP

12) Physics - *Short Answer* Gases observing Bose-Einstein statistics can be cooled to a condensate in systems with many particles. What principle makes cooling a Fermi gas in such a system with hundreds of particles to near absolute zero impossible?

ANSWER: Pauli exclusion principle

### BONUS

12) Physics - *Short Answer* Near a black hole, the curvature of spacetime causes the shortest distance between two points to appear as an arc when translated to flat space. What is the name of this curve-apparent path?

ANSWER: Geodesic

### TOSS-UP

13) X-Risk - *Short Answer* Smallpox is the only human disease to have been eradicated. What is the only livestock disease to have been eradicated?

ANSWER: Rinderpest (ACCEPT: Cattle pest, Steppe murrain)

### BONUS

13) X-Risk - *Multiple Choice* Which of the following is NOT a task that language models are typically used for?

- W) Generating text
- X) Translating text from one language to another
- Y) Evaluating mathematical expressions
- Z) Summarizing long texts

ANSWER: Y) Evaluating mathematical expressions

### TOSS-UP

14) Math - *Short Answer* How many integers  $a$  from 1 to 50 have the property that the greatest common denominator of  $a$  and 50 is 5?

ANSWER: 4

### BONUS

14) Math - *Short Answer* How many expected rolls of a standard six-sided die are required to roll one followed by two if the die is rolled continuously until this is achieved?

ANSWER: 42

### TOSS-UP

15) Chemistry - *Short Answer* Identify all of the following three statements that are true of nucleophilic substitution reactions: 1)  $S_N2$  reactions occur in a single step; 2)  $S_N1$  reactions always lead to inversion of stereochemistry; 3)  $S_N2$  reactions are favored by polar protic solvents.

ANSWER: 1 only

### BONUS

15) Chemistry - *Multiple Choice* Which of the following gases is paramagnetic?

W)  $H_2$

X)  $O_2$

Y)  $N_2$

Z)  $F_2$

ANSWER: X)  $O_2$



### TOSS-UP

16) Earth and Space - *Multiple Choice* Which of the following sediment deposits would exhibit the least sorting?

- W) River delta
- X) Aeolian deposit
- Y) Turbidite
- Z) Glacial till

ANSWER: Z) Glacial till

### BONUS

16) Earth and Space - *Multiple Choice* Tsunami waves are shallow water waves, which means their wave speed is determined by which of the following values?

- W) Water column depth
- X) Wavelength
- Y) Wave height
- Z) Water density

ANSWER: W) Water column depth

### TOSS-UP

17) Biology - *Multiple Choice* Bacteria are protected against their own restriction enzymes via the addition of which of the following groups to their DNA?

- W) Acetyl
- X) Ubiquityl [yoo-BIK-wit-ul]
- Y) Methyl
- Z) Phosphate

ANSWER: Y) Methyl

### BONUS

17) Biology - *Multiple Choice* Which of the following structures does the telencephalon [tel-en-SEF-uh-lon] NOT develop into?

- W) Occipital [ock-SIP-uh-tul] lobe of cerebral cortex
- X) Basal nuclei
- Y) Basal ganglia
- Z) Epithalamus [ep-ee-THAL-uh-mis]

ANSWER: Z) Epithalamus

### TOSS-UP

18) Physics - *Short Answer* What is the ratio between the energy of the first-excited state and the third-excited state of a rigid rotor?

ANSWER:  $\frac{1}{6}$

### BONUS

18) Physics - *Short Answer* The positional wavefunction of a particle in a box of length  $L$  is given by  $\Psi(x) = Ae^{-3ix}$  [psi of x equals A e to the negative 3 i x]. Find the normalization factor  $A$  as a function of  $L$ .

ANSWER:  $\frac{\sqrt{L}}{L}$

### TOSS-UP

19) X-Risk - *Short Answer* In game theory, what is the term for a situation in which no participant in the game can benefit by changing their strategy on their own?

ANSWER: Nash equilibrium

### BONUS

19) X-Risk - *Multiple Choice* What type of ensemble meta-algorithm is used to reduce bias and variance in supervised learning, and is part of a family of machine learning algorithms that convert weak learners into strong ones?

- W) Boosting
- X) Bagging
- Y) Decision trees
- Z) Random forest

ANSWER: W) Boosting

### TOSS-UP

20) Math - *Short Answer* What probability distribution is used to model the number of times a certain event occurs within a fixed time interval?

ANSWER: Poisson distribution

### BONUS

20) Math - *Multiple Choice* Which of the following is closest to the area of a triangle with sides of length 10, 15, and 23?

W) 55

X) 65

Y) 75

Z) 85

ANSWER: W) 55

### TOSS-UP

21) Chemistry - *Multiple Choice* What two functional groups are formed in a saponification [suh-pon-uh-fic-AY-shin] reaction?

W) Alcohol and ether [EE-thur]

X) Ester and ether

Y) Alcohol and carboxylate [car-BOX-uh-late] salt

Z) Ester and carboxylate salt

ANSWER: Y) Alcohol and carboxylate salt

### BONUS

21) Chemistry - *Short Answer* Identify all of the following three statements that are true about the reaction of cyanide ions with (S)-2-bromo-pentane: 1) Cyanide acts as a base; 2) The reaction forms (R)-2-cyano-pentane; 3) The reaction would be faster if (S)-2-iodopentane was used instead of (S)-2-bromopentane

ANSWER: 2 and 3

### TOSS-UP

22) Earth and Space - *Multiple Choice* A reverting time evolution of the Universe would require which of the following physical constraints?

- W) High matter density capacity
- X) Low matter density capacity
- Y) High dark energy proportion
- Z) Low dark energy proportion

ANSWER: X) Lower density limit

### BONUS

22) Earth and Space - *Short Answer* Star A and Star B are eclipsing binaries that are separated by 10 AU, and have an orbital period of 10 years. If the mass of star A is three solar masses, what is the mass of star B, in solar masses?

ANSWER: 7

### TOSS-UP

23) Biology - *Short Answer* Whether a muscle is fast or slow twitch is determined by the activity of an ATP hydrolysing enzyme. This ATP is attached to what molecule?

ANSWER: Myosin

### BONUS

23) Biology - *Multiple Choice* If B type blood is given to a man, his blood will agglutinate and he will die. Which of the following types of blood types is he?

W) AB+

X) AB-

Y) A+

Z) B-

ANSWER: Y) A+



### TOSS-UP

24) Physics - *Short Answer* What principle states that in the limit of large quantum numbers, quantum physics becomes equivalent to classical physics?

ANSWER: Correspondence principle

### BONUS

24) Physics - *Multiple Choice* Which of the following reasons best explains why the phenomena of flux pinning can occur in Type II superconductors while not in Type I?

W) Type I superconductors have non-zero magnetic field penetration depth

X) Type I superconductors have no metallic impurities

Y) Type II superconductors have non-zero magnetic field penetration depth

Z) Type II superconductors have no metallic impurities

ANSWER: X) Type I superconductors have no metallic impurities