

DOUBLE ELIMINATION 8

TOSS-UP

1) Longtermism - *Multiple Choice* Which of the following types of climate model uses the Navier-Stokes equations to model the effects of thermodynamic changes on the atmosphere and ocean?

- W) General circulation model
- X) Radiative-convective model
- Y) Modular EMIC model
- Z) Zonal equilibrium model

ANSWER: W) General circulation model

BONUS

1) Longtermism - *Short Answer* Many GCMs save computational time by using spectral modeling rather than grid modeling. In spectral modeling, which equation is used to decompose the variation of temperatures into spectra for analysis?

ANSWER: Fourier transform

TOSS-UP

2) Math - *Short Answer* If $x^2 + \frac{1}{x^2} = 23$, what are the possible values of $x + \frac{1}{x}$?

ANSWER: ± 5 [plus or minus five] (DO NOT ACCEPT: 5)

BONUS

2) Math - *Short Answer* What term describes the situation in which the residuals of a linear model are non-constant across the independent variable?

ANSWER: Heteroscedastic [HEH-der-oh-ske-DAS-dik]

TOSS-UP

3) Chemistry - *Short Answer* Order the following 3 d-orbitals in order of increasing splitting in a linear complex, assuming that the ligands coordinate along the z-axis: 1) dz^2 ; 2) dxy ; 3) dxz .

ANSWER: 2, 3, 1

BONUS

3) Chemistry - *Multiple Choice* Which of the following is a possible equation for a nodal surface of the highest energy d orbital in the complex $NiCl_4^{2-}$, in accordance with the conventional axis labeling of three dimensional space?

W) $x = 0$

X) $y = 0$

Y) $x + y = 0$

Z) $x^2 = 1$

ANSWER: Y) $x + y = 0$

TOSS-UP

4) Earth and Space - *Multiple Choice* Which of the following best explains why siliceous [suh-LIH-shis] ooze is dominant at the equator and rare in most other regions?

- W) Rainfall from the ITCZ decreases salinity
- X) The equator has more sunlight for photosynthesis
- Y) Equatorial water is warmer than other regions
- Z) Equatorial upwelling provides more nutrients

ANSWER: Z) Equatorial upwelling provides more nutrients

BONUS

4) Earth and Space - *Multiple Choice* Which of the following types of volcanoes would most likely form layers of hyaloclastite [HIGH-low-CLASS-tite]?

- W) Subglacial
- X) Phreatomagmatic [free-A-duh-mag-MA-dik]
- Y) Fissure vent
- Z) Stratovolcano

ANSWER: W) Subglacial

TOSS-UP

5) Biology - *Multiple Choice* Which of the following is the shape of the amplicon [AM-plih-kon] production curve in a typical RT-PCR experiment once processed by software?

- W) Linear
- X) Exponential
- Y) Quadratic
- Z) Sigmoidal

ANSWER: Z) Sigmoidal

BONUS

5) Biology - *Short Answer* The eye color of Greek gods is controlled by multiple genes with polygenic inheritance, with the two most extreme phenotypes being red and blue. If there are 15 distinct eye color phenotypes, determine both the number of genes controlling eye color and the proportion of F2 offspring that would display either extreme phenotype in a cross between an individual with red eyes and an individual with blue eyes.

ANSWER: 5; $\frac{1}{512}$

TOSS-UP

6) Physics - *Short Answer* What method in quantum physics is used to determine an upper bound for the ground state wavefunction energy by evaluating the expectation value of the Hamiltonian of a trial wavefunction?

ANSWER: Variational principle

BONUS

6) Physics - *Short Answer* Identify all of the following three actions that would NOT affect the capacitance of a single hollow spherical conductor: 1) Inserting a spherical dielectric inside; 2) Making it a solid conductor; 3) Increasing its radius.

ANSWER: 1 and 2

TOSS-UP

7) Longtermism - *Short Answer* In 2015, researchers engineered a gene drive into mosquitoes to shift the sex ratios of offspring, in the hopes of controlling mosquito population. The gene they added codes for which type of enzyme, which is intended to hydrolyze DNA at particular locations?

ANSWER: Homing endonuclease

BONUS

7) Longtermism - *Short Answer* Due to the multiple diseases they spread, gene drive research on mosquito population control has been targeted at which species, known for being the primary vector for the Zika virus?

ANSWER: Aedes aegypti [AY-dees ee-JIP-tie]

TOSS-UP

8) Math - *Short Answer* What is the coefficient on the x^6 term in the Maclaurin [mik-LER-in] series expansion of the function $f(x) = \cosh x$ [f of x equals the hyperbolic cosine of x]?

ANSWER: 1/720

BONUS

8) Math - *Multiple Choice* Which of the of the following is NOT true about the chi [kai]-square goodness-of-fit test?

- W) It may be used for individual or grouped data
- X) It can be used for both continuous and discrete fits
- Y) The critical value is dependent on the sample size
- Z) Higher weight is placed on intervals with low fitted probability

ANSWER: Y) The critical value is dependent on the sample size

TOSS-UP

9) Chemistry - *Short Answer* Identify all of the following three molecules that typically undergo the Cannizzaro [CAN-ih-ZAR-oh] reaction: 1) Benzaldehyde [ben-ZAL-duh-hide]; 2) Acetaldehyde [A-sih-TAL-duh-hide]; 3) Acetone.

ANSWER: 1 only

BONUS

9) Chemistry - *Short Answer* To two significant figures, what is the ratio of the frequency of a carbon-protium [PRO-dee-um] bond stretch to the frequency of a carbon-deuterium [doo-TEER-ee-um] bond stretch?

ANSWER: 1.4

TOSS-UP

10) Earth and Space - *Short Answer* In the 1990s, a group of researchers set out to use gravitational microlensing to detect what class of dark, massive objects that may explain the apparent presence of dark matter in galactic halos?

ANSWER: Massive compact halo objects (ACCEPT: MACHOs)

BONUS

10) Earth and Space - *Short Answer* Order the following three features surrounding a Kerr black hole from innermost to outermost: 1) Innermost stable circular orbit; 2) Corotating photon sphere; 3) Counterrotating photon sphere.

ANSWER: 2, 3, 1

TOSS-UP

11) Biology - *Short Answer* In the synthesis of thyroid hormones, iodine trapped in the colloid of the thyroid is incorporated onto what amino acid residue on thyroglobulin [THIGH-ruh-GLOB-yew-lin]?

ANSWER: Tyrosine

BONUS

11) Biology - *Short Answer* TALEN and CRISPR are two different technologies that can be used for genome editing. Identify all of the following three statements which are true regarding advantages that CRISPR has over TALEN: 1) CRISPR is more sensitive to methylated [METH-ih-lay-did] DNA than TALEN; 2) CRISPR relies on protein-DNA interactions, while TALEN relies on RNA-DNA interactions; 3) CRISPR is cheaper and less time consuming than TALEN.

ANSWER: 3 only

TOSS-UP

12) Physics - *Multiple Choice* Let $V(r)$ denote the electric potential at a distance r away from a charge distribution that forms an ideal electric quadrupole. For what value of n is $V(r)$ proportional to r^n ?

- W) 1
- X) -1
- Y) -3
- Z) -5

ANSWER: Y) -3

BONUS

12) Physics - *Short Answer* Identify all of the following three statements that are true about protons: 1) The Δ^+ [delta plus] baryon is a high mass excitation of the proton; 2) The Georgi-Glashow model predicts the decay of a proton into a positron and a neutral pion; 3) A proton's spin is equal to the net spin of its quarks.

ANSWER: 1 and 2

TOSS-UP

13) Longtermism - *Short Answer* One consequentialist moral philosophy asserts that happiness and suffering both matter, and can typically counterbalance each other, but that there exists a level of suffering which no happiness can outweigh. What is this philosophy called?

ANSWER: Lexical-threshold negative utilitarianism

BONUS

13) Longtermism - *Multiple Choice* In which of the following cases does lexical-threshold negative utilitarianism disagree with most other types of negative utilitarianism?

- W) Benevolent world exploder
- X) Happy sadists problem
- Y) Torture vs. dust specks
- Z) Utility monster

ANSWER: Y) Torture vs. dust specks

TOSS-UP

14) Math - *Short Answer* Identify all of the following three distributions that are memoryless: 1) Exponential; 2) Gaussian; 3) Geometric.

ANSWER: 1 and 3

BONUS

14) Math - *Short Answer* What adjective is defined to describe a linear operator T which satisfies $T^{-1} = T^\dagger$ [inverse of T equals T adjoint]?

ANSWER: Unitary

TOSS-UP

15) Chemistry - *Multiple Choice* During azo-coupling, which of the following orbitals on the diazonium [die-uh-ZOH-nee-um] salt acts as the electron acceptor?

- W) Carbon-nitrogen sigma star orbital
- X) Nitrogen-nitrogen pi star orbital
- Y) Carbon-carbon sigma star orbital
- Z) Carbon-nitrogen pi star orbital

ANSWER: X) Nitrogen nitrogen pi star orbital

BONUS

15) Chemistry - *Short Answer* The 2016 Nobel Prize was awarded jointly to Fraser Stoddart, who designed a series of molecular motors. These motors were interlocked macromolecules with a characteristic “thread and ring” structure, typically known as what kind of molecule?

ANSWER: Rotaxanes [roh-TAX-anes]

TOSS-UP

16) Earth and Space - *Multiple Choice* In 2021, Bekaert [BAY-kurt] et al. discovered the presence of a horizontal movement of magma beneath Panama due to spreading from the Galápagos plume. Which of the following best describes the geochemical signature of this magma?

- W) Enriched in all incompatible elements
- X) Depleted of most incompatible elements
- Y) Enriched in some incompatible elements
- Z) Depleted of some incompatible elements

ANSWER: W) Enriched in all incompatible elements

BONUS

16) Earth and Space - *Multiple Choice* When plotted on an AFM ternary diagram, a certain magma first moves from the M towards the F, then finally towards the A as it cools. Which of the following statements about this magma is true?

- W) It is part of the calc-alkaline series
- X) It crystallizes iron-rich minerals first
- Y) It likely formed at a mid-ocean ridge
- Z) It is relatively oxidized

ANSWER: Y) It likely formed at a mid-ocean ridge

TOSS-UP

17) Biology - *Multiple Choice* With overdominance, highest mean fitness occurs in which of the following situations?

- W) All alleles are dominant
- X) Allele proportions are no longer changing
- Y) All alleles are at equal frequency
- Z) Allele proportions are maximally changing

ANSWER: Y) All alleles are at equal frequency

BONUS

17) Biology - *Short Answer* What enzyme used in pyrosequencing catalyses the conversion of pyrophosphate to ATP, which is later used as a substrate for luciferase [loo-SIH-fer-ace]?

ANSWER: ATP Sulfurylase (ACCEPT: Suflurylase, Sulfate adenylyltransferase)

TOSS-UP

18) Physics - *Multiple Choice* Which of the following mechanisms of Higgs boson production is the dominant contributor at the LHC, since it is about 10 times as likely to occur compared to other processes?

- W) Gluon fusion
- X) Higgs-strahlung [STRAH-lung]
- Y) Vector boson fusion
- Z) Top fusion

ANSWER: W) Gluon Fusion

BONUS

18) Physics - *Multiple Choice* Two small balls of negligible radius fall from a height H , one on top of the other. The upper sphere has a mass of $M/2$ where M is the mass of the lower sphere. Assuming only elastic collisions, in terms of H , what is the maximum height the upper sphere can reach?

- W) H
- X) $\frac{5}{3}H$
- Y) $\frac{25}{9}H$
- Z) $\frac{125}{27}H$

ANSWER: Y) $\frac{25}{9}H$

TOSS-UP

19) Longtermism - *Short Answer* Carnegie Mellon's SUR project on speech recognition was cancelled in the 1970s, during the first AI winter. Which technology, pioneered by SUR, involved modeling an unobservable process as a probabilistic sequence of states and transitions by observing a related process?

ANSWER: Hidden Markov modeling

BONUS

19) Longtermism - *Short Answer* A hidden Markov model relies on which algebraic formalism of probability, also used in Kalman filtering?

ANSWER: Bayesian [bay-EE-zhin] programming

TOSS-UP

20) Math - *Short Answer* The solution to the Schrodinger equation for a particle in the one-dimensional infinite square potential well with any initial condition can always be written as the superposition of the eigenfunctions of the Hamiltonian operator. This is an example of the application of what theorem from linear algebra?

ANSWER: Spectral theorem

BONUS

20) Math - *Short Answer* Identify all of the following three vector fields that are conservative in R^2 space, 1) $F = [1, 1]$, 2) $F = [-y, -x]$, 3) $F = [(e^{-x}) \cos y, (e^{-x}) \sin y]$.

ANSWER: All

TOSS-UP

21) Chemistry - *Multiple Choice* Alkali metal azides play an important role in the synthesis of inorganic chemical compounds. Which of the following are the major metal-containing products of the thermal decomposition of lithium azide and sodium azide respectively?

- W) Lithium and sodium
- X) Lithium and sodium nitride
- Y) Lithium nitride and sodium
- Z) Lithium nitride and sodium nitride

ANSWER: Y) Lithium nitride and sodium

BONUS

21) Chemistry - *Multiple Choice* Which of the following choices best describes the tacticity of a polymer that has alternating stereochemistry in its monomers?

- W) Atactic [ay-TAK-tik]
- X) Isotactic
- Y) Syndiotactic [SIN-dee-uh-TAK-tik]
- Z) Heterotactic

ANSWER: Y) Syndiotactic

TOSS-UP

22) Earth and Space - *Short Answer* The Ostriker-Vishniac [AW-striker VISH-nee-ak] effect can be described by what phenomena observed by the different measurements of the cosmic microwave background in different directions?

ANSWER: Anisotropy [an-EYE-suh-tro-pee]

BONUS

22) Earth and Space - *Short Answer* Electron degeneracy pressure in white dwarves can satisfy the Lane-Emden equation and take the form of $k\rho^x$ [k rho to the x], where k and x are constants and ρ is the density. An electron gas pressure that can be modeled as such has what unique name?

ANSWER: Polytrope

TOSS-UP

23) Biology - *Multiple Choice* Which of the following enzymes catalyses the rate limiting step of the Urea cycle?

W) Ornithine transcarbamylase [OR-nih-theen trans-CAR-buh-MIH-lace]

X) Carbamoyl-phosphate synthetase

Y) Arginosuccinate lyase [AR-jih-nuh-SUCK-sih-nate LIE-ace]

Z) Arginase

ANSWER: X) Carbamoyl-Phosphate Synthetase

BONUS

23) Biology - *Short Answer* Identify all of the following three statements that are true about the dorsal column medial lemniscus [lem-NIS-kus] pathway: 1) It is an ascending pathway that mediates pressure, pain, and temperature; 2) The primary sensory afferent crosses the midline before synapsing on the second order neuron; 3) The second order neuron synapses on the third order neuron in the thalamus.

ANSWER: 3 only

TOSS-UP

24) Physics - *Short Answer* Two particles that obey Fermi-Dirac statistics make up a system where particle A is spin-up and particle B is spin-down. If there are only two possible energy states for both particles, what is the total number of distinct accessible states for this system?

ANSWER: 4

BONUS

24) Physics - *Multiple Choice* For a given one dimensional potential of the form $V(x) = -A \cdot f(x)$, the number of bound state solutions to the Schrodinger equation increases with the value of A . As A approaches zero, there is one bound state solution, and past some value of A , the number of bound state solutions remains constant. Which of the following best describes the form of the function $f(x)$?

W) f is a polynomial

X) f is a step function

Y) f is a single delta function

Z) f is the sum of delta functions centered at multiple x values

ANSWER: Z) f is the sum of delta functions centered at multiple x values