Double Elimination 5

TOSS-UP

1) Biology – *Multiple Choice* Giant tubeworms lack a mouth, gut, and anus. They receive their nutrition entirely through symbiotic bacteria located in what specialized organ?
W) Trophosome
X) Nodules
Y) Lophophore
Z) Hydrogenosome
ANSWER: W) Trophosome

BONUS

1) Biology – *Multiple Choice* Which of the following is FALSE about sphingolipids?
W) Ceramides are composed of sphingosine and a fatty acid joined by an ester bond
X) Cerebrosides are ceramides with a glucose or galactose at the 1-hydroxy position
Y) Sphingomyelins are ceramides with a phosphocholine or phosphoethanolamine at the 1-hydroxy position
Z) Gangliosides are composed of a ceramide and three or more sugars, one of which must be sialic acid
ANSWER: W) Ceramides are composed of sphingosine and a fatty acid joined by an ester bond

TOSS-UP

2) Energy (ML Triv) – *Short Answer* Noah is using machine learning to segment 3D scans of prostates. What machine learning architecture, developed for image segmentation, consists of a contracting path of convolutional blocks followed by an expansive pathway of up-convolutions?

ANSWER: U-Net

BONUS

2) Energy (ML Triv) – *Multiple Choice* Which of the following is NOT true about Support Vector Machines?

W) Support Vector Machines can be reduced to a cubic optimization problem
X) The Kernel Trick allows for mapping to a higher dimensional space
Y) Support Vector Machines use the method of Lagrange Multipliers for optimization
Z) The L1 norm soft margin sum is a method of regularization for Support Vector Machines

ANSWER: W) Support Vector Machines can be reduced to a cubic optimization problem

TOSS-UP

3) Earth and Space – *Multiple Choice* Which of the following conditions is most directly associated with siliceous ooze formation?
W) Low surface temperatures
X) Net downwelling
Y) High surface temperatures
Z) Net upwelling
ANSWER: Z) Net upwelling

BONUS

3) Earth and Space – *Multiple Choice* Which of the following best describes how an increase in the water content of a subducting slab will affect the occurrence of earthquakes and magma formation in the subduction zone, respectively?
W) Decreased earthquakes, decreased magma formation
X) Decreased earthquakes, increased magma formation
Y) Increased earthquakes, decreased magma formation
Z) Increased earthquakes, increased magma formation
ANSWER: Z) Increased earthquakes, increased magma formation

TOSS-UP

4) Physics (Thermo/EM) – *Short Answer* Which of the following will decrease magnetization of a sample? 1) Increasing magnetic field 2) Decreasing magnetic field 3) Increasing Temperature 4) Decreasing Temperature
ANSWER: 2 and 3

BONUS

4) Physics (EM) – *Short Answer* Call the time derivative of current the "torrent." Consider a hypothetical circuit component called a "Danny" such that the energy stored by a danny is equal to a constant α [alpha] multiplied by the torrent squared. If a circuit is made by connecting a danny and an inductor with inductance L in series, and some small current is added to the circuit, what is the angular frequency of oscillation of the current in terms of L and alpha?
ANSWER: $\sqrt{\frac{L}{2\alpha}}$ (or mathematically equivalent forms)

TOSS-UP

5) Math – *Short Answer* What is the term for a function whose laplacian is zero everywhere it is defined?

ANSWER: Harmonic

BONUS

5) Math – *Short Answer* How many ways are there to assign nonnegative integer values to the variables in the equation x + y + z = 12 such that x,y,z are all less than or equal to 9?

ANSWER: 73

TOSS-UP

6) Chemistry – *Short Answer* When a diazoketone is heated, what reaction occurs, and what molecule is expelled?

ANSWER: Wolff Rearrangement, nitrogen gas

BONUS

6) Chemistry – *Long Bonus* Answer the following two questions about organometallic reactions:

1. What is the name of the reaction that occurs between iodobenzene and ethenyl benzene in the presence of a catalytic amount of PdCl2?

2. What is the name of the mechanistic step when a Grignard reagent is formed from an alkyl bromide and magnesium metal?

ANSWER: 1) Heck Reaction, 2) oxidative addition

TOSS-UP

7) Physics (Modern) – *Short Answer* In the debye model, frequency is defined as the wave speed multiplied by what quantity?

ANSWER: The wave vector

BONUS

7) Physics (Optics) – *Short Answer* A light ray parallel to the y-axis hits a parabolic mirror defined by $y = \frac{x^2}{8}$ [the quantity x squared divided by 8] at x=8. What is the x-coordinate of the other point on the mirror the light ray will hit?

ANSWER: -2

TOSS-UP

8) Biology – *Multiple Choice* A man unable to rotate his eyes away from his nose has likely damaged which of the following cranial nerves?

W) Oculomotor
X) Optic
Y) Trigeminal
Z) Abducens

ANSWER: Z) Abducens

BONUS

8) Biology – *Multiple Choice* The Luna moth lacks a mouth and digestive system, giving it only 1 week to reproduce before it starves to death. Which of the following hormones would you expect to be produced in lower amounts in the Luna moth?

W) Juvenile hormones
X) Adipokinetic hormones
Y) Tachykinin-related peptides
Z) Steroid hormones

ANSWER: Y) Tachykinin-related peptides

TOSS-UP

9) Earth and Space – *Multiple Choice* Greenschist typically forms from which of the following parent rocks?
W) Sandstone
X) Shale
Y) Granite
Z) Basalt
ANSWER: Z) Basalt

BONUS

9) Earth and Space – *Multiple Choice* During a strong warming event, which of the following best describes the anomalies in oxygen-18 concentrations in oceanic and glacial deposits, respectively?
W) Decreased, decreased
X) Decreased, increased
Y) Increased, decreased
Z) Increased, increased
ANSWER: X) Decreased, increased

TOSS-UP

10) Math – *Multiple Choice* Let f of x be equal to $x^2 \sin(\frac{1}{x})$[x squared times the sine of the quantity one over x] when x is nonzero and zero otherwise. Which of the following is TRUE of f of x at x=0?
W) F of x is NOT continuous and IS differentiable
X) F of x is NOT continuous and is NOT differentiable
Y) F of x IS continuous and IS differentiable
Z) F of x IS continuous and is NOT differentiable
ANSWER: Y

BONUS

10) Math – *Short Answer* What method is used to, when given a set of vectors spanning a space, find an orthonormal basis for that space?
ANSWER: Gram-Schmidt process

TOSS-UP

11) Chemistry – *Short Answer* What is the analogue of the Curie temperature for antiferromagnetism, above which a given material cannot be antiferromagnetic?

ANSWER: NÉEL TEMPERATURE or MAGNETIC ORDERING TEMPERATURE

BONUS

11) Chemistry – *Multiple Choice* McNair is performing an acid-base titration. He is adding dilute sodium hydroxide to an unknown amount of nitric acid. He was going to use methyl orange as his indicator, but found it contaminated with a significant amount of xylene cyanol. What color will the solution turn at the endpoint?

W) Orange
X) Yellow
Y) Green
Z) Purple

ANSWER: Y) Green

TOSS-UP

12) Earth and Space – *Multiple Choice* A spacecraft follows a circular orbit around the Sun until it suddenly boosts to double its velocity at Point A along its orbit. Which of the following best describes the new orbit of this spacecraft?

W) Elliptical with perihelion at Point A
X) Elliptical with aphelion at Point A
Y) Parabolic with vertex at Point A
Z) Hyperbolic with vertex at Point A

ANSWER: Z) Hyperbolic with vertex at Point A

BONUS

12) Earth and Space – *Short Answer* What line on the HR diagram indicates the point at which a given star will blow away the surrounding nebula and transition from a protostar to a visible pre-main sequence object?

ANSWER: Birthline

TOSS-UP

13) Physics (Mech) – *Multiple Choice* What is the moment of inertia of a uniform density annulus of mass m of outer radius R and central hole radius $\frac{R}{2}$ about its center of mass, in terms of R and m?
W) $(\frac{7}{16})mR^2$
X) $(\frac{1}{2})mR^2$
Y) $(\frac{17}{32})mR^2$
Z) $(\frac{5}{8})mR^2$
ANSWER: Z

BONUS

13) Physics (Thermo) – *Multiple Choice* Consider a spherical volume at constant statistical temperature T filled with particles, where each particle has an equal probability of being at any point in the sphere. In terms of T and boltzmann's constant k, what is the absolute difference in energy between a shell of particles 1 meter away and 2 meters away from the center of the volume?
ANSWER: kTln(4)

TOSS-UP

14) Math – *Multiple Choice* A uniform polyhedron is a polyhedron that has regular polygons as faces and each vertex is congruent to every other vertex. If a vertex of a uniform polyhedron touches three squares and one triangle, how many faces does the polyhedron have?
W) 24
X) 26
Y) 28
Z) 30
ANSWER: X) 26

BONUS

14) Math – *Multiple Choice* How many horizontal and vertical asymptotes are there of the fraction with a numerator of 2 times the absolute value of the product between the 2 polynomials $(x + 2)$ and $(x^2 + 5x + 4)$ and a denominator of the product between the 2 polynomials $(x + 1)$ and $(x^2 + 3x + 2)$?
W) 0 horizontal, 1 vertical
X) 1 horizontal, 1 vertical
Y) 2 horizontal, 1 vertical
Z) 2 horizontal, 2 vertical
ANSWER: Y) 2 horizontal, 1 vertical

TOSS-UP

15) Biology – *Multiple Choice* Which of the following is NOT an example of a six-carbon aldose?
W) Allose
X) Altrose
Y) Arabinose
Z) Talose
ANSWER: Y) Arabinose

BONUS

15) Biology – *Multiple Choice* In the context of CRISPR-Cas systems, which of the following is TRUE regarding the mechanism by which Cas9 recognizes and binds to its target sequence?
W) Cas9 initially binds to a PAM (read out letters) before unwinding the DNA
X) Cas9 relies on exonuclease activity to cleave its target sequence
Y) Cas9 cleaves the target DNA sequence exclusively at the PAM region
Z) Cas9 requires a guide RNA with a 3' poly-A tail to recognize its target
ANSWER: W) Cas9 initially binds to a PAM (read out letters) before unwinding the DNA

TOSS-UP

16) Energy (Misc) – *Multiple Choice* Which of the following is NOT an example of neuromorphic computing?
W) Designing circuits based on the Hodgkin-Huxley Model
X) Creating a specialized chip to train rat neurons through electrical stimulation
Y) Neural Networks that carry and transfer information through the leaky integrate and fire model
Z) Simulating a complete human brain in a supercomputer
ANSWER: X) Creating a specialized chip to train rat neurons through electrical stimulation

BONUS

16) Energy (Sci ESS) – *Multiple Choice* In N-body simulations, what structure is often used to divide structure into 3d cells?
W) Quadrupole
X) Octree
Y) Particle mesh
Z) Dipolar grid
ANSWER: X) Octree

TOSS-UP

17) Biology – *Multiple Choice* Which of the following best describes the molecular mechanism by which histone acetylation affects gene expression?
W) It promotes chromatin compaction, silencing gene expression
X) It recruits DNA methyltransferases to silence gene expression
Y) It neutralizes the positive charge of histones, facilitating gene expression
Z) It inhibits the binding of transcription factors by modifying DNA directly
ANSWER: Y) It neutralizes the positive charge of histones, facilitating gene expression

BONUS

17) Biology – *Multiple Choice* Which of the following statements about RNA interference (RNAi) is FALSE?
W) RNA-induced silencing complexes (RISC) degrade target mRNA sequences complementary to the guide strand
X) RNAi can regulate gene expression at both the transcriptional and post-transcriptional levels
Y) The guide strand of siRNA is loaded into the RISC for target recognition
Z) siRNA typically requires a double-stranded RNA substrate to initiate gene silencing
ANSWER: X) RNAi can regulate gene expression at both the transcriptional and post-transcriptional levels

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TOSS-UP

18) Chemistry – *Multiple Choice* Which of the following metals DOES NOT have a green flame test?
W) Tungsten
X) Niobium
Y) Tantalum
Z) Niobium
ANSWER: Y) Tantalum

BONUS

18) Chemistry – *Short Answer* Identify the symmetry point group of the staggered conformation of ferrocene.
ANSWER: D_{5d}

TOSS-UP

19) Chemistry – *Multiple Choice* Two identical samples of ideal gas, sample 1 and sample 2, both start at initial conditions P_0 and V_0 and T_0 in a chamber sealed with a moveable piston. Sample 1 is expanded reversibly and adiabatically to $2V_0$, and sample 2 was expanded reversibly and isothermally to $2V_0$. Which statement best describes the final conditions of the two samples?

W) Sample 1 has a higher temperature than sample 2, but sample 1 has a lower pressure than sample 2.

X) Sample 1 has a lower temperature than sample 2, but sample 1 has a higher pressure than sample 2.

Y) Sample 1 has both a lower temperature and a higher pressure than sample 2.

Z) Sample 1 has both a higher temperature and a higher pressure than sample 2.

ANSWER: Y) Sample 1 has both a lower temperature and a lower pressure than sample 2.

BONUS

19) Chemistry – *Short Answer* One mole of helium gas initially at 1 atm and 25 ° C is isothermally expanded from 2 liters to 5.44 liters. To the nearest tenth of a kilojoule, what is the difference between the maximum and minimum amounts of heat gained by the system?

ANSWER: 1.9 kJ

TOSS-UP

20) Math – *Short Answer* Which of the following are true about the laplace transform?

1. The laplace transform of a convolution is the product of the laplace transform of the functions being convolved

2. The laplace transform of any ordinary differential equation with constant coefficients is an algebraic equation

3. The Laplace transform of the dirac delta function is exponential in the s-space

ANSWER: 1 and 3

BONUS

20) Math – *Short Answer* Bonus - Math - Short Answer - Define a new 2D coordinate system such that $u = xy$ and $v = \frac{x}{y}$ [x over y]. In terms of u and v, what is $\frac{dxdy}{dudv}$ [the quantity dx times dy divided by the quantity du times dv]? Answer: $\frac{-1}{2v}$

TOSS-UP

21) Physics – *Multiple Choice* Tossup - Physics (EM) - Multiple Choice - A conducting spherical shell of radius 1 meter is placed at the origin, and a point charge of 2 nanocoulombs is placed at x=2. An electric field is applied such that it is always perpendicular to the line connecting the charge and the center of the shell. Which of the following best describes the motion of the charge?
W) Circular about the center of the shell
X) Circular about a point outside the shell
Y) Spiraling outward
Z) Spiraling inward
ANSWER: Y) Spiraling outward

BONUS

21) Physics – *Short Answer* What hybrid formulation of Lagrangian and Hamiltonian mechanics replaces some but not all generalized velocities with generalized momentums?
ANSWER: Routhian Mechanics

TOSS-UP

22) Earth and Space – *Multiple Choice* A star in which of the following branches of the HR diagram would likely have the largest degenerate helium core?
W) Main sequence
X) Red giant branch
Y) Horizontal branch
Z) Asymptotic giant branch
ANSWER: X) Red giant branch

BONUS

22) Earth and Space – *Multiple Choice* Which of the following best describes how gas moves within granules on the Sun's surface?
W) Up at the poleward side and down at the equatorial side
X) Up at the equatorial side and down at the poleward side
Y) Up at the center and down at the edges
Z) Up at the edges and down at the center
ANSWER: Y) Up at the center and down at the edges

TOSS-UP

23) Energy – *Multiple Choice* Which of the following are NOT true about the word-RAM model?
W) Word-RAM has infinite memory
X) Word-RAM does operations on words of finite length
Y) Word-RAM has O(1) time random-access indexing
Z) Word-RAM memory addresses can access all items in its memory
ANSWER: W) Word-RAM has infinite memory

BONUS

23) Energy – *Short Answer* What spin-glass Ising model is able to learn to model probability distributions using the Hebbian update rule?
ANSWER: Boltzmann Machine