Double Elimination 2

TOSS-UP

1) Physics (Mech) – *Multiple Choice* A toy submarine moves very slowly horizontally through a very large sealed fish tank with an incompressible fluid. The propeller of the submarine pushes a stream of the fluid with speed v. If the pressure of the fluid in the tank is P, which of the following describes the pressure in the stream?
W) Less than $P/2$
X) Less than P but greater than $P/2$
Y) Greater than P
Z) Equal to P
ANSWER: Z

BONUS

1) Physics (Thermo) – *Short Answer* As temperature approaches infinity what law states that the heat capacity at constant pressure and volume of solids approaches a constant value?
ANSWER: Dulong-petit Law

TOSS-UP

2) Earth and Space – *Multiple Choice* Which of the following minerals commonly has trace amounts of uranium and thorium, which helps it play an important role in radioactive dating?
W) Andalusite
X) Dolomite
Y) Zircon
Z) Aragonite
ANSWER: Y

BONUS

2) Earth and Space – *Short Answer* Order the following 3 metamorphic facies in order of increasing temperature of formation: 1) Granulite; 2) Blueschist; 3) Amphibolite
ANSWER: 2,3,1

TOSS-UP

3) Math – *Short Answer* What is the largest power of 3 that is a factor of $5^{243} - 2^{243}$?
W) 9
X) 81
Y) 243
Z) 729
ANSWER: Z) 729

BONUS

3) Math – *Short Answer* Identify all of the following 4 functions that the Mean Value Theorem does not apply to from the open interval -1 to 1.
1) $\tan^{-1}(x)$ [arctan of x]
2) $\tan(2x)$ [tangent of the quantity 2 times x]
3) $\frac{1}{\cos(x)}$ [1 over cosine of x]
4) $\cosh(x)$ [hyperbolic cotangent of x]
ANSWER: 2, 4

TOSS-UP

4) Chemistry – *Multiple Choice* Which of the following metal cations is an example of a soft acid?
W) Rubidium 1+
X) Mercury 2+
Y) Cerium 3+
Z) Thorium 4+
ANSWER: X

BONUS

4) Chemistry – *Give the systematic IUPAC name of the simplest alkene that can undergo a degenerate Cope arrangement.* **ANSWER:**

1,3,5-HEXATRIENE (or HEXATRI-1,3,5-ENE)

TOSS-UP

5) Biology – *Short Answer* Identify all of the following three phases of interphase that will not be present in cells undergoing cleavage in animal development: 1) G1, 2) S, 3) G2.
ANSWER: 1 and 3

BONUS

5) Biology – *Short Answer* Order the following four components of the ETC in order of increasing electronegativity: 1) cytochrome b, 2) FMN, 3) cytochrome a3, 4) ubiquinone
ANSWER: 2, 4, 1, 3

TOSS-UP

6) Energy (Misc) – *Short Answer* Identify all of the following four statements that are true of abstract and concrete types.
1) Abstract types can be instantiated directly
2) Concrete types can be instantiated directly
3) Interfaces are abstract types
4) Abstract classes can have methods
ANSWER: 2, 3,4

BONUS

6) Energy (ML Eng) – *Multiple Choice* Which of the following best describes the issue with the sigmoid activation function in machine learning?
W) Overfitting
X) Vanishing gradients
Y) Nonlinearity
Z) Death at negative values
ANSWER: X

TOSS-UP

7) Earth and Space – *Short Answer* By name or number, identify which of the following minerals have a sheet-like silicate structure: 1) Biotite, 2) Augite, 3) Microcline, 4) Talc.
ANSWER: 1, 4

BONUS

7) Earth and Space – *Multiple Choice* Large crystals of muscovite embedded in an igneous rock most likely cooled in what type of environment?
W) Quick cooling time, high temperatures
X) Quick cooling time, low temperatures
Y) Slow cooling time, high temperatures
Z) Slow cooling time, low temperatures
ANSWER: Z

TOSS-UP

8) Math – *Multiple Choice* Which of the following approximations will be the closest to the actual value of the area under the curve for the function f of x equals open parentheses x plus 1 close parentheses cubed from x = 0 to x = 1?
W) Right hand Riemann sum
X) Left hand Riemann sum
Y) Trapezoidal rule
Z) Simpson's rule
ANSWER: Z

BONUS

8) Math – *Short Answer* The number 12 factorial has 792 factors. How many odd factors are there in 12 factorial?
ANSWER: 72

TOSS-UP

9) Physics (EM) – *Multiple Choice* You hook up circuits A and B to an alternating voltage source. You then attach an audio amplifier of high input impedance in parallel to the circuits. Circuit A has a resistor in series with a capacitor, and Circuit B has a resistor in series with an inductor. Which of the following best describes the function of circuits A and B?
W) Circuit A is a low-pass filter and Circuit B is a high-pass filter
X) Circuit A is a high-pass filter and Circuit B is a band-pass filter
Y) Circuit A is a high-pass filter and Circuit B is a low-pass filter
Z) Circuit A is a band-pass filter and Circuit B is a high-pass filter
ANSWER: Y

BONUS

9) Physics (Thermo) – *Short Answer* Which of the following are natural variables of Gibbs Free Energy?
1) Pressure
2) Volume
3) Entropy
4) Temperature
ANSWER: 1 and 4

TOSS-UP

10) Chemistry – *Short Answer* What is the most common industrial process used to produce elemental nickel?

ANSWER: Mond Process

BONUS

10) Chemistry – *Short Answer* What is the only known transition metal to have zero valence s electrons in its ground state?

ANSWER: Palladium

TOSS-UP

11) Biology – *Short Answer* What enzyme in the eicosanoid pathway produces prostaglandins from arachidonic acid?

ANSWER: Cyclooxygenase, COX

BONUS

11) Biology – *Short Answer* In aerobic respiration, what is the primary function of cytochrome c in the electron transport chain?

W) Transfers electrons from Complex I to Complex III
X) Transfers electrons from Complex III to Complex IV
Y) Pumps protons into the mitochondrial matrix
Z) Generates ATP by directly phosphorylating ADP

ANSWER: X

TOSS-UP

12) Energy (ML Triv) – *Multiple Choice* Ryan wants to train a model to generate images based on some cool rocks he found. Which of the following types of models could best be used to do this?
W) Recurrent Neural Network
X) Variational Autoencoder
Y) Fully Connected Neural Network
Z) GRU [Read: G-R-U]
ANSWER: X) Variational Autoencoder

BONUS

12) Energy (Classical) – *Short Answer* Identify all of the following 3 tasks for which you could achieve a significant speedup using dynamic programming.
1) Sorting a list using mergesort
2) Finding the shortest path through a grid with weighted edges
3) Computing the best move in a checkers game
ANSWER: 2, 3

TOSS-UP

13) Math – *Short Answer* How many unique intersections are there between the diagonals of a convex pentagon assuming no 3 diagonals intersect at a single point?

ANSWER: 5

BONUS

13) Math – *Short Answer* Consider a sequence of positive numbers defined by the relation $16a_{n+1}^2 + 6a_n a_{n+1} - a_n^2 = 0$. If $a_0 = 1$, what is the sum from $n = 0$ to infinity of a_n?

ANSWER: 8/7

TOSS-UP

14) Earth and Space – *Multiple Choice* Which of the following techniques or relations cannot be used to determine the distance to a galaxy?

W) Tully-Fisher relation
X) Surface Brightness Fluctuations
Y) Faber-Jackson relation
Z) Titius-Bode Relation

ANSWER: Z) Titius-Bode relation

BONUS

14) Earth and Space – *Short Answer* The semi-major axis length of a planet's orbit is 2 AU. When it is 3 AU away from the star it is orbiting, it moves at speed v_0. What is its speed when it is at a distance of 0.8 AU away from the star?

ANSWER: $v_0 \cdot \sqrt{3}$

TOSS-UP

15) Chemistry – *Short Answer* What is the degree of unsaturation of a compound with molecular formula $C_6H_5N_3O$?

ANSWER: 6

BONUS

15) Chemistry – *Short Answer* Rank the following four carboxylic acid derivatives in order of increasing reactivity towards nucleophilic attack:

1) Thioester
2) Ester
3) Amide
4) Ketone

ANSWER: 3, 2, 1, 4

TOSS-UP

16) Physics (Modern) – *Short Answer* Which of the following terms best describes the distribution of conduction electrons in a metal?

W) Uniform
X) Exponential
Y) Logistic
Z) Normal

ANSWER: Y) Logistic

BONUS

16) Physics (Mechanics) – *Short Answer* Gojo Satoru, who has a mass of 25 kg, runs through Shibuya station at a velocity of 10 m/s. He hits idle transfigured humans of mass 5 kg with his hands on both sides, such that their bodies are sent in the direction Gojo is moving at a velocity of 7 m/s. There are 5 humans per meter along his path. What is the time constant, in seconds, of the exponential decay of Gojo's velocity?

ANSWER: $\frac{1}{14}$ seconds

TOSS-UP

17) Biology – *Multiple Choice* Which of the following best describes the Bohr effect in hemoglobin's oxygen affinity?
W) Hemoglobin's affinity for oxygen increases in lower pH
X) Hemoglobin's affinity for oxygen decreases in lower pH
Y) Hemoglobin's affinity for oxygen increases in higher pH
Z) Hemoglobin's affinity for oxygen decreases in higher pH
ANSWER: X) Hemoglobin's affinity for oxygen decreases in lower pH

BONUS

17) Biology – *Multiple Choice* In *Xenopus laevis* (African clawed frog) development, the gray crescent is essential for which of the following processes?
W) Axis formation and differentiation of dorsal structures
X) Establishing the left-right symmetry of the embryo
Y) Formation of the neural crest cells
Z) Induction of ventral structures
ANSWER: W) Axis formation and differentiation of dorsal structures

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TOSS-UP

18) Energy (Machine Learning) – *Multiple Choice* Which of the following best describes the purpose of regularization in machine learning models?
W) Reduces variance
X) Reduces bias
Y) Increases convergence speed
Z) Decreases convergence speed
ANSWER: W) Reduces variance

BONUS

18) Energy – *Short Answer* Spectral Embeddings allow for clustering of higher-dimensional data in a lower-dimensional space. Spectral Embeddings perform eigendecomposition on what quantity for a graph, defined as the difference between the diagonal and adjacency matrices?
ANSWER: Graph Laplacian (Accept: Laplacian)

TOSS-UP

19) Chemistry – *Short Answer* What is the name of the 3D cage analogue of crown ethers that often use nitrogen at branch points?

ANSWER: Cryptands

BONUS

19) Chemistry – *Short Answer* An enzyme-catalyzed reaction obeying Michaelis-Menten kinetics can proceed at a maximum speed of $10M/s$ and has a K_M of 5M. Find the slope of the line giving the rate of reaction on a Lineweaver-Burke plot.

ANSWER: 0.5

TOSS-UP

20) Earth and Space – *Short Answer* Order the following layers of an ophiolite complex from top to bottom:

1) Sheeted dikes
2) Peridotite
3) Pillow Lavas
4) Layered gabbro

ANSWER: 3, 1, 4, 2

BONUS

20) Earth and Space – *Multiple Choice* What is the name for the group of monoclinic ores of manganese with Mohs hardness between 5 and 6 that includes Romanechite?

W) Pyrolusite
X) Psilomelane
Y) Black Hematite
Z) Manganite

ANSWER: X) Psilomelane

TOSS-UP

21) Biology – *Multiple Choice* During beta-oxidation of fatty acids, what molecule is repeatedly cleaved off of the acyl chain to generate energy?
W) Acetyl-CoA
X) Pyruvate
Y) NADH
Z) $FADH_2$
ANSWER: W) Acetyl-CoA

BONUS

21) Biology – *Short Answer* During embryonic development, which germ layer gives rise to the nervous system?
ANSWER: Ectoderm

TOSS-UP

22) Math – *Short Answer* Rank the following three numbers from least to greatest:
1) Two to the power of thirty
2) Three to the power of twenty
3) Ten to the power of nine
ANSWER: 3, 1, 2

BONUS

22) Math – *Short Answer* Identify all of the following 6answer choices that are real proof methods:
1) Proof by Exhaustion
2) Proof by Construction
3) Probabilistic Proof
4) Mathematical Induction
5) Infinite Descent
6) Proof by Formality
ANSWER: 1,2,3,4,5

TOSS-UP

23) Physics (Optics) – *Short Answer* Point A is at the origin. Point B is at the point (3, 0). In between them is a rectangular slab with bottom left corner at (1, -1) and top left corner at (2, 1), and index of refraction 2. What is the optical path length traveled by a light ray going from point A to point B?

ANSWER: $1+2\sqrt{2}$

BONUS

23) Physics (Relativity) – *Short Answer* After committing numerous war crimes, William is being chased by an intergalactic police car, whose lights flash with frequency f in the car's frame. If the car is moving toward William at 0.8c, in terms of f, what does he observe the frequency of the flashing of the light to be?

ANSWER: 3f