Double Elimination 4

TOSS-UP

1) Physics – *Multiple Choice* Which of the following processes would cause the greatest magnitude of the change in Helmholtz free energy?
W) Isobaric expansion
X) Isobaric compression
Y) Adiabatic expansion
Z) Adiabatic compression
ANSWER: X

BONUS

1) Physics (Modern) – *Short Answer* What is the result when the kinetic energy operator is applied to the function f(x)=5xsin(x), in terms of the mass m and fundamental constants?
ANSWER: -$\frac{\hbar^2}{2m}(10\cos(x) - 5x\sin(x))$, accept h/2pi instead of hbar

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TOSS-UP

2) Biology – *Multiple Choice* Which of the following glial cells would most likely be defective in a person suffering from Guillain-Barre disease?
W) Microglia
X) Ependymal cells
Y) Oligodendrocytes
Z) Schwann cells
ANSWER: Z) Schwann cells [EH]

BONUS

2) Biology – *Short Answer* Edwin is measuring the vital capacity of his lungs. If he measures his functional reserve volume to be 2.5 liters, his inspiratory capacity to be 3 liters, and his reserve volume to be 1 liter, what is his vital capacity in liters?
ANSWER: 4.5 [EH]

TOSS-UP

3) Math – *Short Answer* Shreyas and Michael are playing a game where both of them roll a 6-sided dice. Whoever rolls the higher number is the winner. If they roll the same number, then they keep rolling until someone wins. What is the chance that Shreyas will win on his second roll?

ANSWER: 5/72

BONUS

3) Math – *Short Answer* Let $f(x)$ be equal to $x^3 + 2x^2 + 3x + 1$ [x cubed plus two x squared plus three x plus one]. What is the sum of the squares of the reciprocals of the roots of $f(x)$?

ANSWER: 5

TOSS-UP

4) Chemistry – *Short Answer* What equation in chromatography is used to determine the resolving power of a column?

ANSWER: VAN DEEMTER EQUATION

BONUS

4) Chemistry – *Short Answer* Identify the type of borane that is B_8H_{12}. [EM, DE 3]

ANSWER: NIDO-BORANE

TOSS-UP

5) Earth and Space – *Multiple Choice* Topaz would most likely form in which of the following environments?
W) Subduction zone
X) Glacier
Y) Aureole
Z) Geyser
ANSWER: Z) Geyser

BONUS

5) Earth and Space – *Multiple Choice* In which of the following tectonic settings would you expect to find flysch [flish]?
W) Mid Ocean Ridge
X) Back Arc Basin
Y) Accretionary Wedge
Z) Strike slip fault
ANSWER: Y) Accretionary Wedge

TOSS-UP

6) Energy (ML Triv) – *Multiple Choice* Which of the following models could be considered generative?
W) Support vector machine
X) Gaussian Discriminant Analysis
Y) Multilinear Regression
Z) K Nearest Neighbors
ANSWER: X) Gaussian Discriminant Analysis

BONUS

6) Energy – *Short Answer* Which of the following best describes the issue with self-attention?
W) It has issues maintaining long-sequence dependencies
X) It is hard to parallelize
Y) It has time complexity $O(n^2)$
Z) It has space complexity $O(n^2)$
ANSWER: Z

TOSS-UP

7) Biology – *Short Answer* Identify all of the following three muscle types that open Ca^{2+} ion channels in the plasma membrane during to start contraction: 1) Skeletal; 2) Smooth; 3) Cardiac.

ANSWER: 2 and 3 [EH]

BONUS

7) Biology – *Multiple Choice* McNair is performing ChIP-seq (chip seek) in his lab. Which of the following best describes why he is using this technique?

W) He wants to measure the relative amount of a certain protein
X) He wants to measure the relative amount of a certain mRNA transcript
Y) He wants to identify the genomic binding sites of a certain protein
Z) He wants to determine the exact sequence of nitrogenous bases in a certain gene

ANSWER: Y

TOSS-UP

8) Chemistry – *Multiple Choice* Superacids are acids with an acidity greater than 100% pure sulfuric acid. What scale, denoted by capital H naught, is used to compare the strength of superacids?

ANSWER: HAMMETT ACIDITY FUNCTION

BONUS

8) Chemistry – *Short Answer* Order the following four compounds by increasing positiveness in the triboelectric series.

1) Wood
2) Amber
3) Mica
4) Gold

ANSWER: 4,2,1,3

TOSS-UP

9) Earth and Space – *Multiple Choice* In which of the following volcano types would one likely find agglutinate?
W) Cryptodome
X) Submarine volcano
Y) Spatter cone
Z) Cinder cone
ANSWER: Y) Spatter cone

BONUS

9) Earth and Space – *Short Answer* Identify all of the following statements that are true of pegmatites: 1) They form from the solidification of anhydrous melt; 2) They are fine-grained igneous rocks; 3) They contain high amounts of corundum
ANSWER: 3 only

TOSS-UP

10) Math – *Multiple Choice* According to the prime number counting function, which of the following choices is closest to how many prime numbers there are below 10,000?
W) 800
X) 1000
Y) 2500
Z) 4000
ANSWER: X) 1000

BONUS

10) Math – *Short Answer* What is the summation of the series from $n = 1$ [n equals 1] to infinity of $\frac{2n}{3^n}$ [2 times n divided by 3 to the power of n]?
ANSWER: 3/2

TOSS-UP

11) Physics (EM) – *Multiple Choice* Which of the following types of functions could be used to define the voltage-current relationship in a typical diode?
W) Quadratic
X) Exponential
Y) Linear
Z) Logistic
ANSWER: X

BONUS

11) Physics (EM) – *Short Answer* Consider a special voltage source that oscillates sinusoidally with a linearly time-dependent frequency. This voltage source is connected in series to a resistor and an inductor. Identify all of the following four statements that are true about the current versus time graph.
1) Its amplitude is constant
2) It is symmetric about some time t
3) Its maximum value is dependent only on the resistance
4) Its maximum value is dependent only on the inductance
ANSWER: 3 only

TOSS-UP

12) Biology – *Multiple Choice* Which of the following phosphoester hydrolysis reactions release the most energy?
W) Hydrolysis of ATP to ADP
X) Hydrolysis of pyrophosphate to inorganic phosphate
Y) Hydrolysis of G6P to glucose
Z) Hydrolysis of Glyceraldehyde 3-phosphate to glyceraldehyde
ANSWER: W) HYDROLYSIS OF ATP TO ADP

BONUS

12) Biology – *Short Answer* Edwin is studying the infection mechanism of HIV. Identify all of the following three cells in which Edwin would not find a HIV provirus in its genome:
1) Cytotoxic T cell;
2) Helper T cell;
3) B cell.
ANSWER: 1 and 3 [EH]

TOSS-UP

13) Physics (Modern) – *Short Answer* What unit is commonly used to define the magnitude of the spin angular momentum of an electron?

ANSWER: Bohr magneton

BONUS

13) Physics (Mech) – *Short Answer* Compute the difference between the effective potential and the potential energy for a two-body system orbiting in a circular orbit of radius 100000 (one million) meters where both bodies have mass 3000 kg and move with velocity 5 m/s, in joules in scientific notation to 2 significant figures.

ANSWER: $7.5*10^4$

TOSS-UP

14) Energy (Sci ESS) – *Multiple Choice* Ocean General Circulation Models model physical and thermodynamical processes in oceans. One method in Ocean General Circulation Models uses a triangular grid. What is the name of this method?

W) Finite Element Grid
X) Finite Differences Grid
Y) Spectral Grid
Z) Neural Grid Answer: W) Finite Element Grid

ANSWER: X

BONUS

14) Energy – *Short Answer* Which of the following are true of hash functions? 1) No hash function is injective 2) There are no collision-resistant hash functions 3) Probing occurs during closed hashing 4) Probing occurs during open hashing

ANSWER: 1, 2, 3

TOSS-UP

15) Earth and Space – *Short Answer* Identify all of the following three spectral classes that typically show titanium oxide absorption lines: 1) O; 2) F; 3) M.

ANSWER: 3 only

BONUS

15) Earth and Space – *Short Answer* Order the following three boundaries in the outer solar system from innermost to outermost: 1) Bow shock; 2) Termination shock; 3) Heliopause.

ANSWER: 2, 3, 1

TOSS-UP

16) Chemistry – *Short Answer* Rank the following five compounds in terms of increasing acidity. Acetic acid Ammonia Trifluoroacetic acid [TFA] p-toluene sulfonic acid DBU

ANSWER: 5, 2, 1, 3, 4

BONUS

16) Chemistry – *Short Answer* Which of the following five characteristics of various analytical graphs would you expect to see in analysis of p-chlorobenzoic acid?

1) A cluster of signals in an H1 NMR spectra around 7 to 8 ppm
2) A duplet in an H1 NMR spectra around 3 ppm
3) An absorption at 100 ppm in a C13 NMR
4) A strong, sharp absorption at 2200 inverse cm in an IR spectra
5) A strong absorption at 1700 inverse cm in an IR spectra

ANSWER: 1 and 5

TOSS-UP

17) Math – *Short Answer* What is the smallest value of x that satisfies the mean value theorem for derivatives for the function $\sin(x) + \cos(x)$ [sine of x plus cosine of x] for the interval from 0 to 2π?

ANSWER: $\pi/4$

BONUS

17) Math – *Short Answer* How many subsets of the natural numbers from 1 to 12 with at least 2 elements have the property such that the sum of any 2 numbers in the subset is always even?

ANSWER: 114

TOSS-UP

18) Physics (Rel) – *Multiple Choice* Andrey is floating in space. In a desperation to alert home, he pulls out his trusty spherical light orb gun, and shoots an orb at a speed 0.6c towards earth. Which of the following best describes the shape of the light emitted from the orb according to an observer at rest?

W) Uniformly emitted in all directions
X) A uniform cylinder emitted against direction of travel
Y) A cone with vertex at the front of the orb emitted in direction of travel
Z) A cone with vertex at the back of the orb emitted against direction of travel

ANSWER: Y) A cone with vertex at the front of the orb emitted in direction of travel

BONUS

18) Physics (Thermo) – *Short Answer* A temperature field is defined as T=4 x^2 y+ 5y^3x+ 3xz in Kelvin. If the thermal diffusivity is 0.01 square meters per second, find the rate of change of the temperature at the point (3, 8, 8) to one significant figure.

ANSWER: 7 Kelvin/second

TOSS-UP

19) Chemistry – *Multiple Choice* What is the shape of the molecular cation H_3^+?
W) Linear
X) Bent
Y) Equilateral Triangle
Z) This ion does not exist
ANSWER: Y) Equilateral Triangle

BONUS

19) Chemistry – *Short Answer* In H_3^+, what is the average bond order between each hydrogen?
ANSWER: 1/3

TOSS-UP

20) Energy – *Short Answer* In semiconductor electronics, what scaling law states that as transistors get smaller, their power density stays relatively constant?
ANSWER: Dennard Scaling Law, MOSFET Scaling Law

BONUS

20) Energy (Sci Chem) – *Multiple Choice* Which of the following problems could NOT be well solved using Density Functional Theory?
W) Predicting parameters in Mossbauer Spectroscopy
X) Determining the sensitivity of nanostructures to pollutants
Y) Finding the pressure in a non-ideal gas
Z) Determining the effects of dopants on a semiconductor
ANSWER: Y) Finding the true pressure in a non-ideal gas

TOSS-UP

21) Biology – *Multiple Choice* Under which of the following metabolic conditions would a cell undergo only the oxidative phase of the pentose phosphate pathway, followed by gluconeogenesis?
W) Needs NADPH and needs Ribulose-5-phosphate
X) Needs NADPH and does not need Ribulose-5-phosphate
Y) Does not need NADPH and needs ribulose-5-phosphate
Z) Does not need NADPH and does not need Ribulose-5-phosphate
ANSWER: X) Needs NADPH and does not need Ribulose-5-phosphate

BONUS

21) Biology – *Short Answer* Identify all of the following three genes that are proto-oncogenes:
1) HER2;
2) APC;
3) BRCA1.
ANSWER: 1 only [EH]

TOSS-UP

22) Math – *Short Answer* If e^4 is approximately 54.6, which of the following is closest to e^2 multiplied by hyperbolic cosine of two?
W) 26
X) 27
Y) 28
Z) 29
ANSWER: Y) 28

BONUS

22) Math – *Short Answer* What is the order of 3 modulo 17?
ANSWER: 16

TOSS-UP

23) Earth and Space – *Short Answer* In contrast to the main rings of Jupiter which lie within the Roche lobe of the planet, the impact dust from inner Jovian moons Amalthea and Thebe form another ring of Jupiter known by what name?

ANSWER: Gossamer Rings

BONUS

23) Earth and Space – *Multiple Choice* Which of the following values is closest to the albedo of a typical comet?

W) 0.1
X) 0.3
Y) 0.7
Z) 0.9

ANSWER: W) 0.1