Round Robin 3

TOSS-UP

1) Biology – *Multiple Choice* Which class of immunoglobulin is primarily involved in mediating allergic reactions?
W) IgG
X) IgA
Y) IgM
Z) IgE
ANSWER: Z) IgE

BONUS

1) Biology – *Short Answer* What plant hormone promotes shoot growth from a plant callus?
ANSWER: Cytokinin(s)

TOSS-UP

2) Earth and Space – *Short Answer* What type of supernovae, also known as standard candles, are distinguishable from other supernovae by the presence of silicon in their spectral lines?
ANSWER: Type 1a

BONUS

2) Earth and Space – *Short Answer* Order the following 4 types of ice in terms of increasing air percentage. 1) Glacial Ice, 2) Snow, 3) Firn 4) Neve
ANSWER: 1, 3, 4, 2

TOSS-UP

3) Math – *Short Answer* What is the minimum number of colors required to color any planar graph?

ANSWER: 4

BONUS

3) Math – *Short Answer* A circle is inscribed in an equilateral triangle with side length 2. An equilateral triangle is inscribed in this circle. What is the area of the smaller equilateral triangle?

ANSWER: $\frac{\sqrt{3}}{4}$

TOSS-UP

4) Chemistry – *Short Answer* In a buffer solution, the concentration of fluoride anions is 1 molar, while the concentration of hydrofluoric acid is 0.1 molar. If the pKa of hydrofluoric acid is 3.17, what is the pOH of the buffer to two significant figures?

ANSWER: 9.8

BONUS

4) Chemistry – *Multiple Choice* Some chemists have theorized that cesium, rather than francium, is the element with the lowest ionization energy. This could be due to what phenomenon?

W) Lanthanide contraction
X) D orbital splitting
Y) Relativistic effects
Z) Inert pair effect

ANSWER: Y) Relativistic effects

TOSS-UP

5) Energy – *Short Answer* K-Means is an example of what type of machine learning model that learns patterns from data without being given explicit instruction or labels?

ANSWER: Unsupervised

BONUS

5) Energy – *Multiple Choice* You are working on a model with a dataset that has a small number of rows. Which of the following training patterns would be best for this?

W) Hold-out cross-validation
X) k-fold cross-validation
Y) 80-20 train-test split
Z) 80-10-10 train-test-validation split

ANSWER: X) k-fold cross-validation

TOSS-UP

6) Chemistry – *Short Answer* If a cyclic, planar molecule has 18 pi electrons, what rule states that it is considered aromatic?

ANSWER: Huckel's Rule

BONUS

6) Chemistry – *Short Answer* In the reaction between sulfuric acid and 3 liters of water [pause] to form hydrogen sulfate and hydronium, there are 2 mols of sulfuric acid [pause], 3 mols of hydrogen sulfate [pause], and 4 mols of hydronium in equilibrium. What is the concentration equilibrium constant for this reaction?

ANSWER: 0.5

TOSS-UP

7) Earth and Space – *Short Answer* What is the name given to small fragments of airborne molten material that solidify into tear-like droplets of glass?

ANSWER: Pele's Tears

BONUS

7) Earth and Space – *Short Answer* What is the term for a rift system that started to develop but did not evolve into a fully developed oceanic rift?

ANSWER: Aulacogen

TOSS-UP

8) Physics (Modern) – *Short Answer* What is the general term for an object with emissivity less than 1 but non-zero?

ANSWER: Graybody

BONUS

8) Physics (Mech) – *Short Answer* To the nearest integer, find the total energy in joules for a parabolic orbit with a focal length of 150 km and a latus rectum distance of 30,000 km.

ANSWER: 0

TOSS-UP

9) Energy – *Short Answer* William is using ChatGPT to do his homework. What machine learning model, utilizing multi-head attention, does the "T" in ChatGPT stand for?

ANSWER: Transformer

BONUS

9) Energy – *Short Answer* Chemistry researchers have recently started applying graph neural networks to chemical compounds. For which of the following four scenarios could graph neural networks be used well?

1) Generating compounds based on NMR spectra
2) Approximating macroscopic quantities for gases
3) Estimating environmental conditions based on a compounds concentration over time
4) Determining the stability of a crystal lattice

ANSWER: 1, 2, 4

TOSS-UP

10) Biology – *Short Answer* What type of bond is formed between the phosphate group of one nucleotide and the sugar of the next nucleotide in a DNA strand?

ANSWER: Phosphodiester bond

BONUS

10) Biology – *Multiple Choice* Venous return is aided most by which of the following?

W) Adipocytes
X) Skeletal muscle
Y) Gravity
Z) Capillary action

ANSWER: X

TOSS-UP

11) Math – *Short Answer* How many ways are there to arrange the word IRONCITY [read: I-R-O-N-C-I-T-Y]?

ANSWER: 20160

BONUS

11) Math – *Multiple Choice* What is the largest prime factor of $2^{12} - 1$?

W) 3
X) 7
Y) 11
Z) 13

ANSWER: Z) 13

TOSS-UP

12) Chemistry – *Multiple Choice* Eli has finally synthesized a microkid, and wants to know what functional groups are on it. What technique should he use?

W) NMR Spectroscopy
X) Infrared Spectroscopy
Y) Mass Spectrometry
Z) Column Chromatography

ANSWER: X) Infrared Spectroscopy

BONUS

12) Chemistry – *Short Answer* Identity all of the following three that are true of following are true of absorbance?

1) Absorbance is proportional to path length
2) In a first-order reaction, the absorbance vs time graph will be linear
3) Spectrophotometers determine the angle light is refracted through a cuvette

ANSWER: 1 only

TOSS-UP

13) Physics (EM) – *Short Answer* The electric field inside a nonconducting charged sphere of uniform charge density is proportional to what power of distance from its center?

ANSWER: 1

BONUS

13) Physics (Modern) – *Short Answer* Identify all of the following 3 quantities that are conserved in weak decays.

1) Baryon number
2) Charge
3) Strangeness

ANSWER: 1, 2

TOSS-UP

14) Biology – *Short Answer* The cortical reaction in mammals is triggered when a wave of what ion spreads throughout the egg cell?

ANSWER: Calcium (Accept: Ca2+)

BONUS

14) Biology – *Short Answer* Before crossing over can occur between chromosomes, homologous chromosomes must be attached to each other. What zipper-like structure forms in early prophase I to hold the homologs tightly together?

ANSWER: Synaptonemal complex

TOSS-UP

15) Physics (Optics) – *Multiple Choice* Which of the following is closest to Brewster's angle for light traveling from a vacuum to a medium with index of refraction 1.7?
W) 15 degrees
X) 30 degrees
Y) 45 degrees
Z) 60 degrees
ANSWER: X) 30 degrees

BONUS

15) Physics (Modern) – *Short Answer* The concept of a black hole is typically believed to have emerged from what set of equations?
ANSWER: Einstein's field equations

TOSS-UP

16) Earth and Space – *Short Answer* The Maunder Minimum is a time period that had a notable lack of what phenomena?
ANSWER: Sunspots

BONUS

16) Earth and Space – *Short Answer* Name all of the following 3 types of objects that are known causes of Gamma-Ray Bursts:
1) Magnetars
2) Neutron star mergers
3) Hypernovae
ANSWER: 1, 2, 3 or All of them

TOSS-UP

17) Energy – *Short Answer* One algorithm to play Go involves sampling many possible games after a move is played to determine how optimal that move is. This is an example of what general class of methods that use repeated random sampling to approximate values?

ANSWER: Monte Carlo methods

BONUS

17) Energy – *Multiple Choice* Which of the following describes the purpose of the BLAST algorithm in computational biology?

W) Identifying mutations in a DNA sequence
X) Removing repetitive sequences from a DNA database
Y) Converting a database of DNA sequences into a graph-based representation
Z) Finding matches between a DNA sequence and DNA sequences in a database

ANSWER: Z) Finding matches between a DNA sequence and DNA sequences in a database

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TOSS-UP

18) Math – *Short Answer* What is the coefficient of the x^3 term in the expansion of $(x+2)^4$?

ANSWER: 8

BONUS

18) Math – *Multiple Choice* Akhil and Greeshma are painting a house. Akhil and Greeshma alone would finish the house in 4 hours and 6 hours, respectively. If Greeshma works on the house for 2 hours, and then Akhil starts to help, then how much time would it take for the house to be fully painted, including the time Greeshma originally worked on the house?

W) 1 Hour, 36 Minutes
X) 3 Hours, 12 Minutes
Y) 3 Hours, 36 Minutes
Z) 4 Hours

ANSWER: Y) 3 Hours, 36 Minutes

TOSS-UP

19) Physics (Mech) – *Short Answer* The Earth is squeezed and trimmed such that its density is tripled and its radius is halved. Assuming the earth to be a uniform homogenous sphere of rock, what is the new acceleration due to gravity in meters per second squared to the nearest integer?

ANSWER: 15

BONUS

19) Physics (Thermo) – *Short Answer* William and Adi have metal rods. William's rod has an initial temperature of 20 Kelvin, and a heat capacity of 9 Joules/Kelvin, while Adi's rod has an initial temperature of 30 Kelvin and a heat capacity of 4 Joules/Kelvin. When William and Adi touch their rods together, what is the temperature of the two-rod system after a long time, to the nearest Kelvin?

ANSWER: 23 Kelvin

TOSS-UP

20) Chemistry – *Short Answer* Order the following three molecules by increasing boiling points:

1) NH_3
2) Water
3) CH_4

ANSWER: 3, 1, 2

BONUS

20) Chemistry – *Multiple Choice* Which of the following are NOT included in the net ionic equation for the precipitation reaction between Copper (II) chloride and potassium sulfate?

W) Copper cation
X) Phosphate anion
Y) Potassium cation
Z) Copper (II) phosphate

ANSWER: Y) Potassium cation

TOSS-UP

21) Math – *Short Answer* What is the name of the conic with polar equation $r = \frac{1}{1-\cos\theta}$?
[READ: "r is equal to 1 over the quantity 1 minus cosine of theta"]
ANSWER: Parabola

BONUS

21) Math – *Short Answer* William, deciding to finally wash his clothes, accidentally drops his dirty laundry on the floor, which includes 5 shorts, 6 shirts, and 10 pairs of socks. Given that one pair of socks counts as one article of clothing, if William randomly picks up three articles of clothing, what is the chance that it makes a complete outfit of shorts, shirt, and socks?
ANSWER: 30/133

TOSS-UP

22) Earth and Space – *Multiple Choice* Which of the following types of silicates have the most complex 3D bonding structure?
W) Nesosilicates
X) Inosilicates
Y) Phyllosilicates
Z) Tectosilicates
ANSWER: Z) Tectosilicates

BONUS

22) Earth and Space – *Short Answer* McNair has been working out recently! William, however, doesn't believe him. To prove so, McNair pulverizes a boulder made of granite. When he does so, he finds a large quartz crystal inside, embedded within the boulder. What is the term for this large quartz crystal?
ANSWER: Phenocryst

TOSS-UP

23) Biology – *Multiple Choice* In which of the following parts of the human body would a sperm mature?
W) Seminiferous tubules
X) Epididymis
Y) Urethra
Z) Vas deferens
ANSWER: X) Epididymis

BONUS

23) Biology – *Short Answer* What specialized cells found in the tentacles of jellyfish contain stinging threads called nematocysts to penetrate and immobilize their prey?
ANSWER: Cnidocytes