1) Tossup - Biology - Short Answer - Identify all of the following three enzymes involved in DNA replication that are correctly matched to their functions: 1) Topoisomerase, relieve supercoiling; 2) Helicase, unwind DNA strands; 3) Single strand binding proteins, prevent re-annealing

ANSWER: All [AY]

1) Bonus - Biology - Short Answer - Keith loves looking at cross-sections of things. If he were to observe the cross-section of a eukaryotic flagellum, how many total microtubules would he be able to count?

ANSWER: 20 [AY]

2) Tossup – Chemistry – Multiple Choice – Which of the following species would have the greatest polarizing power?

W) Li^{+}

X) Na^{+}

Y) Be^{2+}

Z) Mg^{2+}

ANSWER: Y) Be^{2+} [AB]

2) Bonus – Chemistry – Short Answer – Identify all of the following 3 options that possess short range order: 1) Crystals; 2) Liquids; 3) Glasses

ANSWER: All [AB]

3) Tossup - Math - Multiple Choice - Which of the following is true of the polynomial x squared plus 12 x plus 42?

W) It has 2 real unique roots.

X) It has 1 real unique root.

Y) It has no real roots.

Z) It has no roots.

ANSWER: Y) It has no real roots. [AC]

3) Bonus - Math - Short Answer - A tennis ball container is in the shape of a cylinder, containing a total of 3 spherical tennis balls. The three tennis balls are aligned from top to bottom, and the top of the container is tangent to the highest tennis ball. If the tennis balls each have radius 3, then what is the volume of the space in the container outside of the tennis balls?

W) 108pi

X) 81pi

Y) 54pi

Z) 36pi

ANSWER: Y) 54pi [AC]

4) Tossup - Physics - Short Answer - A ball both hits the ground and rebounds vertically at a speed of 20 m/s in 10^-2 second. If the ball has mass 1/2 kilogram, in newtons, what was the average force exerted on the ball by the ground in this time frame?

ANSWER: 2000 [EW]

4) Bonus - Physics - Short Answer - A horizontal spring-mass system has a period of 0.4 second. When hung from the ceiling, the equilibrium length of the spring extends by 4 centimeters. What is the period of the vertical system in seconds?

ANSWER: 0.4 [EW]

5) Tossup - Earth and Space - Short Answer - Consider a hypothetical planet A with escape velocity E. In terms of E, what is the new escape velocity of planet A if the mass of A is doubled and the radius is quadrupled?

ANSWER: √2/2 E [AB]

5) Bonus - Earth and Space - Short Answer - McNair and Eli are zooming around the solar system in their favorite rocket ship. As they approach the asteroid belt, they suddenly notice that they are running

out of fuel. What specific points could they go to to minimize the amount of fuel usage and keep a stable orbit, due to a balance of gravitational and centrifugal forces?

ANSWER: Lagrange points [AB]

6) Tossup - Computer Science - Multiple Choice – Learning rate, number of hidden layers, and optimizer choice are best described as which of the following?

W) Parameters

X) Hyperparameters

Y) Objects

Z) Biases

ANSWER: X) Hyperparameters

6) Bonus - Computer Science - Short Answer - Due to the complex shape of many molecules, chemistry based models tend to understand the structure of a chemical species through what compact line notation with flexible molecular representation?

ANSWER: SMILES [EW]

7) Tossup - Biology - Multiple Choice - Which of the following is not a symptom of a deficiency in vitamin A?

W) Night blindness

X) Scurvy

Y) Skin disorders

Z) Impaired immunity

ANSWER: X) Scurvy [AS]

7) Bonus - Biology - Short Answer - Rank the following three types of plant cells from least to greatest based on the number of complete sets of chromosomes they contain: 1) Seed coat; 2) Megaspore; 3) Sieve tube element.

ANSWER: 3, 2, 1 [AY]

8) Tossup – Chemistry – Short Answer – Order the following 3 elements by increasing electron affinity:

1) Fluorine; 2) Chlorine; 3) Silicon

ANSWER: 3 1 2 [AB]

8) Bonus – Chemistry – Multiple Choice – Which of the following choices explains why Nitrogen has a higher first ionization energy than Oxygen?

W) Nitrogen has a completely filled 2p subshell, which makes it more stable

X) Oxygen has a half-filled 2p subshell, which makes it more stable

Y) Nitrogen has a half-filled 2p subshell, which makes it more stable

Z) Oxygen has fewer protons in its nucleus than nitrogen

ANSWER: Y) Nitrogen has a half-filled 2p subshell, which makes it more stable [AB]

9) Tossup - Math - Short Answer - Clark is playing basketball and can either make 2 point shots or 3 point shots. If Clark makes 10 shots and gets 23 points, then how many 2 point shots did Clark make?

ANSWER: 7 [AC]

9) Bonus - Math - Short Answer - What is the probability that the sum of 4 dice rolls is a multiple of 3?

ANSWER: ⅓ [AC]

10) Toss up - Physics - Short Answer - A soccerball is squished until it pops. What physical principle is responsible for the pressure being applied at one point being transmitted equally to all other points and the walls?

ANSWER: Pascal's Principle [EW]

10) Bonus - Physics - Short Answer - An earthquake's primary waves move at 8 kilometers/second, and the secondary wave moves at 4 km/s. Assuming both are produced simultaneously from the same point, how many kilometers away did the earthquake occur if the primary wave arrives 2 minutes before the secondary?

ANSWER: 480 [EW]

11) Tossup - Earth and Space - Multiple Choice – Which of the following ions is present in the highest concentration in an average sample of seawater?

W) Sodium

X) Chloride

Y) Magnesium

Z) Calcium

ANSWER: X) Chloride [AB]

11) Bonus - Earth and Space - Short Answer – Order the following parts of the ocean floor from farthest to closest to the shore: 1) Continental slope; 2) Continental shelf; 3) Continental rise

ANSWER: 3 1 2 [AB]

12) Tossup - Computer Science - Short Answer - When training a model, scientists mistakenly incorporated a portion of their test dataset into their training dataset, leading to artificially inflated training accuracy metrics. What mistake have they made?

ANSWER: Data leakage [EW]

12) Bonus - Computer Science - Multiple Choice - When training a protein shape prediction model like AlphaFold, which of the following would be most effective as an input?

W) Amino Acid Sequence

X) Electronegativity of every atom

Y) Number of Hydrophobic Amino Acids

Z) Hydrogen Bonding Sites

ANSWER: W) Amino Acid Sequence [EW]

13) Tossup – Biology – Short Answer - Identify all of the following 3 diseases that are inherited recessively: 1) Huntington's disease; 2) Cystic fibrosis; 3) Achondroplasia

ANSWER: 2 only [AB]

13) Bonus – Biology – Short Answer – In certain people, a dehydrogenase acting in alcohol fermentation causes the buildup of what compound after alcohol consumption, leading to facial flushing and nausea?
ANSWER: Acetaldehyde [AB]

14) Tossup – Chemistry – Short Answer – What is the oxidation number of chromium in $K_2Cr_2O_7$?
ANSWER: +6 [AB]

14) Bonus – Chemistry – Short Answer – Identify all of the following 3 compounds that are covalent network solids: 1) SiO_2; 2) BN; 3) Graphite
ANSWER: All [AB]

15) Tossup - Math - Short Answer - Albert is buying chicken nuggets. If he can buy either packets of 6 or 7 chicken nuggets, what is the greatest integer number of chicken nuggets that Albert can not buy?
ANSWER: 29 [EW]

15) Bonus - Math - Short Answer - A group of 5 juniors and 4 seniors are sitting together at a circular table. Juniors must sit adjacently and seniors must sit adjacently. How many ways can they sit at the table if rotations of an arrangement are considered identical?
ANSWER: 2880 [EW]

16) Tossup – Physics – Multiple Choice – Two frictionless blocks are stacked on each other. Which of the following will immediately occur if the bottom block is pulled to the right with force F?
W) The top block does not experience any net force
X) The top block experiences a force 1/2 F to the right
Y) The top block experiences a force F to the right
Z) The top block experiences a force 2F to the right
ANSWER: W) The top block does not experience any net force [EW]

16) Bonus – Physics – Short Answer – In a circuit consisting of a battery and a resistor of resistance R, which of the following would not cause the current running through the resistor to approach zero when

the circuit reaches steady state? 1) Adding a capacitor in series 2) Forming a loop connecting the battery to itself with wires of no resistance 3) Adding an inductor in series

ANSWER: 3 only

17) Tossup - Earth and Space - Short Answer - Order the following elements by relative abundance in the Earth's crust from most abundant to least abundant: 1) Silicon; 2) Oxygen; 3) Aluminum

ANSWER: 2 1 3 [AB]

17) Bonus - Earth and Space – Short Answer – What is the term for the maximum particle size a river or stream can carry?

ANSWER: Competence [AB}

18) Tossup – Computer Science – Short Answer – In 2020, over a million citizen scientists contributed to Folding@Home's [read: folding at home's] exascale level simulations of the Covid-19 proteome [read: pro-tee-ohm]. What term refers to Folding@Home's use of many, non-local computers to solve large computational problems?

ANSWER: Distributed computing (ACCEPT: Parallel computing) [EW]

18) Bonus – Computer Science – Which of the following best describes the purpose of activation functions?

W) To reduce the likelihood of overfitting

X) To compress data into more memory efficient spaces

Y) To create continuous, differentiable layers for gradient descent

Z) To introduce non-linearity to layers

ANSWER: Z) To introduce non-linearity to layers [EW]

19) Tossup - Biology - Multiple Choice - Which of the following is an example of aposematism in animals?

W) Skunks can emit a foul smelling liquid

X) Seals have light fur on their stomachs and dark fur on their backs

Y) Moths have thick, fluffy coverings that absorb sound

Z) Some bird species perform elaborate mating dances

ANSWER: W) Skunks can emit a foul smelling liquid [AY]

19) Bonus – Biology – Multiple Choice – What is the term for the type of cellular signalling where cells release a signal directly to only cells next to it?

W) Autocrine

X) Paracrine

Y) Endocrine

Z) Juxtacrine

ANSWER: Z) Juxtacrine [AB]

20) Tossup – Chemistry – Short Answer – In a galvanic cell, where does reduction occur?

Answer: Cathode [AB]

20) Bonus – Chemistry – Short Answer – Identify all of the following 3 salts that are insoluble in water:

1) $CaSO_4$; 2) $ZnCl_2$; 3) LiOH;

ANSWER: 1 only [AB]

21) Tossup - Math - Multiple Choice - What is the derivative of e to the power of x times sine x?

W) e to the power of x times cosine x

X) negative e to the power of x times cosine x

Y) e to the power of x times sine x plus e to the power of x times cosine x

Z) e to the power of x times sine x minus e to the power of x times cosine x

Answer: Y) e to the power of x times sine x plus e to the power of x times cosine x [AC]

21) Bonus - Math - Short Answer - Regular hexagon ABCDEF has an inscribed triangle ACE. What is the ratio of the area of hexagon ABCDEF to triangle ACE?

Answer: 2 [AC]

22) Tossup – Physics – Multiple Choice – If 0 work is done in a thermodynamic process, then it is best described by which of the following adjectives?

W) Adiabatic

X) Isothermic

Y) Isochoric

Z) Isobaric

ANSWER: Y) Isochoric [AB]

22) Bonus – Physics – Short Answer – The precession of the Earth indicates that what conserved quantity is changing?

ANSWER: Angular momentum [EW]

23) Tossup - Earth and Space [AB] – What is the name of the zone around a black hole where tidal forces are so strong that no object can survive intact?

ANSWER: Roche limit [AB]

23) Bonus – Earth and Space – Short Answer – What type of unconformity exists between sedimentary rocks overlying metamorphic or igneous rocks?

ANSWER: Nonconformity [AB]