DOUBLE ELIMINATION 2

TOSS-UP

1) Physics - *Short Answer* Identify all of the following three particles that are released when a nucleus undergoes beta-minus decay: 1) Neutron; 2) Positron; 3) Electron antineutrino.

ANSWER: 3 only

BONUS

1) Physics - *Multiple Choice* A uniform solid sphere of mass m rolls without slipping on a flat surface. If its center moves with speed v, which of the following best describes its total kinetic energy?

W) $\frac{1}{5}mv^2$
X) $\frac{2}{7}mv^2$
Y) $\frac{1}{2}mv^2$
Z) $\frac{7}{10}mv^2$

ANSWER: Z) $\frac{7}{10}mv^2$

TOSS-UP

2) Biology - *Multiple Choice* Which of the following observations from X-ray crystallography provided evidence for specific base pairing in DNA?

W) Purines **[PURE-eens]** form two hydrogen bonds, while pyrimidines **[PEER-uh-muh-deens]** form three hydrogen bonds
X) The uniform diameter of the DNA helix is maintained by purine-pyrimidine base pairing
Y) The helical structure of DNA revealed alternating purine-purine and pyrimidine-pyrimidine pairings
Z) Aromaticity is only preserved when purines base pair with pyrimidines

ANSWER: X) The uniform diameter of the DNA helix is maintained by purine-pyrimidine base pairing

BONUS

2) Biology - *Short Answer* Flower color is determined by recessive epistasis involving two unlinked genes, A and B, producing a 9 purple to 3 white to 4 blue offspring ratio in a dihybrid cross. Identify all of the following three statements that can reasonably be inferred: 1) Knocking out both genes results in blue flowers; 2) If gene A produces purple pigment, gene B must produce blue pigment; 3) Purple flowers require at least one dominant allele in both genes.

ANSWER: 1 and 3

TOSS-UP

3) Chemistry - *Multiple Choice* Oxygen in the superoxide ion has which of the following oxidation states?

W) -1
X) -1/2
Y) 0
Z) 1/2

ANSWER: X) -1/2

BONUS

3) Chemistry - *Multiple Choice* Which of the following statements about solubility is correct?

W) $Al(OH)_3$ **[Al, open parentheses, OH, close parentheses, 3]** is soluble in strong base solution
X) AgF is insoluble in water
Y) CaF_2 is highly soluble in water
Z) $PbCl_2$ is typically insoluble in water regardless of temperature

ANSWER: W) Al(OH)3 is soluble in strong base solution

TOSS-UP

4) Energy - *Multiple Choice* Scientists supported by Stanford's Wu Tsai Institute are studying myelin disorders in the spinal cord. Which of the following cells, responsible for the myelination **[my-li-NAY-shin]** of axons in the central nervous system, would these scientists be interested in?

W) Schwann cells
X) Astrocytes
Y) Microglia **[micro-GLEE-uh]**
Z) Oligodendrocytes **[uh-lig-oh-DEN-droh-sites]**

ANSWER: Z) Oligodendrocytes

BONUS

4) Energy - *Short Answer* Researchers in Stanford's Natural Language Processing Lab are studying the architecture of large language models. Most current LLMs are based on what deep learning architecture, which converts tokens into vectors and passes them through alternating attention and feedforward layers before turning them back into tokens?

ANSWER: Transformer

TOSS-UP

5) Math - *Short Answer* Let $p(x)$ be a degree m polynomial, $q(x)$ be a degree n polynomial, and $r(x) = p(q(x))$ **[r of x equals p of q of x]**. In terms of m and n, what is the degree of $r'(x)$ **[r prime of x]**?

ANSWER: $mn - 1$

BONUS

5) Math - *Multiple Choice* The following rotations are performed, in order, on an object: **[read slowly]** rotation about x by 90°, rotation about y by 90°, rotation about z by 90°, rotation about x by -90°, rotation about y by -90°, and rotation about z by -90°. Which of the following is equivalent to this sequence of operations?

W) No rotation
X) Rotation about x by 180°
Y) Rotation about y by 180°
Z) Rotation about z by 180°

ANSWER: Z) Rotation about z by 180°

TOSS-UP

6) Earth and Space - *Multiple Choice* Which of the following types of coastlines would most likely be observed during a global ice age?

W) Divergent
X) Submergent
Y) Convergent
Z) Emergent

ANSWER: Z) Emergent

BONUS

6) Earth and Space - *Multiple Choice* Which of the following best describes the crust's relative thickness beneath a mountain range?

W) Thicker than average due to the additional weight causing the crust to sink toward the mantle
X) Thicker than average due to volcanic activity leading to the emplacement of magmatic material
Y) Thinner than average due to compression from pressure exerted by the overlying mountain
Z) Thinner than average due to delamination of the crustal root

ANSWER: W) Thicker than average due to the additional weight causing the crust to sink toward the mantle

TOSS-UP

7) Physics - *Multiple Choice* The primary of a 1-to-3 step-up transformer is connected to a source, and the secondary is connected to a resistor. If the resistor dissipates power P, which of the following best describes the power that would be dissipated by the resistor if it was connected directly to the source?

W) $P/9$
X) $P/3$
Y) $3P$
Z) $9P$

ANSWER: W) $P/9$

BONUS

7) Physics - *Multiple Choice* In mechanics, what units are typically given to strain?

W) Newtons
X) Meters
Y) Pascals
Z) It has no units

ANSWER: Z) It has no units

TOSS-UP

8) Chemistry - *Multiple Choice* Which of the following functional groups does NOT contain an oxygen atom?

W) Aldehyde **[AL-duh-hide]**
X) Ester
Y) Imine **[IM-een]**
Z) Epoxide **[eh-POX-ide]**

ANSWER: Y) Imine

BONUS

8) Chemistry - *Short Answer* How many pi bonds would a monocyclic molecule with the chemical formula $C_8H_{12}ClBr$ have?

ANSWER: 1

TOSS-UP

9) Math - *Short Answer* Find the remainder when the polynomial $4x^2 - 9x + 5$ is divided by $x - 3$.

ANSWER: 14

BONUS

9) Math - *Short Answer* Evaluate $\lim_{x \to 0^+} x \log x$ **[the limit as x approaches 0 from the right of (pause) x log x]**.

ANSWER: 0

TOSS-UP

10) Energy - *Multiple Choice* Researchers at SLAC are developing methods to better understand fundamental forces at the quantum level. Which of the following fundamental forces is not currently explained by quantum physics?

W) Gravity
X) Electromagnetic
Y) Weak interaction
Z) Strong interaction

ANSWER: W) Gravity

BONUS

10) Energy - *Short Answer* Scientists in the Ricci Lab at Stanford are studying the fluidity of the phospholipid **[FOS-foh-lip-id]** bilayer. Identify all of the following three statements that are true regarding membrane fluidity: 1) Cod living in the Arctic Ocean have membranes with more unsaturated hydrocarbon tails; 2) Saturated lipids increase membrane viscosity; 3) Cholesterol acts as a fluidity buffer in the cell membrane of plants.

ANSWER: 1 and 2

TOSS-UP

11) Earth and Space - *Multiple Choice* A sailor in the Northern Hemisphere notices that, on average, the winds at their position blow south. In which of the following directions would the surface currents at their position most likely push the boat?

W) West
X) Southwest
Y) East
Z) Southeast

ANSWER: X) Southwest

BONUS

11) Earth and Space - *Short Answer* Order the following three geologic periods in terms of increasing CO_2 concentration in their atmospheres: 1) Cambrian; 2) Jurassic; 3) Paleogene.

ANSWER: 3, 2, 1

TOSS-UP

12) Biology - *Short Answer* In mammals, what brain structure in the hypothalamus **[hy-poh-THAL-uh-mis]** receives light input from the eyes through the optic nerve to help synchronize the body's internal clock with external light and dark cycles?

ANSWER: Suprachiasmatic **[soop-ruh-ky-as-MAT-ic]** nucleus (ACCEPT: SCN)

BONUS

12) Biology - *Short Answer* Identify all of the following three meristems **[MAIR-uh-stems]** that are more common in eudicots **[YOU-dy-cots]** than monocots: 1) Cork cambium; 2) Protoderm; 3) Vascular cambium.

ANSWER: 1 and 3

TOSS-UP

13) Chemistry - *Multiple Choice* The activation energy of a reaction is decreased by a catalyst. How does this affect the rate constant of the reaction?

W) Increases linearly
X) Increases exponentially
Y) Decreases
Z) Does not change

ANSWER: X) Increases exponentially

BONUS

13) Chemistry - *Multiple Choice* A positive deviation from Raoult's Law will be observed when which of the following substances forms a solution with acetone?

W) Benzene
X) Chloroform
Y) Ethanol
Z) Water

ANSWER: W) Benzene

TOSS-UP

14) Biology - *Short Answer* Identify all of the following three locations in which peristalsis **[pair-uh-STAHL-sis]** could occur: 1) Trachea **[TRAY-kee-uh]**; 2) Esophagus; 3) Small intestine.

ANSWER: 2 and 3

BONUS

14) Biology - *Short Answer* Identify all of the following three signaling pathways that are possible: 1) A second messenger binding to an ion channel in the endoplasmic reticulum; 2) Receptor of a hormone acting directly as a transcription factor once activated; 3) A protein kinase **[KY-nase]** inhibiting the function of another kinase.

ANSWER: All

TOSS-UP

15) Physics - *Multiple Choice* Which of the following is the term for the angle of incidence at which p-polarized light experiences perfect transmission through an interface?

W) Critical angle
X) Brewster's angle
Y) Fresnel's angle
Z) Snell's angle

ANSWER: X) Brewster's angle

BONUS

15) Physics - *Multiple Choice* Two charges are placed on the x-axis. A charge with magnitude $2e$ is placed at $x = 0$, and a charge with magnitude $-e$ is placed at $x = 1$. At which of the following locations on the x-axis is the total electric field equal to zero?

W) $x = 2 - \sqrt{2}$
X) $x = 2 - \sqrt{2}$ and $x = 2 + \sqrt{2}$
Y) $x = 2 + \sqrt{2}$
Z) Nowhere

ANSWER: Y) $x = 2 + \sqrt{2}$

TOSS-UP

16) Math - *Short Answer* What is the dot product of the two vectors $\langle 3, -8, 1 \rangle$ and $\langle 4, 5, -4 \rangle$?

ANSWER: -32

BONUS

16) Math - *Short Answer* Stanford Science Bowl writers want to form a 3-person playtesting committee from 8 potential members. If Peter and Emmanuel refuse to be on the committee together, how many possible committees are there?

ANSWER: 50

TOSS-UP

17) Earth and Space - *Multiple Choice* Which of the following correctly describes how an El Niño event affects the thermocline in the western and eastern Pacific Ocean, respectively?

W) Western Pacific gets deeper, eastern Pacific gets deeper
X) Western Pacific gets deeper, eastern Pacific gets shallower
Y) Western Pacific gets shallower, eastern Pacific gets deeper
Z) Western Pacific gets shallower, eastern Pacific gets shallower

ANSWER: Y) Western Pacific gets shallower, eastern Pacific gets deeper

BONUS

17) Earth and Space - *Multiple Choice* Which of the following best describes the direction of wind in pressure systems within the planetary boundary layer?

W) Roughly perpendicular to isobars because the pressure gradient force dominates
X) Roughly angled 30° to isobars because the direction of the pressure gradient force is affected by friction
Y) Roughly angled 30° to isobars because the direction of the Coriolis force is affected by friction
Z) Roughly parallel to isobars because the pressure gradient and Coriolis forces are balanced

ANSWER: Y) Roughly angled 30° to isobars because the direction of the Coriolis force is affected by friction

TOSS-UP

18) Physics - *Short Answer* Confinement is the phenomenon in which quarks and gluons cannot be isolated because they carry a nonzero amount of what type of charge?

ANSWER: Color (ACCEPT: Color charge)

BONUS

18) Physics - *Multiple Choice* Which of the following is closest to the momentum, in kilogram meters per second, of a photon with wavelength 660 nanometers?

W) 10^{-18}
X) 10^{-21}
Y) 10^{-24}
Z) 10^{-27}

ANSWER: Z) 10^{-27}

TOSS-UP

19) Biology - *Short Answer* Certain species of moths perform evasive aerial maneuvers instantaneously upon hearing the sounds of an echolocating bat. The same aerial loops are done even when the high-pitch sound comes from an ultrasonic whistle. What type of innate behavior might this defense mechanism be?

ANSWER: Fixed action pattern

BONUS

19) Biology - *Short Answer* What enzyme catalyzes the first committed step into glycolysis **[gly-KOL-uh-sis]** and serves as a major point of regulation?

ANSWER: Phosphofructokinase **[FAWS-pho-frewk-toh-KY-nase]**

TOSS-UP

20) Math - *Short Answer* The sum of the first ten terms of an arithmetic sequence is 500 less than the sum of the next ten terms. What is the common difference of the arithmetic sequence?

ANSWER: 5

BONUS

20) Math - *Short Answer* The difference between the roots of the quadratic $x^2 - 5x + c$ is 7. What is the value of c?

ANSWER: -6

TOSS-UP

21) Chemistry - *Multiple Choice* Which of the following elements exhibits the highest oxidation state in the compounds it commonly forms?

W) Titanium
X) Lead
Y) Chromium
Z) Vanadium

ANSWER: Y) Chromium

BONUS

21) Chemistry - *Short Answer* Order the following three trifluoride molecules from smallest to largest F-X-F angle, where X represents the central atom: 1) BF_3, 2) PF_3, 3) NF_3.

ANSWER: 2, 3, 1

TOSS-UP

22) Energy - *Multiple Choice* Stanford scientists are using the Gemini Planet Imager to discover new exoplanets. This instrument is useful because previous telescopes could only resolve the motion of exoplanets with semimajor axes greater than 30 AU. Which of the following is closest to the period, in years, of a planet with semimajor axis 30 AU?

W) 60
X) 160
Y) 260
Z) 360

ANSWER: X) 160

BONUS

22) Energy - *Short Answer* Researchers in the StorageX Initiative at Stanford recently discovered a new technique for initially charging lithium-ion batteries. When these batteries are charged, lithium ions are inserted into the structure of the graphite anode. What term is given to this process?

ANSWER: Intercalation

TOSS-UP

23) Earth and Space - *Short Answer* Venus's extreme atmospheric conditions can lead to the synthesis of complex compounds in its numerous cloud layers. What compound makes up Venus's characteristic pale-yellow clouds?

ANSWER: Sulfuric acid (DO NOT ACCEPT: Sulfur)

BONUS

23) Earth and Space - *Multiple Choice* Which of the following statements about lunar highlands and maria **[MAR-ee-uh]** is not correct?

W) Highland rocks are mostly composed of feldspars
X) Maria are mostly composed of mafic rock
Y) Highlands are older than maria
Z) Maria solidifed from a global magma ocean

ANSWER: Z) Maria solidified from a global magma ocean