DOUBLE ELIMINATION 3

TOSS-UP

1) Earth and Space - *Short Answer* Each hemisphere of Venus contains how many atmospheric circulation cells?

ANSWER: 1

BONUS

1) Earth and Space - *Multiple Choice* Which of the following statements is NOT true regarding stellar spectra?

W) B-type stars are typically hotter than F-type stars
X) K-type stars have longer lifespans than A-type stars
Y) O-type stars have strong Balmer lines
Z) G-type stars have strong ionized sodium absorption lines

ANSWER: Y) O-type stars have strong Balmer lines

TOSS-UP

2) Math - *Short Answer* The first three terms of an arithmetic sequence are 3, 6 + p, and 21 - p. What is the value of p?

ANSWER: 4

BONUS

2) Math - *Short Answer* Let f be a twice differentiable function over the real numbers such that $|f''| \leq 3$ **[the absolute value of f double prime is less than or equal to 3]**. If $f(0) = f'(0) = 0$ **[f of 0 equals f prime of 0 equals 0]**, what is the difference between the maximum and minimum possible values of $\int_0^5 f(x)\mathrm{d}x$ **[the integral from 0 to 5 of f of x dx]**?

ANSWER: 125

TOSS-UP

3) Physics - *Short Answer* William is driving his Tesla down Campus Drive, accelerating from rest to 60 miles per hour. David is driving down the road in the opposite direction at 60 miles per hour. An observer standing on the side of the road calculates William's change in kinetic energy to be E. In David's frame of reference and in terms of E, what is William's change in kinetic energy?

ANSWER: $3E$

BONUS

3) Physics - *Short Answer* A thin, uniform string is fixed at both ends and oscillates in a standing wave pattern with one antinode. By what factor must the tension on the string be multiplied to create a standing wave with two antinodes?

ANSWER: $\frac{1}{4}$

TOSS-UP

4) Chemistry - *Multiple Choice* Which of the following close-packing models has the highest packing efficiency?

W) Hexagonal
X) Simple cubic
Y) Diamond cubic
Z) Body-centered cubic

ANSWER: W) Hexagonal

BONUS

4) Chemistry - *Multiple Choice* Which of the following crystals would NOT give a blue solution after dissolving in a base?

W) Vanadyl **[vuh-NAY-dul]** sulfate
X) Copper sulfate pentahydrate
Y) Iron hexacyanoferrate **[hex-uh-psi-an-oh-FAIR-ate]**
Z) Potassium dichromate **[di-KROH-mate]**

ANSWER: Z) Potassium dichromate

TOSS-UP

5) Energy - *Short Answer* Researchers in the Micheli group at Stanford are working with fishing collectives in Baja California to minimize the impact of heat waves. Identify all of the following three measurements that would be associated with anomalously warm waters near Baja California: 1) Low rainfall in Australia; 2) High air pressure over the eastern Pacific; 3) Strong Pacific Countercurrent.

ANSWER: 1 and 3

BONUS

5) Energy - *Short Answer* Researchers in the Goldhaber-Gordon group at Stanford recently discovered magnetism in twisted bilayer graphene by observing a potential difference created by the Hall effect. For the Hall effect to occur in a superconductor sample, both a magnetic field and what other phenomenon must be present in the sample?

ANSWER: Electric current (ACCEPT: Current)

TOSS-UP

6) Physics - *Multiple Choice* Given a point 3 meters away from an infinite plane of constant charge density, by what factor does the electric field change when considering a point 6 meters away from the plane?

W) 0.25
X) 0.5
Y) 1
Z) 2

ANSWER: Y) 1

BONUS

6) Physics - *Short Answer* Suppose that an ideal gas is kept in a container at temperature T. Order the following three speeds by increasing magnitude: 1) Mean speed; 2) Most probable speed; 3) Root-mean-square speed.

ANSWER: 2, 1, 3

TOSS-UP

7) Biology - *Short Answer* The pre-mRNA sequence AAUAAA represents what signal, which when transcribed recruits special proteins to cut the transcript free from RNA polymerase **[puh-LIM-er-ase]**, ending transcription in eukaryotes?

ANSWER: Polyadenylation **[poly-uh-deen-ul-AY-shin]** signal (ACCEPT: Polyadenylation)

BONUS

7) Biology - *Multiple Choice* Edward is studying the electron transport chain. He notices that cytochrome b **[SIGHT-oh-chrome b]** is in complex III **[three]** and cytochrome a3 is in complex IV. Being mischievous, he rearranges the electron transport chain by swapping the two proteins' locations. Which of the following statements correctly describes the result of this change?

W) Cytochrome a3 can transport electrons while cytochrome b remains oxidized
X) Cytochrome a3 remains reduced while cytochrome b remains oxidized
Y) Both cytochromes are always in the oxidized state
Z) Both cytochromes are always in the reduced state

ANSWER: X) Cytochrome a3 remains reduced while cytochrome b remains oxidized

TOSS-UP

8) Earth and Space - *Short Answer* Identify all of the following three geologic features that are considered concordant: 1) Dike; 2) Lopolith **[LOP-uh-lith]**; 3) Sill.

ANSWER: 2 and 3

BONUS

8) Earth and Space - *Short Answer* Identify all of the following three factors that would increase the probability of cloud droplet coalescence in the context of precipitation formation: 1) Presence of strong updrafts; 2) Droplets with opposing electrical charges; 3) Droplets with high surface tension.

ANSWER: 1 and 2

TOSS-UP

9) Chemistry - *Multiple Choice* Given a weak polyprotic acid H_2A with pK_{a1} **[p-k-a-1]** and pK_{a2} **[p-k-a-2]** equal to 3 and 7, respectively, what is the pH of a buffer system with equal parts HA^- and A^{2-}?

W) 3
X) 5
Y) 7
Z) 10

ANSWER: Y) 7

BONUS

9) Chemistry - *Short Answer* Identify all of the following three compounds that would have a Van't Hoff factor of at least 2 in aqueous solution: 1) Sulfuric acid; 2) Magnesium phosphate; 3) Acetic acid.

ANSWER: 1 only

TOSS-UP

10) Math - *Multiple Choice* Alice is repainting the 3-point line on a basketball court so that every point on the new 3-point line has equal distance to the basket and the half-court line. Which of the following best describes the shape of the new 3-point line?

W) Parabola
X) Hyperbola
Y) Circular arc
Z) Cycloid

ANSWER: W) Parabola

BONUS

10) Math - *Short Answer* Let X_k be drawn independently from a normal distribution with mean k and standard deviation k. What are the mean and standard deviation, respectively, of $X_2 + X_3 - X_6$?

ANSWER: -1 and 7 (DO NOT ACCEPT: 7 and -1)

TOSS-UP

11) Energy - *Short Answer* Scientists at SLAC recently observed electron pairing at high temperatures in a cuprate **[COOP-rate]** superconductor. In conventional superconductors, this pairing typically occurs due to the interaction between electrons and what quasiparticle?

ANSWER: Phonon

BONUS

11) Energy - *Multiple Choice* Scientists at Stanford's Center for Ocean Solutions are studying coastal sand dune formation. Which of the following types of sand dunes would most likely form in a coastal region with significant vegetation?

W) Barchan **[BAR-kan]**
X) Parabolic
Y) Star
Z) Transverse

ANSWER: X) Parabolic

TOSS-UP

12) Biology - *Short Answer* Identify all of the following three changes that characterize a tree during the dry season: 1) Increased proportion of tracheids **[TRAY-kee-ids]** to vessel elements in secondary xylem **[ZY-lum]** tissue; 2) Increased water transport by the heartwood; 3) Increased shedding of sapwood.

ANSWER: 1 only

BONUS

12) Biology - *Short Answer* Order the following three regions of a nephron from least to greatest amount of water absorption: 1) Proximal convoluted tubule; 2) Ascending loop of Henle **[HEN-lee]**; 3) Distal tubule.

ANSWER: 2, 3, 1

TOSS-UP

13) Earth and Space - *Short Answer* Shreyas is located 100 parsecs away from Earth. If this star has an absolute magnitude of 5, what is its apparent magnitude?

ANSWER: 10

BONUS

13) Earth and Space - *Short Answer* In 1912, Vesto Slipher **[SLY-fer]** used spectroscopy to estimate that Andromeda is moving towards the Milky Way at a speed of 3×10^5 meters per second. To the nearest nanometer, at what wavelength would Slipher have observed a spectral line typically found at 1000 nanometers?

ANSWER: 999

TOSS-UP

14) Physics - *Multiple Choice* An electron and a photon have the same momentum. How does the de Broglie **[da BROY]** wavelength of the electron compare to the wavelength of the photon?

W) Greater
X) Smaller
Y) Equal
Z) Depends on the velocity of the electron

ANSWER: Y) Equal

BONUS

14) Physics - *Short Answer* A capacitor with capacitance C is composed of two parallel, circular conducting plates with area A and separation d in a vacuum. An insulating cylinder with area $A/2$, thickness d, and relative permittivity 2 is placed between the plates. In terms of C, what is the new capacitance of the capacitor?

ANSWER: $1.5C$ (ACCEPT: $\frac{3}{2}C$)

TOSS-UP

15) Biology - *Short Answer* Follicle-stimulating hormone stimulates what cells located in the seminiferous **[see-min-IF-er-is]** tubules that are important for spermatogenesis?

ANSWER: Sertoli **[sur-TOLL-ee]** cells

BONUS

15) Biology - *Multiple Choice* Growth of a pollen tube toward the micropyle **[micro-pile]** of the ovules is an example of which of the following phenomena?

W) Gravitropism
X) Thigmotropism **[thig-muh-TROHP-ism]**
Y) Chemotropism
Z) Phototropism

ANSWER: Y) Chemotropism

TOSS-UP

16) Energy - *Short Answer* Researchers in the Stanford Machine Learning Group are working on improving the practicality of machine learning algorithms. Models developed with little training data often suffer from what phenomenon, which causes them to generalize poorly to new data?

ANSWER: Overfitting

BONUS

16) Energy - *Short Answer* Scientists in the Peay Group at Stanford are studying fungal diversity across different biomes. They found that species richness is higher in the transitional area between two biomes than within each individual biome. What term describes the part of the ecosystem that they are studying?

ANSWER: Ecotone

TOSS-UP

17) Chemistry - *Multiple Choice* Which of the following conditions would increase the solubility of CO_2 gas in water?

W) Increasing the temperature of the water
X) Decreasing the temperature of the water
Y) Decreasing the pressure of CO_2 above the water
Z) Adding a strong base to the water

ANSWER: X) Decreasing the temperature of the water

BONUS

17) Chemistry - *Multiple Choice* Which of the following compounds does NOT have an octahedral geometry about its central atom?

W) SF_6
X) $Co(NH_3)_6^{3+}$ **[Co, open parentheses, NH3, close parentheses, 6, 3 plus]**
Y) $XeOF_5^-$
Z) WCl_6

ANSWER: Y) $XeOF_5^-$

TOSS-UP

18) Math - *Short Answer* A diray **[DIE-ray]** consists of two distinct rays emanating in any direction from a single point in a plane. What is the maximum number of regions into which two dirays can divide a plane?

ANSWER: 7

BONUS

18) Math - *Short Answer* Tanner rolls two standard six-sided dice. What is the probability that the product of the two numbers rolled is not divisible by 4?

ANSWER: $\frac{7}{12}$

TOSS-UP

19) Biology - *Short Answer* Similar in mechanism to semicircular canals, fishes have numerous tiny cupula **[KYU-pyu-luh]**-filled pits on the sides of their bodies covered in hair cells able to detect low-frequency waves. What is the name of this sensory system that can help fishes perceive the direction and velocity of water currents flowing over their bodies?

ANSWER: Lateral line system (ACCEPT: Lateral line)

BONUS

19) Biology - *Short Answer* Order the following three biomes by increasing average decomposition rate of organic matter: 1) Tropical rain forests; 2) Bogland; 3) Taiga **[TY-guh]**.

ANSWER: 2, 3, 1

TOSS-UP

20) Physics - *Multiple Choice* A spherical planet with constant density has radius R. The acceleration due to gravity at the surface of the planet is proportional to which of the following functions of R?

W) $1/R^2$
X) $1/R$
Y) R
Z) R^2

ANSWER: Y) R

BONUS

20) Physics - *Short Answer* Anurag is flying through space in his ellipsoid-shaped spaceship. The semi-major axis of the ship in the direction of travel has length 50 meters, and the semi-minor axes perpendicular to the direction of travel have equal lengths of 40 meters. Meanwhile, an inertial observer observes that Anurag's spaceship is shaped like a perfect sphere. In terms of c, at what speed is Anurag observed to be moving?

ANSWER: $\frac{3}{5}c$

TOSS-UP

21) Earth and Space - *Multiple Choice* Which of the following mineral groups consists of nesosilicates?

W) Feldspar
X) Mica
Y) Olivine
Z) Pyroxene

ANSWER: Y) Olivine

BONUS

21) Earth and Space - *Multiple Choice* Which of the following statements best describes how oceanic plate height and accumulated sediment thickness change, respectively, as the distance from a mid-ocean ridge axis increases?

W) Plate height increases, sediment thickness increases
X) Plate height increases, sediment thickness decreases
Y) Plate height decreases, sediment thickness increases
Z) Plate height decreases, sediment thickness decreases

ANSWER: Y) Plate height decreases, sediment thickness increases

TOSS-UP

22) Math - *Multiple Choice* Let a sequence be defined by $d_1 = 1$ and $d_{n+1} = 2d_n + n^2$ **[d sub n plus one equals 2 d sub n plus n squared]** for n greater than or equal to 1. Which of the following is the value of d_4?

W) 27
X) 28
Y) 29
Z) 30

ANSWER: Y) 29

BONUS

22) Math - *Short Answer* Evaluate $\int_0^{\sqrt{\pi}} x \sin(x^2)\,dx$ **[the integral from 0 to square root of pi of x time sine of the quantity x squared dx]**.

ANSWER: 1

TOSS-UP

23) Chemistry - *Short Answer* The decomposition of nitrous acid is an example of what type of redox reaction, in which one chemical is both oxidized and reduced?

ANSWER: Disproportionation **[dis-pruh-pour-shin-AY-shin]**

BONUS

23) Chemistry - *Multiple Choice* Which of the following statements is true regarding the geometry of nitric acid?

W) The oxygen in the oxygen-hydrogen bond is sp^3 hybridized
X) All three nitrogen-oxygen bonds are the same length
Y) The whole molecule is planar within a few degrees
Z) One resonance structure includes the central nitrogen being sp^3 hybridized

ANSWER: Y) The whole molecule is planar to a few degrees