

DOUBLE ELIMINATION ~ ROUND 4

TOSS UP

1. MATH *Multiple Choice* Which of the following is equivalent to $\ln(1/8)$ [*the natural log of one eighth*]?

- W) $3\ln 2$ [*3 natural log of 2*]
- X) $-\ln 3$ [*negative natural log of 3*]
- Y) $-3\ln 2$ [*negative 3 natural log of 2*]
- Z) $\log_2 3$ [*log base 2 of 3*]

ANSWER: Y) $-3\ln 2$

BONUS

1. MATH *Short Answer* Providing your answer in simplest form, what is the volume generated by rotating the region bounded by $y = x^2$ and $y = x$ about the line $x = 2$?

ANSWER: $\pi/2$

TOSS UP

2. EARTH AND SPACE *Short Answer* What is the collective name for the pair of galaxies that are visible in the Earth's southern hemisphere and are separated by 21 degrees in the sky?

ANSWER: MAGELLANIC CLOUDS

BONUS

2. EARTH AND SPACE *Multiple Choice* Currently, the least biased method of discovering planets is which of the following?

- W) Radial velocity measurements
- X) Gravitational microlensing
- Y) Transit surveys
- Z) Astrometry

ANSWER: X) GRAVITATIONAL MICROLENSING

TOSS UP

3. BIOLOGY *Multiple Choice* Which of the following structures would NOT produce a child with Down Syndrome if fertilized by a sperm containing 2 copies of chromosome 21?

- W) A haploid secondary oocyte [**OH-uh-syt**] with a normal complement of chromosomes
- X) A haploid polar body
- Y) A haploid secondary oocyte that undergoes meiosis II [**my-OH-sis**] after the sperm penetrates the cell membrane
- Z) An oocyte that undergoes disjunction during meiosis II

ANSWER: X) A HAPLOID POLAR BODY

BONUS

3. BIOLOGY *Short Answer* Name all of the following four muscles that have origins or insertions on the human scapula: 1) Rhomboideus [**rom-BOI-dee-uhs**] major, 2) gracilis [**GRAS-uh-lis**], 3) subclavius [**suhb-KLAY-vee-uhs**], 4) trapezius.

ANSWER: 1, 4

TOSS UP

4. PHYSICS *Multiple Choice* The concept of inducing an EMF by rotating in a magnetic field is the fundamental physical effect needed for the function of which of the following devices?

- W) Ceiling fan
- X) Transformer
- Y) Electric dynamo
- Z) Electric motor

ANSWER: Y) ELECTRIC DYNAMO

BONUS

4. PHYSICS *Short Answer* A mass of 10 kilograms is rolling down an inclined plane. The plane has a height of 20 meters and a horizontal extent of 40 meters. What is the mechanical advantage of the inclined plane to the nearest tenth?

ANSWER: 2.2

TOSS UP

5. ENERGY *Multiple Choice* Which of the following types of battery has the highest energy density?

- W) Lithium-ion
- X) Lead-acid
- Y) Nickel-cadmium
- Z) Metal hydride

ANSWER: W) LITHIUM-ION

BONUS

5. ENERGY *Short Answer* By number, rank the following four electricity generating resources in terms of total fixed and variable cost of operation and maintenance per megawatt-hour from least to greatest: 1) nuclear, 2) hydropower, 3) conventional coal, 4) natural gas.

ANSWER: 2, 1, 3, 4

TOSS UP

6. CHEMISTRY *Multiple Choice* During an electrochemistry lab, you carefully construct a voltaic cell with two electrodes: a lead cathode and magnesium anode based on the standard reduction potentials. You place the two electrodes on the opposite sides of a beaker divided by a porous membrane, and then fill the beaker with a solution of potassium chloride. When you connect the two electrodes using wires and a voltmeter, you notice that no voltage flows through the voltmeter. Which of the following is the most likely cause of the lack of voltage?

- W) There are no anions in the solution that are able to be reduced by the cell
- X) There are no cations in the solution that are able to be reduced by the cell
- Y) The lead (III) cations produce a precipitate with chloride, so they do not reduce
- Z) The magnesium ions produce a precipitate with chloride, so they do not reduce

ANSWER: X) THERE ARE NO CATIONS IN THE SOLUTION THAT ARE ABLE TO BE REDUCED BY THE CELL

BONUS

6. CHEMISTRY *Short Answer* Identify, respectively, the types of substance generated when using the following four industrial processes: 1) Bessemer process, 2) Deville process, 3) Ostwald process, 4) Mond process.

ANSWER: 1) BESSEMER = STEEL, 2) DEVILLE = ALUMINUM, 3) OTSWALD = NITRIC ACID, 4) MOND = NICKEL

TOSS UP

7. MATH *Short Answer* What is the limit as x approaches 0 of $\frac{\sin(3x)}{x}$ [*the fraction with numerator sine of 3x and denominator x*]?

ANSWER: 3

BONUS

7. MATH *Short Answer* Identify, in the context of regression analysis, all of the following three statements that are ALWAYS true: 1) When the data set includes an influential point, the data set is nonlinear; 2) Influential points reduce the coefficient of determination, 3) All outliers are influential data points.

ANSWER: NONE

TOSS UP

8. EARTH AND SPACE *Multiple Choice* Cation exchange capacity (CEC) refers to the total number of cations a soil can hold, which is the same as the soil's total negative charge. Which of the following soil horizons would typically have the lowest CEC?

- W) Dark colored sands
- X) Light colored sands
- Y) Light colored loams and silt loams
- Z) Organic soils

ANSWER: X) LIGHT COLORED SANDS

BONUS

8. EARTH AND SPACE *Multiple Choice* The Hubble Ultra-Deep Field is the deepest image of the universe ever taken. After examining the image, scientists concluded all of the following, EXCEPT:

- W) Active galactic nuclei are less common at high redshifts
- X) Galaxies at high redshifts are smaller and less symmetric than low redshift galaxies
- Y) The luminosity function of high redshift galaxies is better constrained
- Z) Galaxies at high redshifts have higher star formation rates than galaxies at low redshifts

ANSWER: W) ACTIVE GALACTIC NUCLEI ARE LESS COMMON AT HIGH REDSHIFTS

TOSS UP

9. BIOLOGY *Multiple Choice* After being shipwrecked and lost at sea, you happen to wash up on a remote beach. Off in the distance, you spot a Nene **[nee-nee]** goose. Where in the world are you?

- W) The Hawaiian Islands
- X) The Galapagos Islands
- Y) The San Juan Islands
- Z) The Seychelles Islands **[say-SHELs]**

ANSWER: W) THE HAWAIIAN ISLANDS

BONUS

9. BIOLOGY *Short Answer* Plants that are classified as C4 are able to fix carbon in an alternate mechanism that produces a 4-carbon molecule. When carbon dioxide is added to phosphoenolpyruvate **[fohs-foh-uh-nol-py-ROO-vayt]** (PEP) to form the 4-C product oxaloacetate **[ok-suh-loh-AS-uh-tayt]**, what is the name of the enzyme that catalyzes this reaction?

ANSWER: PEP CARBOXYLASE (ACCEPT: PHOSPHOENOLPYRUVATE CARBOXYLASE)

TOSS UP

10. PHYSICS *Short Answer* A ball is thrown perfectly horizontally with a speed of 30 meters per second from the top of an 80 meter tall building. Given g as 10 meters per second squared and neglecting air resistance, with what speed in meters per second will it hit the ground?

ANSWER: 50

BONUS

10. PHYSICS *Multiple Choice* Two parallel identical conducting wires with radii of 1 millimeter are spaced 1 meter apart. Given ϵ_0 **[epsilon naught]** as 9×10^{-12} coulombs squared per newton meters squared, if a 10 volt potential difference is applied to the wires, which of the following is the force in newtons per meter between the wires?

- W) 3×10^{-7}
- X) 3×10^{-9}
- Y) 3×10^{-11}
- Z) 3×10^{-13}

ANSWER: Y) 3×10^{-11}

TOSS UP

11. CHEMISTRY *Multiple Choice* Which of the following species cannot act as an oxidizing agent on calcium metal in aqueous conditions?

- W) Iodide
- X) Permanganate
- Y) Nitrate
- Z) Bromine

ANSWER: W) IODIDE

BONUS

11. CHEMISTRY *Short Answer* Molecular orbital theory predicts that the nitric oxide molecule will have 8 valence electrons in bonding orbitals and 3 electrons in antibonding orbitals. With what bond order does this correspond?

ANSWER: 2.5

TOSS UP

12. BIOLOGY *Multiple Choice* Which of the following is the only duck in North America that specializes in eating fish?

- W) Bufflehead
- X) Common Merganser
- Y) King Eider
- Z) Northern Shoveler

ANSWER: X) COMMON MERGANSER

BONUS

12. BIOLOGY *Short Answer* What small cetacean [*si-TAY-shuhn*] has been declared functionally extinct within the past ten years?

ANSWER: YANGTZE RIVER DOLPHIN (ACCEPT: CHINESE RIVER DOLPHIN, WHITEFIN DOLPHIN, YANGTZE DOLPHIN) (DO NOT ACCEPT: CHINESE WHITE DOLPHIN)

TOSS UP

13. MATH *Short Answer* Pablo walks 4 miles north, 6 miles east, and then 2 miles north again. In simplest form, how many miles is he from his starting point?

ANSWER: $6\sqrt{2}$

BONUS

13. MATH *Short Answer* Evaluate $\lim_{x \rightarrow \infty} x(-1 + e^{1/x})$ [*the limit as x approaches infinity of x times the quantity negative 1 plus e to the 1 over x*].

ANSWER: 1

TOSS UP

14. EARTH AND SPACE *Multiple Choice* Which of the following is the lifetime of M dwarfs on the main sequence?

- W) Less than 100 million years
- X) Between 100 million and 1 billion years
- Y) Between 1 billion and 10 billion years
- Z) Longer than a Hubble time

ANSWER: Z) LONGER THAN A HUBBLE TIME

BONUS

14. EARTH AND SPACE *Multiple Choice* When orthoclase is green in color, which of the following mineral names is it given?

- W) Amazonite
- X) Augite [**AW-jyt**]
- Y) Olivine
- Z) Malachite [**MAL-uh-kyt**]

ANSWER: W) AMAZONITE

TOSS UP

15. BIOLOGY *Short Answer* What type of plant cells normally undergo apoptosis, providing structural support to the plant with their rigid cell walls?

ANSWER: SCLERENCHYMA (ACCEPT: FIBERS OR SCLEREIDS)

BONUS

15. BIOLOGY *Short Answer* What is the name of the ion with the following characteristics: it is a second-messenger, has a low concentration in the cytoplasm, and has a high concentration in the endoplasmic reticulum [***EN-duh-plaz-mik ri-TIK-yuh-luhm***]?

ANSWER: CALCIUM (ACCEPT: Ca⁺²)

TOSS UP

16. PHYSICS *Short Answer* If a hydrogen nucleus resonates at 200 megahertz in a field strength of 4.7 teslas, the same nucleus will resonate at what frequency in megahertz at 14.1 teslas?

ANSWER: 600

BONUS

16. PHYSICS *Short Answer* A spacecraft is in circular low-Earth orbit at an altitude of 400 kilometers and needs to be transferred to a circular orbit at an altitude of 120,000 kilometers. Providing your answer with one significant figure, what is the delta-v required for the spacecraft to get into the Hohmann transfer orbit, if the initial velocity is about 7,500 meters per second?

ANSWER: 3000

TOSS UP

17. ENERGY *Short Answer* Besides length, what is the primary characteristic that determines line losses in electricity transmission?

ANSWER: FREQUENCY

BONUS

17. ENERGY *Short Answer* Many battery chargers can consume 5 times the amount of power in the battery itself, even when not actively charging a product. Assuming this is true and the charger is plugged in constantly, what is the expected annual consumption in kilowatt-hours of a battery charger for a 5 watt battery, rounded to one significant figure?

ANSWER: 200

TOSS UP

18. CHEMISTRY *Short Answer* How many electrons in an atom of vanadium in its ground state have an angular-momentum quantum number of 2?

ANSWER: 3

BONUS

18. CHEMISTRY *Short Answer* What is the IUPAC name of the organic product formed from the hydroboration-oxidation of 1-Hexyne?

ANSWER: HEXANAL

TOSS UP

19. MATH *Multiple Choice* Which of the following represents the number of inches a rolling wheel with a radius of 4 inches travels on level ground in 6 revolutions?

- W) 24π
- X) 48π
- Y) 96π
- Z) 144π

ANSWER: X) 48π

BONUS

19. MATH *Short Answer* Expressing your answer in simplest form, find all values of x for which the determinant of the following matrix is 3: $\begin{bmatrix} x-3 & 6 \\ 1 & 2x+1 \end{bmatrix}$ **[the 2 by 2 matrix with row 1: the quantity x minus 3, 6 and row 2: 1, the quantity $2x$ plus 1].**

ANSWER: -1.5 AND 4 (ACCEPT: -3/2 AND 4)

TOSS UP

20. EARTH AND SPACE *Short Answer* Many different parameters are measured when conducting water quality studies. Which parameter refers to the buffering capacity of water?

ANSWER: ALKALINITY (ACCEPT: TOTAL ALKALINITY) (DO NOT ACCEPT: PH)

BONUS

20. EARTH AND SPACE *Short Answer* By number, identify all of the following four statements that are true when comparing basaltic rock to granitic rock, 1) basaltic rock is composed of more magnesium and iron; 2) basaltic rock is more common in continental crust; 3) basaltic rock is more dense; 4) basaltic rock is formed from magma with a lower viscosity and lower gas content.

ANSWER: 1, 3, 4

TOSS UP

21. BIOLOGY *Short Answer* Face recognition is located in which lobe of the human cerebrum?

ANSWER: TEMPORAL

BONUS

21. BIOLOGY *Multiple Choice* When a G-protein coupled receptor binds to its ligand, which of the following is the most direct outcome?

- W) The G protein binds the ligand-bound receptor
- X) The G protein releases GDP and binds GTP
- Y) The G protein hydrolyzes GTP into GDP and inorganic phosphate
- Z) Adenylyl cyclase converts ATP into cyclic AMP

ANSWER: W) THE G PROTEIN BINDS THE LIGAND-BOUND RECEPTOR

TOSS UP

22. PHYSICS *Short Answer* Name the process by which the loss of an orbital electron results from an inelastic particle collision?

ANSWER: IONIZATION

BONUS

22. PHYSICS *Short Answer* A piston containing an ideal gas at a temperature of 300 Kelvin and pressure of 2 bar expands isothermally from a volume of 3 cubic meters to 30 cubic meters. How much work is done by the gas in megajoules to the nearest tenth?

ANSWER: 1.4

TOSS UP

23. ENERGY *Multiple Choice* Members of which of the following series, such as plutonium, are generally used in the nuclear energy field?

- W) C
- X) F
- Y) J
- Z) K

ANSWER: Z) K

BONUS

23. ENERGY *Short Answer* If a single 5 megawatt wind turbine generates 17,000 megawatt-hours of electricity annually, to the nearest 10%, what is its capacity factor?

ANSWER: 40%

TOSS UP

24. BIOLOGY *Multiple Choice* Which of the following is the type of plant growth hormone that promotes stem and pollen tube elongation and vascular tissue differentiation?

- W) Auxins [**AWK-sins**]
- X) Brassinosteroids
- Y) Cytokinins [**sy-tuh-KY-nins**]
- Z) Gibberellins [**jib-uh-REL-ins**]

ANSWER: X) BRASSINOSTEROIDS

BONUS

24. BIOLOGY *Short Answer* What is the genus of the Italian theropod fossil that exhibits rare fossilization of soft tissue?

ANSWER: SCIPIONYX

TOSS UP

25. CHEMISTRY *Multiple Choice* Which of the following is true of the Born-Oppenheimer approximation?

- W) Molecular vibrations do not significantly contribute to the translational energy of the molecule
- X) The exact position of the nucleus in a bond cannot be determined
- Y) Electronic and nuclear motion can be separated since nuclear motion is significantly slower than electron motion
- Z) Two nuclei that approach one another at a distance have no attractive or repulsive forces

ANSWER: Y) ELECTRONIC AND NUCLEAR MOTION CAN BE SEPARATED SINCE NUCLEAR MOTION IS SIGNIFICANTLY SLOWER THAN ELECTRON MOTION

BONUS

25. CHEMISTRY *Multiple Choice* A current, equivalent to 0.5 faradays, is passed through a solution containing copper (II) sulfate. How much copper in grams can be plated out?

- W) 3.2
- X) 16
- Y) 32
- Z) 64

ANSWER: X) 16