

## DOUBLE ELIMINATION ~ ROUND 1

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### TOSS UP

1. PHYSICS *Short Answer* A 9 volt battery is connected to a 9 ohm resistor. The current flowing through this circuit is found to be 0.9 amperes. Neglecting the resistance of the wires, what is the internal resistance of the battery in ohms?

ANSWER: 1

### BONUS

1. PHYSICS *Multiple Choice* The root mean square current of an alternating current is equal to the direct current that does which of the following?

- W) Dissipates an equal amount of power in a resistor as the peak power dissipated by the alternating current
- X) Dissipates an equal amount of power in a resistor as the average power dissipated by the alternating current
- Y) Produces the same average voltage across a resistor as the alternating current would
- Z) Provides the same average current in a resistor as the alternating current would

ANSWER: X) DISSIPATES AN EQUAL AMOUNT OF POWER IN A RESISTOR AS THE AVERAGE POWER DISSIPATED BY THE ALTERNATING CURRENT

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### TOSS UP

2. ENERGY *Short Answer* Roof overhangs used to shade windows, walls, and doors from direct solar radiation in order to cut down on cooling costs are an example of what kind of home energy design?

ANSWER: PASSIVE SOLAR

### BONUS

2. ENERGY *Short Answer* In megawatts, providing your answer to the nearest tenth, how much power is generated from a hydroelectric facility that has a head of 50 meters, a flow rate of 5,000 liters per second, and a coefficient of efficiency of 0.6?

ANSWER: 1.5

### TOSS UP

3. CHEMISTRY *Short Answer* Dinitrogen tetroxide decomposes according to the reaction:  $\text{N}_2\text{O}_4(\text{g}) \leftrightarrow 2\text{NO}_2(\text{g})$ . If nitrogen dioxide appears at a rate of 4 molar per second, at what rate in molar per second is the dinitrogen tetroxide disappearing?

ANSWER: 2

### BONUS

3. CHEMISTRY *Multiple Choice* Which of the following is the most sensitive type of polarography?

- W) Normal pulse
- X) Classical
- Y) Differential pulse
- Z) Current-sampled

ANSWER: Y) DIFFERENTIAL PULSE

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### TOSS UP

4. MATH *Short Answer* Evaluate  $\lim_{x \rightarrow 0} \frac{-5 + 5e^x}{x}$  [*the limit as x approaches 0 of the fraction with numerator negative 5 plus 5 times e to the x and denominator x*].

ANSWER: 5

### BONUS

4. MATH *Short Answer* Determine the quadratic equation with real coefficients and least integral leading coefficient that has  $3 - 2i$  as one root.

ANSWER:  $x^2 - 6x + 13 = 0$

### TOSS UP

5. EARTH AND SPACE *Short Answer* Which physical property of soil involves the concepts of matric potential and field capacity?

ANSWER: SOIL MOISTURE (ACCEPT: MOISTURE)

### BONUS

5. EARTH AND SPACE *Multiple Choice* Why are massive compact halo objects (MACHOs) thought to be unable to completely explain the dark matter problem?

- W) They would have evaporated by Hawking radiation in less than a Hubble time
- X) Cosmic microwave background radiation observations indicate that MACHOs could not have formed in a Hubble time
- Y) Several MACHOs would be detectable in the solar system but are not observed
- Z) There should be a lot more MACHOs observed through microlensing

ANSWER: Z) THERE SHOULD BE A LOT MORE MACHOS OBSERVED THROUGH MICROLENSING

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### TOSS UP

6. BIOLOGY *Multiple Choice* During electron transport chains in both photosynthesis and cellular respiration, the electron transport chain directly transfers energy from electrons to which of the following?

- W) ATP
- X) ATP synthase
- Y) The proton gradient
- Z) NADH or NADPH

ANSWER: Y) THE PROTON GRADIENT

### BONUS

6. BIOLOGY *Short Answer* When under heat stress, pelicans perform a specific type of panting behavior. What is this heat induced behavior called?

ANSWER: GULAR FLUTTERING (ACCEPT: GULAR FLUTTER)

### TOSS UP

7. PHYSICS *Multiple Choice* Which of the following scientists made the theoretical prediction that electromagnetic waves travel through a vacuum at the speed of light?

- W) James Clark Maxwell
- X) Michael Faraday
- Y) Heinrich Lenz
- Z) Heinrich Hertz

ANSWER: W) JAMES CLARK MAXWELL

### BONUS

7. PHYSICS *Multiple Choice* During the season when the Northern Hemisphere experiences winter, the Earth is located closest to the Sun. Which of the following effects does this have on the Earth's revolution speed?

- W) The Earth revolves faster around the Sun at this point
- X) The Earth revolves slower around the Sun at this point
- Y) The speed of revolution at this point is proportional to the cube of the Earth-Sun distance
- Z) The speed of Earth's revolution is always constant

ANSWER: W) THE EARTH REVOLVES FASTER AROUND THE SUN AT THIS POINT

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### TOSS UP

8. CHEMISTRY *Short Answer* Given that the half-life of uranium-235 is 700 million years, if you had 160 grams of U-235, how many grams would remain after 2.1 billion years?

ANSWER: 20

### BONUS

8. CHEMISTRY *Multiple Choice* Sodium crystallizes in the form of a body-centered cubic unit cell. If one atom of sodium has a radius of 180 picometers, what is the length, in picometers, of one side of the unit cell?

- W) 255
- X) 360
- Y) 416
- Z) 509

ANSWER: Y) 416

### TOSS UP

9. MATH *Short Answer* What is the equation of the circle with a diameter that has endpoints (-5, 12) and (5, -12)?

ANSWER:  $x^2 + y^2 = 169$

### BONUS

9. MATH *Short Answer* Evaluate:  $\int_{-1}^2 (x^3 + 1)dx$  [***the integral from negative 1 to 1 of open parenthesis x cubed plus 1 close parenthesis dx***].

ANSWER: 6.75 (ACCEPT:  $6\frac{3}{4}$ )

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### TOSS UP

10. EARTH AND SPACE *Short Answer* What is the term for a highly magnetized neutron star?

ANSWER: MAGNETAR

### BONUS

10. EARTH AND SPACE *Short Answer* Defining the density of a black hole to be its mass divided by the cube of its Schwarzschild radius, what is the density of a typical supermassive black hole, in grams per cubic centimeter, to within two orders of magnitude?

ANSWER: 10 (ACCEPT: ANY ANSWER BETWEEN 0.1 AND 1000)

### TOSS UP

11. BIOLOGY *Short Answer* What is the specific name of the chemical compound found in jellyfish and squid that is oxidized to cause bioluminescence?

ANSWER: COELENTERAZINE (DO NOT ACCEPT: LUCIFERIN)

### BONUS

11. BIOLOGY *Multiple Choice* Sperm whales have a specialized organ that is filled with oil that becomes solid at a relatively high temperature. Which of the following kinds of fatty acid would you predict to be found in the spermaceti organ?

- W) Trans
- X) Saturated
- Y) Polyunsaturated
- Z) Unsaturated

ANSWER: X) SATURATED

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### TOSS UP

12. CHEMISTRY *Multiple Choice* Kinetic-molecular theory makes several assumptions concerning ideal gases. Which of the following is NOT one of those assumptions?

- W) The average kinetic energy of the molecules is independent of temperature
- X) There are no attractive or repulsive forces between molecules
- Y) All collisions between molecules are elastic
- Z) The volume occupied by the gas molecules is negligible compared to the volume of the container

ANSWER: W) THE AVERAGE KINETIC ENERGY OF THE MOLECULES IS INDEPENDENT OF TEMPERATURE

### BONUS

12. CHEMISTRY *Multiple Choice* Water can frequently be employed in the self-assembly of nanoparticles by taking advantage of its surface properties. However, your teacher proposes that a particular self-assembly needs to take place in oil. Which of the following assembly processes would take advantage of the properties of the oil to make assembly possible?

- W) Electrostatic
- X) Magnetic
- Y) Hydrophobic
- Z) Capillary

ANSWER: W) ELECTROSTATIC

### TOSS UP

13. PHYSICS *Multiple Choice* If you drop an ice cube into a mixture of alcohol and water and you notice that the ice floats, which of the following can you conclude about the liquid?

- W) The liquid is mostly water
- X) The liquid is mostly alcohol
- Y) Nothing, because information on the temperature of the liquid is not given
- Z) The liquid contains exactly equal amounts of water and alcohol

ANSWER: W) THE LIQUID IS MOSTLY WATER

### BONUS

13. PHYSICS *Multiple Choice* The Rayleigh criterion defines a limit on which of the following?

- W) Resolution in an optical system
- X) Particle velocity in an inelastic collision
- Y) Sustainable pressure for a given material
- Z) Shear stress for a given material

ANSWER: W) RESOLUTION IN AN OPTICAL SYSTEM

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### TOSS UP

14. ENERGY *Multiple Choice* If a utility uses a true real time pricing rate structure, a residential customer could reduce consumption during the times of peak demand by upgrading all but which of the following?

- W) Lighting
- X) Heating
- Y) Air conditioning
- Z) Water heating

ANSWER: W) LIGHTING

### BONUS

14. ENERGY *Short Answer* What process is represented by the following:  $(\text{Coal}) + \text{O}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2 + \text{CO}$ ?

ANSWER: COAL GASIFICATION (ACCEPT: SYNGAS PRODUCTION)

### TOSS UP

15. CHEMISTRY *Short Answer* What is the molecular geometry of the coordination compound  $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$ ?

ANSWER: OCTAHEDRAL

### BONUS

15. CHEMISTRY *Short Answer* Match the following reactions: E2, S<sub>N</sub>2, and E1 to the following three solvents in which they generally occur : 1) polar aprotic, 2) polar protic, 3) a variety of solvents.

ANSWER: E2 = 3 (ACCEPT: VARIETY OF SOLVENTS); S<sub>N</sub>2 = 1 (ACCEPT: POLAR APROTIC); E1 = 2 (ACCEPT: POLAR PROTIC)

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### TOSS UP

16. MATH *Multiple Choice* Peano's Axioms underlie which of the following mathematical concepts?

- W) Non Euclidean geometry
- X) Group theory
- Y) Natural numbers
- Z) Complex numbers

ANSWER: Y) NATURAL NUMBERS

### BONUS

16. MATH *Short Answer* What is the exact value of  $\cos 75^\circ$  [*cosine of 75 degrees*] in simplest radical form?

ANSWER:  $\frac{\sqrt{6}-\sqrt{2}}{4}$

### TOSS UP

17. EARTH AND SPACE *Multiple Choice* How does the angle of repose change as an alluvial **[uh-LOO-vee-uhl]** fan increases in size over time?

- W) It increases because the sediment increases in cohesion over time
- X) It increases to a maximum of 15 degrees
- Y) It remains the same
- Z) It is highly variable due to the nature of the sediments

ANSWER: Y) IT REMAINS THE SAME

### BONUS

17. EARTH AND SPACE *Multiple Choice* A disadvantage of an altazimuth **[al-TAZ-uh-muhth]** mount compared to an equatorial mount is which of the following?

- W) It is more complicated to track stars as they move across the sky
- X) The telescope cannot observe the north celestial pole
- Y) It is more complicated to construct than an equatorial mount
- Z) It requires a larger dome

ANSWER: W) IT IS MORE COMPLICATED TO TRACK STARS AS THEY MOVE ACROSS THE SKY

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### TOSS UP

18. BIOLOGY *Multiple Choice* Which of the following pairs correctly matches the cellular structure or organelle with its function?

- W) Nucleolus and rRNA synthesis
- X) Smooth endoplasmic reticulum and carbohydrate synthesis
- Y) Centriole and transport of vesicles
- Z) Golgi apparatus and protein synthesis

ANSWER: W) NUCLEOLUS AND rRNA SYNTHESIS

### BONUS

18. BIOLOGY *Multiple Choice* African, Egyptian, Caucasian, and Carniolan are all races of which of the following colonizing insects?

- W) Termites
- X) Bees
- Y) Ants
- Z) Grasshoppers

ANSWER: X) BEES

### TOSS UP

19. PHYSICS *Multiple Choice* How many electrons are required to make up a net negative charge of 1 coulomb?

- W)  $1.6 \times 10^{-19}$
- X)  $6.2 \times 10^{18}$
- Y)  $1.6 \times 10^{19}$
- Z)  $6.2 \times 10^{19}$

ANSWER: X)  $6.2 \times 10^{18}$

### BONUS

19. PHYSICS *Multiple Choice* A pendulum attached to the ceiling has a mass  $m$ , a length  $L$ , and is held at rest at an angle  $\theta$  [**theta**] with respect to the vertical. If the pendulum [**PEN-juh-luhm**] is released, then which of the following is the equation for the kinetic energy of the pendulum at the lowest point in its oscillation?

- W)  $mgL \sin\theta$
- X)  $mgL (1 - \sin\theta)$  [ **$m g L$  times the quantity 1 minus the sine of theta**]
- Y)  $mgL \cos\theta$
- Z)  $mgL (1 - \cos\theta)$

ANSWER: Z)  $mgL (1 - \cos\theta)$

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### TOSS UP

20. ENERGY *Short Answer* What is the name for the cooling process that employs water's large enthalpy of vaporization?

ANSWER: EVAPORATIVE COOLING

### BONUS

20. ENERGY *Multiple Choice* An argument escalates from 20 decibels to 60 decibels. By what factor is the peak-to-peak air pressure variation associated with the argument multiplied?

- W) 3
- X) 100
- Y) 1,000
- Z) 10,000

ANSWER: X) 100

### TOSS UP

21. BIOLOGY *Multiple Choice* In the ocean, which of the following is the depth at which the rate of respiration of a photosynthetic organism is equal to its rate of photosynthesis?

- W) Compensation depth
- X) Critical depth
- Y) Oxygen minimum layer
- Z) Deep scattering layer

ANSWER: W) COMPENSATION DEPTH

### BONUS

21. BIOLOGY *Multiple Choice* Which of the following correctly identifies the body of water in which you would find Vaquita [**va-KEY-tuh**], the most endangered Cetacean?

- W) Northwest corner of the Gulf of California
- X) Throughout the Sea of Cortez
- Y) Southeast corner of the Sea of Cortez
- Z) Shallow lagoons off the coast of northern California

ANSWER: W) NORTHWEST CORNER OF THE GULF OF CALIFORNIA

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### TOSS UP

22. CHEMISTRY *Multiple Choice* In the gas phase, one mole of hydrogen gas reacts reversibly with one mole of iodine gas to form two moles of hydrogen iodide gas. If the system is at equilibrium at constant temperature, how will the equilibrium shift if the volume of the reaction vessel is doubled?

- W) It will shift toward the reactants
- X) It will shift toward the products
- Y) It will not shift in either direction
- Z) It is not possible to determine shift direction

ANSWER: Y) IT WILL NOT SHIFT IN EITHER DIRECTION

### BONUS

22. CHEMISTRY *Short Answer* Uridine monophosphate (UMP) [**YOOR-i-deen mon-uh-FOS-fayt**] is essential to the synthesis of pyrimidine nucleotides [**py-RIM-i-deen NOO-kee-uh-tyds**]. What amino acid combines with a bicarbonate ion and two ATPs in the first step of *de novo* synthesis of UMP?

ANSWER: GLUTAMINE

### TOSS UP

23. MATH *Short Answer* Maximize the area in square feet of a rectangular pen bounded by the side of a barn and 100 feet of fencing that forms the other three sides.

ANSWER: 1250

### BONUS

23. MATH *Short Answer* For the arithmetic sequence  $a_n$  with  $a_1 = 5$  and  $a_3 = -3$ , what is  $a_{98}$ ?

ANSWER: -383

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### TOSS UP

24. EARTH AND SPACE *Short Answer* What is the defining characteristic for detection of Type I supernovae [*soo-per-NOH-vee*]?

ANSWER: LACK OF HYDROGEN LINES

### BONUS

24. EARTH AND SPACE *Multiple Choice* Which of the following is a location where serpentinite [*suhr-pen-TUH-nyt*] often forms?

- W) Flanks of a volcano
- X) Accreted terranes
- Y) Sedimentary basins
- Z) Magma chambers

ANSWER: X) ACCRETED TERRANES

### TOSS UP

25. BIOLOGY *Multiple Choice* As a volcanically formed island begins to experience subsidence, you would see a temporal progression of reef types in which of the following orders?

- W) Fringing reef, barrier reef, atoll
- X) Atoll, fringing reef, barrier reef
- Y) Barrier reef, fringing reef, atoll
- Z) Fringing reef, atoll, barrier reef

ANSWER: W) FRINGING REEF, BARRIER REEF, ATOLL

### BONUS

25. BIOLOGY *Multiple Choice* Ciguatera [***sig-wa-ter-ra***] is an illness caused by eating fish that contain toxins produced by a tropical marine dinoflagellate [***din-uh-FLAJ-uh-layt***]. Which of the following fish would be the safest to eat if you wanted to avoid getting ciguatera?

- W) Barracuda
- X) Grouper
- Y) Trevally [***truh-valley***]
- Z) Halibut

ANSWER: Z) HALIBUT