

DOUBLE ELIMINATION ~ ROUND 2

TOSS UP

1. BIOLOGY *Multiple Choice* Which of the following species in the Great Lakes would be most likely to be affected by PCBs from industrial waste?

- W) Zooplankton
- X) Lake trout
- Y) Herring gull
- Z) Phytoplankton [*fy-tuh-PLANGK-tuhn*]

ANSWER: Y) HERRING GULL

BONUS

1. BIOLOGY *Multiple Choice* Which of the following components of the sarcomere [*SAHR-kuh-meer*] changes its dimensions during muscle contraction or relaxation?

- W) A band
- X) M line
- Y) H zone
- Z) Z disc

ANSWER: Y) H ZONE

TOSS UP

2. CHEMISTRY *Short Answer* In general, what is the name for each individual step in a mechanism?

ANSWER: ELEMENTARY REACTION (ACCEPT: ELEMENTARY STEP)

BONUS

2. CHEMISTRY *Short Answer* What is the common name for the amino acid having the side chain of methyl, CH₃?

ANSWER: ALANINE (DO NOT ACCEPT: ALA OR A)

TOSS UP

3. MATH *Short Answer* Solve for x : $(x - 3)(x + 5) = x^2 + x$.

ANSWER: 15

BONUS

3. MATH *Short Answer* Find the coordinates of the point on the graph of $f(x) = 2 + 4\sqrt{x}$ where the tangent line is parallel to the line $4x - 6y = 3$.

ANSWER: (9, 14)

TOSS UP

4. PHYSICS *Multiple Choice* If thermal energy is supplied to an insulated solid substance and the temperature does not change, which of the following is true of the solid?

- W) It has a high value of thermal conductivity
- X) It is undergoing a phase change
- Y) It has a very low specific heat
- Z) It has a high specific heat

ANSWER: X) IT IS UNDERGOING A PHASE CHANGE

BONUS

4. PHYSICS *Multiple Choice* Which of the following is the frequency, in hertz, of a 50 megavolt photon, given 6.6×10^{-34} joule seconds as Planck's constant and 1.6×10^{-19} coulombs as the elementary charge?

- W) 1.2×10^{24}
- X) 8.3×10^{23}
- Y) 1.2×10^{22}
- Z) 8.3×10^{21}

ANSWER: Y) 1.2×10^{22}

TOSS UP

5. EARTH AND SPACE *Multiple Choice* The first exoplanet was discovered around which of the following kinds of stars?

- W) K dwarf
- X) M dwarf
- Y) Pulsar
- Z) Brown dwarf

ANSWER: Y) PULSAR

BONUS

5. EARTH AND SPACE *Multiple Choice* Which of the following best approximates the percentage of solar-type stellar systems that are triples?

- W) 0.01%
- X) 0.1%
- Y) 1%
- Z) 10%

ANSWER: Z) 10%

TOSS UP

6. ENERGY *Multiple Choice* Which of the following provides the highest average efficiency increase in vehicle engines?

- W) Variable valve timing and lift
- X) Cylinder deactivation
- Y) Integrated starter/generator systems
- Z) Direct fuel injection with turbocharging or supercharging

ANSWER: Z) DIRECT FUEL INJECTION WITH TURBOCHARGING OR SUPERCHARGING

BONUS

6. ENERGY *Short Answer* Rank the following four locations in terms of evaporative cooling effectiveness, from worst to best: 1) Portland, Oregon; 2) New York City, New York; 3) Tucson, Arizona; 4) Boise, Idaho.

ANSWER: 1, 2, 4, 3 (ACCEPT: PORTLAND, OREGON; NEW YORK CITY, NEW YORK; BOISE, IDAHO; TUCSON, ARIZONA)

TOSS UP

7. BIOLOGY *Short Answer* A person with the genotype aaBbCcDd [**little a little a big B little b big C little c big D little d**] could produce how many different gamete genotypes?

ANSWER: 8

BONUS

7. BIOLOGY *Short Answer* Name all of the following four arteries that are found in the human arm or hand: 1) tibial, 2) brachial [**BRAY-kee-uhl**], 3) deep plantar, 4) axillary.

ANSWER: 2, 4 (ACCEPT: BRACHIAL, AXILLARY)

TOSS UP

8. CHEMISTRY *Short Answer* In an endothermic reaction, dinitrogen tetroxide decomposes to form nitric oxide. If the two substances were in equilibrium [**ee-kwuh-LIB-ree-uhm**] in a piston, identify all of the following three conditions that would lead to the generation of more nitric oxide: 1) pressure is removed from the system; 2) the temperature of the reaction is increased; 3) more dinitrogen tetroxide is added to the system.

ANSWER: ALL

BONUS

8. CHEMISTRY *Short Answer* Codeine is a powerful, naturally occurring opiate that is sometimes prescribed as a painkiller. If a codeine solution has a pH of 8.3, what is the solution hydroxide ion molarity to one significant figure?

ANSWER: 2×10^{-6}

TOSS UP

9. MATH *Short Answer* What are the coordinates of the center of the circle with equation:
 $x^2 + y^2 - 4x + 6y = 0$?

ANSWER: (2, -3)

BONUS

9. MATH *Short Answer* Providing your answer in slope intercept form, what is the equation of the line that is normal to the graph of the function $f(x) = 3x^2 - 5x$ at the point (1, -2)?

ANSWER: $y = -x - 1$

TOSS UP

10. PHYSICS *Short Answer* A 4 kilogram object is moving with a speed of 10 meters per second to the left when it explodes into two equal pieces. If one of the pieces is moving 2 meters per second to the right after the explosion, what is the speed in meters per second and direction of the other piece?

ANSWER: 22, LEFT

BONUS

10. PHYSICS *Multiple Choice* There are two point charges situated at a distance of 10.0 meters from each other. Each of them has a charge of 2.0 microcoulombs. Which of the following is the amount of work in millijoules required to separate them to infinity?

- W) 3.6
- X) -3.6
- Y) 0.4
- Z) -0.4

ANSWER: X) -3.6

TOSS UP

11. EARTH AND SPACE *Multiple Choice* How is it known that the engine powering active galactic nuclei, or AGN, must be at most several hundred AU in size?

- W) AGN that have been spatially resolved indicate that they cannot be any larger
- X) The timescale on which gas is observed to cool is comparable to the sound crossing time of several hundred AU
- Y) The timescale on which AGN vary is the light crossing time of several hundred AU
- Z) The orbits of stars around AGN are only several hundred AU in diameter

ANSWER: Y) THE TIMESCALE ON WHICH AGN VARY IS THE LIGHT CROSSING TIME OF SEVERAL HUNDRED AU

BONUS

11. EARTH AND SPACE *Short Answer* To the nearest order of magnitude, what was the temperature of the universe, in Kelvin, at the time of recombination?

ANSWER: 10^3 (ACCEPT: 10^4)

TOSS UP

12. BIOLOGY *Multiple Choice* Which of the following organisms is most likely to be found in the profundal zone of a lake?

- W) Blue-green algae
- X) Aquatic plants
- Y) Blood worms
- Z) Fish that feed on phytoplankton

ANSWER: Y) BLOOD WORMS

BONUS

12. BIOLOGY *Multiple Choice* In a longitudinal section of simple columnar epithelium [*ep-uh-THEE-lee-uhm*], such as that lining the intestine and gallbladder, the capillaries would be found in which of the following layers?

- W) Basement membrane
- X) Lamina propria
- Y) Surface epithelium
- Z) Basal epithelium

ANSWER: X) LAMINA PROPRIA

TOSS UP

13. CHEMISTRY *Short Answer* Suppose that one day, Boyle's law becomes inverted but all other gas laws remain unchanged. Identify all of the following three experimental situations you would expect to observe: 1) as a balloon is put underwater, its diameter increases; 2) filling a tire causes the tire to cool; 3) as helium is let out of a tank, the temperature of the tank increases.

ANSWER: 1 (ACCEPT: AS A BALLOON IS PUT UNDERWATER, ITS DIAMETER INCREASES)

BONUS

13. CHEMISTRY *Short Answer* Assuming that all particles within a solid are equally spaced hard spheres, what two crystal structures have the least amount of empty space?

ANSWER: HEXAGONAL CLOSE PACKING AND CUBIC CLOSE PACKING (ACCEPT: HCP AND CCP)

TOSS UP

14. MATH *Short Answer* What are the equations of each vertical asymptote for the graph of the function $f(x) = \frac{x-1}{x^3-x}$ **[f of x equals the fraction with numerator x minus 1 and denominator x cubed minus x].**

ANSWER: $x = 0$ and $x = -1$

BONUS

14. MATH *Short Answer* What is the value of the differential approximation error $dy - \Delta y$ **[dy minus delta y]** for $y = x^2 + 2$ as x changes from 1 to 1.1?

ANSWER: -0.01

TOSS UP

15. PHYSICS *Short Answer* Three resistors with resistances of 20 ohms, 40 ohms, and 60 ohms are connected in series to a 6 volt battery. What is the voltage drop in volts across the 20 ohm resistor?

ANSWER: 1

BONUS

15. PHYSICS *Multiple Choice* You sit on a pier and look straight down into the pond below. The apparent depth of the pond from the surface of the water is 5.0 meters. Which of the following is the real depth of the pond in meters, given that the refractive indices of air and water are, respectively, 1.0 and 1.3?

- W) 0.3
- X) 3.8
- Y) 5.0
- Z) 6.7

ANSWER: Z) 6.7

TOSS UP

16. EARTH AND SPACE *Multiple Choice* The focal ratio of a radio telescope is generally which of the following?

- W) Less than 1
- X) Between 1 and 2
- Y) Between 2 and 10
- Z) Greater than 10

ANSWER: W) LESS THAN 1

BONUS

16. EARTH AND SPACE *Short Answer* The Sagittarius Dwarf Irregular Galaxy is 1.0 megaparsecs away. To two significant figures, what is its distance modulus?

ANSWER: 25

TOSS UP

17. ENERGY *Multiple Choice* Which of the following statements is NOT true about the “snowflake diverter” at Princeton Plasma Physics Laboratory?

- W) It is used in fusion research
- X) It increases the impurity contamination level of the main plasma
- Y) Its name is derived from the appearance of its magnetic field lines
- Z) It reduces the interaction between hot plasma and the cold walls surrounding it

ANSWER: X) IT INCREASES THE IMPURITY CONTAMINATION LEVEL OF THE MAIN PLASMA

BONUS

17. ENERGY *Short Answer* By number, rank the following four choices by their R-value from least to greatest: 1) 4-inch thick brick, 2) Half-inch thick drywall, 3) One eighth inch thick flat glass, 4) 3.5 inch thick stagnant air space.

ANSWER: 4, 2, 3, 1

TOSS UP

18. BIOLOGY *Multiple Choice* Telomerase [*tuh-LOM-uh-rays*] is frequently activated in cancer cells. Which of the following describes the action of telomerase?

- W) It cuts the telomeres to make them shorter
- X) It prevents the telomeres from getting shorter
- Y) It controls the spindle fibers during cell division
- Z) It inhibits DNA repair

ANSWER: X) IT PREVENTS THE TELOMERES FROM GETTING SHORTER

BONUS

18. BIOLOGY *Multiple Choice* At which of the following stages of meiosis [*my-OH-sis*] could trisomy 13, Patau syndrome, be introduced?

- W) Anaphase I
- X) Telophase I
- Y) Telophase II
- Z) Prophase I

ANSWER: W) ANAPHASE I

TOSS UP

19. CHEMISTRY *Short Answer* The Haber process is an industrial process in which nitrogen gas and hydrogen gas are mixed at over 800 Kelvin and 150 atmospheres. The two gases react in this extreme environment to produce ammonia. Providing your answer to two significant figures, if 22.4 liters of hydrogen and 22.4 liters of nitrogen are mixed and react to completion, how many liters of ammonia will be produced?

ANSWER: 15

BONUS

19. CHEMISTRY *Multiple Choice* Which of the following elements, if doped into germanium, would produce a p-type semiconductor?

- W) Gallium
- X) Silicon
- Y) Arsenic
- Z) Selenium

ANSWER: W) GALLIUM

TOSS UP

20. MATH *Short Answer* Evaluate $\lim_{x \rightarrow \infty} \frac{x^5}{e^x}$ **[the limit as x goes to infinity of the fraction x to the fifth over e to the x].**

ANSWER: 0

BONUS

20. MATH *Short Answer* In interval notation, give the open interval on which the function $f(x) = x^3 + 12x^2 - 3$ is concave down.

ANSWER: $(-\infty, -4)$ (ACCEPT: THE OPEN INTERVAL FROM NEGATIVE INFINITY TO -4)

TOSS UP

21. PHYSICS *Multiple Choice* Given that the electric potential at infinity is zero, which of the following is true midway between two positive charges of equal magnitude?

- W) The electric field is zero and the electric potential is zero
- X) The electric field is zero and the electric potential is nonzero
- Y) The electric field is nonzero and the electric potential is zero
- Z) The electric field is nonzero and the electric potential is nonzero

ANSWER: X) THE ELECTRIC FIELD IS ZERO AND THE ELECTRIC POTENTIAL IS NONZERO

BONUS

21. PHYSICS *Short Answer* Kirk's hearing has minimum audible intensity of 1.0×10^{-12} watts per square meter. If Kirk listens to a sound of intensity 1.0×10^{-11} watts per square meter, what is its sound level in decibels?

ANSWER: 10

TOSS UP

22. EARTH AND SPACE *Multiple Choice* Which of the following most directly contributes to the opacity of a star's atmosphere?

- W) Hydrogen
- X) Metal lines
- Y) Free electrons
- Z) Helium

ANSWER: X) METAL LINES

BONUS

22. EARTH AND SPACE *Multiple Choice* If the sidereal period of a superior planet were exactly a century, the synodic period would be which of the following?

- W) Slightly longer than a year
- X) Slightly shorter than a century
- Y) Slightly longer than a century
- Z) Exactly 50 years

ANSWER: W) SLIGHTLY LONGER THAN A YEAR

TOSS UP

23. ENERGY *Short Answer* What is the term for the rate at which an electricity generator steadily changes its output to meet electricity demand?

ANSWER: RAMP RATE

BONUS

23. ENERGY *Short Answer* By number, identify all of the following four statements regarding energy systems that are true: 1) Aerobic and anaerobic distinction is made depending on whether carbon dioxide is produced in the production of energy; 2) Both aerobic and anaerobic energy systems use substrate phosphorylation to synthesize ATP; 3) Energy systems differ from each other with respect to the rate and the duration of energy production; 4) Lactic acid is produced during energy production by the high energy phosphate system.

ANSWER: 2 AND 3

TOSS UP

24. BIOLOGY *Multiple Choice* The calamus, rachis [**RAY-kis**], and barb are structures belonging to which of the following?

- W) A bird's feather
- X) A snail's tongue
- Y) A bear's claw
- Z) A porcupine's quill

ANSWER: W) A BIRD'S FEATHER

BONUS

24. BIOLOGY *Multiple Choice* Shark livers help with their buoyancy by producing which of the following oily materials?

- W) Squalene
- X) Isoprene
- Y) Oleic acid
- Z) Linoleic acid

ANSWER: W) SQUALENE

TOSS UP

25. CHEMISTRY *Multiple Choice* Consider the following chemical reaction: $\text{NH}_4\text{HS}_{(s)} \rightarrow \text{NH}_3_{(g)} + \text{H}_2\text{S}_{(g)}$. When 0.020 moles of NH_4HS are placed in a 2.0 liter container and heated to 127° Celsius, all of the solid decomposes. Given that $R = 0.0821$ liter atmospheres per mole Kelvin, which of the following is the pressure in atmospheres inside the container?

- W) 0.02
- X) 0.16
- Y) 0.66
- Z) 1.0

ANSWER: Y) 0.66

BONUS

25. CHEMISTRY *Short Answer* Radiation enters the human body from a variety of sources. Place the following four doses of radiation in order from the largest to smallest effect: 1) chest X-ray, 2) eating 100 bananas, 3) airplane flight from New York to Los Angeles, 4) mammogram.

ANSWER: 4, 3, 1, 2