BASH

Double Elimination 4

TOSS-UP

1. Energy *Multiple Choice* Students at Amador Valley want bands but have to settle with Jupiter's atmospheric bands. Which of the following is NOT true regarding Jupiter's atmospheric bands, which consist of zones and belts?

W) Zones are brighter in color, while belts are darker
X) Zones are manifestations of upwelling, while belts are manifestations of downwelling
Y) Zones are regions of high pressure, while belts are regions of low pressure
Z) Zones lie at a lower altitude relative to belts

ANSWER: Z) ZONES LIE AT A LOWER ALTITUDE RELATIVE TO BELTS

BONUS

1. Energy *Multiple Choice* Students at Montgomery Blair are getting on a sugar high. They observe a glucose and a fructose molecule joining together to form an acetal functional group in sucrose. Which of the following best describes this acetal's stability under acidic and basic conditions, respectively?

W) Stable, stable
X) Stable, unstable
Y) Unstable, stable
Z) Unstable, unstable

ANSWER: Y) UNSTABLE, STABLE

TOSS-UP

2. Earth and Space *Short Answer* Breakers form along a beach when the depth of the water is less than what fraction of the incoming wave's wavelength?

ANSWER: 1/2

BONUS

2. Earth and Space *Multiple Choice* The presence of xenoliths is most characteristic of which of the following types of unconformities?

W) Angular unconformity

X) Disconformity

Y) Nonconformity

Z) Paraconformity

ANSWER: Y) NONCONFORMITY

TOSS-UP

3. Chemistry *Short Answer* Order the following three reactions by increasing number of transition states:

1) Ring flip of cyclohexane
2) Diels-Alder reaction
3) SN1 reaction

ANSWER: 2, 3, 1

BONUS

3. Chemistry *Short Answer* Order the following three double bonds by increasing nucleophilicity:

1) Double bond in 1-butene
2) Double bond in 2-methyl-2-butene
3) Double bond in benzene.

ANSWER: 3, 1, 2 [EH]

TOSS-UP

4. Physics *Multiple Choice* It is mathematically fairly difficult to find the electric field of an ideal dipole by summing up the vectors from the two point charges. Instead, the electric field can be found by finding the electric potential, then applying which of the following operations?

W) Gradient

X) Curl

Y) Divergence

Z) Laplacian

ANSWER: W) GRADIENT

BONUS

4. Physics *Short Answer* A planet is orbiting around a star with a gravitational attractive force proportional to the distance to the star to the power of n. Identify all of the following three values of n such that the planet can maintain a stable elliptical orbit:

1) -2

2) -1

3) +1

ANSWER: 1 AND 3

TOSS-UP

5. Math *Short Answer* Identify all of the polynomials for which the sum of their real roots is 0:

1) $x^2 - 1$

2) $x^3 - 1$

3) $x^4 - 1$

ANSWER: 1 AND 3

BONUS

5. Math *Short Answer* An ellipse has semimajor axis of length 8 and semiminor axis of length 6. The distance between the ellipse's foci remains constant at all times. If the length of the semimajor axis is increasing at a rate of 2 units per second, at what rate is the area of the ellipse increasing, in terms of pi?

ANSWER: 100pi/3

TOSS-UP

6. Biology *Multiple Choice* Evan spends 10 years observing a harmless species of snake which mimics a harmful species of snake. Which of the following best describes the graph of the frequency of the mimic phenotype in the harmless species over time?

W) Line with positive slope
X) Line with negative slope
Y) Logarithmic
Z) Sinusoidal

ANSWER: Z) SINUSOIDAL

BONUS

6. Biology *Short Answer* Regions of the human genome evolve at varying rates due to differences in selection pressure. Order the following three DNA sequences in which a mutation would experience the strongest negative selection to the strongest positive selection:

1) Short tandem repeats
2) TATA box
3) Antibody V gene segments

ANSWER: 2, 1, 3

TOSS-UP

7. Earth and Space *Multiple Choice* All of Jupiter's Galilean moons are involved in a Laplace resonance except which of the following?

W) Callisto
X) Europa
Y) Ganymede
Z) Io

ANSWER: W) CALLISTO

BONUS

7. Earth and Space *Short Answer* What term describes an electron's state that causes rare transitions between energy levels, resulting in the emission of forbidden lines?

ANSWER: METASTABLE

TOSS-UP

8. Chemistry Short Answer Evan is titrating a 20 milliliter solution of 1 molar phosphoric acid with 1 molar sodium hydroxide. Given that phosphoric acid has pKas of 2, 7, and 12, how many milliliters of sodium hydroxide must be added to make the pH of the solution 12?

ANSWER: 50

BONUS

8. Chemistry *Multiple Choice* The Baeyer-Villiger oxidation of an aldehyde creates which of the following functional groups?

W) Ester
X) Carboxylic acid
Y) Acid anhydride
Z) Amide

ANSWER: X) CARBOXYLIC ACID

TOSS-UP

9. Physics *Short Answer* When a magnetic field is applied orthogonal to a current-carrying conductor, a voltage difference is generated between the top and bottom faces of the conductor. What is the name for this effect?

ANSWER: HALL EFFECT

BONUS

9. Physics *Multiple Choice* If the Mach number of an airplane is 1.25, then which of the following angle measures, in degrees, is closest to the Mach angle of the airplane?

W) 10

X) 30

Y) 50

Z) 70

ANSWER: Y) 50

TOSS-UP

10. Math *Short Answer* When the Taylor Series of the function x^3e^x is expanded, what is the coefficient on x^{10}?

ANSWER: 1/5040

BONUS

10. Math *Short Answer* Let M be the number of distinct permutations of the letters in the word HULLABALOO, spelled H-U-L-L-A-B-A-L-O-O. One of the Ls is removed from the word, and there are now N distinct permutations of the word. What is N/M?

ANSWER: ⅓

TOSS-UP

11. Biology *Short Answer* What group of noncoding RNA expressed in the germ line blocks the movement of transposons to prevent mutations from being passed onto offspring?

ANSWER: PIWI-INTERACTING RNA (ACCEPT: piRNA)

BONUS

11. Biology *Short Answer* Identify all of the following three scenarios that would increase the likelihood that genetic drift will lead to the fixation of a single allele on the Y chromosome:

1) Gene flow with another population, but size remains constant

2) Stronger stabilizing selection pressure of a polygenic trait

3) Increased sexual dimorphism

ANSWER: 3 ONLY

TOSS-UP

12. Energy *Short Answer* Students at Amador Valley are studying Breadth First Search. Breadth First Search normally can only find shortest paths on unweighted graphs. However, for graphs where the edge weights are all either 0 or 1, it is possible to use a modified version of BFS called 0-1 BFS which is still linear in the number of edges and vertices. This is done using what data structure?

ANSWER: DEQUE **[DECK]**

BONUS

12. Synergy *Short Answer* Evan likes to take planar organic molecules and redraw them as simple regular polygons. Identify all of the following three organic molecules that, after Evan's redrawing, would be able to tessellate the plane:

1) Naphthalene
2) Pyrrole
3) Pyridine

ANSWER: 1 AND 3

TOSS-UP

13. Earth and Space *Short Answer* Evan is playing the hit New York Times game Spelling Bee on pillars of basalt that are shaped like hexagons. Given their shape, these pillars were probably created by what process?

ANSWER: COLUMNAR JOINTING

BONUS

13. Earth and Space *Multiple Choice* Submarine fans are deposited when turbidity currents first begin to slow down. Given this, where on a passive continental margin are submarine fans found?

W) Continental shelf
X) Continental slope
Y) Continental rise
Z) Abyssal plain

ANSWER: Y) CONTINENTAL RISE

TOSS-UP

14. Chemistry *Short Answer* The Wolff–Kishner reduction proceeds irreversibly due to the loss of what gaseous byproduct from a reaction intermediate, which shifts the equilibrium to the products?

ANSWER: NITROGEN GAS

BONUS

14. Chemistry *Multiple Choice* According to hard-soft acid base theory, which of the following cations would form the least stable ionic compound with iodide?

W) NH_4^+

X) Ag^+

Y) Li^+

Z) Pb^{2+}

ANSWER: Y) Li^+

TOSS-UP

15. Physics *Short Answer* Identify all of the following three types of scattering that are considered elastic:

1) Rayleigh

2) Thomson

3) Compton

ANSWER: 1 AND 2

BONUS

15. Physics *Multiple Choice* Which of the following circuits has the largest time constant?

W) 5-Farad capacitor, 3-Ohm resistor

X) 10-Farad capacitor, 2-Ohm resistor

Y) 30-Henry inductor, 2-Ohm resistor

Z) 25-Henry inductor, 1-Ohm resistor

ANSWER: Z) 25 HENRY INDUCTOR, 1 OHM RESISTOR

TOSS-UP

16. Math *Short Answer* Daniel has 3 real numbers x, y, and z. He tells you the values of x + y + z, xy + yz + xz, and xyz. Identify all of the following that could be the number of ordered triples (x,y,z) that satisfy these 3 properties:

1) One

2) Two

3) Three

ANSWER: 1 AND 3

BONUS

16. Math *Short Answer* How many positive integers x less than or equal to 900 satisfy x^2 is congruent to 9 modulo 30?

ANSWER: 60

TOSS-UP

17. Biology *Multiple Choice* In a blood transfusion, type B blood was accidentally donated to a patient with type A blood. Which of the following classes of immunoglobulins would most likely target the foreign red blood cells, leading to their eventual destruction?

W) IgM

X) IgG

Y) IgA

Z) IgD

ANSWER: W) IGM

BONUS

17. Biology *Short Answer* Rohan is preparing to run a PCR reaction but makes a critical error by using ddNTPs instead of dNTPs. After a few cycles, identify all of the following three outcomes that could result from this mistake, which would not occur if PCR was conducted normally:

1) DNA copies would be found at various lengths

2) No base pairing would occur between nucleotides in product DNA

3) Less copies of DNA would be found at the same amount of cycles

ANSWER: 3 ONLY

TOSS-UP

18. Earth and Space *Short Answer* Order the following three spectral classes in order of increasing temperature:

1) L

2) T

3) Y

ANSWER: 3, 2, 1

BONUS

18. Earth and Space *Multiple Choice* In which of the following types of stars does heat transfer occur primarily through conduction?

W) Wolf-Rayet star

X) Red supergiant

Y) Brown dwarf

Z) White dwarf

ANSWER: Z) WHITE DWARF

TOSS-UP

19. Chemistry *Multiple Choice* Rohan is preparing to perform NMR on a variety of nuclei from his cabinet. Which of the following nuclei could he not observe using NMR?

W) Hydrogen-2

X) Lithium-5

Y) Beryllium-8

Z) Boron-11

ANSWER: Y) BERYLLIUM-8

BONUS

19. Chemistry *Short Answer* Identify all of the following three elements whose diatomic form has a lower ionization energy than their monatomic form:

1) Carbon

2) Nitrogen

3) Oxygen

ANSWER: 3 ONLY

TOSS-UP

20. Physics *Short Answer* As an object precesses, the axis can sometimes be observed to rock back and forth. What is the term for this effect, which can be described as a change in the second Euler angle?

ANSWER: NUTATION

BONUS

20. Physics *Short Answer* As measured in the lab frame, the spacetime interval between two events in spacetime is 30 meters. In meters, what is the spacetime interval between the two events as measured in a reference frame moving at 0.8 times the speed of light in the positive x direction?

ANSWER: 30

TOSS-UP

21. Math *Multiple Choice* A 2 by 2 matrix has all-positive integer entries. The sum of the entries on its main diagonal is 8 and the sum of all the entries is 15. What is the maximum possible determinant of the matrix?

W) 10

X) 11

Y) 12

Z) 13

ANSWER: W) 10

BONUS

21. Math *Short Answer* What is the sum from n = 1 to 1000 of the sum of the digits of n?

ANSWER: 13501

TOSS-UP

22. Biology *Multiple Choice* Flowers that are wind-pollinated would most likely first appear during which of the following times of the year?

W) Early spring
X) Late spring
Y) Early summer
Z) Late summer

ANSWER: W) EARLY SPRING

BONUS

22. Biology *Multiple Choice* Edwin is observing the effect of varying concentrations of ATP on the rate of glycolysis in bacterial cells. As he decreases the concentration of ATP to 0, which of the following best describes how the observed rate will change?

W) Decrease monotonically
X) Decrease then increase
Y) Increase monotonically
Z) Increase then decrease

ANSWER: Z) INCREASE THEN DECREASE

TOSS-UP

23. Energy *Multiple Choice* Students at Montgomery Blair are studying the life cycle of malaria. Which of the following best describes the ploidy of a sporozoite and merozoite respectively?

W) Haploid, haploid

X) Haploid, diploid

Y) Diploid, haploid

Z) Diploid, diploid

ANSWER: W) HAPLOID, HAPLOID

BONUS

23. Synergy *Multiple Choice* Rohan does not understand what a Ramachandran plot is and thinks its an HR diagram due its four separated quadrants. When looking at a certain quadrant, he notices that there are no stars, but instead beta-pleated sheets. If this was a HR diagram, which of the following types of stars would he find in that region?

W) Wolf-rayet

X) Carbon star

Y) Silicon star

Z) White dwarf

ANSWER: W) WOLF-RAYET
