BASH

Double Elimination 6

TOSS-UP

1. Energy *Short Answer* Students at Amador Valley are doing hella advanced CS stuff. Identify all of the following three problems that are considered NP-complete:

1) Finding a Hamiltonian path
2) Knapsack
3) Boolean satisfiability

ANSWER: ALL

BONUS

1. Energy *Multiple Choice* Students at Amador Valley are studying their state rock, serpentinite, and its formation. In which of the following locations can serpentinite most likely be found?

W) Bed of playa lakes
X) Aureole of a laccolith
Y) Mélange of oceanic lithosphere
Z) High-elevation exposures of granitic batholith

ANSWER: Y) MELANGE OF OCEANIC LITHOSPHERE

TOSS-UP

2. Earth and Space *Multiple Choice* Which of the following soil orders is characterized by high clay levels that cause it to dramatically change volume when it absorbs water?

W) Aridisol
X) Mollisol
Y) Vertisol
Z) Spodosol

ANSWER: Y) VERTISOL

BONUS

2. Earth and Space *Short Answer* Identify all of the following three rotating phenomena that necessarily rotate counterclockwise with increasing height in the Northern Hemisphere:

1) Tornado
2) Hurricane eye wall
3) Ekman spiral

ANSWER: 2 AND 3

TOSS-UP

3. Chemistry *Multiple Choice* Which of the following compounds will most likely demonstrate the anomeric effect?

W) Cyclohexane

X) Benzene

Y) Glucose

Z) Tetrahydrofuran

ANSWER: Y) GLUCOSE

BONUS

3. Chemistry *Short Answer* A trimethylsilyl group is installed as a protecting group for an alcohol. Identify all of the following three reactions in which this protecting group will stay on the alcohol:

1) Clemmensen reduction

2) Dess-Martin oxidation

3) Michael addition with a Gilman reagent

ANSWER: 2 AND 3

TOSS-UP

4. Physics *Multiple Choice* A brachistochrone is a curve that minimizes the time it takes for a ball to roll from one point to another. Which of the following shapes best characterizes a brachistochrone curve?

W) Cycloid

X) Parabola

Y) Hyperbola

Z) Catenary

ANSWER: W) CYCLOID

BONUS

4. Physics *Short Answer* In an antiferromagnetic material, magnetic domains are perfectly antiparallel, leading to a cancellation of the magnetic field. In contrast, what type of magnetism involves imperfectly aligned magnetic domains that results in a net small magnetic moment?

ANSWER: FERRIMAGNETISM

TOSS-UP

5. Math *Short Answer* Identify all of the following three counting problems which have their solution modeled by the Fibonacci sequence:

1) Number of subsets of 1 through n not containing any consecutive elements
2) Number of partitions of n using only 1s and 2s
3) Number of paths from (0,0) to (n,n) allowing steps of length 1 or 2 in the positive x and y directions

ANSWER: 1 ONLY

BONUS

5. Math *Short Answer* Identify all of the following 3 groups that can be written as the direct sum of cyclic groups:

1) Dihedral group of order 8
2) Quaternion group
3) Klein group

ANSWER: 3 ONLY

TOSS-UP

6. Biology *Multiple Choice* A protein contains a high proportion of acidic amino acids like glutamate and aspartate. Which of the following proteins is most likely to be this mystery protein?

W) Calmodulin
X) Transcription factor 2A
Y) Histone 3
Z) Cytochrome C

ANSWER: W) CALMODULIN

BONUS

6. Biology *Multiple Choice* Which of the following is true about bipolar cells in the ON-pathway in the human retina?

W) cGMP phosphodiesterase in bipolar cells is activated in the presence of light
X) Glutamate release by bipolar cells happens during hyperpolarization
Y) The glutamate receptor in bipolar cells is metabotropic
Z) The glutamate receptor in bipolar cells is excitatory

ANSWER: Y) THE GLUTAMATE RECEPTOR IN BIPOLAR CELLS IS METABOTROPIC

TOSS-UP

7. Earth and Space *Short Answer* Identify all of the following three dark matter candidates that are thought to interact with the weak force:

1) Sterile neutrinos
2) WIMPS
3) SIMPS

ANSWER: 2 AND 3

BONUS

7. Earth and Space *Short Answer* Yunyi is observing the surface of Venus and notices several flat landforms that he deduces were formed by the eruption of highly viscous lava. What feature has he most likely observed?

ANSWER: PANCAKE DOME

TOSS-UP

8. Chemistry *Short Answer* In the solid state, phosphorus pentafluoride does not exist as a molecular solid. Instead, it exists as a salt of two phosphorus-containing ions. What is the molecular geometry of the anion in this salt?

ANSWER: OCTAHEDRAL

BONUS

8. Chemistry *Short Answer* Identify all of the following three metals that would form a diamagnetic complex when bonded to six cyano ligands in the +2 oxidation state:

1) Iron
2) Zinc
3) Manganese

ANSWER: 1 AND 2

TOSS-UP

9. Physics *Multiple Choice* The Hamiltonian matrix is an example of a Hermitian matrix, which means that all of its eigenvalues must be which of the following types of numbers?

W) Real

X) Imaginary

Y) Rational

Z) Transcendental

ANSWER: W) REAL

BONUS

9. Physics *Short Answer* The linear momentum of a particle with mass m is 3mc. What is the Lorentz factor of this particle?

ANSWER: sqrt(10)

TOSS-UP

10. Math *Short Answer* Consider the 64th row of Pascal's triangle, which contains the entries 64 choose i for each i from 0 to 64 inclusive. If an entry is chosen randomly, what is the probability it is even?

ANSWER: 63/65

BONUS

10. Math *Short Answer* What is the sum of all primes p for which 1/p has a period of 6 when written as a repeating decimal?

ANSWER: 20

TOSS-UP

11. Biology *Short Answer* A single-celled eukaryote is breaking down a 33-carbon triglyceride through hydrolysis, then beta oxidation. Assuming it completely breaks down the fatty acids into acetyl CoA, how many acetyl CoA will it generate from this breakdown?

ANSWER: 15

BONUS

11. Biology *Short Answer* Identify all of the following three scenarios in which a cell would need a high NADPH to NADP+ ratio:

1) Cornea cell exposed to environmental oxygen radicals
2) Muscle cell breaking down glucose during intense physical activity
3) Adrenal gland synthesizing aldosterone from acetyl CoA

ANSWER: 1 AND 3

TOSS-UP

12. Energy *Short Answer* Students at Montgomery Blair are sequencing the mRNA from the trp operon in the 5 prime to 3 prime direction. Order the following three sequences from first to last they would encounter while sequencing the mRNA:

1) Start codon
2) Shine-Dalgarno sequence
3) Operator sequence

ANSWER: 3, 2, 1

BONUS

12. Synergy *Short Answer* Gaurav writes all the magic numbers from 2 to 126 inclusive. By name or number, identify all of the following three types of numbers that appear in this list:

1) Perfect number
2) Highly composite number
3) Semiprime

ANSWER: ALL

TOSS-UP

13. Earth and Space *Short Answer* Because not too much weathering occurs in the headwaters of a river, alluvial fans are especially rich in what type of sandstone?

ANSWER: ARKOSE

BONUS

13. Earth and Space *Short Answer* Forsterite and fayalite are the endmembers of the olivine solid-solution series. What is the only metal found in forsterite and the only metal found in fayalite, respectively?

ANSWER: MAGNESIUM AND IRON

TOSS-UP

14. Chemistry *Multiple Choice* Which of the following correctly describes the role of hydrogen peroxide in the hydroboration reaction of ethylene to ethanol?

W) Catalyst

X) Electrophile

Y) Oxidizing agent

Z) Reducing agent

ANSWER: Y) OXIDIZING AGENT

BONUS

14. Chemistry *Multiple Choice* Katherine is oxidizing antimony using nitric acid. Which of the following correctly describes the gas evolved if she uses low and high concentrations of nitric acid, respectively?

W) NO and NO_2

X) NO_2 and NO

Y) NO and NH_3

Z) NH_3 and NO

ANSWER: W) NO AND NO_2

TOSS-UP

15. Physics *Short Answer* Arnav is interested in studying composite particles that do not contain quarks. In particular, he is studying what particle, which consists of an electron bound with a positron?

ANSWER: POSITRONIUM

BONUS

15. Physics *Short Answer* Evan is trying to use dimensional analysis to solve his physics homework. If he has 5-variables and is working with 4-dimensions, what theorem states that there exists a unique independent, dimensionless combination of these variables?

ANSWER: BUCKINGHAM PI THEOREM

TOSS-UP

16. Math *Short Answer* Given two n by n matrices A and B, identify all of the following three properties of the two matrices AB and BA that are necessarily the same:

1) Trace

2) Characteristic polynomial

3) Determinant

ANSWER: ALL

BONUS

16. Math *Short Answer* What is the radius of the largest circle that can be inscribed in a unit cube?

ANSWER: SQRT(6)/4

TOSS-UP

17. Biology *Multiple Choice* Which of the following responses would occur in lung tissue and brain tissue respectively in response to low oxygen levels?

W) Vasodilation, vasodilation

X) Vasodilation, vasoconstriction

Y) Vasoconstriction, vasodilation

Z) Vasoconstriction, vasoconstriction

ANSWER: Y) VASOCONSTRICTION, VASODILATION

BONUS

17. Biology *Short Answer* Edwin finds a population of white, pink, and red bears in his backyard and wants to estimate the number of each color. He finds out the red allele is incompletely dominant to the white allele, then finds 20 random bears and tags them. A year later, he recaptures 100 bears and notices that 16 are white and 10 are tagged. Given this information, how many bears would Edwin estimate are pink in this population?

ANSWER: 96

TOSS-UP

18. Earth and Space *Short Answer* Identify all of the following three values in solar masses that a star undergoing a helium flash can have:

1) 1 solar mass
2) 2 solar masses
3) 3 solar masses

ANSWER: 1 AND 2

BONUS

18. Earth and Space *Short Answer* Edwin is studying binary star systems and is trying to determine their properties. Order the following three types of binary systems in increasing order of Edwin's ability to determine their properties:

1) Visual binary
2) Spectroscopic binary
3) Eclipsing binary

ANSWER: 2, 3, 1

TOSS-UP

19. Chemistry *Multiple Choice* Which of the following compounds will have a constant pressure specific heat capacity of 10R, assuming sufficiently high temperatures for all vibrational modes to be excited?

W) Methane

X) Ethylene

Y) Carbon dioxide

Z) Benzene

ANSWER: X) ETHYLENE

BONUS

19. Chemistry *Short Answer* What are the thermodynamically and kinetically most stable allotropes of phosphorus, respectively?

ANSWER: BLACK PHOSPHORUS AND RED PHOSPHORUS

TOSS-UP

20. *Physics Short Answer* Kian is orbiting around a black hole. What is the term for the closest distance that a particle can be from a black hole to maintain a stable circular orbit, which is equal to roughly three times the Schwarzschild radius?

ANSWER: ISCO (ACCEPT: INNERMOST STABLE CIRCULAR ORBIT)

BONUS

20. Physics *Short Answer* The ground state energy of a 3-dimensional particle-in-a-box system with all three sides equal is 3 electron-volts. At most how many electrons can have an energy of 9 electron-volts?

ANSWER: 6

TOSS-UP

21. Math *Short Answer* Consider a closed interval [a,b] over which a function is differentiable. What variant of the Intermediate Value Theorem says that for each c between f prime of a and f prime of b, there exists an x between a and b such that f prime of x is equal to c?

ANSWER: DARBOUX'S THEOREM

BONUS

21. Math *Short Answer* We say a positive integer x is healthy with y if there are finitely many positive integers n for which we cannot write n as the sum of a multiple of x and a multiple of y. What is the maximum number of consecutive positive integers which are healthy with 899?

ANSWER: 28

TOSS-UP

22. Biology *Multiple Choice* Which of the following characteristics is unique to a single fungal phylum?

W) Formation of arbuscular mycorrhizal associations
X) Presence of a prolonged dikaryotic stage in the fruiting body
Y) Symbiotic association with algae in lichen formation
Z) Production of flagellated spores

ANSWER: W) FORMATION OF ARBUSCULAR MYCORRHIZAL ASSOCIATIONS

BONUS

22. Biology *Multiple Choice* CFTR is an essential ion channel found in various tissues throughout the body, but is nonfunctional in individuals with cystic fibrosis. Which of the following consequences is least likely to result from a defective CFTR channel?

W) Higher inactivation of digestive enzymes in the duodenum
X) Less bile secretion through the Sphincter of Oddi
Y) Thickened mucus in the lungs
Z) Reduced chloride reabsorption in the ascending loop of Henle

ANSWER: Z) REDUCED CHLORIDE REABSORPTION IN THE ASCENDING LOOP OF HENLE

TOSS-UP

23. Energy *Short Answer* Students at the sister school Amador Blair are studying forces. Identify all of the following three forces that must have zero curl:

1) Kinetic friction
2) Gravity
3) Hookean force

ANSWER: 2 AND 3

BONUS

23. Synergy *Short Answer* Katherine is using a sphygmomanometer to listen to Korotkoff sounds and wonders if it can apply to other scenarios. Identify all of the following three scenarios that would produce Korotkoff-like sounds:

1) Airflow through a Venturi constriction with reduced downstream pressure
2) Clamping and then slowly releasing pressure on a garden hose carrying water
3) Listening with a stethoscope to airflow through an unobstructed flute mouthpiece

ANSWER: 1 AND 2
