

### Niskayuna Summer Invitational Single Elimination 3

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#### TOSS-UP

1) Physics – *Short Answer* A particle with a rest mass of 1.5 kg is moving with a speed of  $0.9c$  (0.9 times the speed of light). To three significant figures, in kilogram meters per second, what is the relativistic momentum of the particle?

ANSWER: 1.76 kg·m/s

#### BONUS

1) Physics – *Short Answer* A rocket is launched vertically upward from the ground with an initial velocity of 50 m/s. Assuming  $g$  equals  $10 \text{ m/s}^2$ , calculate the maximum height (in meters) it will reach before falling back to the ground.

ANSWER: 125 M

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#### TOSS-UP

2) Chemistry – *Multiple Choice* Which of the following molecules is a carbocation?

- W) Nitromethane
- X) Tropylium
- Y) Ethide
- Z) Acetonitrile

ANSWER: X) TROPYLIUM

#### BONUS

2) Chemistry – *Short Answer* How many lobes are present in each of the orbitals of the atomic sublevel which is a constituent of  $\phi$  bonds?

ANSWER: 6

### TOSS-UP

3) Energy – *Short Answer* Although now used for rapid weight loss, in 1921 Dr. Russell Wilder used what type of diet characterized by its high fat yet low carbohydrate content to combat epilepsy? (AI)

ANSWER: KETOGENIC (ACCEPT: KETO)

### BONUS

3) Energy – *Short Answer* By name or number, rank the following 4 microwave frequency bands in terms of shortest to longest wavelength:

- 1) C
- 2) P
- 3) S
- 4) L

ANSWER: 1, 3, 4, 2

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### TOSS-UP

4) Earth and Space – *Multiple Choice* Which of the following is not a ring of Neptune?

- W) Adams
- X) Arago
- Y) Galatea
- Z) Lassell

Answer: Y) GALATEA

### BONUS

4) Earth and Space – *Multiple Choice* In which of the following water bodies would a tsunami travel the slowest, on average?

- W) Pacific Ocean
- X) Indian Ocean
- Y) Arctic Ocean
- Z) Atlantic Ocean

ANSWER: Y) ARCTIC OCEAN

### TOSS-UP

5) Math – *Short Answer* A fair coin is flipped 5 times, what is the probability that there are at least 3 consecutive flips of the same kind?

ANSWER: 1/2

### BONUS

5) Math – *Multiple Choice* Which of the following values of x will give you a perfect square from the function  $f(x) = x^2 + 19x + 38$  (READ AS: f of x equals x squared plus 19x plus 38)

- W) 11
- X) 24
- Y) 43
- Z) 52

ANSWER: Y) 43

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### TOSS-UP

6) Chemistry – *Multiple Choice* When left in open-air, a solution of Iron (II) Chloride will gradually turn from green to yellow-brown. Which of the following will most effectively prevent this?

- W) Keeping the solution at low temperatures
- X) Keeping the solution at high temperatures
- Y) Adding a small amount of iron wool to solution
- Z) Adding a small amount of iron (iii) chloride to solution

ANSWER: Y) ADDING A SMALL AMOUNT OF IRON WOOL TO SOLUTION

### BONUS

6) Chemistry – *Short Answer* Lithium-ion batteries function on the reduction of cobalt (IV) oxide to lithium cobalt oxide. However, if discharged for too long, the lithium cobalt oxide can become irreversibly reduced, forming what two products?

ANSWER: LITHIUM OXIDE AND COBALT (II) OXIDE (ACCEPT: Li<sub>2</sub>O AND CoO)

### TOSS-UP

7) Physics – *Multiple Choice* Which of the following best describes how the drift velocity of electrons in a metal changes as the electric field strength in the metal is increased?

- W) Always increases
- X) Always decreases
- Y) Increases, then flattens out
- Z) Decreases, then increases

ANSWER: Y) INCREASES, THEN FLATTENS OUT

### BONUS

7) Physics – *Short Answer* Two systems, A and B, each contain a large number of identical particles. Assume that the chemical potential of particles in system A is 500 kilojoules per mole and the chemical potential of particles in system B is 350 kilojoules per mole. If system A is held at a constant temperature of 600 Kelvin, what is the final temperature in Kelvin of system B if the systems are connected and allowed to exchange particles?

ANSWER: 420

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### TOSS-UP

8) Biology – *Short Answer* What protein, the largest in the human body, is responsible for most of the passive force in muscles? (MK)

ANSWER: TITIN

### BONUS

8) Biology – *Multiple Choice* Which of the following classes of diuretics would not decrease serum K<sup>+</sup> concentration? (DY)

- W) Thiazide diuretic
- X) Mineralocorticoid receptor antagonist
- Y) Loop diuretics
- Z) Carbonic anhydrase inhibitor

ANSWER: X) MINERALOCORTICOID RECEPTOR ANTAGONIST

### TOSS-UP

9) Earth and Space – *Multiple Choice* Which of the following mineral groups is the most important in terms of transport of water and halogens from the crust into the mantle via subduction? (Titus)

- W) Mica
- X) Serpentine
- Y) Feldspar
- Z) Olivine

ANSWER: X) SERPENTINE

### BONUS

9) Earth and Space – *Short Answer* What term describes the gravity-driven winds coming off an ice sheet, which may open up polynyas in the surrounding ice shelf?

ANSWER: KATABATIC WINDS

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### TOSS-UP

10) Math – *Short Answer* What are the last 3 digits of  $15^{2023}$ ?

ANSWER: 375

### BONUS

10) Math – *Short Answer* How many more ways can 72 be written as the difference of perfect squares than 48?

ANSWER: 0

### TOSS-UP

11) Physics – *Short Answer* A block of mass 4 kg is connected to a horizontal spring with a spring constant of 900 N/m. The block is displaced by 0.3 meters and then released. Calculate the maximum velocity (in m/s<sup>2</sup>) of the block as it oscillates back and forth.

ANSWER: 4.5 M/S

### BONUS

11) Physics – *Multiple Choice* ANDrey drinks a can of Orange Fanta, oriented vertically, by puncturing a hole on the side of the can near the bottom. At some moment, the Fanta flies out of the hole and travels a distance  $d$  before hitting the ground. ANDrey decides, at that moment, to puncture the can again, producing a second hole halfway up the can. At the moment he makes the second hole, what is the new distance that the Fanta from the first hole will travel before hitting the ground?

W) Less than  $d$

X) Equal to  $d$

Y) Greater than  $d$

Z) Cannot be determined without knowing how high the can is above the ground relative to the length of the can

ANSWER: X) EQUAL TO  $d$

### TOSS-UP

12) Energy – *Multiple Choice* Which of the following organisms has the slowest metabolism?  
(AI)

W) Homo sapien

X) Loxodonta africana

Y) Acinonyx jubatus

Z) Cardinalis cardinalis

ANSWER: X) LOXODONTA AFRICANA

### BONUS

12) Energy – *Short Answer* Which country is known for their use of tidal energy, and houses the largest tidal power station in the world?

ANSWER: SOUTH KOREA

### TOSS-UP

13) Biology – *Multiple Choice* What 5-carbon ketose sugar is acted on by transketolase in the presence of Ribose-5-Phosphate to produce Glyceraldehyde-3-Phosphate, as well as a 7-carbon sugar? (MK)

- W) Ribulose-5-Phosphate
- X) Arabinose
- Y) Xylulose-5-Phosphate
- Z) Erythrose-4-Phosphate

ANSWER: Y) Xylulose-5-Phosphate

### BONUS

13) Biology – *Short Answer* In proteins, what structural motif, made up of 5 heptads of amino acids dimerizes the protein by interlacing leucine helices?

ANSWER: LEUCINE ZIPPER

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### TOSS-UP

14) Earth and Space – *Short Answer* What is the primary component of dark matter according to current leading theories?

ANSWER: WIMPs (Weakly Interacting Massive Particles)

### BONUS

14) Earth and Space – *Short Answer* By name or number, identify all of the following 4 galaxy structures or types of structures that are types of spiral galaxies: (ANDrey)

- 1) Barred
- 2) Flocculent
- 3) Ring
- 4) Shell

ANSWER: 1 AND 2

### TOSS-UP

15) Math – *Short Answer* What is the value of  $\int_0^{\infty} (\frac{1}{2})^{\lfloor x \rfloor} dx$  (READ AS: the integral from 0 to infinity of one half to the power of the floor of x with respect to x)?

ANSWER: 2

### BONUS

15) m, – *Short Answer* What is the normal vector to the surface:  $x^2 + y^3z^2 = 0$  at the point (1, 1, 1)?

ANSWER: (2, 3, 2) (ACCEPT: 2I + 3J + 2K)

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### TOSS-UP

16) Chemistry – *Short Answer* A Dieckmann condensation is an intermolecular version of what reaction between two esters which forms a beta-ketoester, noted for its ability to create carbon-carbon bonds through alpha-carbon chemistry?

ANSWER: CLAISEN CONDENSATION

### BONUS

16) Chemistry – *Multiple Choice* Which of the following is the least likely to undergo the Canizzarro reaction?

- W) Acetaldehyde
- X) Formaldehyde
- Y) Benzaldehyde
- Z) 2,2-dimethylpropanal

ANSWER: W) ACETALDEHYDE



### TOSS-UP

17) Energy – *Multiple Choice* The critical mass of a material is the amount of material necessary to sustain a nuclear chain reaction. In kilograms, which of the following is closest to the critical mass of a sphere of uranium-235 at normal density? (DY)

- W) 10
- X) 25
- Y) 50
- Z) 100

ANSWER: Y) 50

### BONUS

17) Energy – *Short Answer* What 2 elements composed the initiator at the center of the Fat Man bomb that was dropped on Nagasaki?

ANSWER: POLONIUM, BERYLLIUM (IN ANY ORDER)

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### TOSS-UP

18) Biology – *Short Answer* What theory, proposed by Gregor Mendel in 1865, states that parents pass on discrete genes to offspring? (MK)

ANSWER: PARTICULATE HYPOTHESIS OF INHERITANCE (ACCEPT: THE GENE IDEA)

### BONUS

18) Biology – *Short Answer* Tay-Sachs disease is an inherited disorder that follows an autosomal recessive pattern, most common in Eastern European Jews. The neurons of individuals who have Tay-Sachs disease are unable to break down the lipid GM2 ganglioside, leading to its accumulation intracellularly. The lack of what enzyme, that breaks down GM2 ganglioside, is characteristic of Tay-Sachs disease?

ANSWER: BETA-HEXOSAMINIDASE A (ACCEPT: HEXOSAMINIDASE A)

## TOSS-UP

19) Earth and Space – *Short Answer* By name or number, identify all of the following 4 seismic waves which are surface waves:

- 1) Love wave
- 2) Primary wave
- 3) Stoneley wave
- 4) Rayleigh wave. (AP)

ANSWER: Love wave, Stoneley wave, Rayleigh wave (accept 1, 3, 4)

## BONUS

19) Earth and Space – *Multiple Choice* Which of the following is not a term related to Karst topography? (AP)

- W) Gryke (READ AS: gr-ike)
- X) Abîme
- Y) Scree
- Z) Polje (READ AS: pohlj)

Answer: Y) SCREE

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## ESTIMATION

20) Estimation – *Short Answer* To the nearest power of 10, how many joules of energy were released by the Tsar Bomba, the largest nuclear weapon ever detonated, on impact?

ANSWER:  $10^{17}$  (ACCEPT: 17)