

## NSI2 Semifinals

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### TOSS-UP

1) BIOLOGY – *Short Answer* Oxygenation of the blood in the lungs increases hemoglobin's affinity for oxygen over carbon dioxide. What is the name given to this effect?

ANSWER: HALDANE EFFECT

### BONUS

1) BIOLOGY – *Multiple Choice* In the glycolytic pathway, Fructose 1,6 bisphosphate is broken down into glyceraldehyde 3 phosphate and what other compound which can be isomerized into another glyceraldehyde 3 phosphate?

W) Dihydroxyacetone Phosphate

X) Phosphoenol Pyruvate

Y) Phosphoglyceraldehyde

Z) 1, 3 Bisphosphoglycerate

ANSWER: W) Dihydroxyacetone Phosphate

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### TOSS-UP

2) CHEMISTRY – *Short Answer* By name or number, which of the following 3 changes would increase the transmittance of a .05 molar crystal violet solution in a 1 cm radius cuvette?

1 Diluting the solution to 0.04 molar

2 Increasing the radius of the cuvette to 2 cm

3 Increasing the wavelength of light from 600 nm to 700 nm

ANSWER: 1 and 3

### BONUS

2) CHEMISTRY – *Short Answer* An IR spectrum with a weakly intense absorption peak around 1700 inverse centimeters would be most indicative of what type of organic compounds?

Answer: Arenes (Accept: Aromatics)

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### TOSS-UP

3) EARTH AND SPACE – *Short Answer* What is the maximum angle a cliff face can remain stable at before collapsing known as?

ANSWER: Angle of Repose

### BONUS

3) EARTH AND SPACE – *Short Answer* What is the incident stellar flux, to the nearest hundredth, of a star of 5 solar luminosities at a distance of  $9.8 \times 10^5$  meters?

ANSWER:  $0.31 \text{ W/m}^2$  ( $3.8 \times 10^{26} / (4\pi(9.8 \times 10^5)^2)$ )

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### TOSS-UP

4) PHYSICS – *Multiple Choice* Which of the following is closest to the decay time of a bottom quark?

W)  $10^{-43}$  seconds

X)  $10^{-24}$  seconds

Y)  $10^{-12}$  seconds

Z)  $10^{-3}$  seconds

ANSWER: Y)  $10^{-12}$  seconds

### BONUS

4) PHYSICS – *Short Answer* A particle with a rest mass of 3.4 kg is moving with a speed of  $0.6c$ . To three significant figures, in kilogram meters per second and in terms of  $c$ , what is the relativistic momentum of the particle?

ANSWER: 2.55 C

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### TOSS-UP

5) MATH – *Multiple Choice* If an ellipse has equation  $\frac{(x-2)^2}{144} + \frac{(y-3)^2}{25}$ , what is the distance between its two foci?

W)  $2\sqrt{17}$

X)  $2\sqrt{119}$

Y)  $4\sqrt{17}$

Z)  $4\sqrt{119}$

ANSWER: X)  $2\sqrt{119}$

### BONUS

5) MATH – *Short Answer* The rate at which Oscar types his words in his codeforces contest at time  $t$  minutes after starting can be modeled by the equation  $R(t) = 30\pi\sin^3(\pi t) + 1$ . If Oscar begins programming with zero words typed, how many words will be present after 3 minutes?

ANSWER: 43

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### TOSS-UP

6) ENERGY – *Short Answer* Scientists at Brookhaven National Lab are studying the lac operon. In the lac operon of *E. coli*, lactose serves as an inducer that enables the transcription of genes involved in lactose metabolism. However, the presence of glucose inhibits the lac operon even if lactose is available. What is the name of the regulatory mechanism that allows glucose to inhibit the lac operon?

ANSWER: catabolite repression

### BONUS

6) ENERGY – *Multiple Choice* Researchers for the Renewable Energy Lab are studying geothermal power. In a geothermal power plant, the efficiency of energy conversion is influenced by the type of geothermal resource used. Which of the following types of geothermal resources is typically associated with the highest efficiency in a geothermal power plant?

- W) hot dry rock
- X) liquid-dominated
- Y) vapor-dominated
- Z) low-temperature

ANSWER: Y) vapor-dominated

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### TOSS-UP

7) BIOLOGY – *Multiple Choice* The absence of Vitamin B12 causes pernicious anemia. Which of the following gastrointestinal secretions plays the largest role in the absorption of Vitamin B12?

- W) Pepsinogen
- X) Intrinsic factor
- Y) Bile
- Z) Pancreatic protease

ANSWER: X) INTRINSIC FACTOR

### BONUS

7) BIOLOGY – *Multiple Choice* What type of mimicry is exhibited when a Bird-dropping Spider produces similar pheromones as moths - their prey - thereby mimicking their scent.

- W) Batesian
- X) Mullerian
- Y) Peckhamian
- Z) Vavilovian

ANSWER: Y) Peckhamian

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### TOSS-UP

8) CHEMISTRY – *Multiple Choice* Given the equilibrium constant value for a 2 L system undergoing the Haber process is 8, if the system at equilibrium includes 2 moles of hydrogen gas and 4 moles of Nitrogen gas, how many moles of Ammonia are in the tank?

- W) 6
- X) 8
- Y) 10
- Z) 12

Answer: X) 8

### BONUS

8) CHEMISTRY – *Multiple Choice* Jimmy is performing a radical halogenation on propane. Which of the following best explains why he would do a bromination instead of a chlorination?

- W) Bromination is faster than chlorination
- X) Chlorine is not reactive enough
- Y) Bromination is more selective
- Z) Bromine is less stinky than chlorine

ANSWER: Y) Bromination is more selective

### TOSS-UP

9) EARTH AND SPACE – *Short Answer* Below a certain depth in glaciers, known as the brittle-plastic deformation, ice crystals will begin to flow rather than crack. What depth is this layer found at?

ANSWER: 60 meters

### BONUS

9) EARTH AND SPACE – *Short Answer* What is the three-mile-thick area of the mesosphere which emits a yellow light due to, and is the most visible constituent of, airglow called?

ANSWER: sodium layer

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### TOSS-UP

10) PHYSICS – *Short Answer* A car starts from rest and accelerates uniformly over a time of 10 seconds for a distance of 25 m. Determine the acceleration of the car in meters per second squared.

ANSWER: 0.5

### BONUS

10) PHYSICS – *Short Answer* Find the maximum torque, in Newton meters, on a 50-turn square loop of a wire of 20.0 cm on a side that carries 15.0 A of current in a 4.00-T field

ANSWER: 120

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### TOSS-UP

11) MATH – *Short Answer* How many digits are there in  $2^{204}$ ?

ANSWER: 62

### BONUS

11) MATH – *Short Answer* Find all solutions to the equation  $(x-5)^6 = 1$ .

ANSWER:  $6, 4, \frac{9}{2} \pm \frac{i\sqrt{3}}{2}, \frac{11}{1} \pm \frac{i\sqrt{3}}{2}$

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### TOSS-UP

12) ENERGY – *Short Answer* Researchers at ArDa SIAM have bacterial infections and are not being cured by antibiotics that target cell wall synthesis. Which unique group of bacteria is able to resist these kinds of antibiotics due to its lack of a cell wall?

ANSWER: mycoplasma

### BONUS

12) ENERGY – *Short Answer* Researchers at Niskayuna Newtons Lab are studying Type II superconductors. What is the phenomenon present in Type II superconductors in which they can retain their superconductivity in the presence of more powerful magnetic fields compared to Type I superconductors?

ANSWER: flux pinning

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### TOSS-UP

13) BIOLOGY – *Short Answer* What plant hormone, derived from linoleic acid, is responsible for development of reproductive structures?

ANSWER: Jasmonate

### BONUS

13) BIOLOGY – *Multiple Choice* Which of the following bacteria can produce endotoxins?

- W) Salmonella typhi
- X) Mycobacterium tuberculosis
- Y) Clostridium botulinum
- Z) Leuconostoc mesenteroides

ANSWER: W) SALMONELLA TYPHI



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### TOSS-UP

14) CHEMISTRY – *Multiple Choice* What is the lowest unoccupied molecular orbital in a molecule of O<sub>2</sub>?

W Sigma 2p

X Pi 2p

Y Pi 2p star

Z Sigma 2p star

ANSWER: Z) Sigma 2p star

### BONUS

14) CHEMISTRY – *Short Answer* How many stereoisomers are possible for the complex [Co(H<sub>2</sub>O)<sub>2</sub>(CN)<sub>2</sub>F<sub>2</sub>]?

ANSWER: 6

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### TOSS-UP

15) EARTH AND SPACE – *Short Answer* The presence of hornfels would indicate what geologic conditions of pressure and temperature?

ANSWER: low pressure, mid-high temperature

### BONUS

15) EARTH AND SPACE – *Short Answer* What is the incident stellar flux, to the nearest hundred, on an extrasolar planet given a distance of  $1.496 \times 10^{11}$  meters and stellar luminosity of  $1.339 \times 10^{28}$ ?

ANSWER: 47600 W/m<sup>2</sup>

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### TOSS-UP

16) PHYSICS – *Multiple Choice* Bottom quarks most often decay into either an up-quark or a charm quark via what fundamental force?

- W) Strong
- X) Weak
- Y) Electromagnetic
- Z) Gravity

ANSWER: X) Weak

### BONUS

16) PHYSICS – *Short Answer* An object is placed 15 cm in front of a diverging lens which has a focal length with a magnitude of 10 cm. Determine the image distance, in centimeters, from the lens.

ANSWER: 30 cm

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### TOSS-UP

17) MATH – *Short Answer* Identify all of the following series that converge: 1)  $\sum_{n=1}^{\infty} \frac{\ln(n)}{n}$ , 2)

$$\sum_{n=1}^{\infty} \frac{n!}{e^n}, 3) \sum_{n=1}^{\infty} \left(\frac{n+3}{n+4}\right)^n$$

ANSWER: NONE

### BONUS

17) MATH – *Short Answer* What is the determinant of the following 3 by 3 matrix? (Row One: Three, One, Two. Row Two: Negative Three, Five, Negative One. Row Three: Negative Two, Zero, Two)

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$$\begin{bmatrix} 3 & 1 & 2 \\ -3 & 5 & -1 \\ -2 & 0 & 2 \end{bmatrix}$$

ANSWER: 58

### TOSS-UP

18) ENERGY – *Multiple Choice* Scientists at Niskayuna Newtons Lab are researching the various layers of the earth. What is the approximate depth of the Earth's D'' (d double prime) layer?

- W) 700 km
- X) 1400 km
- Y) 3800 km
- Z) 2700 km

ANSWER: Z) 2700 km

### BONUS

18) ENERGY – *Multiple Choice* In radar systems, microwave frequency bands are crucial for different applications due to their specific propagation characteristics. Consider a radar system designed to detect small objects at long ranges with high resolution. If the radar operates in a frequency band that balances resolution with the ability to penetrate atmospheric moisture, which microwave frequency band would be most suitable?

- W) L-band
- X) W-band
- Y) V-band
- Z) X-band

ANSWER: Z) X-band