

NSI2 RR3

TOSS-UP

1) BIOLOGY – *Short Answer* What term refers to organisms who rely on autotrophic and heterotrophic nutrition?

ANSWER: MIXOTROPHS

BONUS

1) BIOLOGY – *Multiple Choice* Which of the following features or conditions would be least likely to show up on a PET scan?

- W) Aggressive metastatic cancer
- X) Alzheimer's disease
- Y) Benign tumor
- Z) Cardiac ischemia

ANSWER: Y) BENIGN TUMOR

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**TOSS-UP**

2) CHEMISTRY – *Multiple Choice* Which of the following nuclei does not contain a magic number of protons?

- W) Oxygen-16
- X) Sulfur-32
- Y) Nickel-56
- Z) Tin-116

ANSWER: X) Sulfur-32

**BONUS**

2) CHEMISTRY – *Short Answer* In terms of R, what is the molar heat capacity at constant pressure for iodine gas?

ANSWER:  $7/2 R$

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### TOSS-UP

3) EARTH AND SPACE – *Multiple Choice* Which of the following is closest to the axial tilt of Saturn?

W) 24°

X) 3°

Y) 177°

Z) 98°

ANSWER: W) 24 degrees

### BONUS

3) EARTH AND SPACE – *Short Answer* Comets which pass extremely close to the Sun and often evaporate or fragment are known by what name?

ANSWER: Sungrazers

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TOSS-UP

4) PHYSICS – *Short Answer* Given that Lithium has density 0.53 grams per centimeter cubed, to the nearest percentage, if a block of solid lithium is placed in a bucket of water, at equilibrium, and before any reaction can occur, what percentage of the blocks volume can be expected to be above the water surface?

ANSWER: 47%

BONUS

4) PHYSICS – *Short Answer* The magnetic field strength around a current carrying wire is proportional to the distance from the wire raised to what power?

ANSWER: -1

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TOSS-UP

5) MATH – *Short Answer* What is the absolute difference between the sum of the first 2023 evens and the first 2023 odds

ANSWER: 2023

BONUS

5) MATH – *Short Answer* What is $\sum_{n=0}^{\infty} 3\left(\frac{1}{4}\right)^n$ (READ AS: the sum from n=0 to infinity of 3 times one-fourth to the power n)?

ANSWER: 4

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### TOSS-UP

6) ENERGY – *Short Answer* Researchers are using graph based models to represent traffic dynamics in densely populated cities. What word describes a graph where each node is connected to every other node?

ANSWER: Complete

### BONUS

6) ENERGY – *Short Answer* Researchers are working on thinning key caches by using query-driven pruning to reduce expensive memory costs. Identify all of the following 3 computer components that can store memory: 1) SSD; 2) SDRAM; 3) ROM.

ANSWER: all

**TOSS-UP**

7) BIOLOGY – *Multiple Choice* Which of the following is characteristic of a dicot?

- W) Netlike Veins
- X) Fibrous root system
- Y) 1 Pore in pollen
- Z) Floral parts in multiples of 3

ANSWER: W) Netlike Veins

**BONUS**

7) BIOLOGY – *Multiple Choice* In diabetic ketoacidosis, due to a decrease in the level of carbohydrate metabolism, ketone bodies build up due to an increase in the metabolism of which of the following molecules?

- W) Glycerol
- X) Glycogen
- Y) Pyruvate
- Z) Fatty acids

ANSWER: Z) Fatty acids

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TOSS-UP

8) CHEMISTRY – *Multiple Choice* Which of the following best describes the pH at the equivalence point when an unknown concentration of oxalic acid is titrated with barium hydroxide?

- W) Less than 7
- X) Exactly 7
- Y) Greater than 7
- Z) The pH cannot be determined

ANSWER) Y) GREATER THAN 7

BONUS

8) CHEMISTRY – *Short Answer* What compound is the anhydride of nitric acid?

ANSWER: N_2O_5 (ACCEPT: Dinitrogen Pentoxide)

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### TOSS-UP

9) EARTH AND SPACE – *Short Answer* An exoplanet is discovered orbiting a star by small changes in redshift exhibited by the star. What method of exoplanet detection was used in this case?

ANSWER: Doppler Spectroscopy (ACCEPT: Radial Velocity method)

### BONUS

9) EARTH AND SPACE – *Multiple Choice* The presence of eclogite would indicate which of the following geologic conditions?

- W) low pressure, low temperature
- X) high pressure, low temperature
- Y) high pressure, high temperature
- Z) low pressure, high temperature

ANSWER: Y) high pressure, high temperature

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NSI2 RR3

TOSS-UP

10) PHYSICS – *Multiple Choice* A frictionless ramp with elevation angle 30 degrees has a pulley attached at the top corner with a rope wrapped around it. At either end of the rope are two boxes of mass 5 kg. One box is sitting on the ramp and the other is hanging off the ramp. Which of the following is closest to the downwards acceleration of the box hanging off the ramp?

W) 2.5 m/s^2

X) 5 m/s^2

Y) 10 m/s^2

Z) 20 m/s^2

ANSWER: W) 2.5 m/s^2

BONUS

10) PHYSICS – *Short Answer* To the nearest thousandth, what is the moment of inertia in kilogram meters squared of a thin uniform rod of mass 4.5 kg and length 20 cm if the rotational axis runs perpendicular to the rod length through the center?

ANSWER: 0.015

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### TOSS-UP

11) MATH – *Short Answer* A right triangle is formed when a ladder is leaned against a wall forming an angle,  $\theta$ . Given that the base of the ladder is 6 meters from the wall and the length of the ladder is 10 meters, calculate  $\cot(\theta)$ .

ANSWER:  $3/4$

### BONUS

11) MATH – *Short Answer* What is the most common method for finding the linear regression line of a data set?

ANSWER: Method of Least Squares

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### TOSS-UP

12) ENERGY – *Multiple Choice* Researchers at Oak Ridge National Lab are tuning vision language models using OmniVal, a GPU intensive program. Which of the following is NOT true regarding a GPU?

- W) It is effectively Turing complete
- X) They have a larger instruction set on average than CPUs
- Y) They can on average perform more operations than CPUs
- Z) It is maximized for optimal parallel throughput

ANSWER: X) They have a larger instruction set on average than CPUs

### BONUS

12) ENERGY – *Multiple Choice* Polystyrene can be found in various forms, including expanded polystyrene and solid polystyrene. Which of the following characteristics is a key difference between these two forms of polystyrene?

- W) Expanded polystyrene has a higher density than solid polystyrene.
- X) Expanded polystyrene is used primarily for its electrical conductivity.
- Y) Solid polystyrene is more commonly used for thermal insulation applications.
- Z) Expanded polystyrene contains trapped air bubbles that give it lightweight and insulating properties.

ANSWER: Z) Expanded polystyrene contains trapped air bubbles that give it lightweight and insulating properties.



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### TOSS-UP

13) BIOLOGY – *Short Answer* When epinephrine binds to adrenergic receptors and activates a G-protein coupled receptor, it converts ATP to cyclic AMP by activating what enzyme?

ANSWER: ADENYLYL CYCLASE (ACCEPT: ADENYLATE CYCLASE)

### BONUS

13) BIOLOGY – *Multiple Choice* Which of the following ethnic groups are more at risk for developing a vitamin D deficiency?

- W) Caucasians
- X) Asians
- Y) African Americans
- Z) Hispanics

ANSWER: Y) AFRICAN AMERICANS

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TOSS-UP

14) CHEMISTRY – *Short Answer* Identify all of the following four orbitals which have zero radial nodes: 1) 2s, 2) 2p, 3) 3p, 4) 3d

ANSWER: 2 AND 4

BONUS

14) CHEMISTRY – *Short Answer* How many sigma and pi bonds, respectively, are in one molecule of 2, 4, 6 trinitrotoluene?

ANSWER: 21 sigma and 6 pi

TOSS-UP

15) EARTH AND SPACE – *Multiple Choice* The juvenile stage of the Wilson Cycle is characterized by which of the following?

- W) widening and filling with water of rift valley
- X) creation of rift valley
- Y) formation of subduction zone at border
- Z) collision of continents

ANSWER: W) widening and filling with water of rift valley

BONUS

15) EARTH AND SPACE – *Short Answer* Which layer, separating the upper mantle from the transition zone, causes an increase in seismic wave velocity?

ANSWER: 410 km discontinuity



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TOSS-UP

16) PHYSICS – *Short Answer* There are two trains moving toward each other. The train moving to the west has velocity 200 m/s and mass 60 kg. The one moving east has velocity 240 m/s and mass 100 kg. After colliding with one another, they stick together. In meters per second, what is the velocity and direction at which the trains move after the collision?

ANSWER: 75 m/s east

BONUS

16) PHYSICS – *Multiple Choice* An upright object is 20 cm away from a concave mirror with focal length 10 cm. Which of the following best describes the image produced.

- W) The image is real and inverted
- X) The image is real and upright
- Y) The image is virtual and inverted
- Z) The image is virtual and upright

ANSWER: W) The image is real and inverted

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**TOSS-UP**

17) MATH – *Multiple Choice* Which of the following functions is even?

- W) Sine
- X) Secant
- Y) Cosecant
- Z) Cotangent

ANSWER: X) Secant

**BONUS**

17) MATH – *Short Answer* What is the area of a triangle with side lengths of 8, 13, and 15?

ANSWER:  $30\sqrt{3}$

**TOSS-UP**

18) ENERGY – *Multiple Choice* In the Material Plasma Exposure eXperiment, materials are subjected to plasma to simulate conditions in environments such as fusion reactors. One key measurement in these experiments is the deuterium ion flux. How does the deuterium ion flux specifically affect the behavior of tungsten, a material often used in plasma-facing components?

- W) It increases the material's thermal conductivity due to enhanced atomic diffusion.
- X) It leads to the formation of tungsten carbide, which improves the material's resistance to erosion.
- Y) It induces surface damage and promotes the formation of a porous structure, reducing the material's lifespan.
- Z) It decreases the material's melting point by introducing impurity atoms that act as flux.

Answer: Y) It induces surface damage and promotes the formation of a porous structure, reducing the material's lifespan.

**BONUS**

18) ENERGY – *Short Answer* Identify all of the following 3 statements are true of Type II errors.

- 1) The probability of a Type II error is represented by the variable 'beta'
- 2) Type II errors are known as false positives
- 3) A decrease in 'alpha' value increases the likelihood of a Type II error occurring.

ANSWER: 1 AND 3