

## Lexington Round 2

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### TOSS-UP

1) Physics – *Short Answer* A four kilogram ball is travelling along the x axis at negative three meters per second and collides inelastically at the origin with a two kilogram ball travelling at positive six meters per second. At what angle in degrees does the combined mass travel at relative to the positive x axis?

ANSWER: 135 DEGREES

### BONUS

1) Physics – *Multiple Choice* For a spherical droplet of water with radius  $r$  and a uniform density  $\rho$  falling from the sky, what power of  $r$  is the terminal velocity of the droplet dependent on?

- W) 0
- X) 0.5
- Y) 1
- Z) 1.5

ANSWER: X) 0.5

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### TOSS-UP

2) Biology – *Short Answer* Identify all of the following three statements concerning the nervous system that are true: 1) Schwann cells are located in the central nervous system only; 2) Microglia perform the functions of macrophages in the nervous system; 3) Myelination decreases neuron conduction speed.

ANSWER: 2 ONLY

### BONUS

2) Biology – *Short Answer* The oxygen evolving complex requires a cofactor of what transition metal in order to function?

ANSWER: MANGANESE

### TOSS-UP

3) Chemistry – *Multiple Choice* What is the molecular geometry around the central atom in iodine pentafluoride?

- W) Trigonal bipyramidal
- X) Square pyramidal
- Y) Pentagonal planar
- Z) See-saw

ANSWER: X) SQUARE PYRAMIDAL

### BONUS

3) Chemistry – *Short Answer* Identify all of the following three statements that are true about a galvanic cell that uses silver and zinc half cells: 1) The silver half cell is the anode; 2) Adding potassium chloride to the silver half cell will increase the cell potential; 3) Positively charged ions travel through the salt bridge to the zinc half cell.

ANSWER: 2 ONLY



### TOSS-UP

4) Earth and Space – *Short Answer* The Tolman-Volkov-Oppenheimer limit is to a neutron star as the Chandrasekar limit is to what stellar object?

ANSWER: WHITE DWARF

### BONUS

4) Earth and Space – *Short Answer* Identify all of the following three statements that are true about pegmatites: 1) They are coarse grained; 2) They are commonly found in dikes; 3) They form from water rich melts.

ANSWER: ALL

### TOSS-UP

5) Math – *Short Answer* In a 45 pointed regular star, what is the measure of each vertex angle in degrees?

ANSWER: 8

### BONUS

5) Math – *Short Answer* What is the sum of the factors of 360?

ANSWER: 1170



### TOSS-UP

6) Physics – *Short Answer* A ball is dropped from a tall building and falls  $d$  meters in the first 3 seconds of free fall. In terms of  $d$ , how many meters will the ball fall in the next 6 seconds?

ANSWER:  $8d$

### BONUS

6) Physics – *Short Answer* Identify all of the following three statements that are true about neutrinos: 1) They are massless; 2) They oscillate between different states; 3) They follow Bose-Einstein statistics.

ANSWER: 2 ONLY

### TOSS-UP

7) Biology – *Multiple Choice* Which of the following animals is NOT a deuterostome?

- W) Garden snail
- X) Sea cucumber
- Y) Shark
- Z) Tunicate

ANSWER: W) GARDEN SNAIL

### BONUS

7) Biology – *Short Answer* Which early generation sequencing method involves the fragmentation of the genome into many parts and then their reconstruction via computers?

ANSWER: WHOLE GENOME SHOTGUN SEQUENCING (ACCEPT: SHOTGUN SEQUENCING)

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### TOSS-UP

8) Chemistry – *Short Answer* Scheele's green is a dye with chemical formula  $\text{CuHAsO}_3$ . What is the oxidation state of arsenic in Scheele's green?

ANSWER: +3

### BONUS

8) Chemistry – *Short Answer* Order the following molecules in increasing carbon oxygen bond lengths: 1) Acetic acid; 2) Methanol; 3) Carbonic acid.

ANSWER: 1, 3, 2

### TOSS-UP

9) Earth and Space – *Multiple Choice* Which of the following is true about oxisols?

- W) They are never found in tropical environments
- X) They are poor in iron and aluminum oxides
- Y) They are low in plant nutrients
- Z) They are highly unweathered

ANSWER: Y) THEY ARE LOW IN PLANT NUTRIENTS

### BONUS

9) Earth and Space – *Short Answer* Identify all of the following classes of stars that possess convective cores as opposed to radiative cores: 1) G; 2) A; 3 ) B.

ANSWER: NONE

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### TOSS-UP

10) Math – *Multiple Choice* How many integer values of  $a$  exist such that the quadratic equation  $x^2 + ax + 9$  has only rational roots?

- W) 11
- X) 12
- Y) 13
- Z) 14

ANSWER: Y) 13

### BONUS

10) Math – *Multiple Choice* Which of the following affine transformation matrices would invert the 2D coordinate system?

- W) First row: 0, 1; Second row: 0, 1
- X) First row: 1, 2; Second row: 1, 3
- Y) First row: 3, 2; Second row: 2, 3
- Z) First row: 1, 3; Second row: 3, 1

ANSWER: Z) FIRST ROW: 1,3; SECOND ROW: 3,1

### TOSS-UP

11) Physics – *Short Answer* What is the energy stored inside a 60 microfarad capacitor connected to a 20 volt battery in millijoules?

ANSWER: 12

11) Physics – *Short Answer* What fraction of the heat capacity at constant volume of a linear molecule in the gas phase is caused by vibrational modes?

ANSWER: 3/5

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### TOSS-UP

12) Biology – *Multiple Choice* According to the ABC hypothesis, which of the following statements concerning flowering is true?

- W) Inactivation of A genes lead to loss of sepals and carpels
- X) Inactivation of A genes leads to complementary expression of C genes
- Y) Inactivation of B genes leads to no flowering
- Z) Inactivation of C genes leads to loss of petals

ANSWER: X) INACTIVATION OF A GENES LEADS TO COMPLEMENTARY EXPRESSION OF C GENES

### BONUS

12) Biology – *Short Answer* Identify all of the following amino acid residues that would be found on the inside of a correctly folded protein, indicating it is more stable in the core than on the surface: 1) Alanine; 2) Tryptophan; 3) Glycine.

ANSWER: ALL

### TOSS-UP

13) Chemistry – *Multiple Choice* Which of the following molecular geometries has the highest steric number?

- W) Tetrahedral
- X) Bent
- Y) Square planar
- Z) Trigonal bipyramidal

ANSWER: Y) SQUARE PLANAR

### BONUS

13) Chemistry – *Short Answer* Order the following three elements in increasing second ionization energy: 1) Lead; 2) Aluminum; 3) Silicon.

ANSWER: 1, 3, 2



### TOSS-UP

14) Earth and Space – *Short Answer* What igneous rocks, which can be found in dikes as well as conduits, can contain diamonds for which they are mined?

ANSWER: KIMBERLITES

### BONUS

14) Earth and Space – *Short Answer* Order the following three layers of an ophiolite in increasing depth: 1) Pillow lavas; 2) Peridotite; 3) Sheeted dikes.

ANSWER: 1, 3, 2

### TOSS-UP

15) Math – *Short Answer* In a convex polygon with 40 sides, how many diagonals will connect to a single vertex?

ANSWER: 37

### BONUS

15) Math – *Short Answer* Two real numbers  $x$  and  $y$  are chosen from the interval  $[0,6]$ . What is the probability that the sum  $2x + y$  is less than 6?

ANSWER:  $1/4$



### TOSS-UP

16) Physics – *Multiple Choice* Which of the following describes how the resistance of most metals changes with increasing temperature?

- W) Increases monotonically
- X) Decreases monotonically
- Y) Increases then decreases
- Z) Decreases then increases

ANSWER: W) INCREASES MONOTONICALLY

### BONUS

16) Physics – *Short Answer* A pipe filled with water decreases in elevation by 10 meters, but does not change in the velocity of water in the pipe. If the initial pressure inside the pipe is 3 times  $10^5$  pascals, what is the pressure of the pipe at the decreased elevation in pascals? The density of water is 1000 kilograms per cubic meter and  $g$  equals 10 meters per second squared.

ANSWER:  $4 \cdot 10^5$



### TOSS-UP

17) Biology – *Short Answer* Which enzyme is responsible for producing the second messenger cyclic GMP?

ANSWER: GUANYLYL CYCLASE

### BONUS

17) Biology – *Short Answer* Ridings experiences a COVID-19 infection in his upper respiratory tract and his J receptors are inactivated. Identify all of the following actions that he is unable to perform: 1) Hering-Breuer reflex; 2) Contraction of diaphragm; 3) Breathing at normal air flow rate.

ANSWER: JUST 1

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### TOSS-UP

18) Chemistry – *Short Answer* Order the following three unit cell structures in increasing packing efficiency: 1) Simple cubic; 2) Face centered cubic; 3) Body centered cubic.

ANSWER: 1, 3, 2

### BONUS

18) Chemistry – *Short Answer* Which of the following explains why hydrated iron 2+ cations complex more completely with cyanide ions than with chloride ions in aqueous solution?

- W) Cyanide is a harder lewis base than chloride
- X) Cyanide accepts pi electrons while chloride donates pi electrons
- Y) Cyanide donates d electrons while chloride accepts d electrons
- Z) Cyanide is a poorer leaving group than chloride

ANSWER: W) CYANIDE IS A STRONGER LEWIS BASE THAN CHLORIDE

### TOSS-UP

19) Earth and Space – *Short Answer* What is the collective term for the group of asteroids whose orbits cross into the inner solar system?

ANSWER: APOLLO-AMOR OBJECTS

### BONUS

19) Earth and Space – *Short Answer* What term is given to the period of evolution in a star's history in which the contents of its convection zone extends to the fusion products and thus changes the spectral signature of the star?

ANSWER: DREDGE-UP

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### TOSS-UP

20) Math – *Short Answer* Sean has picked three digits  $a$ ,  $b$  and  $c$  and arranged them to form the six digit number  $abcabc$ . What is the largest positive integer that must be a factor of Sean's number?

ANSWER: 1001

### BONUS

20) Math – *Short Answer* Identify all of the following three functions whose second derivative with respect to  $x$  is equivalent to the function: 1)  $\ln x$  [*the natural log of  $x$* ]; 2)  $\cosh x$  [*hyperbolic cosine of  $x$* ]; 3)  $e^{-x}$  [ *$e$  to the power of negative  $x$* ].

ANSWER: 2 AND 3

### TOSS-UP

21) Physics – *Short Answer* For a spinning gyroscope, the product of the rate of precession and angular momentum of the gyroscope is equal to what vector quantity?

ANSWER: TORQUE

### BONUS

21) Physics – *Multiple Choice* According to Noether's theorem, the conservation of energy is due to a symmetry in which of the following?

- W) Time
- X) Translation
- Y) Rotation
- Z) Vibration

ANSWER: W) TIME



### TOSS-UP

22) Biology – *Short Answer* Albert is suffering from kwashiorkor and thus has a deficiency of a certain macromolecule. Identify all of the following three foods that would help his kwashiorkor: 1) The lard of a cow; 2) A fresh baguette; 3) The liver of a pig.

ANSWER: 3 ONLY

### BONUS

22) Biology – *Short Answer* What is the causative agent, and genus of the vector of Malaria respectively?

ANSWER: PLASMODIUM FALCIPARUM AND ANOPHELES MOSQUITO

### TOSS-UP

23) Chemistry – *Short Answer* The reaction  $10A + 26B \rightarrow 12C$  has an equilibrium constant of 0.5. What is the equilibrium constant for the reaction  $6C \rightarrow 5A + 13B$  to one decimal place?

ANSWER: 1.4

### BONUS

23) Chemistry – *Short Answer* How many  $^{13}\text{C}$ -NMR signals are observed in the spectrum of 3,5 dimethylaniline?

ANSWER: 5

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### TOSS-UP

24) Earth and Space – *Multiple Choice* Surface salinity of water is highest at which of the following latitudes?

- W) 90 degrees
- X) 60 degrees
- Y) 30 degrees
- Z) 0 degrees

ANSWER: Y) 30 DEGREES

### BONUS

24) Earth and Space – *Short Answer* Identify all of the following three statements that are true of population I stars: 1) They are found in the galactic halo; 2) They can be found in globular clusters; 3) They are metal rich.

ANSWER: 3 ONLY

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### TOSS-UP

25) Math – *Short Answer* Gideon is trying to travel from the origin to the point (3,3) without passing through the point (2,2). How many paths with a length of 6 units can Gideon take?

ANSWER: 8

### BONUS

25) Math – *Short Answer* How many perfect squares are divisors of the product  $1! \times 2! \times 3! \times 4! \times 5! \times 6!$

ANSWER: 42