

## Niskayuna Winter Invitational Finals

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### TOSS-UP

1) PHYSICS – *Short Answer*—What is the term given to the specific spectral line-splitting effect resulting when atoms absorb or emit radiation in the presence of an electric field?

ANSWER: STARK EFFECT

### BONUS

1) PHYSICS – *Multiple Choice*—In optics, which of the following terms describes the phenomenon by which a beam of light splits into two beams with perpendicular polarization states upon passing through a crystal or material?

W) Faraday effect

X) Birefringence

Y) Polarization

Z) Kerr effect

ANSWER: X) BIREFRINGENCE

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### TOSS-UP

2) CHEMISTRY – *Short Answer*—Identify all of the following 3 diatomic species that are paramagnetic: 1)  $\text{Li}_2$ , 2)  $\text{B}_2$ , 3)  $\text{O}_2$

ANSWER: 2 AND 3

### BONUS

2) CHEMISTRY – *Multiple Choice*—When 2,3 dimethylbut-1-ene is reacted with 1 molar sulfuric acid, an alcohol is formed. On what type of carbon will you find the alcohol group on?

W) Primary

X) Secondary

Y) Tertiary

Z) Quaternary

ANSWER: Y) Tertiary

### TOSS-UP

3) ENERGY – *Short Answer*—Scientists at Argonne National Lab are studying Menkes disease, a genetic disease affecting the absorption of copper. Specifically, they are studying what protein, which contain iron-sulfur clusters and act as electron transfer agents in redox reactions?

ANSWER: FERREDOXIN

### BONUS

3) ENERGY – *Short Answer*—Scientists at Berkeley National Lab are studying the structures of proteins. Specifically, they are using what microscopy technique in which electrons are passed through samples that are held at extremely low temperatures to avoid the effects of the high-energy electron beams on the sample?

ANSWER: CRYOGENIC ELECTRON MICROSCOPY

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### TOSS-UP

4) EARTH AND SPACE – *Multiple Choice*—Zeta Persei is a lower luminosity supergiant with an apparent magnitude of 2.9, shining 47,000 times brighter than the sun and 14 times more massive, with a temperature of approximately 21,000K. Which of the following is the Yerkes classification of Zeta Persei?

W) Ib (read as: one-B)

X) 0

Y) B

Z) V (read as: 5)

ANSWER: W) Ib

### BONUS

4) EARTH AND SPACE – *Short Answer*—Stars of what solar mass or greater will only follow the Henyey track throughout their evolution to the main sequence?

ANSWER: 3

**TOSS-UP**

5) MATH – *Multiple Choice*—If a circle with equation  $x^2 + y^2 = 64$  has the part in the third quadrant removed, and turned into a cone, which of the following would be its volume?

W)  $12\sqrt{7}\pi$

X)  $24\sqrt{7}\pi$

Y)  $36\sqrt{7}\pi$

Z)  $72\sqrt{7}\pi$

ANSWER: X)  $24\sqrt{7}\pi$

**BONUS**

5) MATH – *Short Answer*—What is the cross product of the two vectors  $3i+7j+5k$  and  $5i+3j+2k$ ?

ANSWER:  $-i + 19j - 26k$

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**TOSS-UP**

6) BIOLOGY – *Short Answer*—In the fetal circulatory system, the site of gaseous exchange is at the placenta, not at the lungs. As such, a portion of deoxygenated blood entering the lungs through the pulmonary arteries must be detoured to the umbilical cords to be oxygenated at the placenta. What is the name of the opening that enables this detour?

ANSWER: DUCTUS ARTERIOSUS

**BONUS**

6) BIOLOGY – *Multiple Choice*—A dexamethasone suppression test is a test used to diagnose Cushing's syndrome. Dexamethasone, a corticosteroid, is administered to determine if the hypothalamic-pituitary-adrenal axis functions properly as a negative feedback loop. Which of the following is the first hormone in this pathway, secreted by the hypothalamus?

W) Adrenocorticotrophic hormone

X) Corticotropin releasing hormone

Y) Cortisol

Z) Aldosterone

ANSWER: X) CORTICOTROPIN RELEASING HORMONE

### TOSS-UP

7) PHYSICS – *Short Answer*—By name or number, identify all of the following three statements that are true regarding Reynolds number: 1) it is a dimensionless ratio, 2) laminar flow tends to occur at high Reynolds numbers, 3) Reynolds number cannot be calculated for non-Newtonian fluids

ANSWER: 1 ONLY

### BONUS

7) PHYSICS – *Short Answer*—ANDrey hates thermo, so he takes his hollow spherical heat engine and rolls it down a ramp with height 300m. Using  $g$  as  $10\text{m/s}^2$ , when the engine is at the bottom of the ramp and is moving entirely horizontally, what is its speed in m/s?

ANSWER: 60

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### TOSS-UP

8) CHEMISTRY – *Multiple Choice*—Which of the following complexes has the greatest ligand splitting field?

- W)  $[\text{Co}(\text{CN})_6]^{4-}$  (hexacyanocobaltate 2)
- X)  $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$  (hexaaquacobalt 2)
- Y)  $[\text{Co}(\text{OH})_6]^{3-}$  (hexahydroxycobalt 3)
- Z)  $[\text{Fe}(\text{SCN})_6]^{3-}$  (iron 3 hexathiocyanate)

ANSWER: W)  $[\text{Co}(\text{CN})_6]^{4-}$

### BONUS

8) CHEMISTRY – *Short Answer*—Identify all of the following 3 solvents that are ethereal: 1) 1,2-dimethylcyclohexane; 2) 2-(2-Methoxyethoxy)ethanol; 3) Benzene?

ANSWER: 2 ONLY

### TOSS-UP

9) ENERGY – *Multiple Choice*—Researchers at Northwestern’s Center for Sleep and Circadian Biology have demonstrated that NMDAR activation plays a key role in regulating sleep-wake cycles. NMDA belongs to which of the following classes of receptors, primarily found on neuronal and glial cells and whose ligand is the most common excitatory neurotransmitter in the nervous system?

- W) Alpha receptors
- X) Beta receptors
- Y) Glutamate receptors
- Z) Muscarinic receptors

ANSWER: Y) GLUTAMATE RECEPTORS

### BONUS

9) ENERGY – *Multiple Choice*—Researchers at NYU’s Kirsch lab are studying the role of annexins in chondrocyte differentiation events. Which of the following is not true about annexins?

- W) They are not found in prokaryotes
- X) They function as scaffolding proteins
- Y) They lack quaternary structure
- Z) They primarily function in the nucleus

ANSWER: Z) THEY PRIMARILY FUNCTION IN THE NUCLEUS

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### TOSS-UP

10) EARTH AND SPACE – *Short Answer*—By name or number, identify all of the following three species that are not classified as a living fossil: 1) *Lepidodendron*, 2) *Ammonite*, 3) *Mudskipper*

ANSWER: 1 AND 2

### BONUS

10) EARTH AND SPACE – *Multiple Choice*—Which of the following trilobite genera is classified as an Agnostid?

- W) *Corynexochida* (read as: cory-nex-o-chee-da)
- X) *Peronopsis*
- Y) *Eldredgeops* (read as: el-dredge-e-ops)
- Z) *Ptychopariida* (read as: pity-cho-pa-ree-da)

ANSWER: X) PERONOPSIS

**TOSS-UP**

11) MATH – *Multiple Choice*—Which of the following values is closest to  $\sin(0.5)$ ?

W) 0.47

X) 0.48

Y) 0.49

Z) 0.50

ANSWER: X) 0.48

**BONUS**

11) MATH – *Short Answer*—Solve the equation  $(x + 3)^6 = 1$

ANSWER:  $-4, -2, \frac{-5}{2} \pm \frac{i\sqrt{3}}{2}, \frac{-7}{2} \pm \frac{i\sqrt{3}}{2}$

### TOSS-UP

12) BIOLOGY – *Short Answer*—You decide to experiment with severing different optic nerves to see what will happen. By name or number, identify all of the following four nerves that would cause complete blindness in the left eye, if severed: 1) left optic tract, 2) left optic nerve, 3) right optic tract, 4) right optic nerve

ANSWER: 2 ONLY

### BONUS

12) BIOLOGY – *Multiple Choice*—FSH is responsible for stimulating the granulosa cells in the ovarian follicles to produce aromatase. As such, which of the following steps in the synthesis of estradiol is influenced by FSH?

- W) Cholesterol to pregnenolone
- X) Pregnenolone to androstenedione
- Y) Androstenedione to testosterone
- Z) Testosterone to 17 $\beta$ -estradiol

ANSWER: Z) TESTOSTERONE TO 17 $\beta$ -ESTRADIOL

### TOSS-UP

13) PHYSICS – *Multiple Choice*—Which of the following types of mesons is distinguished by strangeness?

W) pion

X) kaon

Y) rho

Z) eta-c (read as: ey-tuh)

ANSWER: X) KAON

### BONUS

13) PHYSICS – *Short Answer*—Which law states that the direction of an induced electrical current will oppose the change that induced it?

ANSWER: LENZ'S LAW

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### TOSS-UP

14) CHEMISTRY – *Short Answer*—What type of strain is caused by atoms of the same molecule being multiple bonds away from each other, and getting forced closer together than their Van der Waals radii allow?

ANSWER: STERIC STRAIN

### BONUS

14) CHEMISTRY – *Short Answer*— To the nearest tenth of a celsius, what is the boiling point, in degrees celsius, of a solution of 4 moles of sodium hydroxide dissolved in one liter of water?

ANSWER: 104.1



### TOSS-UP

15) ENERGY – *Short Answer*—Scientists at Oak Ridge National Lab propose that the cause of pulmonary edema, nausea and fatigue due to COVID-19 is related to the excess secretion of bradykinin. What term is used to describe this model of COVID-19 pathogenesis?

ANSWER: BRADYKININ STORM

### BONUS

15) ENERGY – *Short Answer*—Similarly to the conversion of angiotensinogen to angiotensin-I by renin, what family of proteases are responsible for converting kininogen to bradykinin?

ANSWER: KALLIKREIN

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### TOSS-UP

16) EARTH AND SPACE – *Multiple Choice*—Which of the following atmospheric circulations has the strongest influence on high precipitation near the equator?

- W) Intertropical convergence zone
- X) Ferrel cell
- Y) Westerlies
- Z) Hadley cell

ANSWER: Z) HADLEY CELL

### BONUS

16) EARTH AND SPACE – *Short Answer*—By name or number, identify all of the following three forms of precipitation that can be formed by riming (read as: rhyming): 1) sleet, 2) hail, 3) graupel

ANSWER: 3 ONLY

### TOSS-UP

17) MATH – *Short Answer*—What is the inverse of the 2x2 matrix with first row 8, 3 and second row 4, 7.

ANSWER:  $\begin{bmatrix} \frac{7}{44} & \frac{-3}{44} \\ \frac{-1}{11} & \frac{2}{11} \end{bmatrix}$  (ACCEPT: FIRST ROW 7/44, -3/44 SECOND ROW -1/11, 2/11 OR EQUIVALENT WORDINGS)

### BONUS

17) MATH – *Short Answer*—Solve the first order differential equation where  $\frac{dy}{dx} = -2xy^2$  and  $y(1) = 0.25$ .

ANSWER:  $y=1/(x^2 + 3)$

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### TOSS-UP

18) BIOLOGY – *Multiple Choice*—Which of the following steps in the Citric Acid Cycle generates  $FADH_2$ ?

- W) Citrate to cis-aconitase
- X)  $\alpha$ -ketoglutarate to succinyl-CoA
- Y) succinate to fumarate
- Z) Malate to Oxaloacetate

ANSWER: Y) SUCCINATE TO FUMARATE

### BONUS

18) BIOLOGY – *Multiple Choice*—Which of the following sets of conditions would promote the nonoxidative phase of the pentose phosphate pathway but NOT the oxidative phase?

- W) The body needs Ribose-5-phosphate, but does not need NADPH
- X) The body does not need Ribose-5-phosphate, but needs NADPH
- Y) The body needs both Ribose-5-phosphate and NADPH
- Z) The body needs neither Ribose-5-phosphate nor NADPH

ANSWER: W) THE BODY NEEDS RIBOSE-5-PHOSPHATE, BUT DOES NOT NEED NADPH

### TOSS-UP

19) EARTH AND SPACE – *Multiple Choice*—Which of the following correctly identifies the difference between laccoliths and lopoliths?

- W) laccoliths will have an attached dike while lopoliths will not
- X) laccoliths are intrusive while lopoliths are extrusive
- Y) laccoliths form a dome while lopoliths form a depression
- Z) laccoliths are formed by high-viscosity magmas while lopoliths are formed by low-viscosity magmas

ANSWER: Y) LACCOLITHS FORM A DOME WHILE LOPOLITHS FORM A DEPRESSION

### BONUS

19) EARTH AND SPACE – *Multiple Choice*—In which of the following environments is serpentinization most likely to occur?

- W) divergent boundary between continental and oceanic crust
- X) transform boundary between oceanic crust
- Y) convergent boundary between continental crust
- Z) divergent boundary between oceanic crust

ANSWER: Z) DIVERGENT BOUNDARY BETWEEN OCEANIC CRUST



### TOSS-UP

20) MATH – *Multiple Choice*—Which of the following is a function defined for all reals which is continuous everywhere but differentiable nowhere?

- W) Mobius Function
- X) Weierstrass Function
- Y) Riemann Zeta Function
- Z) Thomae's Function

ANSWER: X) WEIERSTRASS FUNCTION

### BONUS

20) MATH – *Short Answer* — Evaluate  $\int_0^5 x[x]dx$ .

ANSWER: 35