## MEHS ROUND 13

### TOSS-UP

1) Physics – *Short Answer* An entire glass of wine flows down Tyrell Wellick's throat at an elevation of 0.9 meters. As the elevation of his throat gradually decreases, and assuming pressure is constant, what other quantity of the fluid flow must increase?

ANSWER: VELOCITY (ACCEPT: SPEED)

### BONUS

1) Physics – *Short Answer* The molar mass of smoke is 289 kilograms per mole. Assuming the temperature of the room is 8.31 kelvin, and the boltzmann constant is 8.31, and giving your answer in terms of radical 3 meters rounded to the nearest tenth, what is the root mean square speed of the smoke?

ANSWER: 0.5

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### TOSS-UP

2) Chemistry – *Multiple Choice* Which of the following is the molecular geometry of iodine heptafluoride?

W) Octahedral
X) Pentagonal bipyramidal
Y) Trigonal prismatic
Z) Cubic

ANSWER: X) PENTAGONAL BIPYRAMIDAL

### BONUS

2) Chemistry – *Short Answer* What ring structure does the cyclohexane ring adopt in order to minimize molecular strain?

ANSWER: CHAIR
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**TOSS-UP**

3) Energy – *Short Answer* Scientists at Oak Ridge National Lab are using x-rays to study the potential of using existing drugs to treat COVID-19. Scientists have determined that several hepatitis C drugs can inhibit the SARS-CoV-2 main protease. What organ does the hepatitis C virus mainly affect by causing inflammation?

ANSWER: LIVER

**BONUS**

3) Energy – *Short Answer* Scientists at Pacific Northwest National Lab are researching the impact of deep convective circulations on large storm complexes. Identify all of the following 3 statements regarding the circulation and development of thunderstorms that are true:
1) Thunderstorms start to dissipate shortly after it reaches the mature stage; 2) Multicell thunderstorms form in regions with weak wind speed shear; 3) Ordinary cell thunderstorms tend to form in regions with limited vertical wind shear.

ANSWER: 1 AND 3

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**TOSS-UP**

4) Earth and Space – *Short Answer* Thermohaline circulation drives the ocean conveyor belt. Thermohaline circulation is driven by global density gradients. What two factors together determine the density of seawater?

ANSWER: TEMPERATURE AND SALINITY

**BONUS**

4) Earth and Space – *Short Answer* Identify all of the following 3 statements regarding rayleigh waves that are true: 1) Rayleigh waves travel as ripples through liquids; 2) They are body waves that have a similar wavelength to love waves; 3) They have a distinct transverse wave motion that decreases in amplitude as the distance from the surface increases.

ANSWER: NONE OF THEM
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**TOSS-UP**

5) Math – *Multiple Choice* What is the sum of log base 3 of 243 plus log base 25 of one-fifth?

W) 3
X) 4.5
Y) 6.5
Z) 7

ANSWER: X) 4.5

**BONUS**

5) Math – *Short Answer* Calculate the average value of the function f of x equals 5 x to the fourth plus 3 x over the interval 0 to 3.

ANSWER: 31.5 (ACCEPT: 63/2)

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**TOSS-UP**

6) Chemistry – *Multiple Choice* Which of the following elements has their highest energy electron with angular momentum quantum number of 2 and magnetic quantum number of -3?

W) Chromium
X) Molybdenum
Y) Indium
Z) Tantalum

ANSWER: Z) TANTALUM

**BONUS**

6) Chemistry – *Short Answer* What is the product that forms as a result of the hydroboration-oxidation of 2-pentyne?

ANSWER: 2-PENTANAL
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**TOSS-UP**

7) Physics – *Short Answer* A wire carries a negative charge with a current density in the negative z direction. In what direction does the velocity in the wire move?

ANSWER: POSITIVE Z

**BONUS**

7) Physics – *Multiple Choice* A satellite burning at the perapsis of its' orbit will gain more speed than if it burned at the apoapsis of its' orbit. This phenomena is best explained by which of the following?

W) Tsiolkovsky rocket equation
X) Orbital decay
Y) Oberth effect
Z) Newton's law of universal gravitation

ANSWER: X) OBERTH EFFECT

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**TOSS-UP**

8) Biology – *Short Answer* The pericycle is a cylindrical structure in plants that strengthens the roots and provides protection for the vascular bundles. What two ground tissue types mainly make up the pericycle?

ANSWER: PARENCHYMA AND SCLERENCHYMA

**BONUS**

8) Biology – *Multiple Choice* Which of the following calcium-regulating hormones maintains the level of calcium and stimulates both resorption and formation of bones?

W) PTH
X) Calcitriol
Y) Calcitonin
Z) TSH

ANSWER: W) PTH
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**TOSS-UP**

9) Earth and Space – *Short Answer* What type of cloud forms in the stratosphere during the winter in northerly latitudes and are best observed during civil twilight due to its bright, iridescent appearance?

ANSWER: POLAR STRATOSPHERIC CLOUD (ACCEPT: NACREOUS CLOUDS)

**BONUS**

9) Earth and Space – *Short Answer* To one significant digit, what is the distance modulus of a star that has an apparent magnitude of 5.4 and an absolute magnitude of 2.4?

ANSWER: 40

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**TOSS-UP**

10) Math – *Multiple Choice* Which of the following pairs of degree measures satisfies the equation secant of x is equal to 2 over the square root of 3?

W) 30 and 330
X) 60 and 120
Y) 60 and 240
Z) 150 and 210

ANSWER: W) 30 AND 330

**BONUS**

10) Math – *Short Answer* A 13 foot ladder is sliding down a wall at a rate of 1 foot per second. How fast is the distance between the ladder and the wall changing, in feet per second, when the base of the ladder is 5 feet from the wall?

ANSWER: 2.4 (ACCEPT: 12/5)

11) Physics – *Multiple Choice* If a planet with gravitational acceleration g equals 9 meters per second squared has its radius doubled and its density halved, in meters per second squared, what is the new gravitational acceleration of the planet?

W) 4.5
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**TOSS-UP**

X) 9
Y) 18
Z) 36

ANSWER: X) 9

**BONUS**

11) Physics – *Short Answer* The maximum value for which quantity can be found by taking one minus the difference in temperature of the hot reservoir and the cold reservoir all over the temperature of the cold reservoir?

ANSWER: THERMAL EFFICIENCY (ACCEPT: EFFICIENCY)

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**TOSS-UP**

12) Energy – *Multiple Choice* Researchers at Fermi National Accelerator Lab have been studying high-energy proton antiproton collisions. A theoretical reaction of a proton decaying into a positron and electron neutrino violates which of the following conservation laws?

W) Conservation of lepton number
X) Conservation of charge
Y) Conservation of energy
Z) Conservation of baryon number

ANSWER: Z) CONSERVATION OF BARYON NUMBER

**BONUS**

12) Energy – *Short Answer* Researchers at Ames National Lab have been studying the role of different types of conductors in the national power grid. To minimize power losses due to resistance, what quantity is maximized in transmission lines which transmit electricity over long distances?

ANSWER: VOLTAGE

13) Biology – *Short Answer* In the extracellular matrix of animal cells, cells are binded to integrins on the membrane by what glycoprotein?

ANSWER: FIBRONECTIN

**BONUS**
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**TOSS-UP**

13) Biology – *Short Answer* Necrosis is a form of cell injury in which cells die prematurely. In necrosis, what process refers to the self-digestion and destruction of a cell through the action of its own enzymes?

ANSWER: AUTOLYSIS

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**TOSS-UP**

14) Earth and Space – *Short Answer* What type of hydrothermal vent has water temperatures below 30°C and generally emits water that is clear in color?

ANSWER: WARM-WATER VENTS

**BONUS**

14) Earth and Space – *Short Answer* What is the name of periodic variable stars that are used as standard candles and are located on the horizontal branch of the HR diagram, with spectral classes of A or F?

ANSWER: RR LYRAE VARIABLES
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**TOSS-UP**

15) Math – *Short Answer* What is the derivative of sin of x times the cotangent of x?

ANSWER: NEGATIVE SINE OF X

**BONUS**

15) Math – *Short Answer* If x cubed plus y cubed is equal to 27, in simplest form, find d squared y over d x squared.

ANSWER: NEGATIVE 54X OVER Y TO THE FIFTH (DO NOT ACCEPT ANY OTHER ANSWERS)

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**TOSS-UP**

16) Chemistry – *Multiple Choice* Which of the following molecules best demonstrates hyperconjugation?

W) Benzene
X) Diethyl Ether
Y) Ethyl carbocation
Z) Ethene

ANSWER: Y) ETHYL CARBOCATION

**BONUS**

16) Chemistry – *Short Answer* Identify all of the following 4 orbitals that have exactly 3 radial nodes: 1) 5d; 2) 4s; 3) 3p; 4) 6f

ANSWER: 2 AND 4 ONLY
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**TOSS-UP**

17) Energy – *Short Answer* Researchers at Thomas Jefferson National Lab have been imaging the coronavirus through scattering x-rays off of the coronavirus and determining an image from the scattered x-rays. What effect observes the increase in wavelength when x-rays are scattered by an object?

ANSWER: COMPTON SHIFT (ACCEPT: COMPTON EFFECT)

**BONUS**

17) Energy – *Multiple Choice* Researchers at Argonne National Lab are working on an upgrade to its' Advanced Photon Source user facility. Which of the following quantities is directly proportional to the energy of a photon?

W) Amplitude
X) Frequency
Y) Wavelength
Z) Period

ANSWER: X) FREQUENCY

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**TOSS-UP**

18) Biology – *Multiple Choice* Which of the following is not an adaptation of xerophytes?

W) Complex roots that grow deeply in all directions
X) Waxy and thorny leaves
Y) Reflective waves and hairs
Z) Thin cuticles

ANSWER: Z) THIN CUTICLES

**BONUS**

18) Biology – *Short Answer* In what phase of the cell cycle does growth and preparation for mitosis occur?

ANSWER: G2 PHASE

19) Earth and Space – *Short Answer* What is the name of the stellar objects that include OB associations, emission nebulae, young star clusters, and are used to map spiral arms?
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**TOSS-UP**

ANSWER: SPIRAL TRACERS

**BONUS**

19) Earth and Space – *Short Answer* Identify all of the following 3 statements regarding stellar populations that are true: 1) Population II stars are metal rich, containing 4 to 5 percent metals; 2) Population I stars belong to the disk component of galaxies; 3) Population I stars are relatively young compared to population II stars.

ANSWER: 2 AND 3

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**TOSS-UP**

20) Math – *Multiple Choice* A company sells donuts in boxes of 18 and boxes of 7. What is the largest number of donuts that cannot be purchased from a whole number of boxes given?

W) 95
X) 97
Y) 101
Z) 113

ANSWER: Y) 101

**BONUS**

20) Math – *Short Answer* What is the limit of the function f of x equals 1 minus cosine of x, all over the quantity 3x?

ANSWER: 0
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**TOSS-UP**

21) Physics – *Multiple Choice* Which of the following will decrease the capacitance of a parallel-plate capacitor?

W) Decreasing the plate area of the capacitor plates
X) Decreasing the distance between the plates
Y) Inserting a dielectric into the capacitor
Z) Increasing the plate area of the capacitor plates

ANSWER: W) DECREASING THE PLATE AREA OF THE CAPACITOR PLATES

**BONUS**

21) Physics – *Short Answer* The young man stands in front of a mirror, and sees an inverted reflection of himself. What type of mirror is he standing in front of?

ANSWER: CONCAVE (ACCEPT: CONCAVE MIRROR)

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**TOSS-UP**

22) Chemistry – *Multiple Choice* What is the name given to a system where the melting point of a homogenous mixture is less than the melting point of any of its elements?

W) Suspension
X) Colloidal
Y) Emulsive
Z) Eutectic

ANSWER: Z) EUTECTIC

**BONUS**

22) Chemistry – *Short Answer* What is the solubility product constant of aluminum sulfate, rounded to 2 decimal places, if the molar solubility of aluminum sulfate is 2.0 times 10 to the negative 4?

ANSWER: 3.46 TIMES 10 TO THE NEGATIVE 17
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**TOSS-UP**

23) Biology – *Short Answer* The globular form of which protein attaches at the plus end and dissociates at the minus end in a process known as treadmilling?

ANSWER: ACTIN

**BONUS**

23) Biology – *Short Answer* Wernicke–Korsakoff syndrome is caused by a deficiency of what vitamin?

ANSWER: VITAMIN B1 (ACCEPT: THIAMINE) (DO NOT ACCEPT: ANY OTHER B VITAMINS)