MEHS ROUND 12

TOSS-UP

1) Physics – *Short Answer* The Young's modulus for Sharon's throat is 430 pascals, while the shear modulus for her throat is 132 pascals. If the length of her throat is 6 centimeters, and giving your answer in pascals, how much pressure is required for her throat to stretch by 5 meters?

ANSWER: 11,000

BONUS

1) Physics – *Short Answer* A ball is launched into the air from ground level at an angle of 30 degrees. The initial velocity of the ball is 16 meters per second. Assuming that the acceleration due to gravity is 10 meters per second, and rounded to the nearest whole number, what is the maximum height that the ball reaches?

ANSWER: 3 METERS

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TOSS-UP

2) Chemistry – *Multiple Choice* Which of the following is not the possible name of a molecule with formula C5H8?

W) 2-pentyne
X) 1-ethyl cyclopropene
Y) 2-ethyl-1-butyne
Z) 3-methyl-1,2-butadiene

ANSWER: Y) 2-ETHYL-1-BUTYNE

BONUS

2) Chemistry – *Short Answer* Arrange the following 3 unit cell types from least dense to most dense: 1) Body-centered cubic; 2) Face-centered cubic; 3) Simple cubic.

ANSWER: 3, 1, 2
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TOSS-UP

3) Energy – *Multiple Choice* Scientists at Brookhaven National Lab are using lanthanide-binding tags to image proteins at the level of a cell membrane. What is the general name of proteins that utilize enzymes to assist in the moving of another molecule across a cell membrane?

ANSWER: TRANSLOCASE

BONUS

3) Energy – *Short Answer* Scientists at Lawrence Berkeley National Lab are conducting research on aquatic microbes to better understand food chains and chemical cycles. In harmful algal blooms, colonies of algae grow out of control while producing toxins when there is an excess of nutrients. Identify all of the following 3 nutrients that algal blooms might use when there is an excess: 1) Phosphorus; 2) Oxygen; 3) Sulfur.

ANSWER: 1 ONLY

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TOSS-UP

4) Earth and Space – *Short Answer* What is the name of the intermediate star stage that occurs between the last asymptotic giant branch phase and the planetary nebula phase, and emits strongly in infrared radiation?

ANSWER: PROTOPLANETARY NEBULA (ACCEPT: PREPLANETARY NEBULA)

BONUS

4) Earth and Space – *Short Answer* What is the name of the process that occurs when a river flowing in a single steam separates into two or more separate streams, often forming complex networks of distributaries?

ANSWER: RIVER BIFURCATION
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TOSS-UP

5) Math – *Multiple Choice* If f of 3 is 4, f prime of 3 is 0, g of 3 is 3, and g prime of 3 is negative 7, what is the derivative of f of x times g of x at x equals 3?

W) -28
X) -21
Y) 12
Z) 24

ANSWER: W) -28

BONUS

5) Math – *Short Answer* How many real number solutions are in the equation f of x equals x cubed minus 3 x plus 2?

ANSWER: 2

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TOSS-UP

6) Chemistry – *Multiple Choice* Which of the following is the smallest element capable of undergoing spontaneous alpha decay?

W) Beryllium
X) Iron
Y) Technetium
Z) Tellurium

ANSWER: W) BERYLLIUM

BONUS

6) Chemistry – *Short Answer* How many isomers can exist in a coordination complex if there are three different ligands in a central atom with octahedral geometry?

ANSWER: 6
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TOSS-UP

7) Physics – *Short Answer* A set of backup tapes are stored at a specific standard temperature at the Steel Mountain backup facility. If the standard temperature is tripled, then the tapes will lose data. By what factor will the amount of energy that the tapes absorb from thermal radiation increase?

ANSWER: 81

BONUS

7) Physics – *Multiple Choice* A confined electron can be classified as which of the following?

W) Matter wave
X) Boson
Y) Baryon
Z) Meson

ANSWER: W) MATTER WAVE

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TOSS-UP

8) Biology – *Multiple Choice* Which of the following types of sensory receptors are responsible for detecting stimuli that might be harmful?

W) Chemoreceptors
X) Thermoreceptors
Y) Nociceptors
Z) Mechanoreceptors

ANSWER: Y) NOCICEPTORS

BONUS

8) Biology – Short Answer The scutellum is a specialized structure with a large surface area found in grasses such a maize and wheat. What structure, found in dicots, is analogous to the scutellum in grasses?

ANSWER: COTYLEDONS
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TOSS-UP

9) Earth and Space – *Multiple Choice* Which of the following planets could not possibly be in opposition with the Earth?

W) Venus
X) Mars
Y) Jupiter
Z) Saturn

ANSWER: W) VENUS

BONUS

9) Earth and Space – *Short Answer* Order the following 3 minerals from first to crystallize in a magma chamber to last: 1) Amphibole; 2) Potassium feldspar; 3) Biotite mica.

ANSWER: 1, 3, 2

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TOSS-UP

10) Math – *Multiple Choice* What is the y component of a vector with magnitude of 3 and angle of 330 degrees?

W) Negative 1.5 root 3
X) Negative 1.5
Y) 1.5
Z) 1.5 root 2

ANSWER: X) NEGATIVE 1.5

BONUS

10) Math – *Short Answer* What is the equation of the line, given in slope-intercept form, that is tangent to the function f of x equals the natural log of the quantity x to the 4th power?

ANSWER: Y EQUALS 4 X MINUS 4

11) Physics – *Short Answer* What causes the scattering of a beam of light by an aerosol to make visible a light beam entering a window?

ANSWER: TYNDALL EFFECT
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TOSS-UP

BONUS

11) Physics – *Multiple Choice* What is the ratio of the total emitted power of a blackbody at 3000 K to one that is 600 K?

W) 625
X) 1000
Y) 3375
Z) 10000

ANSWER: W) 625

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TOSS-UP

12) Energy – *Multiple Choice* Researchers from Thomas Jefferson National Lab are studying the internal structure of the proton. From which of the following sources does the majority of a proton's charge derive from?

W) Nucleus that the proton is inside of
X) Gluons inside the proton
Y) Quarks inside the proton
Z) The effects of the nuclear strong force on the proton

ANSWER: Y) QUARKS INSIDE THE PROTON

BONUS

12) Energy – *Short Answer* Researchers at Oak Ridge National Lab are conducting experiments into using graphene to build semiconductors. Identify all of the following that are always true about semiconductors: 1) The gap between the conduction band and valence band in a semiconductor is greater than the gap between the two bands in insulators; 2) A semiconductor that has not been doped is still able to carry a current; 3) At absolute zero, a semiconductor will always have a greater fermi energy than a conductor if it has less conduction electrons;

ANSWER: 2 ONLY

13) Biology – *Multiple Choice* Which of the following neurotransmitters serves as the primary inhibitory neurotransmitter in the brain and applies its primary function in the synapses between neurons by binding to postsynaptic receptors?

W) Acetylcholine
X) GABA
Y) Serotonin
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TOSS-UP

Z) Dopamine

ANSWER: X) GABA

BONUS

13) Biology – *Short Answer* Identify all of the following 4 animals that belong in the phylum Arthropoda: 1) Snail; 2) Crab; 3) Ant; 4) Leeches.

ANSWER: 2 AND 3

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TOSS-UP

14) Earth and Space – *Multiple Choice* Which of the following events is most likely to cause a short gamma-ray burst?

W) Collision and explosion of two binary neutron stars
X) Collapse of a blue supergiant star
Y) Core-collapse of a supernova
Z) A tidal disruption event

ANSWER: W) COLLISION AND EXPLOSION OF TWO BINARY NEUTRON STARS

BONUS

14) Earth and Space – *Short Answer* In the formation of clouds, condensation nuclei are nuclei that water vapor condenses onto to form clouds. What is the name of the smallest class of condensation nuclei that only induce condensation when the air is supersaturated with water?

ANSWER: AITKEN NUCLEI
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TOSS-UP

15) Math – *Short Answer* What is the integral of the function h of x equals the natural log of 2x minus 1 from x equals 0 to x equals 3?

ANSWER: UNDEFINED (ACCEPT: INFINITY)

BONUS

15) Math – *Short Answer* There is a number 10 factorial that is equal to the product of a factorial and b factorial. What is the sum of a squared plus b squared?

ANSWER: 85

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TOSS-UP

16) Chemistry – *Multiple Choice* Which of the following elements requires the most energy to split its d orbital in the spectrochemical series?

W) Cyanide ion
X) Fluoride ion
Y) Ammonia
Z) Carbon monoxide

ANSWER: Z) CARBON MONOXIDE

BONUS

16) Chemistry – *Short Answer* What is the name of the phenomenon where the two outermost s electronsremain unshared in compounds of post-transition metals?

ANSWER: INERT PAIR EFFECT
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TOSS-UP

17) Energy – *Short Answer* Researchers at Argonne National lab are building a new quantum internet, which is immune to eavesdropping, as third-parties cannot view messages sent without destroying or altering the message. What quantum principle states that it is impossible to know the exact momentum and position of a particle simultaneously?

ANSWER: HEISENBERG UNCERTAINTY PRINCIPLE (ALSO ACCEPT: UNCERTAINTY PRINCIPLE)

BONUS

17) Energy – *Multiple Choice* Researchers at Fermi National lab have been conducting research into the properties of the Higgs Boson particle. Which of the following is the reason why the Higgs Boson is classified as a Boson particle?

W)The Higgs boson can form a Bose-Einstein condensate
X) The Higgs boson obeys the Pauli exclusion principle
Y) The Higgs boson is composed of 3 quarks
Z) The Higgs boson is affected by the nuclear strong force

ANSWER: W) THE HIGGS BOSON CAN FORM A BOSE-EINSTEIN CONDENSATE

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TOSS-UP

18) Biology – *Multiple Choice* Which of the following diseases are autosomal dominant?

W) Cystic fibrosis
X) Sickle cell anemia
Y) Tay-sachs disease
Z) Huntington's disease

ANSWER: Z) HUNTINGTON'S DISEASE

BONUS

18) Biology – *Short Answer* In the RAAS system, from what specialized structure composed of cells that are formed by the glomerular afferent arteriole is the enzyme renin released from?

ANSWER: JUXTAGLOMERULAR APPARATUS (ACCEPT: JGA)
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TOSS-UP

19) Earth and Space – *Multiple Choice* Which of the following minerals has two planes of cleavage that intersect at 90º?

W) Amphibole
X) Calcite
Y) Pyroxene
Z) Biotite

ANSWER: Y) PYROXENE

BONUS

19) Earth and Space – *Short Answer* In the solar system, what 2 planets have magnetic axes that are significantly offset from their centers?

ANSWER: URANUS AND NEPTUNE

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TOSS-UP

20) Math – *Multiple Choice* How many factors are there in the number 1 thousand and 1?

W) 4
X) 6
Y) 10
Z) 12

ANSWER: X) 6

BONUS

20) Math – *Short Answer* Calculate the limit of the function u of x equals tangent 2x over the quantity x times cosine of x at the value x equals 0?

ANSWER: 2
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TOSS-UP

21) Physics – *Multiple Choice* A perpetual motion machine has been built through a flowing current inducing a magnet to move, which then re-induces the flowing current. Which of the following laws of physics will need to be changed?

W) Newton's first law of force
X) Lenz's law
Y) Kirchhoff's junction rule
Z) Gauss's law

ANSWER: X) LENZ'S LAW

BONUS

21) Physics – *Short Answer* Whiterose is travelling in a spaceship. Relative to a stationary observer, Whiterose's ship is traveling at 0.4c. Rounded up to the nearest tenth, by what factor will the time of whiterose differ from the time of the observer?

ANSWER: 0.05

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TOSS-UP

22) Chemistry – *Multiple Choice* Which of the following Fluorides is not insoluble?

W) Lead (II) fluoride
X) Silver fluoride
Y) Calcium fluoride
Z) Aluminum fluoride

ANSWER: X) SILVER FLUORIDE

BONUS

22) Chemistry – *Short Answer* What is the sum of the degrees of the units in the rate constant of a reaction that is third order with respect to time?

ANSWER: -3
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TOSS-UP

23) Biology – *Short Answer* In the human body, what enzyme protects cellular organelles and tissues from damage by peroxide, and catalyzes the decomposition of hydrogen peroxide to water and oxygen?

ANSWER: CATALASE

BONUS

23) Biology – *Short Answer*

ANSWER: