MEHS ROUND 6

TOSS-UP

1) Physics – *Short Answer* Giving your answer in terms of the speed of light, and rounded to the nearest hundredth, what is the nuclear binding energy of a hydrogen cation?

ANSWER: 0

BONUS

1) Physics – *Short Answer* What is the combined resistance of three resistors, connected in parallel, which have individual resistances of 10 ohms, 15 ohms, and 6 ohms?

ANSWER: 3 OHMS

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TOSS-UP

2) Chemistry – *Multiple Choice* Which of the following is not an example of a free radical?

W) Hydroxyl group
X) Nitric oxide
Y) Carbenium
Z) Superoxide

ANSWER: Y) CARBENIUM

BONUS

2) Chemistry – *Short Answer* Which gas law states that, when the volume remains constant, the pressure of a given mass of gas is directly proportional with the temperature of the gas?

ANSWER: GAY-LUSSAC'S LAW
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TOSS-UP

3) Energy – *Multiple Choice* Scientists at Lawrence Berkeley National Lab are studying geothermal brines in an attempt to elucidate geothermal energy. Which of the following features could NOT develop in a geothermal region?

W) Mudpots
X) Geyser
Y) Hot springs
Z) Waterspout

ANSWER: Z) WATERSPOUT

BONUS

3) Energy – *Short Answer* Scientists at Pacific Northwest National Lab are studying groundwater flow using predictive models. Identify all of the following statements regarding groundwater that are true: 1) The topography of the water table varies with precipitation;
2) Primary porosity refers to the new pore spaces that formed after the first rock formation;
3) Aquitards are sediments or rocks that have low permeability and porosity.

ANSWER: 1 AND 3

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TOSS-UP

4) Earth and Space – *Multiple Choice* Which of the following terms would a geologist most likely use to describe how easily fluids are able to pass through an aquifer?

W) Porosity
X) Permeability
Y) Viscosity
Z) Fluidity

ANSWER: X) PERMEABILITY

BONUS

4) Earth and Space – *Short Answer* What general type of glacier exists in or adjacent to mountainous regions and flows from higher elevations to lower elevations?

ANSWER: MOUNTAIN GLACIER (ACCEPT: ALPINE GLACIER)
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TOSS-UP

5) Math – *Multiple Choice* What is the sum of the first 4 perfect cubes?

W) 75
X) 100
Y) 125
Z) 144

ANSWER: X) 100

BONUS

5) Math – *Short Answer* What is the area of a regular hexagon, given that the length of the apothem is 6 inches?

ANSWER: 72 ROOT 3

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TOSS-UP

6) Chemistry – *Multiple Choice* Which of the following chemical processes is exothermic?

W) Melting of ice
X) Breaking of bonds in a molecule
Y) Condensation of nitrogen gas
Z) Combustion of methane

ANSWER: Y) CONDENSATION OF NITROGEN GAS

BONUS

6) Chemistry – *Short Answer* To 3 decimal places, what is the number of kilojoules of energy in a 240 calorie cupcake, given that the specific heat of water is 4.2 joules per gram degree celsius?

ANSWER: 1.01 KILOJOULES
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TOSS-UP

7) Physics – *Short Answer* The total potential energy that a capacitor with capacitance 5 farads can store is 14.4 joules. Giving your answer in coulombs, what is the maximum charge that the capacitor can store?

ANSWER: 14

BONUS

7) Physics – *Multiple Choice* Alpha decay occurs in atoms due to which of the following phenomena?

W) Pair production
X) Quantum tunneling
Y) Proton capture
Z) Electron capture

ANSWER: X) QUANTUM TUNNELING

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TOSS-UP

8) Biology – *Short Answer* Marine snow is the name of the continuous shower of organic matter that supplies food for organisms living in the benthic zone. What is the general name that refers to all of the dead organic matter that comprises marine snow?

ANSWER: DETRITUS

BONUS

8) Biology – *Multiple Choice* Which of the following organs is an excretory and osmoregulatory system found in insects that are responsible for removing nitrogenous wastes?

W) Protonephridia
X) Metanephridia
Y) Malpighian tubules
Z) Kidneys

ANSWER: Y) MALPIGHIAN TUBULES

9) Earth and Space – *Multiple Choice* Which of the following features would be classified as a trace fossil?
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TOSS-UP

W) Carbon impression of a leaf
X) Insect embedded in amber
Y) A dinosaur's footprints
Z) The preserved bones of a dinosaur

ANSWER: Y) A DINOSAUR'S FOOTPRINTS

BONUS

9) Earth and Space – *Short Answer* Identify all of following statements about volcanic eruptions that are true: 1) Molten rock that has emerged through a volcano is referred to as a lava flow; 2) Pyroclastic debris are clouds of pre-existing igneous rock and blobs of lava sent into the sky through a volcanic eruption; 3) Effusive eruptions are characterized by lava flowing out of a vent, creating a lava flow.

ANSWER: 2 AND 3

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TOSS-UP

10) Math – *Multiple Choice* Which of the following is the greatest number of consecutive integers whose sum is equal to 67?

W) 67
X) 69
Y) 133
Z) 134

ANSWER: Z) 134

BONUS

10) Math – *Short Answer* What is the square root of the quantity (95 times 103, plus 16)?

ANSWER: 99

11) Physics – *Short Answer* A hydraulic press makes use of what principle to lift heavy objects?

ANSWER: PASCAL'S PRINCIPLE
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TOSS-UP

BONUS

11) Physics – *Multiple Choice* What is a process known as if it causes no net change in entropy?

W) Reversible
X) Irreversible
Y) Adiabatic
Z) Isobaric

ANSWER: W) REVERSIBLE

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TOSS-UP

12) Energy – *Multiple Choice* Researchers at Brookhaven National Lab have been investigating the link between electron spin and charge. Which of the following quantities are directly proportional to the magnitude of electron spin?

W) Spin quantum number
X) Orbital quantum number
Y) ħ ***[h-bar]***
Z) $\hbar^2$ ***[h-bar squared]***

ANSWER: Y) ħ ***[h-bar]***

BONUS

12) Energy – *Short Answer* Researchers at Princeton Plasma Physics National Lab have been conducting research into building fusion reactors. What is the general class of fusion reactors that rely on magnetic fields to contain plasma in a donut-shaped container?

ANSWER: TOKAMAK
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TOSS-UP

13) Biology – *Multiple Choice* Which of the following techniques are used to separate DNA fragments according to their size?

W) Polymerase chain reaction
X) Gel electrophoresis
Y) Molecular cloning
Z) Microarray assays

ANSWER: X) GEL ELECTROPHORESIS

BONUS

13) Biology – *Short Answer* What stage in animal development occurs after cleavage in the zygote?

ANSWER: BLASTULA

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TOSS-UP

14) Earth and Space – *Multiple Choice* Which of the following types of galaxies are characterized by quasar-like nuclei with a high-ionization emission line spectrum?

W) Spiral
X) Barred spiral
Y) Elliptical
Z) Seyfert

ANSWER: Z) SEYFERT

BONUS

14) Earth and Space – *Multiple Choice* Which of the following is responsible for separating the H I ***[H-one]*** clouds in the interstellar medium?

W) Intercloud medium
X) Local bubbles
Y) Interstellar dust
Z) Molecular dust

ANSWER: W) INTERCLOUD MEDIUM

15) Math – *Short Answer* If the surface area of a cube is 600 square centimeters, give the volume of the cube, and express your answer in terms of cubic centimeters.
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TOSS-UP

ANSWER: 1000

BONUS

15) Math – *Short Answer* What is the maximum value of the quadratic function, negative 2x squared + 6x + 4?

ANSWER: 17/2 (ACCEPT: 8.5, 8 1/2)

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TOSS-UP

16) Chemistry – *Multiple Choice* What is the name of an aliphatic, saturated hydrocarbon with a 6 carbon backbone?

W) Butane
X) Pentane
Y) Hexane
Z) Heptane

ANSWER: Y) HEXANE

BONUS

16) Chemistry – *Short Answer* Given that the solubility product constant for calcium sulfate is 4.9 times 10 to the negative 7, what is the molar solubility of calcium sulfate?

ANSWER: 7 TIMES 10 TO THE NEGATIVE 4
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TOSS-UP

17) Energy – *Short Answer* Researchers at Argonne National Lab have been conducting research into superfluids by exploring computer simulations of the Bose-Einstein condensate. Identify all of the following particles can't be in matter that is considered to be a Bose-Einstein condensate: 1) Proton; 2) Electron; 3) Pion; 4) Neutron.

ANSWER: 3 ONLY

BONUS

17) Energy – *Multiple Choice* Researchers at Oak Ridge National Lab have been streamlining the process of building a nuclear reactor. Which of the following is the main reason for nuclear reactors to have a large reactor core?

W) To reduce the chance of nuclear meltdown
X) A large reactor core reduces neutron leakage
Y) A large reactor core can hold more uranium fuel
Z) Neutrons move slower in a larger reactor core

ANSWER: X) A LARGE REACTOR CORE REDUCES NEUTRON LEAKAGE

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TOSS-UP

18) Biology – *Short Answer* What direction does helicase unwind DNA during replication?

ANSWER: 3 PRIME TO 5 PRIME

BONUS

18) Biology – *Multiple Choice* In the Cori cycle, glucose is metabolized to pyruvate and then to lactate in muscle. In which of the following organs is the lactate released into the blood and carried to?

W) Pancreas
X) Liver
Y) Gallbladder
Z) Spleen

ANSWER: X) LIVER
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TOSS-UP

19) Earth and Space – *Short Answer* What type of mass movement is the slowest and is caused by the downslope movement of particles that occurs on slopes covered with loose material?

ANSWER: CREEP

BONUS

19) Earth and Space – *Short Answer* Identify all of the following 4 glacial features that are depositional: 1) Cirque; 2) Moraine; 3) Kame; 4) Esker.

ANSWER: 2, 3, AND 4

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TOSS-UP

20) Math – *Multiple Choice* What is the maximum number of intersection points between 2 ellipses?

W) 1
X) 2
Y) 3
Z) 4

ANSWER: Z) 4

BONUS

20) Math – *Short Answer* What is the equation in slope-intercept form of a line passing through the point (2, –1) that is perpendicular to the line y = 1/4x - 2?

ANSWER: Y = -4X + 7
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TOSS-UP

21) Physics – *Multiple Choice* Suppose that the period of a pendulum with a 2 kilogram ball attached to it is 4.5 seconds. Which of the following would the length of the period be if the mass of the ball attached to the string was tripled?

W) 2.25
X) 4.5
Y) 9
Z) 18

ANSWER: X) 4.5

BONUS

21) Physics – *Short Answer* What is the name of the phenomenon that occurs when light is travelling from a more dense medium to a less dense medium, and the incident angle is greater than the critical angle for the material it is passing through?

ANSWER: TOTAL INTERNAL REFLECTION

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TOSS-UP

22) Chemistry – *Multiple Choice* How many atomic orbitals exist with the principal quantum number n = 4?

W) 4
X) 8
Y) 9
Z) 16

ANSWER: Z) 16

BONUS

22) Chemistry – *Short Answer* What is the name of the temperature and pressure at which the three phases of that substance coexist in thermodynamic equilibrium for a given substance?

ANSWER: TRIPLE POINT
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TOSS-UP

23) Biology – *Short Answer* What cellular organelle contains chromatin, which condenses into chromosomes during prophase?

ANSWER: NUCLEUS

BONUS

23) Biology – *Short Answer* Identify all of the following 3 statements that are true regarding ribozymes: 1) Ribozymes are DNA molecules that can catalyze reactions; 2) Self-splicing group one introns are a type of ribozymes; 3) Ribozymes are found in the golgi apparatus where they join amino acids together to form protein chains.

ANSWER: 2 ONLY