MEHS ROUND 5

TOSS-UP

1) Physics – *Short Answer* A falling object is no longer experiencing any acceleration. If the gravitational force on the object is 600 newtons, giving your answer in newtons, what is the drag force on the same object?

ANSWER: 600

BONUS

1) Physics – *Short Answer* How many quantum numbers are used to describe an electron confined in a two-dimensional electron trap?

ANSWER: 3

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TOSS-UP

2) Chemistry – *Multiple Choice* In a reaction mechanism, a substance first appears in the reactants side of a chemical step, then is used up later. Which of the following terms best describes this substance, which does not appear in the rate law?

W) Intermediate
X) Oxidizing agent
Y) Catalyst
Z) Grignard reagent

ANSWER: Y) CATALYST

BONUS

2) Chemistry – *Short Answer* Identify all of the following three statements that are true regarding Bronsted-Lowry acids and bases: 1) A Bronsted-Lowry base is a proton donor; 2) The chloride ion is the conjugate base of hydrochloric acid; 3) The ammonium ion is a weak acid.

ANSWER: 2 ONLY
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TOSS-UP

3) Energy – *Short Answer* Scientists at Oak Ridge National Lab are researching how changes in environment conditions can lead to an increase in tree death and possibly stunt the regrowth. What type of succession is demonstrated when trees in a forest regrow after a forest fire?

ANSWER: SECONDARY SUCCESSION

BONUS

3) Energy – *Short Answer* Scientists at SLAC National Accelerator Lab are conducting research on the early universe by studying signs of inflation. Order the following 4 events from the EARLIEST to the LATEST in the universe's evolution: 1) Galaxy formation; 2) Star formation; 3) Reionization; 4) Accelerated expansion.

ANSWER: 2, 1, 3, 4 (ACCEPT: STAR FORMATION, GALAXY FORMATION, REIONIZATION, ACCELERATED EXPANSION)

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TOSS-UP

4) Earth and Space – *Short Answer* What type of metamorphism occurs around intrusive igneous rocks and forms when a magma body enters the upper part of the crust, converting sedimentary rocks into metamorphic rocks?

ANSWER: CONTACT METAMORPHISM

BONUS

4) Earth and Space – *Short Answer* Identify all of the following three sources where terrigenous ***(te-RIJ-en-es)*** sediments could originate from: 1) Volcanoes; 2) Grinding by glaciers; 3) Chemical deposits.

ANSWER: 1 AND 2
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TOSS-UP

5) Math – *Multiple Choice* A basketball player has made 6 of 10 free throws in a game. How many more consecutive successful free throws must the player make in order to have a free throw percentage equal to 75%?

W) 3
X) 4
Y) 5
Z) 6

ANSWER: Z) 6

BONUS

5) Math – *Short Answer* There are 58 people in a room. What is the minimum number of people in the room who share the same birth month?

ANSWER: 5

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TOSS-UP

6) Chemistry – *Multiple Choice* Which of the following substances has the greatest molar entropy?

W) Solid methane
X) Gaseous butane
Y) Liquid methane
Z) Liquid butane

ANSWER: X) GASEOUS BUTANE

BONUS

6) Chemistry – *Short Answer* How many electrons are present in a neutral atom of calcium-44?

ANSWER: 20
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TOSS-UP

7) Physics – *Short Answer* What is the frequency of a wave, in hertz, if its period is 0.025 seconds?

ANSWER: 40

BONUS

7) Physics – *Multiple Choice* If the diameter of a planet was halved, but its density remained the same, how would the planet's gravitational force be affected at the surface of the planet?

W) Increase by a factor of 4
X) Increase by a factor of 2
Y) Decrease by a factor of 2
Z) Decrease by a factor of 4

ANSWER: Y) DECREASE BY A FACTOR OF 2

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TOSS-UP

8) Biology – *Multiple Choice* Which of the following chemicals is responsible for the stem elongation, flower growth, and germination of plant cells?

W) Jasmonates
X) Gibberellins
Y) Ethylene
Z) Cytokinins

ANSWER: X) GIBBERELLINS

BONUS

8) Biology – *Short Answer* Identify all of the 3 following brain regions that are correctly matched with its function: 1) Forebrain and regulation of complex processing; 2) Midbrain and routing of sensory input; 3) Hindbrain and coordination of motor and involuntary activities.

ANSWER: ALL (ACCEPT: 1, 2, 3)

9) Earth and Space – *Multiple Choice* Which of the following oceanic zones is the most productive and is responsible for supporting the majority of marine life?
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TOSS-UP

W) Intertidal
X) Neritic
Y) Oceanic
Z) Photic

ANSWER: X) NERITIC

BONUS

9) Earth and Space – *Multiple Choice* Which of the following hurricane parts is characterized by a ring of intense thunderstorms around the center, heavy precipitation, and strong winds?

W) Eye
X) Eyewall
Y) Spiral rain band
Z) Rainband

ANSWER: X) EYEWALL

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TOSS-UP

10) Math – *Multiple Choice* What is the sum of the prime factors of 90?

W) 10
X) 15
Y) 18
Z) 20

ANSWER: W) 10

BONUS

10) Math – *Short Answer* What is the area of a rhombus with a long diagonal of 12 and a side length of 10.

ANSWER: 96

11) Physics – *Multiple Choice* Which of the following conditions are required for Bernoulli's equation to be true?

W) The fluid flowing must be viscous
X) The fluid flowing must be compressible
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TOSS-UP

Y) The fluid flowing must have a rotational flow
Z) The fluid flowing must have a laminar flow

ANSWER: Z) THE FLUID FLOWING MUST HAVE A LAMINAR FLOW

BONUS

11) Physics – *Short Answer* Two waves of amplitude 13 meters have a phase difference of 60 degrees. To the nearest whole number, and in meters, when the two waves collide, what is the amplitude of the resultant wave?

ANSWER: 22

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TOSS-UP

12) Energy – *Multiple Choice* Researchers at Oak Ridge National Lab have been developing sensors to accurately measure the amount of electricity used by household appliances, by channeling the flux produced by an electric current into a wire in the sensor and measuring the resultant current. Which of the following relies on magnetic flux to generate a current?

W) RC circuit
X) Synchrotron
Y) Transformer
Z) Resistor

ANSWER: Y) TRANSFORMER

BONUS

12) Energy – *Short Answer* Researchers at Brookhaven National Lab have been researching the properties of charm quarks. What type of particles can be made up of at least two quarks?

ANSWER: HADRON

13) Biology – *Multiple Choice* Which of the following would most likely occur if vasoconstriction were to occur within arteriole walls?

W) Blood pressure would increase
X) Blood pressure would decrease
Y) Blood pressure would stay the same
Z) Blood pressure would increase, then decrease
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TOSS-UP

ANSWER: W) BLOOD PRESSURE WOULD INCREASE

BONUS

13) Biology – *Short Answer* What type of mimicry is demonstrated when two unpalatable species resemble each other, often causing the predator to learn to avoid prey with that particular appearance?

ANSWER: MULLERIAN MIMICRY

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TOSS-UP

14) Earth and Space – *Multiple Choice* Which of the following pressure systems would be found at the polar front?

W) Subtropical high
X) Subtropical low
Y) Subpolar high
Z) Subpolar low

ANSWER: Z) SUBPOLAR LOW

BONUS

14) Earth and Space – *Short Answer* What is the name of the process through which substances are added into clouds to act as condensation nuclei in order to increase precipitation?

ANSWER: CLOUD SEEDING
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TOSS-UP

15) Math – *Short Answer* What is the area of a sector of a circle, in terms of pi, with a radius of 12 and a central angle of 60 degrees?

ANSWER: 24π

BONUS

15) Math – *Short Answer* What is the median of the set of all positive factors of 100?

ANSWER: 10

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TOSS-UP

16) Chemistry – *Multiple Choice* Which of the following is the sum of the whole number coefficients in the smallest balanced reaction of the combustion of methane?

W) 4
X) 6
Y) 8
Z) 12

ANSWER: X) 6

BONUS

16) Chemistry – *Short Answer* If a gas at 300 kelvin has a pressure of 1.8 atm, calculate the pressure, in atm, of the container when the gas is heated to 450 kelvin, assuming the volume of the container remains the same and no new gas is added to the container.

ANSWER: 2.7 ATM
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TOSS-UP

17) Energy – *Short Answer* Researchers at Lawrence Berkeley National Lab have been investigating discrepancies in the standard model surrounding leptons. What fundamental force does not affect leptons?

ANSWER: STRONG NUCLEAR FORCE (ACCEPT: STRONG NUCLEAR)

BONUS

17) Energy – *Multiple Choice* Researchers at Argonne National Lab have been researching ways to produce sustainable fusion reactions. Which of the following reactions are most commonly used in fusion experiments to generate a fusion reaction?

W) Proton-proton reactions
X) Deuterium-deuterium reactions
Y) Neutron-neutron reactions
Z) Electron-electron reactions

ANSWER: X) DEUTERIUM-DEUTERIUM REACTIONS

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TOSS-UP

18) Biology – *Short Answer* What is the name of the process in which a protein loses its shape and ceases to perform its function?

ANSWER: DENATURATION

BONUS

18) Biology – *Multiple Choice* If a food tested with an iodine indicator turns purple, what compound does the food contain?

W) Monosaccharides
X) Proteins
Y) Polysaccharides
Z) Lipids

ANSWER: Y) POLYSACCHARIDES
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TOSS-UP

19) Earth and Space – *Short Answer* What is the name of the zone of charged particles in Earth's magnetosphere that is caused by the collision of charged particles radiated from solar wind?

ANSWER: VAN ALLEN BELTS

BONUS

19) Earth and Space – *Multiple Choice* Which of the following elements occurs in higher proportions in the Uranus and Neptune compared to Jupiter and Saturn, and is also responsible for the blue color of planets when it is the upper atmosphere due to its ability to absorb red light?

W) Methane
X) Nitrogen
Y) Helium
Z) Ammonia

ANSWER: W) METHANE

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TOSS-UP

20) Math – *Multiple Choice* If 20% of a number is 12, what is 30% of the same number?

W) 15
X) 18
Y) 20
Z) 24

ANSWER: X) 18

BONUS

20) Math – *Short Answer* What is the smallest positive integer whose digits have a product equal to 4 factorial?

ANSWER: 38
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TOSS-UP

21) Physics – *Multiple Choice* An electron and positron collide at very high speeds. What particles are produced from the reaction?

W) Two photons
X) Two neutrons
Y) One up quark and one down quark
Z) One proton and one electron

ANSWER: W) TWO PHOTONS

BONUS

21) Physics – *Short Answer* A capacitor stores 20 coulombs of charge and has a capacitance of 3.3 farads. Rounded to the nearest whole number, what is the potential energy of the capacitor?

ANSWER: 6 JOULES

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TOSS-UP

22) Chemistry – *Multiple Choice* If a weak base is titrated with a strong acid, which of the following pH ranges will most likely contain the pH of the solution at the equivalence point?

W) Between 12 and 14
X) Between 9 and 12
Y) Exactly 7
Z) Between 4 and 7

ANSWER: Z) BETWEEN 4 AND 7

BONUS

22) Chemistry – *Short Answer* How many hybridized orbitals are present on a carbon atom in a molecule of ethylene?

ANSWER: 3
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TOSS-UP

23) Biology – *Short Answer* What kind of cell is activated by MHC-1 antigen complexes and kills infected cells by releasing proteins called granzymes and perforin?

ANSWER: CYTOTOXIC T CELL

BONUS

23) Biology – *Short Answer* A scientist is looking at an animal cell under a microscope. He observes the formation of a cleavage furrow, and a contractile ring is shrinking near the equator of the cell. What process is the cell currently undergoing?

ANSWER: CYTOKINESIS