MEHS ROUND 4

TOSS-UP

1) Physics – *Multiple Choice* A car is parked on a hill. Which of the following interactions is not affecting the car?

W) Normal force
X) Gravitational force
Y) Tractional force
Z) Frictional force

ANSWER: Y) TRACTIONAL FORCE

BONUS

1) Physics – *Short Answer* If the frequency of a transverse wave doubles, by what factor would the average power of the wave increase?

ANSWER: 4

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TOSS-UP

2) Chemistry – *Multiple Choice* What is the type of reaction that occurs when baking soda is heated?

W) Double replacement
X) Single replacement
Y) Synthesis
Z) Decomposition

ANSWER: Z) DECOMPOSITION

BONUS

2) Chemistry – *Short Answer* What is the energy of a light wave, in joules, if its wavelength is 663 nanometers? Assume the value of the speed of light to be 3 times 10 to the 8th power and Planck's constant to be 6.63 times 10 to the negative 34th power.

ANSWER: 3 $*10^{-19}$JOULES
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TOSS-UP

3) Energy – *Multiple Choice* Scientists at Sandia National Lab are doing research on comet NEOWISE. Which of the following comet parts appears blue and always points away from the sun due to solar wind?

W) Nucleus
X) Coma
Y) Ion tail
Z) Dust tail

ANSWER: Y) ION TAIL

BONUS

3) Energy – *Short Answer* Scientists at SLAC National Accelerator Lab are doing research on iron in the Earth's core. Identify all of the following 3 statements regarding iron in the Earth's core that are true: 1) Earth's inner core is made up of an iron-nickel alloy; 2) The dynamo effect is generated by convection in the lower mantle; 3) Iron sunk to the Earth's core during its formation due to differentiation.

ANSWER: 1 AND 3

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TOSS-UP

4) Earth and Space – *Short Answer* What is the cross-sectional area of a stream with a discharge rate of 78 meters cubed and an average velocity of 6 meters a second, giving your answer in meters squared?

ANSWER: 13

BONUS

4) Earth and Space – *Multiple Choice* Which of the following magma types would typically have the highest silica content and be the most viscous and gaseous?

W) Basaltic
X) Andesitic
Y) Rhyolitic
Z) Dacitic

ANSWER: Y) RHYOLITIC

5) Math – *Multiple Choice* Phil had an average score of 64 for his first three rounds of golf. If his scores for the first two rounds were 68 and 61, what was his score for the third round?
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TOSS-UP

W) 63
X) 65
Y) 67
Z) 69

ANSWER: W) 63

BONUS

5) Math – *Short Answer* How many two-digit prime numbers have 3 as their units digit?

ANSWER: 6

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TOSS-UP

6) Chemistry – *Multiple Choice* What is the name of the series of light waves that occurs when an excited electron in a hydrogen atom falls to its second energy level?

W) Lyman
X) Rydberg
Y) Balmer
Z) Paschen

ANSWER: Y) BALMER

BONUS

6) Chemistry – *Short Answer* Identify all of the following four metals that are diamagnetic in their ground state: 1) Iron; 2) Beryllium; 3) Zinc; 4) Silver.

ANSWER: 2, 3, 4 (ACCEPT: ALL BUT 1)
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TOSS-UP

7) Physics – *Short Answer* A current of magnitude 8 amperes produces a uniform magnetic field of radius 4 meters. Assuming that the magnetic constant is 4 pi, and giving your answer in teslas, what is the magnitude of the magnetic field produced?

ANSWER: 2

BONUS

7) Physics – *Multiple Choice* Engineers at Steel Mountain have built a door capable of withstanding any direct collisions without deforming, given that it does not apply any tension on the door. This would require which of the following aspects of the object to be infinite?

W) Young's modulus
X) Bulk modulus
Y) Shear modulus
Z) Weight

ANSWER: Y) SHEAR MODULUS

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TOSS-UP

8) Biology – *Short Answer* In signal transduction, what stage occurs when a target cell detects a signaling molecule coming from outside of the cell?

ANSWER: RECEPTION

BONUS

8) Biology – *Short Answer* Dermatitis and enteritis are deficiency diseases that occur when there is a deficiency of what vitamin?

ANSWER: VITAMIN B7 (ACCEPT: BIOTIN)

9) Earth and Space – *Short Answer* What is the name of the phenomenon that occurs when there is a reversal of east-to-west wind flow, causing a countercurrent of warm water to develop in the Pacific ocean and gradually move to the east?
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TOSS-UP

ANSWER: EL NINO

BONUS

9) Earth and Space – *Short Answer* Identify all of the following 3 statements regarding air masses that are true: 1) The source region of an air mass is the region where the air mass originated from; 2) An air mass is a large body of air that has similar temperature and humidity in any horizontal direction at any altitude; 3) Air masses are classified based on the temperature and humidity of their source region.

ANSWER: ALL OF THEM

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TOSS-UP

10) Math – *Multiple Choice* The length and width of a rectangle add up to 16 units, and the length is three times the width. What is the area of the rectangle?

W) 12
X) 24
Y) 48
Z) 60

ANSWER: Y) 48

BONUS

10) Math – *Short Answer* If the side length of a cube is increased by 50%, by what factor is the volume of the cube increased?

ANSWER: 3.375 (ACCEPT: 27/8)

11) Physics – *Short Answer* Annihilation is the opposite of what phenomenon?

ANSWER: PAIR PRODUCTION

BONUS
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TOSS-UP

11) Physics – *Multiple Choice* What conditions must be necessary for two metals to cold-weld upon impact in a vacuum?

W) The two metals must have a very low temperature
X) The two metals must be made out of a very specific material
Y) The two metals must be moving at a very high speed
Z) The two metals must be very smooth and clean

ANSWER: Z) THE TWO METALS MUST BE VERY SMOOTH AND CLEAN

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TOSS-UP

12) Energy – *Multiple Choice* Researchers at Lawrence Berkeley National Lab have been conducting research into the composition of dark matter. Dark matter is primarily observed through interactions via which of the following fundamental forces?

W) Gravity
X) Electromagnetic
Y) Strong nuclear force
Z) Weak nuclear force

ANSWER: W) GRAVITY

BONUS

12) Energy – *Short Answer* Researchers at Idaho National Lab have created a new multi-mission radioisotope thermoelectric generator for use in space travel. The generator relies on the heat produced by the decay of the radioactive element plutonium-238, which naturally decays to uranium-234. What type of decay does plutonium-238 undergo?

ANSWER: ALPHA DECAY
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TOSS-UP

13) Biology – *Multiple Choice* Which of the following terms would be used to describe a molecule that has both hydrophilic and hydrophobic regions?

W) Selective
X) Amphipathic
Y) Hygroscopic
Z) Permeable

ANSWER: X) AMPHIPATHIC

BONUS

13) Biology – *Multiple Choice* Which of the following processes describes the contraction of a plant cell in a hypertonic solution due to water loss?

W) Turgor pressure
X) Flaccid cell
Y) Hydrolysis
Z) Plasmolysis

ANSWER: Z) PLASMOLYSIS

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TOSS-UP

14) Earth and Space – *Short Answer* What is the name of the model that could be used to explain the magnetic and sunspot patterns on the sun?

ANSWER: BABCOCK MODEL

BONUS

14) Earth and Space – *Short Answer* What geologic feature forms when a sheet of rock forms in a fracture of a pre-existing rock body, cross-cutting horizontal layers of sedimentary rocks?

ANSWER: DIKE
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TOSS-UP

15) Math – *Short Answer* What is the area of a rectangle, in square inches, with a length of 8 inches and a diagonal of 17 inches?

ANSWER: 120

BONUS

15) Math – *Short Answer* What is the smallest number in a group of 3 consecutive odd integers whose sum is equal to 171?

ANSWER: 55

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TOSS-UP

16) Chemistry – *Multiple Choice* Consider the combustion reaction of propane in oxygen in a closed system. Which of the following events would reduce the concentration of product in the reaction?

W) Addition of argon gas
X) Increasing the volume of the reaction vessel
Y) Removal of water vapor
Z) Increasing the temperature of the system

ANSWER: Z) INCREASING THE TEMPERATURE OF THE SYSTEM

BONUS

16) Chemistry – *Short Answer* Given that the atomic mass of copper to be 64 grams per mole and the atomic mass of oxygen to be 16 grams per mole, what is the mass of copper(II) oxide produced in a reaction of 2.5 moles of pure copper with excess oxygen gas?

ANSWER: 200 GRAMS
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TOSS-UP

17) Energy – *Short Answer* Researchers at Pacific Northwest National Lab have been conducting research into neutrinos. What is the numerical value of the spin of the neutrino?

ANSWER: 1/2

BONUS

17) Energy – *Multiple Choice* Researchers at Princeton Plasma Physics Lab have been conducting research into man-made fusion reactors. Which of the following is often used to contain plasma inside a fusion reactor?

W) Moderators
X) Fuel rods
Y) Control rods
Z) Magnetic confinement

ANSWER: Z) MAGNETIC CONFINEMENT

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TOSS-UP

18) Biology – *Short Answer* What is the name of the daily cycle of consciousness and unconsciousness that is controlled by the secretion of melatonin in animals?

ANSWER: CIRCADIAN RHYTHM

BONUS

18) Biology – *Multiple Choice* In which step of meiosis does crossing over of DNA between non-sister chromatids occur?

W) Metaphase 1
X) Telophase 2
Y) Anaphase 1
Z) Prophase 1

ANSWER: Z) PROPHASE 1
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TOSS-UP

19) Earth and Space – *Short Answer* What type of nebula is formed when evolved AGB stars expel their outer layers that move outwards due to stellar winds, forming gaseous shells of ionized gas?

ANSWER: PLANETARY NEBULA

BONUS

19) Earth and Space – *Short Answer* Using the mass-luminosity relation for main sequence stars, which of the following values is closest to how much brighter a main sequence star is with 4 times as much mass as the Sun to 3 significant digits?

ANSWER: 128 TIMES

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TOSS-UP

20) Math – *Multiple Choice* Mrs. A gave her probability class two tests. 18.4% of her class passed both tests, and 40% of her class passed her first test. What percent of her students who passed the first test also passed both tests?

W) 40%
X) 42%
Y) 44%
Z) 46%

ANSWER: Z) 46%

BONUS

20) Math – *Short Answer* Given the center of a circle is at (2, –4) and that one of the points on the circle is (5, –8), what is the length of the diameter of the circle?

ANSWER: 10
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TOSS-UP

21) Physics – *Multiple Choice* Which of the following is the potential energy, in joules, of a 5 kg object on the moon raised 8 meters in the air, with an acceleration due to gravity of 1.6 meters per second squared?

W) 8
X) 40
Y) 64
Z) 320

ANSWER: Y) 64

BONUS

21) Physics – *Short Answer* What is the moment of inertia, in kg * km^2, on the surface of a spherical planet with a mass of 6,250 kg and a diameter of 320 km?

ANSWER: 6.4 * 10 ^ 8

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TOSS-UP

22) Chemistry – *Multiple Choice* If a reaction mechanism is split into 3 elementary steps, the step that determines the rate of the reaction is always which of the following?

W) The first step
X) The slowest step
Y) The fastest step
Z) The last step

ANSWER: X) THE SLOWEST STEP

BONUS

22) Chemistry – *Short Answer* In collision theory, what is the name given to a collision where the particles collide with proper orientation and enough energy for a reaction to occur?

ANSWER: EFFECTIVE COLLISION
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TOSS-UP

23) Biology – *Short Answer* A patient goes to the doctor's office to find out what is wrong with him. The doctor performs medical evaluations and finds that the patient has increased cup-to-disc ratio resulting in high intraocular pressure due to poor drainage of aqueous humor. What disease or ailment does the patient have?

ANSWER: GLAUCOMA

BONUS

23) Biology – *Short Answer* What is the name of the plant hormones that play important roles in apical dominance, phototropism, and gravitropism by promoting cell division to one side of the plant in response to sunlight and gravity?

ANSWER: AUXINS