MEHS ROUND 3

TOSS-UP

1) Physics – *Short Answer* At what point could a force act upon a body to cause only linear acceleration of that body?

ANSWER: CENTER OF MASS (DO NOT ACCEPT: CENTER OF GRAVITY)

BONUS

1) Physics – *Short Answer* Identify all of the following quantities for which the internal energy of an ideal gas would be directly proportional: 1) Temperature; 2) Degrees of freedom; 3) Entropy.

ANSWER: 1 AND 2

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TOSS-UP

2) Chemistry – *Multiple Choice* Which of the following is the concentration of chloride ions when 600 milliliters of a 0.40 molar solution of hydrochloric acid is mixed with 400 milliliters of a 0.20 molar solution of beryllium chloride?

W) 0.30 moles per liter
X) 0.40 moles per liter
Y) 0.50 moles per liter
Z) 0.60 moles per liter

ANSWER: X) 0.40 MOLES PER LITER

BONUS

2) Chemistry – *Short Answer* Arrange the following three ions from smallest to largest atomic radius: 1) Na^{+}; 2) F^{-}; 3) Ca^{2+}.

ANSWER: 1, 3, 2
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TOSS-UP

3) Energy – *Multiple Choice* Researchers at Argonne National Lab are doing research on the value of the Hubble constant, which describes the rate at which the universe is expanding. Which of the following types of energy has the greatest effect on the universe's expansion?

W) Kinetic
X) Gravitational
Y) Radiant
Z) Dark

ANSWER: Z) DARK

BONUS

3) Energy – *Short Answer* Scientists at Ames National Lab are doing research on stellar evolution. Identify all of the following three statements regarding stellar evolution that are true: 1) Stars with less that 3 solar masses in the PMS phase of evolution follow the Hayashi track on the HR diagram; 2) A star with 30 solar masses may undergo a type II supernova at the end of its life, collapsing into a black hole; 3) Stars with masses less than or equal to the sun convert hydrogen to helium through the CNO cycle.

ANSWER: 1 AND 2

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TOSS-UP

4) Earth and Space – *Short Answer* What is the name of a subsurface body of permeable rock that can contain or transmit groundwater?

ANSWER: AQUIFER

BONUS

4) Earth and Space – *Multiple Choice* Which of the following features does tidal locking explain?

W) Why the Earth's ocean generates waves
X) Why there are 2 high tides and 2 low tides in a day
Y) Why the same side of the moon always faces the Earth
Z) Why tsunamis form from displacement

ANSWER: Y) WHY THE SAME SIDE OF THE MOON ALWAYS FACES THE EARTH

5) Math – *Multiple Choice* In degrees, what is the measure of an interior angle in a regular decagon?
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TOSS-UP

W) 120
X) 135
Y) 144
Z) 150

ANSWER: Y) 144

BONUS

5) Math – *Short Answer* Calculate the sum of the zeroes in the quadratic equation: 3x squared minus 24x minus 60

ANSWER: 8

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TOSS-UP

6) Chemistry – *Multiple Choice* Which of the following bonds has the greatest ionic character?

W) Li-F
X) Mg-O
Y) Rb-Cl
Z) Cs-F

ANSWER: Z) CS-F

BONUS

6) Chemistry – *Short Answer* What is the name given to a compound that is formed when an atom with a small enough radius occupies a gap within a metal lattice?

ANSWER: INTERSTITIAL
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TOSS-UP

7) Physics – *Short Answer* What angle do the electric and magnetic fields have to be relative to each other to be considered a crossed field?

ANSWER: 90° (ACCEPT: $\frac{\pi}{2}$ rad)

BONUS

7) Physics – *Multiple Choice* Which of the following describes the spontaneous escape of an electron from a well of negative potential difference?

W) Heisenburg's uncertainty principle
X) Quantum tunneling
Y) Rydberg constant
Z) Paschen series

ANSWER: X) QUANTUM TUNNELING

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TOSS-UP

8) Biology – *Short Answer* What is the name of the organic molecules that can form different kinds of nucleic acids depending on their arrangement?

ANSWER: NUCLEOTIDES

BONUS

8) Biology – *Multiple Choice* Which of the following is responsible for assisting enzymes in biochemical transformation?

W) Coenzyme
X) Cofactor
Y) Apoenzyme
Z) Helper T cells

ANSWER: X) COFACTOR
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TOSS-UP

9) Earth and Space – *Short Answer* Icebergs are produced when large chunks of ice break from the front of a glacier during what process?

ANSWER: W) CALVING

BONUS

9) Earth and Space – *Multiple Choice* Which of the following types of mineral groups contain quartzes, feldspars, and pyroxenes, and make up about 95% of our crust?

W) Silicates
X) Oxides
Y) Sulfates
Z) Carbonates

ANSWER: X) SILICATES

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TOSS-UP

10) Math – *Multiple Choice* Given that there are 12 people in a party, how many distinct handshakes can occur between 2 people?

W) 24
X) 42
Y) 60
Z) 66

ANSWER: Z) 66

BONUS

10) Math – *Short Answer* If it takes Alex 15 minutes to clean a room and Barbara 25 minutes to clean the same room, how much time, in minutes, will it take for the room to be cleaned if they work together?

ANSWER: 75/8 (ACCEPT: 9 3/8, 9.375)

11) Physics – *Short Answer* In an ideal step up transformer with 120 coils, 90 volts, and a resistance of 15 ohms on the primary side, calculate the secondary voltage, in volts, if there are 900 coils on the other side.

ANSWER: 675
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TOSS-UP

BONUS

11) Physics – *Multiple Choice* A truck is driving at a speed of 14 meters per second when the driver sees a squirrel running across the road, causing the driver to apply the brakes, causing the truck to decelerate at a rate of -3.5 meters per second squared until the truck stops moving. What is the displacement of the truck, in meters, during its deceleration?

W) 21
X) 28
Y) 35
Z) 56

ANSWER: X) 28

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TOSS-UP

12) Energy – *Multiple Choice* Researchers at Ames National Lab have been studying nuclear reactors. Why is it preferable to slow down the neutrons produced by fission in a reactor?

W) To minimize neutron leakage
X) To minimize risk of nuclear meltdown
Y) To better induce fission in the reactor
Z) To better induce resonance capture of neutrons

ANSWER: Y) TO BETTER INDUCE FISSION IN THE REACTOR

BONUS

12) Energy – *Short Answer* Scientists at Thomas Jefferson National Lab have been studying an elementary particle to determine its role in keeping nucleons together. What is the name of this elementary particle, known as the messenger of the strong nuclear force?

ANSWER: GLUON

13) Biology – *Multiple Choice* Which of the following terms is used to describe an individual's collection of genes?

W) Phenotype
X) Genotype
Y) Gene expression
Z) Genome

ANSWER: X) GENOTYPE
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TOSS-UP

BONUS

13) Biology – *Short Answer* What is the name of the motor protein that is responsible for binding to actin to pull the actin inwards, generating the force in muscle contraction?

ANSWER: MYOSIN

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TOSS-UP

14) Earth and Space – *Multiple Choice* Which of the following rocks is most likely to form from volcanic lava?

W) Pumice
X) Conglomerate
Y) Marble
Z) Granite

ANSWER: W) PUMICE

BONUS

14) Earth and Space – *Short Answer* What orbit shape does a comet have when its orbital velocity is greater than the escape velocity of the body it is orbiting?

ANSWER: HYPERBOLIC
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TOSS-UP

15) Math – *Short Answer* A month with 30 days has the same number of Mondays and Wednesdays. How many of the seven days of the week could possibly be the first day of this month?

ANSWER: 3

BONUS

15) Math – *Short Answer* What is the area of a regular hexagon with an apothem with length 5 times the square root of 3?

ANSWER: 150 ROOT 3

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TOSS-UP

16) Chemistry – *Multiple Choice* Which of the following is the electrochemical potential of a galvanic cell with a sodium anode (E nought = -2.71 V) and a chlorine cathode (E nought = 1.36 V)?

W) -4.07 V
X) -1.35 V
Y) 1.35 V
Z) 4.07 V

ANSWER: Z) 4.07 V

BONUS

16) Chemistry – *Short Answer* What is the sum of the coefficients in the smallest balanced equation for the reaction: cobalt(II) acetate reacts with sodium hydroxide to form sodium acetate and cobalt hydroxide?

ANSWER: 6
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TOSS-UP

17) Energy – *Short Answer* Scientists at Argonne National Lab have been studying the hall Effect in superconductors. Aside from a running current and electrostatic force, what other force must be acting on a current running through the conductor for the hall effect to occur?

ANSWER: MAGNETIC FORCE

BONUS

17) Energy – *Multiple Choice* Researchers at Fermi National Lab are researching the properties of neutrinos. The oscillation of neutrinos proves that they have what property?

W) Kinetic energy
X) Charge
Y) Angular momentum
Z) Mass

ANSWER: Z) MASS

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TOSS-UP

18) Biology – *Short Answer* What is the generic term to describe archaebacteria ***[ar-kay-bac-TEER-ee-uh]*** that live near hydrothermal vents?

ANSWER: EXTREMOPHILES

BONUS

18) Biology – *Multiple Choice* Which of the following is not an example of a negative feedback loop?

W) Production of insulin in response to high glucose levels
X) Childbirth
Y) Thermoregulation
Z) ADH secretion to retain water when dehydrated

ANSWER: X) CHILDBIRTH
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TOSS-UP

19) Earth and Space – *Short Answer* What is the name of the transition layer in the ocean characterized by a steep temperature gradient, located between warmer water at the surface and the cooler deep water?

ANSWER: THERMOCLINE

BONUS

19) Earth and Space – *Short Answer* The stratosphere is the second major layer in the Earth's atmosphere. Identify all of the following three statements regarding the stratosphere that are true: 1) The increase in temperature with increasing altitude is caused by the presence of ozone; 2) The stratosphere contains most of Earth's weather; 3) The boundary separating the troposphere and the stratosphere is the stratopause.

ANSWER: 1 ONLY

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TOSS-UP

20) Math – *Multiple Choice* Set A has 24 elements, and set B has 16 elements. What is the greatest possible number of elements that can exist in the intersection of sets A and B?

W) 0
X) 8
Y) 16
Z) 24

ANSWER: Y) 16

BONUS

20) Math – *Short Answer* If two mutually exclusive events A and B have probabilities 0.43 and 0.29, respectively, what is the probability of A or B occurring?

ANSWER: 0.72
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TOSS-UP

21) Physics – *Multiple Choice* Which of the following set of conditions must be fulfilled for a body to be in static equilibrium?

W) The net force on the body is greater than zero, while the net torque on the body is zero
X) The linear momentum of the body is greater than zero, while the angular momentum of the body is zero
Y) The net force and the net torque on the body are zero
Z) Both the net force and the net torque on the body are greater than zero

ANSWER: Y) THE NET FORCE AND THE NET TORQUE ON THE BODY ARE ZERO

BONUS

21) Physics – *Short Answer* In an RL circuit, the energy stored by the inductor decreases over time due to the reduction of the rate of change of what quantity?

ANSWER: CURRENT

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TOSS-UP

22) Chemistry – *Multiple Choice* Which of the following is the empirical formula for cyclopropane?

W) CH_2
X) C_2H_3
Y) CH
Z) CH_3

ANSWER: W) CH_2

BONUS

22) Chemistry – *Short Answer* Identify all of the following 3 statements that are true regarding resonance structures: 1) Electrons are delocalized in resonance structures; 2) Sulfur trioxide has 2 resonance structures; 3) Resonance structures where the most electronegative element has a positive charge are the most common.

ANSWER: 1 ONLY
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TOSS-UP

23) Biology – *Short Answer* What is the name of the property that cell membranes exhibit by allowing some substances to pass through to the cell while restricting the flow of others?

ANSWER: SELECTIVE PERMEABILITY (ACCEPT: SEMIPERMEABILITY)

BONUS

23) Biology – *Short Answer* Given a strand of DNA with the sequence AGTCGTCA, what are the bases in the complementary strand?

ANSWER: TCAGCAGT