MEHS ROUND 8

TOSS-UP

1) Physics – *Short Answer* Angela increases the volume of her music from 60 decibels to 90 decibels. By what factor did the intensity of the music increase?

ANSWER: 1000

BONUS

1) Physics – *Short Answer* The frequency of a sound wave is increased from 55 hertz to 110 hertz. Assuming that the intensity of the sound wave was 231 watts per meter squared before the increase, and giving your answer in watts per meter squared, what is the current intensity of the sound wave?

ANSWER: 924

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TOSS-UP

2) Chemistry – *Multiple Choice* Which of the following is the electron pair geometry of sulfur tetrafluoride?

W) See-saw
X) Trigonal Pyramidal
Y) Tetrahedral
Z) Trigonal Bipyramidal

ANSWER: Z) TRIGONAL BIPYRAMIDAL

BONUS

2) Chemistry – *Short Answer* When sodium chloride is added to a dilute solution of hydrochloric acid in water, the ionization of the chloride anion decreases. What is the best explanation for this phenomenon?

ANSWER: COMMON ION EFFECT
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TOSS-UP

3) Energy – *Multiple Choice* Scientists at Lawrence Berkeley National Lab are conducting research on how much wetlands have affected global methane emissions. Which of the following features is NOT a type of wetland?

W) Marsh
X) Bog
Y) Fen
Z) Berm

ANSWER: Z) BERM

BONUS

3) Energy – *Short Answer* Scientists at Lawrence Berkeley National Lab are using the Advanced Light Source to study SARS-CoV-2 antibodies. Identify all of the following 3 statements regarding antibodies that are true: 1) Antibodies have a u-shaped structure; 2) The antigen-binding site of an antibody has a shape that provides a lock-and-key fit with the corresponding epitope; 3) Antibodies directly kill pathogens by interfering with their activity.

ANSWER: 2 AND 3

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TOSS-UP

4) Earth and Space – *Short Answer* What type of drainage pattern is characterized by streams diverging outward from a central high point?

ANSWER: RADIAL

BONUS

4) Earth and Space – *Short Answer* Identify all of the following 3 factors that resist against the compression of an interstellar gas cloud: 1) The thermal energy of the gas; 2) The magnetic field within the interstellar medium; 3) Rotation of the universe.

ANSWER: ALL OF THEM

5) Math – *Multiple Choice* Which of the following is the remainder when 3 to the power of 11 is divided by 5?

W) 1
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TOSS-UP

X) 2
Y) 3
Z) 4

ANSWER: X) 2

BONUS

5) Math – *Short Answer* If a hexagonal prism has a volume of 192 times the square root of 3 and a base length of 4, calculate the lateral surface area of the prism.

ANSWER: 192

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TOSS-UP

6) Chemistry – *Multiple Choice* Which of the following best describes the enthalpy of reaction when work is done on either the system or surroundings?

W) Positive on the system, positive on the surroundings
X) Negative on the system, positive on the surroundings
Y) Positive on the system, negative on the surroundings
Z) Negative on the system, negative on the surroundings

ANSWER: X) POSITIVE ON THE SYSTEM, NEGATIVE ON THE SURROUNDINGS

BONUS

6) Chemistry – *Short Answer* How many pi bonds are present in 1-3 butadiene?

ANSWER: 2
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TOSS-UP

7) Physics – *Short Answer* A green alien has set foot outside his flying saucer when he accidentally drops his ray gun. He notes that it falls a distance of one blip in a time of one bloop. If it is still falling at a time of 3 bloops, in terms of blips, what is the total distance the ray gun has fallen in that time?

ANSWER: 9

BONUS

7) Physics – *Short Answer* Identify all of the following situations in which an object is being accelerated: 1) An object moves with uniform circular motion; 2) An object moves in a straight line at constant speed; 3) An object travels as a projectile in a gravitational field with negligible air resistance

ANSWER: 1 AND 3

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TOSS-UP

8) Biology – *Multiple Choice* Which of the following animals would have a single circulation system?

W) Salmon
X) Salamander
Y) Snake
Z) Human

ANSWER: W) SALMON

BONUS

8) Biology – *Short Answer* Order the following 4 layers in mammalian egg from the outermost layer to the innermost layer: 1) Nucleus; 2) Zona pellucida; 3) Follicle cells; 4) Plasma membrane.

ANSWER: 3, 2, 4, 1
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TOSS-UP

9) Earth and Space – *Short Answer* What is the name of the point where 3 plate boundaries intersect?

ANSWER: TRIPLE JUNCTION

BONUS

9) Earth and Space – *Short Answer* What type of fog is formed when warm, moist air moves over a cool surface, causing the air to cool to dew point, resulting in fog formation?

ANSWER: ADVECTION (DO NOT ACCEPT: ADVECTION-RADIATION)

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TOSS-UP

10) Math – *Multiple Choice* How many zeros does the function x cubed plus 2 x squared minus 4 x minus 8 have?

W) 0
X) 1
Y) 2
Z) 3

ANSWER: Y) 2

BONUS

10) Math – *Short Answer* How many diagonals are formed from a regular 13 sided polygon?

ANSWER: 65

11) Physics – *Short Answer* The speed of sound travelling through a substance is 340 meters per second. The density of the substance is 0.5 kilograms per meter cubed. Giving your answer in gigapascals, what is the bulk modulus for the substance?
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TOSS-UP

ANSWER: 57,800

BONUS

11) Physics – *Multiple Choice* Which of the following states that the predictions of quantum physics match the predictions of classical physics at large enough quantum numbers?

W) Correspondence principle
X) Heisenberg uncertainty principle
Y) Pauli exclusion principle
Z) Confinement principle

ANSWER: W) CORRESPONDENCE PRINCIPLE

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TOSS-UP

12) Energy – *Multiple Choice* Researchers at Oak Ridge National Lab have been studying the properties of the Bose-Einstein condensate. A Bose-Einstein condensate can be composed of which of the following particles?

W) Electron
X) Quarks
Y) Photon
Z) Muon

ANSWER: Y) PHOTON

BONUS

12) Energy – *Short Answer* Researchers at Argonne National Lab have been conducting research into making computer chips based on a 3 nanometer transistor design. What quantum phenomena poses the main challenge to scaling down the transistors used in computer chips?

ANSWER: QUANTUM TUNNELING
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TOSS-UP

13) Biology – *Multiple Choice* From which of the following types of embryonic germ layers is the epithelial lining of the digestive tract, respiratory, and excretory systems derived?

W) Ectoderm
X) Mesoderm
Y) Endoderm
Z) Blastocoel

ANSWER: Y) ENDODERM

BONUS

13) Biology – *Short Answer* What is the name of the extraembryonic membrane in eggs that covers the embryo and fills with the amniotic fluid, expanding and eventually becoming the amniotic sac?

ANSWER: AMNION

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TOSS-UP

14) Earth and Space – *Short Answer* What is the name of the phenomenon that occurs at polar latitudes and is characterized by an unexpected rise in temperature in the stratosphere?

ANSWER: SUDDEN STRATOSPHERIC WARMING

BONUS

14) Earth and Space – *Short Answer* Identify all of the following 3 features that could be caused by gravitational lensing: 1) Shapiro time delay; 2) Einstein ring; 3) Frame dragging.

ANSWER: 2 ONLY

15) Math – *Short Answer* How many numbers between 1 and 100, inclusive, are multiples of 4 but not multiples of 6?

ANSWER: 21
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TOSS-UP

BONUS

15) Math – *Short Answer* What is the minimum value of the function: f of x equals 3 x squared minus 8 x plus 5?

ANSWER: -1/3

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TOSS-UP

16) Chemistry – *Multiple Choice* Which of the following ions is the conjugate acid in an acid-base pair?

W) Chloride ion
X) Ammonium ion
Y) Hydroxide ion
Z) Sulfate ion

ANSWER: X) AMMONIUM ION

BONUS

16) Chemistry – *Short Answer* Identify all of the following 3 salts that are basic in an aqueous solution: 1) Sodium nitrate; 2) Potassium sulfide; 3) Iron(III) chloride

ANSWER: 2 ONLY
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TOSS-UP

17) Energy – *Short Answer* Researchers at Brookhaven National Lab are investigating the strong nuclear force that holds the nucleus together. The strong nuclear force doesn't affect what class of particle?

ANSWER: LEPTON (DO NOT ACCEPT: FERMION)

BONUS

17) Energy – *Multiple Choice* Researchers at SLAC National Accelerator Lab have been conducting research into the properties of dark matter. Dark matter was originally discovered through observed irregularities of which of the following forces?

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

ANSWER: Z) GRAVITY

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TOSS-UP

18) Biology – *Short Answer* Terminally differentiated cells are most often found in what phase of the cell cycle?

ANSWER: G ZERO

BONUS

18) Biology – *Multiple Choice* An animal experiences an acid-base imbalance in the arterial blood that results in acidosis. To increase pH toward normal, which direction would the ventilation rate be changed and what would be the corresponding change in arterial pressure of CO 2?

W) Ventilation rate increases, arterial pressure of CO 2 increases
X) Ventilation rate increases, arterial pressure of CO 2 decreases
Y) Ventilation rate decreases, arterial pressure of CO 2 increases
Z) Ventilation rate decreases, arterial pressure of CO 2 decreases

ANSWER: X) VENTILATION RATE INCREASES, ARTERIAL PRESSURE OF CO 2 DECREASES
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TOSS-UP

19) Earth and Space – *Short Answer* What is the name of the type of movement that occurs when a glacier moves due to meltwater under the ice acting as a lubricant?

ANSWER: BASAL SLIDING

BONUS

19) Earth and Space – Order the following 4 steps in the Bergeron process from the earliest to the latest: 1) Precipitation; 2) Condensation; 3) Accretion; 4) Aggregation.

ANSWER: 2, 3, 4, 1

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TOSS-UP

20) Math – *Multiple Choice* 9 slips of paper are numbered 1 through 9 and placed into a hat. Alice picks one of these slips at random and puts it back, then Bob picks a slip at random. Which digit is most likely to be the units digit of the sum of Alice's and Bob's integer?

W) 0
X) 1
Y) 8
Z) 9

ANSWER: W) 0

BONUS

20) Math – *Short Answer* How many triangles exist such that the side lengths 12, 16, and x have all their angles acute?

ANSWER: 11
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TOSS-UP

21) Physics – *Multiple Choice* Which of the following particles does NOT have a half-integer spin?

W) Electron
X) Pion
Y) Neutrino
Z) Proton

ANSWER: X) PION

BONUS

21) Physics – *Short Answer* An RC circuit consists of a resistor with resistance 4 ohms and a capacitor with capacitance 7 farads, which can hold a charge of up to 31 coulombs, and a battery powering the entire circuit. Rounded to the nearest tenth, and giving your answer in volts, what is the minimum voltage of the battery for there to be a 2 ampere current in the circuit?

ANSWER: 8.2

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TOSS-UP

22) Chemistry – *Multiple Choice* Which of the following substances is not expected to have an enthalpy of formation equal to zero?

W) F2 gas
X) Br2 gas
Y) I2 solid
Z) C solid, graphite

ANSWER: X) BR2 GAS

BONUS

22) Chemistry – *Short Answer* What is the name of the carbon allotrope that forms a geodesic structure?

ANSWER: BUCKMINSTERFULLERENE (ACCEPT: BUCKYBALL)
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TOSS-UP

23) Biology – *Short Answer* The endosymbiotic theory best explains the existence of which organelle?

ANSWER: MITOCHONDRIA

BONUS

23) Biology – *Short Answer* The endosperm of a plant with "monosporic" development has 72 chromosomes. How many chromosomes does the egg cell have?

ANSWER: 72