MEHS ROUND 2

TOSS-UP

1) Physics – *Short Answer* What principle states that two fermions cannot share the same set of quantum numbers?

ANSWER: PAULI EXCLUSION PRINCIPLE (ACCEPT: PAULI EXCLUSION)

BONUS

1) Physics – *Short Answer* The magnitude of the electrostatic force between two electrons is 27 newtons. If the distance between the two electrons doubles, what is the new magnitude of the electrostatic force between the electrons in newtons?

ANSWER: 6.75

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TOSS-UP

2) Chemistry – *Multiple Choice* Which of the following terms is a measure of the force necessary to stretch or break the surface of a liquid?

W) Cohesion
X) Adhesion
Y) Viscosity
Z) Surface tension

ANSWER: Z) SURFACE TENSION

BONUS

2) Chemistry – *Short Answer* Rank the following three substances in terms of decreasing specific heat capacity: 1) Liquid water; 2) Ice; 3) Lead.

ANSWER: 1, 2, 3
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TOSS-UP

3) Energy – *Short Answer* Scientists at Pacific Northwest National Lab are studying clouds in the Arctic circle to try and elucidate how they are able to hold liquid water even in freezing temperatures. What process describes the cooling of liquid water below its freezing point?

ANSWER: SUPERCOOLING (ACCEPT: UNDERCOOLING)

BONUS

3) Energy – *Short Answer* Scientists at Brookhaven National Lab are studying the process of convection in clouds. What is the name for the hot bubbles of air that are responsible for the formation of cumulus clouds and the convection that occurs in them?

ANSWER: THERMALS

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TOSS-UP

4) Earth and Space – *Multiple Choice* In which of the following phases does the moon have to be in for a lunar eclipse to occur?

W) New moon
X) First quarter
Y) Last quarter
Z) Full moon

ANSWER: Z) FULL MOON

BONUS

4) Earth and Space – *Short Answer* Identify all of the following three statements regarding atmospheric stability that are true: 1) Adiabatic processes involve no interchange of heat with surroundings; 2) The dry adiabatic rate applies to both saturated and unsaturated air;
3) The environmental lapse rate is the rate at which air temperature in the atmosphere changes.

ANSWER: 1 AND 3
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TOSS-UP

5) Math – *Multiple Choice* If the area of an equilateral triangle is 49 times the square root of 3, then what is the length of its sides?

W) 7
X) 14
Y) 28
Z) 49

ANSWER: X) 14

BONUS

5) Math – *Short Answer* If a fair 6-sided die and a coin are flipped simultaneously, what is the probability that the die shows a prime number and the coin lands with the "tails" side facing up?

ANSWER: 1/4 (ACCEPT: 0.25 OR 25%)

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TOSS-UP

6) Chemistry – *Multiple Choice* Which of the following laws states that every orbital in a subshell is singly occupied with one electron before any one orbital is doubly occupied?

W) Aufbau principle
X) Heisenberg uncertainty principle
Y) Hund's rule
Z) Dalton's law

ANSWER: Y) HUND'S RULE

BONUS

6) Chemistry – *Short Answer* Order the following 4 ionic molecules from lowest to highest boiling point: 1) NaF; 2) NaCl; 3) MgO; 4) KBr.

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

7) Physics – *Short Answer* A block of wood, when placed in water, displaces 770 grams of water. In newtons and rounded to 2 significant figures, what is the magnitude of the buoyant force on the block of wood when it is in the water?

ANSWER: 7.5

BONUS

7) Physics – *Multiple Choice* Which of the following quantities is the period of an LC circuit directly proportional to?

W) The square of the inductance of the circuit
X) The inductance of the circuit
Y) The resistance of the circuit
Z) The capacitance of the circuit

ANSWER: W) THE SQUARE OF THE INDUCTANCE OF THE CIRCUIT

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TOSS-UP

8) Biology – *Multiple Choice* Which of the following describes the first step of cellular respiration in plants?

W) Alpha-ketoglutarate is oxidized to form a 4-carbon molecule
X) Acetyl-CoA joins with oxaloacetate to form citrate
Y) Glucose is converted to pyruvic acid
Z) Fumarate is converted to malate

ANSWER: X) ACETYL-COA JOINS WITH OXALOACETATE TO FORM CITRATE

BONUS

8) Biology – *Multiple Choice* Snails and slugs are members of what taxonomic class?

W) Mollusca
X) Achatinoidea ***[uh-KATE-in-oi-dea]***
Y) Gastropoda
Z) Animalia

ANSWER: Y) GASTROPODA
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TOSS-UP

9) Earth and Space – *Multiple Choice* Which of the following types of fronts on a weather map is indicated by a line with alternating blue triangles and red semicircles?

W) Warm
X) Cold
Y) Occluded
Z) Stationary

ANSWER: Z) STATIONARY

BONUS

9) Earth and Space – *Multiple Choice* Which of the following types of streams only flow for a short period of time and usually occur after a large storm or snowmelt?

W) Perennial
X) Intermittent
Y) Ephemeral ***[uh-FEH-muh-ruhl]***
Z) Riparian

ANSWER: Y) EPHEMERAL

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TOSS-UP

10) Math – *Multiple Choice* How many lines of symmetry exist in a regular dodecagon?

W) 11
X) 12
Y) 14
Z) 20

ANSWER: X) 12

BONUS

10) Math – *Short Answer* Simplify the following, giving your answer in proper scientific notation: the quantity 3.5 times 10 to the fourth squared.

ANSWER: 1.225 x 10^9

11) Physics – *Short Answer* What type of image is formed by a convex mirror as a result of the object being placed closer to the lens than its foci?
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TOSS-UP

ANSWER: VIRTUAL IMAGE (ACCEPT: VIRTUAL)

BONUS

11) Physics – *Multiple Choice* Which of the following properties would determine whether an object would float or sink in water?

W) Specific gravity
X) Volume
Y) Mass
Z) Melting point

ANSWER: W) SPECIFIC GRAVITY

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TOSS-UP

12) Energy – *Multiple Choice* Scientists at Brookhaven National Lab are exploring the potential uses of an allotrope of carbon as a substance capable of increasing the strength and durability of plastics, building materials, and mobile devices. Which of the following is NOT an allotrope of carbon?

W) Carborundum
X) Buckminsterfullerene
Y) Diamond
Z) Graphene

ANSWER: W) CARBORUNDUM

BONUS

12) Energy – *Short Answer* Researchers at Oak Ridge National Lab have published findings regarding the character of turbulent-like flows in self-consistent models of core-collapse supernovae. Which type of supernova occurs in stars whose mass ranges from 8 to 50 times that of our sun as a result of core collapse?

ANSWER: TYPE II SUPERNOVA
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TOSS-UP

13) Biology – *Multiple Choice* Which of the following types of selection occurs when individuals of an intermediate phenotype are less fit than those of higher and lower phenotype, such that extremes are favored?

W) Directional
X) Disruptive
Y) Stabilizing
Z) Sexual

ANSWER: X) DISRUPTIVE

BONUS

13) Biology – *Multiple Choice* Which of the following cellular organelles is responsible for encasing the genetic material in the nucleus of eukaryotic cells?

W) Cell membrane
X) Nuclear envelope
Y) Cytoplasm
Z) Nucleolus

ANSWER: X) NUCLEAR ENVELOPE

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TOSS-UP

14) Earth and Space – *Short Answer* What is the name for the tiny particles in the air on which water vapor condenses onto in the formation of clouds?

ANSWER: CLOUD CONDENSATION NUCLEI

BONUS

14) Earth and Space – *Short Answer* What is the name for the zone near the equator where air masses converge, producing low atmospheric pressure and windless weather?

ANSWER: INTERTROPICAL CONVERGENCE ZONE (ACCEPT: DOLDRUMS)
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TOSS-UP

15) Math – *Short Answer* Bill has $150,000 deposited in a savings account which has an annual interest rate of 3%. Rounded to the nearest whole number, how many years will it take for the balance in Bill's account to double?

ANSWER: 24

BONUS

15) Math – *Short Answer* The eighth grade class at Elementary Middle School has 93 students. Each student takes a math class or a foreign language class or both. There are 70 eighth graders taking a math class, and there are 54 eight graders taking a foreign language class. How many eight graders take only a math class and not a foreign language class?

ANSWER: 19

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TOSS-UP

16) Chemistry – *Multiple Choice* Which of the following substances is not a strong acid?

W) Hydrochloric acid
X) Sulfuric acid
Y) Nitric acid
Z) Sulfurous acid

ANSWER: Z) SULFUROUS ACID

BONUS

16) Chemistry – *Short Answer* What is the name given to an electrochemical cell that derives electrical energy from spontaneous redox reactions?

ANSWER: GALVANIC CELL (ACCEPT: VOLTAIC CELL)
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TOSS-UP

17) Energy – *Short Answer* Researchers at Thomas Jefferson National Accelerator Lab are studying the source of a proton's spin. What elementary particle found in protons is likely responsible for this?

ANSWER: QUARK

BONUS

17) Energy – *Multiple Choice* Researchers at Argonne National Lab are probing the necessary conditions for building a superconductor. Which of the following properties is required for a superconductor to function properly?

W) Low pressure on the superconductor
X) Low temperature in the superconductor's environment
Y) High pressure on the superconductor
Z) High temperature in the superconductor's environment

ANSWER: X) LOW TEMPERATURE IN THE SUPERDUCTOR'S ENVIRONMENT

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TOSS-UP

18) Biology – *Short Answer* What is the name of channel proteins that facilitate the flow of water between cells?

ANSWER: AQUAPORINS

BONUS

18) Biology – *Multiple Choice* Which of the following parts of a leaf contains the greatest concentration of chloroplasts?

W) Cuticle
X) Stomata
Y) Upper epidermis
Z) Mesophyll

ANSWER: Z) MESOPHYLL
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TOSS-UP

19) Earth and Space – *Short Answer* What is the name of the mass of carbonized plant debris that will eventually undergo burial, compaction, and coalification to transform into coal?

ANSWER: PEAT

BONUS

19) Earth and Space – *Short Answer* Most comets have two tails that appear as they approach the Sun. Identify all of the following three statements regarding comet tails that are NOT true: 1) The ion tail of a comet usually appears blue; 2) The dust tail of a comet usually appears yellow; 3) The dust tail of a comet shines by reflected sunlight.

ANSWER: NONE

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TOSS-UP

20) Math – *Multiple Choice* Which of the following pairs of x values satisfy the equation: $x^2 + 10x - 24$?

W) 4 and 6
X) –4 and –6
Y) –2 and 12
Z) –12 and 2

ANSWER: Y) NEGATIVE 2 AND 12

BONUS

20) Math – *Short Answer* What is the harmonic mean of 1/3 and 1/7?

ANSWER: 10/21
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TOSS-UP

21) Physics – *Multiple Choice* When an atom undergoes beta plus decay, it emits a positron and which of the following other particles?

W) Gluon
X) Electron neutrino
Y) Quark
Z) Muon

ANSWER: X) ELECTRON NEUTRINO

BONUS

21) Physics – *Short Answer* The escape velocity on one planet with radius R is 3900 meters per second. What is the escape velocity in meters per second on a planet with radius R over 4?

ANSWER: 7800

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TOSS-UP

22) Chemistry – *Multiple Choice* If the enthalpy is negative and entropy is positive in a given reaction, which of the following statements is true regarding the Gibbs free energy of the reaction?

W) It is spontaneous at all temperatures
X) It is spontaneous only at low temperatures
Y) It is spontaneous only at high temperatures
Z) It is spontaneous at no temperatures

ANSWER: W) IT IS SPONTANEOUS ONLY AT LOW TEMPERATURES

BONUS

22) Chemistry – *Short Answer* Identify all of the following four metals that are capable of forming ions with a 2 plus charge: 1) Iron; 2) Magnesium; 3) Cesium; 4) Germanium.

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

23) Biology – *Short Answer* Which substance is the primary constituent of the cell wall of bacteria and causes bacteria to turn a violet color in gram staining?

ANSWER: PEPTIDOGLYCAN

BONUS

23) Biology – *Short Answer* What is the name of a chromosomal segment of DNA that can change its position within the genome of an animal or plant?

ANSWER: TRANSPOSON