MEHS ROUND 11

TOSS-UP

1) Physics – *Short Answer* The total flux through a cube with a uniform electric field is 54 volt-meters. What is the flux through one face of the cube?

ANSWER: 9 VOLT-METERS

BONUS

1) Physics – *Short Answer* What force causes orbital decay?

ANSWER: DRAG FORCE (ACCEPT: DRAG)

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TOSS-UP

2) Chemistry – *Multiple Choice* Which functional group refluxes with a carboxylic acid in a Fischer esterification?

W) Ketone
X) Alcohol
Y) Ether
Z) Alkyne

ANSWER: X) ALCOHOL

BONUS

2) Chemistry – *Short Answer* During which process does a single ligand form multiple coordinate covalent bonds with the central metal?

ANSWER: CHELATION
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TOSS-UP

3) Energy – *Multiple Choice* Scientists at SLAC National Accelerator Lab are studying the properties of dark matter by observing dwarf galaxies around the Milky Way. Which of the following types of theoretical dark matter forms consists of particles that travel with ultrarelativistic velocities?

W) Hot
X) Warm
Y) Cold
Z) Mixed

ANSWER: W) HOT

BONUS

3) Energy – *Short Answer* Scientists at Idaho National Lab are seeking ways to design a nuclear power system for the moon. Identify all of the following 3 statements regarding the moon that are true: 1) The sinuous rilles on the moon were formed by the cutting by flowing lava; 2) Lunar crater counts temporarily surged during the late heavy bombardment;
3) Lunar anorthosites mainly make up the maria while basalts mainly make up the highlands.

ANSWER: 1 AND 2

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TOSS-UP

4) Earth and Space – *Multiple Choice* As ocean acidification decreases, which of the following happens to the carbonate compensation depth?

W) It will rise closer to the sea surface
X) It will fall towards the sea floor
Y) It will rise to the aragonite compensation depth
Z) It will fall to the lysocline

ANSWER: W) IT WILL RISE CLOSER TO THE SEA SURFACE

BONUS

4) Earth and Space – *Short Answer* What geologic event is often indicated by changes in sedimentary facies and occurs when sea level rises relative to land, causing the shoreline to move towards higher ground, resulting in flooding?

ANSWER: MARINE TRANSGRESSION
5) Math – *Multiple Choice* What is the determinant of a 2 by 2 matrix with first row 4 and negative 7 and second row negative 2 and negative 1?
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TOSS-UP

W) 10
X) -6
Y) -10
Z) -18

ANSWER: Z) -18

BONUS

5) Math – *Short Answer* Calculate the dot product of the 3 dimensional vectors <4, negative 7, 2> and <negative 2, negative 4, 7 >.

ANSWER: 34

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TOSS-UP

6) Chemistry – *Multiple Choice* During which laboratory practice is the height equivalent to a theoretical plate calculated using the Van Deemter equation?

W) Fractional distillation
X) Decolorization
Y) Titration
Z) Chromatography

ANSWER: Z) CHROMATOGRAPHY

BONUS

6) Chemistry – *Short Answer* By cooling a sample of yttrium barium copper oxide to a temperature of -181 kelvin, what process begins to occur?

ANSWER: SUPERCONDUCTIVITY (ACCEPT: BECOMES A SUPERCONDUCTOR)
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TOSS-UP

7) Physics – *Short Answer* The current density over a wire of 3 meters is 7 amperes per square meter, and the resistivity of the wire is 30 ohm-meters. Giving your answer in volts, what is the potential difference across the wire?

ANSWER: 630

BONUS

7) Physics – *Multiple Choice* Ike and Jungleman set up a double-slit experiment, where the light filtering through the slits is projected onto a large photon detector. Ike turns on the light, and checks to see where the first 10 photons emitted landed. Which of the following statements about the first photons is true?

W) The photons will all land on an interference maxima
X) The photons will all land on an interference minima
Y) The photons will all land on random spots
Z) The photons will all land on the same spot

ANSWER: Y) THE PHOTONS WILL ALL LAND ON RANDOM SPOTS

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TOSS-UP

8) Biology – Multiple Choice Which of the following animals are most likely to demonstrate the adaptation of anhydrobiosis?

W) Tardigrade
X) Camel
Y) Cricket
Z) Worm

ANSWER: W) TARDIGRADE

BONUS

8) Biology – *Multiple Choice* Which of the following statements regarding genetic drift is NOT true?

W) Genetic drift can cause allele frequencies to change randomly
X) The bottleneck effect is usually observed when a large group separates from a population
Y) Genetic drift can cause rare alleles to become fixed
Z) The founder effect causes some groups in populations to diverge and become distinct

ANSWER: X) THE BOTTLENECK EFFECT IS USUALLY OBSERVED WHEN A LARGE GROUP SEPARATES FROM A POPULATION
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TOSS-UP

9) Earth and Space – *Short Answer* What is the name of the process in zeolite facies and sediments that describes the physical and chemical changes caused by increasing temperature and pressure?

ANSWER: DIAGENESIS

TOSS-UP

BONUS

9) Earth and Space – *Multiple Choice* Which of the following types of mineral deposits is characterized by minerals accumulating due to gravity separation from a source rock?

W) Vein
X) Hydrothermal
Y) Epithermal
Z) Placer

ANSWER: Z) PLACER

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TOSS-UP

10) Math – *Multiple Choice* In a triangle with integer side lengths, one side is three times longer than a second side, and the third side is of length 15. What is the greatest possible perimeter of the triangle?

W) 43
X) 44
Y) 45
Z) 46

ANSWER: W) 43

BONUS

10) Math – *Short Answer* The lines x equals one fourth y (short pause) plus a and y equals one fourth x (short pause) plus b intersect at the point (2, 7). What is the value of ab?

ANSWER: 13/8

11) Physics – *Short Answer* The position of a 2 kilogram mass is given by x = 2 t cubed minus 3 t squared meters, where t is in seconds. What is the net horizontal force on the mass, in newtons at t equals 1 second?

ANSWER: 12

BONUS

11) Physics – *Multiple Choice* Which of the following ideas in classical physics stated that an ideal black body at thermal equilibrium will emit radiation in all frequency ranges?
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TOSS-UP

W) Lorentz transformation
X) Twin paradox
Y) Ultraviolet catastrophe
Z) Planck radiation formula

ANSWER: Y) ULTRAVIOLET CATASTROPHE

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TOSS-UP

12) Energy – *Multiple Choice* Researchers at Argonne National Lab are using sound waves to probe the quantum properties of materials. The speed of sound is inversely proportional to which of the following quantities of the material it is traveling through?

W) The square of the bulk modulus of the material
X) The temperature of the material
Y) The density of the material
Z) The square of the density of the material

ANSWER: Z) THE SQUARE OF THE DENSITY OF THE MATERIAL

BONUS

12) Energy – *Short Answer* Researchers at Thomas Jefferson National Lab are conducting research into the existence of the pentaquark. A pentaquark would be in what subcategory of hadrons?

ANSWER: BARYON

13) Biology – *Short Answer* What is the name of the plant structures in bryophytes that are responsible for anchoring them down to the ground and absorbing water, similar to how root hairs on vascular plants work?

ANSWER: RHIZOIDS

BONUS

13) Biology – *Short Answer* Identify all of the following 3 statements regarding cell death that are true: 1) Apoptosis occurs in multicellular and unicellular organisms; 2) Cell death is induced by activating trypsin inhibitors that degrade proteins; 3) Apoptosis often provides detrimental effects to the organism.
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TOSS-UP

ANSWER: NONE OF THEM

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TOSS-UP

14) Earth and Space – *Multiple Choice* Which of the following statements regarding proper motion is NOT true?

W) The total proper motion of a star is given in right ascension and declination
X) A star will have a large proper motion if it is moving directly toward or away from you
Y) Astronomers can use proper motions to identify stars that are nearby
Z) Distant stars will most likely have small proper motions

ANSWER: X) A STAR WILL HAVE A LARGE PROPER MOTION IF IT IS MOVING DIRECTLY TOWARD OR AWAY FROM YOU

BONUS

14) Earth and Space – *Short Answer* Identify all of the following 3 statements regarding fault movement that are true: 1) In normal faults, the block that is pushed above is called the hanging wall block; 2) In strike-slip faults, the line formed by the intersection of a rock surface with a plane is called the dip; 3) Oblique faults show both strike-slip and dip-slip motion.

ANSWER: 3 ONLY
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TOSS-UP

15) Math – *Short Answer* What is the least integer x for which 18 divided by the quantity x minus 1 is an integer?

ANSWER: -17

BONUS

15) Math – *Short Answer* A sequence consists of six integers: 1, a, b, c, d, 100 This sequence has the property that the sum of any two consecutive terms is a power of 3. What is a plus b plus c plus d?

ANSWER: 10

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TOSS-UP

16) Chemistry – *Multiple Choice* Which of the following elements has a hydroxide that is considered to be amphoteric at room temperature in water?

W) Aluminum
X) Boron
Y) Barium
Z) Mercury

ANSWER: W) ALUMINUM

BONUS

16) Chemistry – *Short Answer* For any diatomic salt, what operation must be done on the solubility product constant to obtain the molar solubility?

ANSWER: SQUARE ROOT
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TOSS-UP

17) Energy – *Short Answer* Researchers at Oak Ridge National Lab are conducting research into the structures that lend to magnetic properties in materials. What law proves that magnetic monopoles cannot exist in the real world?

ANSWER: GAUSS' LAW

BONUS

17) Energy – *Multiple Choice* Researchers at Brookhaven National Lab are conducting research into interactions between the electromagnetic and nuclear weak forces. Which of the following particles carries the weak force?

W) Neutrino
X) Tauon
Y) W Boson
Z) Muon

ANSWER: Y) W BOSON

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TOSS-UP

18) Biology – *Short Answer* In the photic zone of shallow bodies of water, along with the littoral zone, what other zone of open water area makes up the photic zone?

ANSWER: LIMNETIC ZONE

BONUS

18) Biology – *Short Answer* What is the term for a fluid-filled cavity formed within the mesoderm in triploblastic animals?

ANSWER: PSEUDOCOELOM
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TOSS-UP

19) Earth and Space – *Short Answer* What is the name of the event that occurs when the moon becomes completely immersed in the penumbral cone of the Earth without touching the umbra?

ANSWER: TOTAL PENUMBRAL LUNAR ECLIPSE (DO NOT ACCEPT: PENUMBRAL LUNAR ECLIPSE OR LUNAR ECLIPSE)

BONUS

19) Earth and Space – *Multiple Choice* According to Dott's sandstone classification scheme, which of the following types of sandstone contain more than 25 percent feldspar and have poorly rounded and sorted grains?

W) Feldspathic arenites
X) Lithic arenites
Y) Arkose
Z) Greywacke

ANSWER: Y) ARKOSE

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TOSS-UP

20) Math – *Multiple Choice* Which of the following integers best approximates the geometric mean of 19 and 24?

W) 20
X) 21
Y) 22
Z) 23

ANSWER: X) 21

BONUS

20) Math – *Short Answer* A three digit number is divisible by 29. The tens digit of the number exceeds the ones digit by five and the sum of these two digits is eleven. What is the value of this number?

ANSWER: 783
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TOSS-UP

21) Physics – *Multiple Choice* For an AC circuit to be at resonance, which of the following must be true?

W) The circuit must be equally capacitive and inductive
X) The total resistance in the circuit is less than the total inductance in the circuit
Y) The total capacitance and inductance of the circuit are equal
Z) The current through the circuit must lag the potential difference of the circuit

ANSWER: W) THE CIRCUIT MUST BE EQUALLY CAPACITIVE AND INDUCTIVE

BONUS

21) Physics – *Short Answer* A gas is enclosed in a cube, where one side of the cube is a piston. If the gas does a total of 130 joules of work on the piston, while exerting 5 pascals of pressure on it, by how much did the gas expand?

ANSWER: 26 LITERS

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TOSS-UP

22) Chemistry – *Multiple Choice* Which of the following quantities does not change in reversible chemical processes?

W) Enthalpy
X) Equilibrium constant
Y) Entropy
Z) Gibbs free energy

ANSWER: Y) ENTROPY

BONUS

22) Chemistry – *Short Answer* In the Arrhenius equation, A is equal to the product of the collision frequency and which factor?

ANSWER: STERIC FACTOR
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TOSS-UP

23) Biology – *Short Answer* What is the name of the phylum which contains a member that possesses a rostrum?

ANSWER: MOLLUSCA

BONUS

23) Biology – *Short Answer* A fluorinated variety of which molecule is the most common tracer for PET scans?

ANSWER: FLUORODEOXYGLUCOSE (ACCEPT: FGC)