MEHS ROUND 10

TOSS-UP

1) Physics – *Short Answer* Kraftwerk flashes 5 beams of light to a concave mirror, in a direction perpendicular to the reflecting surface of the mirror. All 5 beams of light intersect at one point. What is this point known as?

ANSWER: FOCAL POINT

BONUS

1) Physics – *Short Answer* A gas of monatomic helium is confined such that it can only move on the X axis without rotating. Assuming that the gas is at a temperature of 80 degrees kelvin, and giving your answer in terms of the ideal gas constant, what is the internal energy of the gas?

ANSWER: 40

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TOSS-UP

2) Chemistry – *Multiple Choice* If an atom's highest energy electron has an angular momentum quantum number of 2, which of the following could not be the atom?

W) Titanium
X) Zinc
Y) Selenium
Z) Tungsten

ANSWER: Y) SELENIUM

BONUS

2) Chemistry – *Short Answer* Identify all of the following 3 substances that are true regarding indicators in a titration: 1) Phenolphthalein indicator is a weak base that turns pink in the presence of hydroxide ions; 2) Iodine is used as an indicator in iodometric titrations to determine the concentration of the oxidizing agent in a solution; 3) The gradual addition of silver nitrate solution into an analyte consisting of sodium thiocyanate is an example of a precipitation titration.

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

3) Energy – *Short Answer* Scientists at Lawrence Berkeley National Lab are modeling the merger of neutron stars and their explosive aftermath to try and elucidate the life of neutron stars. What is the name of the event that occurs when the crust of a neutron star suddenly begins to shake?

ANSWER: STARQUAKE

BONUS

3) Energy – *Short Answer* Scientists at Pacific Northwest National Lab are researching how microbial communities composed of phototrophs and heterotrophs are able to facilitate sustainable growth. Identify all of the following 3 statements regarding phototrophs and heterotrophs that are true: 1) Chemoautotrophs derive their energy from organic compounds; 2) Phototrophs typically photosynthesize by catabolically converting CO2 into organic compounds; 3) Heterotrophs are unable to produce their own food but instead take in nutrition from mainly plant and animal matter.

ANSWER: 3 ONLY

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TOSS-UP

4) Earth and Space – *Short Answer* What type of fog forms when moist air is cooled to its saturation temperature and flows up along an elevated mountain?

ANSWER: UPSLOPE FOG (ACCEPT: OROGRAPHIC FOG)

BONUS

4) Earth and Space – *Short Answer* Identify all of the following 3 statements regarding the competence and capacity of streams that are true: 1) Competence decreases with stream velocity; 2) Capacity is directly related to discharge; 3) Capacity increases when there is more water in the stream.

ANSWER: 2 AND 3
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TOSS-UP

5) Math – *Multiple Choice* Given the function f of x equals 4 times the absolute value of the quantity x minus three, at which of the following values in the domain is the function continuous, but not differentiable?

W) x = 0
X) x = 3
Y) x = 4
Z) The function is continuous and differentiable throughout the domain

ANSWER: X) X = 3

BONUS

5) Math – *Short Answer* Calculate the slope of the secant line that over the interval from 0 to 3 for the function f of x equals x to the fourth minus 5 x.

ANSWER: 22

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TOSS-UP

6) Chemistry – *Multiple Choice* A student spills 50 milliliters of a 0.2 molar barium hydroxide solution and is told to neutralize the spill using nitric acid before cleaning it up. How many milliliters of 0.1 molar nitric acid are required to neutralize the spill?

W) 50
X) 100
Y) 150
Z) 200

ANSWER: Z) 200

BONUS

6) Chemistry – *Short Answer* Calculate the Kc of a the reaction of oxygen gas with nitrogen gas to form nitrogen monoxide at 2.0 atmospheres and 298 kelvin if the Kp of the reaction is 1.2 times 10 to the negative 4, given that the partial pressures of oxygen and nitrogen are 1.4 atmospheres and 0.6 atmospheres, respectively.

ANSWER: 1.2 TIMES 10 TO THE NEGATIVE 4

7) Physics – *Short Answer* Giving your answer in pi kilogram meters per second squared, and in scientific notation rounded to the nearest tenth, along with assuming that planck's constant is 6.6 x10^{-34}, what is the angular momentum of an electron with a principal quantum number of 2?
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TOSS-UP

ANSWER: 2.1 x 10^{-34}

BONUS

7) Physics – *Short Answer* An engineer in a locomotive sees a car stuck on the track at a railroad crossing in front of the train. When the engineer first sees the car, the locomotive is 200 meters from the crossing and its speed is 20 m/s. If the engineer's reaction time is 0.25 s, what should be the magnitude of the minimum deceleration to avoid an accident, in meters per second squared?

ANSWER: 50/49

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TOSS-UP

8) Biology – *Short Answer* What acid involved in the citric acid cycle serves as the intermediate in the cycle and condenses with acetyl-CoA to form citric acid?

ANSWER: OXALOACETIC ACID

BONUS

8) Biology – *Multiple Choice* Which of the following animals is NOT properly matched with its respective type of fertilization?

W) Sharks and ovoviviparity
X) Humans and viviparity
Y) Salmon and viviparity
Z) Blue jays and oviparity

ANSWER: Y) SALMON AND VIVIPARITY
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TOSS-UP

9) Earth and Space – *Multiple Choice* The rings of Jupiter are primarily composed of which of the following substances?

W) Ice
X) Dust
Y) Gas
Z) Rocks

ANSWER: X) DUST

BONUS

9) Earth and Space – *Short Answer* What tornado life stage is characterized by fine particles and dirt swirling upwards from the ground, forming a funnel that extends downward from the thunderstorm's base?

ANSWER: DUST-WHIRL STAGE

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TOSS-UP

10) Math – *Short Answer* The sum of the digits of a two digit number is 15. The value of the integer is 16 times the ones digit. What is the number?

ANSWER: 96

BONUS

10) Math – *Short Answer* Edward pays for 4 coconuts and 3 fish. Peter spends twice as much paying for 2 coconuts and 16 fish. What is the ratio between the price of a coconut and the price of a fish?

ANSWER: 5/3 (ACCEPT: 5 TO 3)

11) Physics – *Short Answer* A light wave passes from a vacuum with an index of refraction of 1 into a fluid with an index of refraction of 1.45. Assuming that the frequency of the light in a vacuum is 550 megahertz, and giving your answer in meters rounded to the nearest tenth, what is the wavelength of the light in the fluid?
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TOSS-UP

ANSWER: 0.4

BONUS

11) Physics – *Multiple Choice* Which of the following will decrease the maximum amount of energy stored in a circuit?

W) Increasing the resistance of the circuit
X) Decreasing the resistance of the circuit
Y) Decreasing the voltage of the circuit
Z) Increasing the inductance of the circuit

ANSWER: Y) DECREASING THE VOLTAGE OF THE CIRCUIT

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TOSS-UP

12) Energy – *Multiple Choice* Researchers at Fermi National Accelerator Lab are using the muon to probe interactions fundamental forces. The muon is unaffected by which of the following forces?

W) Weak nuclear
X) Strong nuclear
Y) Electromagnetic
Z) Gravitational

ANSWER: X) STRONG NUCLEAR

BONUS

12) Energy – *Short Answer* Researchers at Thomas Jefferson National Lab are conducting research into the types of quarks that compose protons. What are the 3 color charges that a quark can have?

ANSWER: RED, GREEN, BLUE
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TOSS-UP

13) Biology – *Multiple Choice* Which of the following proteins is incorrectly matched with its oxygen binding metal atom?

W) Hemoglobin and iron
X) Hemocyanin and copper
Y) Hemerythrin and silver
Z) Myoglobin and iron

ANSWER: Y) HEMERYTHRIN AND SILVER

BONUS

13) Biology – *Short Answer* Identify all of the following 4 molecules that are homopolysaccharides: 1) Immunoglobulins; 2) Glycogen; 3) Galactan; 4) Collagen.

ANSWER: 2 AND 3

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TOSS-UP

14) Earth and Space – *Short Answer* What is the name of the phenomenon that occurs when long rolls of counter-rotating air are aligned parallel to the ground in the planetary boundary layer, causing clouds to form into rows?

ANSWER: CLOUD STREETS (ACCEPT: HORIZONTAL CONVECTIVE ROLLS)

BONUS

14) Earth and Space – *Short Answer* What is the name of the sedimentary beds that consist of alternating layers of iron oxide minerals and red chert and are thought to have recorded the oxygenation of the oceans?

ANSWER: BANDED IRON FORMATIONS
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TOSS-UP

15) Math – *Short Answer* The sum of a set of consecutive integers from -8 to n is 55. What is the value of n?

ANSWER: 13

BONUS

15) Math – *Short Answer* Real numbers a and b satisfy the equations 3 to the power of a is equal to 81 to the power of the quantity b plus 2 and (pause) 125 to the power of b is equal to 5 to the power of the quantity a minus 3. What is the value of a divided b, in simplest form?

ANSWER: 5/12

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TOSS-UP

16) Chemistry – *Multiple Choice* A thin layer chromatography is performed for 4 food dyes, Red 4, Yellow 40, Blue 6, and Green 28. The distance that each dye travels up the nonpolar paper, in centimeters, is 2.4, 4.9, 3.7, and 4.2, respectively. Which of the four dyes is the most polar?

W) Red 4
X) Yellow 40
Y) Blue 6
Z) Green 28

ANSWER: X) YELLOW 40

BONUS

16) Chemistry – *Short Answer* What is the name of a process where the net heat transfer to the surroundings is zero?

ANSWER: ADIABATIC (ACCEPT: ADIABATIC PROCESS)
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TOSS-UP

17) Energy – *Short Answer* Researchers at SLAC National lab have been conducting research into the detection of neutrinos. What type of nuclear decay also produces neutrinos?

ANSWER: BETA DECAY

BONUS

17) Energy – *Multiple Choice* Researchers at Argonne National lab have been surveying cosmic background radiation. Which of the following values is often calculated from measurements of cosmic background radiation?

W) Lorentz constant
X) Hubble's constant
Y) Vacuum permittivity
Z) Cosmological constant

ANSWER: X) HUBBLE'S CONSTANT

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TOSS-UP

18) Biology – *Multiple Choice* A deficiency of which of the following vitamins would cause beriberi and the wernicke-korsakoff syndrome?

W) B1
X) B3
Y) B6
Z) B12

ANSWER: W) B1

BONUS

18) Biology – *Short Answer* Identify all of the following 3 statements regarding the pentose phosphate pathway that are true: 1) It does not produce nor require ATP; 2) The pathway occurs before glycolysis, using the unbroken glucose; 3) In the oxidative phase of the pathway, NADPH and ribose-5-phosphate are produced.

ANSWER: 1 ONLY
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TOSS-UP

19) Earth and Space – *Multiple Choice* Which of the following galactic components do NOT comprise the galactic halo?

W) Globular clusters
X) Nebulae
Y) Subdwarfs
Z) Field stars

ANSWER: X) NEBULAE

BONUS

19) Earth and Space – *Short Answer* What is the name of the level that marks the base of the cloud and is the height at which the relative humidity of a parcel reaches 100%?

ANSWER: LIFTING CONDENSATION LEVEL (ACCEPT: LCL)

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TOSS-UP

20) Math – *Multiple Choice* The product of two consecutive integers is 756. What is the smaller of the two integers?

W) 22
X) 23
Y) 27
Z) 28

ANSWER: Y) 27

BONUS

20) Math – *Short Answer* Supposed that x and y are nonzero real numbers such that 3x plus y divided by x minus 3y equal negative 2. What is the value of 4x plus 2y divided by 6x minus 2y?

ANSWER: 3/2 (ACCEPT: 1.5)
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TOSS-UP

21) Physics – *Multiple Choice* Kepler's second law is derived from which of the following principles?

W) Conservation of linear momentum
X) Conservation of angular momentum
Y) Conservation of energy
Z) Newton's first law

ANSWER: X) CONSERVATION OF ANGULAR MOMENTUM

BONUS

21) Physics – *Short Answer* The magnitude of a magnetic field 4 meters from a long, straight wire is 6 milliteslas. What is the subsequent current in the wire, assuming that vacuum permeability is 4 pi x 10^{-7}?

ANSWER: 12 KILOAMPERES

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TOSS-UP

22) Chemistry – *Multiple Choice* Which of the following is an example of an aromatic compound?

W) 2-Methyl tetrahydrofuran
X) Aniline
Y) Propene
Z) Toluene

ANSWER: Y) PROPENE

BONUS

22) Chemistry – *Short Answer* In a solution of Phosphoric Acid in water, what is the name of the ion that will have the 2nd lowest concentration?

ANSWER: BIPHOSPHATE ION (ACCEPT: HPO4 2 MINUS)
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TOSS-UP

23) Biology – *Short Answer* What is the name of the enzyme that is responsible for the hydrolyzation of starch and glycogen into smaller polysaccharides?

ANSWER: AMYLASE

BONUS

23) Biology – *Short Answer* Order the following 5 process in the production of cellulose in the plant cell from first to last: 1) Enzyme is manufactured at ribosomes; 2) RNA molecule is transcribed; 3) Carbohydrate polymer is synthesized; 4) Cellulose deposited in cell wall; 5) Nucleic acid migrates from nucleus to ribosome.

ANSWER: 2, 5, 1, 3, 4