MEHS ROUND 7

TOSS-UP

1) Physics – *Short Answer* An object in circular motion accelerates from an initial velocity of 3 radians per second at a rate of 2.5 radians per second squared for 4 seconds. What is the angular displacement of the object, in radians?

ANSWER: 32 RADIANS

BONUS

1) Physics – *Short Answer* A 60 kg person is standing in an elevator which is moving upwards at a rate of 3.2 meters per second. During this upward movement, what is the gravitational force experienced by the person in the elevator, in newtons?

ANSWER: 588

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TOSS-UP

2) Chemistry – *Multiple Choice* Which of the following best explains what occurs to the melting and boiling points of a solvent when solid potassium phosphate is dissolved?

W) Melting point increases, boiling point increases
X) Melting point increases, boiling point decreases
Y) Melting point decreases, boiling point increases
Z) Melting point decreases, boiling point decreases

ANSWER: Y) MELTING POINT DECREASES, BOILING POINT INCREASES

BONUS

2) Chemistry – *Multiple Choice* The existence of which of the following properties explains why adding energy to water at the boiling point does not increase its temperature?

W) Enthalpy of vaporization
X) Melting point decreases, boiling point increases
Y) Melting point increases, boiling point decreases
Z) Melting point increases, boiling point increases

ANSWER: W) ENTHALPY OF VAPORIZATION
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TOSS-UP

3) Energy – *Multiple Choice* Scientists at Lawrence Berkeley National Lab are studying the origin of iron meteorites. Which of the following statements regarding meteorites is NOT true?

W) Iron meteorites often have widmanstätten ***[VEED-mahn-state-en]*** patterns
X) Stony-iron meteorites are the most common meteorites in falls
Y) Most types of chondrites ***[KON-drites]*** contain chondrules
Z) Stony meteorites are made up of minerals that contain silicates

ANSWER: X) STONY-IRON METEORITES ARE THE MOST COMMON METEORITES IN FALLS

BONUS

3) Energy – *Short Answer* Scientists at Pacific Northwest National Lab are studying how the hadley cell is affected by sea temperature changes. Identify all of the following 3 statements regarding the hadley cell that are true: 1) Subtropical highs may form where the hadley and ferrel cells converge; 2) A high pressure zone is formed at the equator where the hadley cells converge; 3) Trade winds located within the hadley cell flow from the equator to the horse latitudes.

ANSWER: 1 ONLY

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TOSS-UP

4) Earth and Space – *Short Answer* What is the name of the boundary that separates Earth's crust and the mantle and explains the abrupt increase in seismic velocity with increasing depth?

ANSWER: MOHO (ACCEPT: MOHOROVICIC DISCONTINUITY)

BONUS

4) Earth and Space – *Short Answer* What is the name of the chemical sedimentary rocks consisting of crystallized calcium carbonate that have directly precipitated from groundwater?

ANSWER: TRAVERTINE

5) Math – *Multiple Choice* Which of the following is the product of the quantity 2 plus 4i and -5 minus 3i?

W) -10 plus 12i
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TOSS-UP

X) 2 minus 14i
Y) -22 plus 26i
Z) 2 minus 26i

ANSWER: Z) 2 MINUS 26I

BONUS

5) Math – *Short Answer* Quadrilateral ABCD is rotated 90° counterclockwise around the origin and dilated by a factor of 3 with the center of dilation located at the origin. If the coordinates of quadrilateral ABCD are A(–2, 2), B(0, 2), C(0, –1), and D(–2, 0), what are the coordinates of A' ***[A prime]*** after rotation and dilation?

ANSWER: (-6, -6)

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TOSS-UP

6) Chemistry – *Multiple Choice* Which of the following substances has the greatest Van't Hoff factor in water?

W) Sodium carbonate
X) Aluminum sulfate
Y) Glucose
Z) Oxygen difluoride

ANSWER: X) ALUMINUM SULFATE

BONUS

6) Chemistry – *Short Answer* What is the absorbance of a 0.4 molar solution of iron thiosulfate in a cuvette with an optical path length of 2 centimeters, given that the molar absorption coefficient of iron thiosulfate is 0.65?

ANSWER: 0.52
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TOSS-UP

7) Physics – *Short Answer* What is the derivative of the total energy in an LC circuit?

ANSWER: 0

BONUS

7) Physics – *Multiple Choice* Modifying which of the following quantities will NOT affect the speed of an ideal fluid flowing inside a pipe?

W) Elevation of the fluid
X) Pressure on the fluid
Y) Heat of the fluid
Z) Density of the fluid

ANSWER: Y) HEAT OF THE FLUID

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TOSS-UP

8) Biology – *Multiple Choice* Which of the following types of speciation occurs when two populations of bears become isolated from each other due to geographic changes and gradually become two different species?

W) Allopatric
X) Peripatric
Y) Parapatric
Z) Sympatric

ANSWER: W) ALLOPATRIC

BONUS

8) Biology – *Multiple Choice* What is the name of the intercellular junctions in animal tissues that fasten cells together into strong sheets and provide strong adhesion between cells?

ANSWER: DESMOSOMES

9) Earth and Space – *Short Answer* What is the name of the large, threadlike formations of gravitationally bound galaxies that form the boundaries between large voids in the universe?
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TOSS-UP

ANSWER: GALAXY FILAMENT

BONUS

9) Earth and Space – *Short Answer* Below what layer of the Sun is helioseismology used by solar astronomers to analyze the vibrations occurring in the Sun to better understand its depths?

ANSWER: PHOTOSPHERE

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TOSS-UP

10) Math – *Multiple Choice* If a rectangle is rotated about an axis going straight through the middle of the rectangle, which of the following would be the resulting three-dimensional solid formed?

W) Cone
X) Sphere
Y) Pyramid
Z) Cylinder

ANSWER: Z) CYLINDER

BONUS

10) Math – *Short Answer* In a right triangle, one angle measures x°, where sin x = 4/5. What is cos(90 + x)?

ANSWER: -0.8 (ACCEPT: -4/5)

11) Physics – *Short Answer* A light wave traveling in a vacuum is reflected off of a material with an index of refraction of 1.44. Assuming that the index of refraction is 1, and giving your answer in degrees, what is the phase difference between the original wave and the reflected wave?

ANSWER: 180
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TOSS-UP

BONUS

11) Physics – *Multiple Choice* The angular velocity of a real pendulum is inversely proportional to which of the following quantities?

W) The square of the radius of the bob from the pivot point
X) The square of the acceleration from gravity
Y) The mass of the bob
Z) The square of the rotational inertia of the pendulum

ANSWER: Z) THE SQUARE OF THE ROTATIONAL INERTIA OF THE PENDULUM

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TOSS-UP

12) Energy – *Multiple Choice* Researchers at Thomas Jefferson National Accelerator Facility are conducting research into the composition and properties of hadrons, such as baryons. Which of the following quark compositions of a particle would be considered a baryon?

W) One up, one down
X) One up, one up
Y) Two up, one down
Z) Two up, two down

ANSWER: Y) TWO UP, ONE DOWN

BONUS

12) Energy – *Short Answer* Scientists at Argonne National Lab have been studying the use of sound waves for levitating objects. Identify all of the following 3 quantities that affect the frequency of a wave: 1) Angular velocity; 2) Period; 3) Amplitude.

ANSWER: 1 AND 2
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TOSS-UP

13) Biology – *Multiple Choice* Which of the following types of meristems is located at the root and shoot tips and contains cells that are responsible for primary growth?

W) Apical
X) Lateral
Y) Ground
Z) Cambium

ANSWER: W) APICAL

BONUS

13) Biology – *Short Answer* Order the following 4 steps in the process by which blood filtrate is processed into urine from first to last: 1) Ascending limb of the loop of Henle; 2) Descending limb of the loop of Henle; 3) Proximal tubule; 4) Distal tubule.

ANSWER: 3, 2, 1, 4

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TOSS-UP

14) Earth and Space – *Multiple Choice* Which of the following times of mass wasting occurs when loose sediments or rocks slide along a concave-upward surface?

W) Rockfall
X) Creep
Y) Slump
Z) Mudflow

ANSWER: Y) SLUMP

BONUS

14) Earth and Space – *Short Answer* Identify all of the following 3 statements that are true regarding El Niño: 1) El Niño is caused by the air pressure rise in the western Pacific and fall in the eastern Pacific; 2) La Niña is a strengthening of the east-to-west wind flow and ocean currents; 3) The El Niño Southern Oscillation describes the seesaw pattern of reversing surface air pressure in the Pacific Ocean.

ANSWER: ALL OF THEM

15) Math – *Short Answer* To the nearest year, how long would it take for Adam's bank account to triple in value given that the interest rate is 6%?
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TOSS-UP

ANSWER: 19

BONUS

15) Math – *Short Answer* What is the whole number remainder when the function f of x equals 7x cubed plus 2x minus 5 is divided by the quantity x minus 1?

ANSWER: 4

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TOSS-UP

16) Chemistry – *Multiple Choice* Which of the following substances exhibits the least volatility at 25 degrees Celsius?

W) Diethyl ether
X) Butane
Y) 1-Pentene
Z) Methyl acetate

ANSWER: Z) METHYL ACETATE

BONUS

16) Chemistry – *Short Answer* Arrange the following 3 acids from least to greatest in terms of their dissociation constant in water: 1) Chlorous Acid; 2) Perchloric Acid; 3) Chloric Acid.

ANSWER: 1, 3, 2
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TOSS-UP

17) Energy – *Short Answer* Researchers at SLAC National Accelerator Lab have built one of the brightest lasers in the world. The laser accelerates an electron beam to nearly the speed of light, then passes the beam through a series of magnets. What is this series of magnets known as?

ANSWER: UNDULATOR

BONUS

17) Energy – *Multiple Choice* Researchers at Ames National Lab have been conducting research into building high-performance magnets with new materials. Which of the following types of magnetism exists in objects with randomly-oriented magnetic dipole moments throughout the material?

W) Diamagnetism
X) Paramagnetism
Y) Ferromagnetism
Z) Antiferromagnetism

ANSWER: X) PARAMAGNETISM

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TOSS-UP

18) Biology – *Short Answer* What is the name given to DNA molecules that can be transferred to other organisms by conjugation or transformation?

ANSWER: PLASMIDS

BONUS

18) Biology – *Multiple Choice* Which of the following is the name of the scientific theory that superseded phyletic gradualism as a model for the creation of new species over time?

W) Gradualism
X) Natural selection
Y) Punctuated equilibrium
Z) Darwinian evolution

ANSWER: Y) PUNCTUATED EQUILIBRIUM
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TOSS-UP

19) Earth and Space – *Short Answer* What is the name of the loosely organized groups in space that consist of very young and massive stars of spectral types O and B?

ANSWER: OB ASSOCIATIONS

BONUS

19) Earth and Space – *Short Answer* Identify all of the following 4 rocks that are foliated metamorphic rocks: 1) Schist; 2) Hornfels; 3) Gneiss; 4) Quartzite.

ANSWER: 1 AND 3

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TOSS-UP

20) Math – *Multiple Choice* Which of the following is true regarding a scatterplot where r^2 is equal to 0.92?

W) The distribution has a strong, positive, linear correlation
X) 92% of the variation in the data can be explained by the least-squares regression line
Y) The distribution has a strong, negative, linear correlation
Z) 8% of the variation in the data can be explained by the least-squares regression line

ANSWER: X) 92% OF THE VARIATION IN THE DATA CAN BE EXPLAINED BY THE LEAST-SQUARES REGRESSION LINE

BONUS

20) Math – *Short Answer* What is the y value of the vertex of the parabola in the equation y = 2x squared minus 6x plus 15?

ANSWER: 21/2 (ACCEPT: 10.5)
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TOSS-UP

21) Physics – *Multiple Choice* The only force acting on a box at rest is a torque applied at one end of the box on the Z axis in the positive X direction. Which of the following forces must be applied for the object to be in static equilibrium ?

W) A torque of equal magnitude but opposite direction of the original torque is applied to the same end of the box on the Z axis
X) A torque of equal magnitude but that same direction as the original torque is applied to the opposite end of the box on the X axis
Y) A torque of greater magnitude and in the opposite direction of the original torque is applied to the end of the box on the Y axis
Z) A force of equal magnitude but opposite direction of the original torque is applied on the center of mass for the box

ANSWER: W) A TORQUE OF EQUAL MAGNITUDE BUT OPPOSITE DIRECTION OF THE ORIGINAL TORQUE IS APPLIED TO THE END OF THE BOX ON THE Z AXIS

BONUS

21) Physics – *Short Answer* The multiplication factor of a nuclear reactor is often set at what number during operation?

ANSWER: 1 (ACCEPT: UNITY)

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TOSS-UP

22) Chemistry – *Multiple Choice* In the equilibrium reaction of phosphorus trichloride with chlorine gas to form phosphorus pentachloride, an endothermic process, which of the following changes to the system will increase the number of phosphorus pentachloride molecules?

W) Increase in the volume of the reaction vessel
X) Addition of gaseous phosphorus pentachloride
Y) Decrease in temperature of the reaction vessel
Z) Decrease in the volume of the reaction vessel

ANSWER: Z) DECREASE IN THE VOLUME OF THE REACTION VESSEL

BONUS

22) Chemistry – *Short Answer* What is the acid anhydride of hypochlorous acid?

ANSWER: DICHLORINE MONOXIDE (ACCEPT: CL2O)
23) Biology – *Short Answer* What is the name of the hormone, known as a hunger suppressant, that melatonin regulates the action of during times when an animal is asleep?
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TOSS-UP

ANSWER: LEPTIN

BONUS

23) Biology – *Short Answer* Identify all of the following 3 statements that are true regarding gene knockout: 1) It is often coupled with loxP-Cre recombination so it only affects certain cells; 2) Non-homologous recombination is the main method for causing a gene knockout; 3) Gene knockouts are primarily used to understand the role of a specific gene or DNA region.

ANSWER: 1 AND 3