MEHS ROUND 9

TOSS-UP

1) Physics – *Short Answer* A semi-compressible cube with sides of length 2 meters is filled with an incompressible fluid. If a force of 5 newtons is applied to the front of the cube, giving your answer in pascals, what is the change in pressure of the face at the bottom of the cube?

ANSWER: 1.25

BONUS

1) Physics – *Short Answer* An RLC circuit has a resistor of resistance 47 ohms, an inductance of 9 henries, a capacitor of 37 farads, and a driving frequency of 103 radians. What is the impedance of the circuit at resonance?

ANSWER: 47

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TOSS-UP

2) Chemistry – *Multiple Choice* Which of the following molecules has the shortest nitrogen-oxygen bond length?

W) Nitrite ion
X) Nitrous oxide
Y) Dinitrogen trioxide
Z) Nitric oxide

ANSWER: Z) NITRIC OXIDE

BONUS

2) Chemistry – *Short Answer* What is the name of the doubly-eponymous phenomenon that describes the cooling of a gas as it expands as a result of weakening intermolecular forces?

ANSWER: JOULE-THOMSON EFFECT (ACCEPT: JOULE-KELVIN EFFECT)
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TOSS-UP

3) Energy – *Short Answer* Scientists at Lawrence Livermore National Lab are doing research on the stellar evolution of brown dwarfs. What element is used to distinguish brown dwarf stars from main sequence stars due to its presence in the atomic spectra of brown dwarfs?

ANSWER: LITHIUM

BONUS

3) Energy – *Short Answer* Scientists at Lawrence Livermore National Lab are studying how clouds affect solar radiation and the process of precipitation within them. Identify all of the following 3 statements concerning clouds that are true: 1) Cumulus clouds form from thermals; 2) Convection is the main form of heat transport in thermal bubbles and causes the rising and sinking of air in cumulus clouds; 3) Stratus clouds can not form when a thick layer of fog rises.

ANSWER: 1 AND 2

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TOSS-UP

4) Earth and Space – *Short Answer* What is the name of the process in which a mid-latitude cyclone develops and increases in strength?

ANSWER: CYCLOGENESIS

BONUS

4) Earth and Space – *Multiple Choice* Which of the following statements regarding streams is NOT true?

W) The line connecting the lowest points of a stream is called the thalweg
X) Erosion in a stream generally occurs at the cut bank
Y) Water flows faster in the hyporheic ***[hy-po-REE-ik]*** zone than it does in the open channel
Z) The competence of a stream is the maximum particle size it is able to carry

ANSWER: Y) WATER FLOWS FASTER IN THE HYPORHEIC ZONE THAN IT DOES IN THE OPEN CHANNEL
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TOSS-UP

5) Math – *Multiple Choice* The mean of one set of 6 numbers is 17 and the mean of another set of 8 numbers is 10. Which of the following is the mean of the combined set of all 14 numbers?

W) 11
X) 12
Y) 13
Z) 14

ANSWER: Y) 13

BONUS

5) Math – *Short Answer* What is the sum of the prime factors of 385?

ANSWER: 23

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TOSS-UP

6) Chemistry – *Multiple Choice* Which of the following best explains how viscosity and surface tension of a liquid are affected with an decrease in temperature?

W) Viscosity increases, surface tension increases
X) Viscosity increases, surface tension decreases
Y) Viscosity decreases, surface tension increases
Z) Viscosity decreases, surface tension decreases

ANSWER: W) VISCOSITY INCREASES, SURFACE TENSION INCREASES

BONUS

6) Chemistry – *Short Answer* If the partial pressures of oxygen and nitrogen gas are 4.0 atm and 3.0 atm, respectively, and they combine to form dinitrogen pentoxide with a k value of 3 times 10 to the negative 4, what is the equilibrium partial pressure of oxygen?

ANSWER: 2.85
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TOSS-UP

7) Physics – *Short Answer* What quantity must be zero for an ideal carnot engine?

ANSWER: ENTROPY

BONUS

7) Physics – *Multiple Choice* Which of the following could be done to slow the discharge of a fully-charged capacitor in an RC circuit without increasing the maximum charge that the capacitor could hold?

W) Increase the voltage of the circuit
X) Increase the resistance of the circuit
Y) Increase the capacitance of the capacitor
Z) Decrease the resistance of the circuit

ANSWER: Z) DECREASE THE RESISTANCE OF THE CIRCUIT

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TOSS-UP

8) Biology – *Multiple Choice* Which of the following processes is NOT a type of endocytosis?

W) Caveolar
X) Secretion
Y) Receptor-mediated
Z) Phagocytosis

ANSWER: X) SECRETION

BONUS

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

W) Benign tumors can be removed by surgery
X) Cells within premalignant tumors are cancerous
Y) Malignant tumors involve cells that can spread to one or more organs
Z) Metastasis is the process by which cancer cells spread to locations away from their original site

ANSWER: X) CELLS WITHIN PREMALIGNANT TUMORS ARE CANCEROUS
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TOSS-UP

9) Earth and Space – *Short Answer* What is the name of the astronomical process that occurs when gases are released from a planet's interior and accumulate to form an atmosphere?

ANSWER: OUTGASSING

BONUS

9) Earth and Space – *Multiple Choice* Which of the following pairs of adjectives best describes the universe?

W) Anisotropic, heterogenous
X) Anisotropic, homogenous
Y) Isotropic, heterogenous
Z) Isotropic, homogenous

ANSWER: Z) ISOTROPIC, HOMOGENOUS

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TOSS-UP

10) Math – *Short Answer* If a function f of x is equal to 2 x squared plus 8, what is f inverse of x for the value 136?

ANSWER: 8

BONUS

10) Math – *Short Answer* The product of three, consecutive, odd, positive integers is 7 times their sum. What is the sum of the three integers?

ANSWER: 15

11) Physics – *Short Answer* What is the electric flux, in volt meters, of a closed surface given that the surface has a permittivity of 0.4 millifarads per meter and the charge is 0.02 Coulombs?
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TOSS-UP

ANSWER: 50

BONUS

11) Physics – *Multiple Choice* A block of mass 28 m can move without friction on a horizontal table. This block is attached to another block of mass 8 m by a cord that passes over a frictionless pulley. If the masses of the cord and the pulley are negligible, in terms of g, what is the magnitude of the acceleration of the descending block?

W) 2/9 g
X) 2/5 g
Y) 7/24 g
Z) 5/14 g

ANSWER: W) 2/9 G

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TOSS-UP

12) Energy – *Multiple Choice* Researchers at Thomas Jefferson National Lab are conducting research into the symmetry between subatomic particles and their antiparticles suggested by the standard model. What is the antiparticle of the electron?

W) Positron
X) Proton
Y) Neutron
Z) Neutrino

ANSWER: W) POSITRON

BONUS

12) Energy – *Short Answer* Researchers at Fermi National Accelerator Lab are conducting research into quantum entanglement. What equation is most commonly used in quantum physics for modeling a trapped particle?

ANSWER: SCHRODINGER'S EQUATION
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TOSS-UP

13) Biology – *Short Answer* What is the name of the type of nephron that is only found in birds and mammals and has a long loop of Henle which penetrates deeply into the renal medulla?

ANSWER: JUXTAMEDULLARY NEPHRON

BONUS

13) Biology – *Short Answer* Identify all of the following 3 pairs of processes and their functions in the nitrogen cycle that are correctly matched: 1) Ammonification, atmospheric nitrogen into ammonium; 2) Nitrification, nitrate into nitrogen gas; 3) Denitrification, nitrite to nitrogen gas.

ANSWER: 1 ONLY

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TOSS-UP

14) Earth and Space – *Short Answer* Identify all of the following 3 present-day continents that once formed Gondwana: 1) North America; 2) South America; 3) Africa.

ANSWER: 2 AND 3

BONUS

14) Earth and Space – *Short Answer* Rank the following 4 water reservoirs from the one with the lowest average residence time to the one with the highest average residence time: 1) Ice caps; 2) Streams; 3) Atmosphere; 4) Oceans.

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

15) Math – *Short Answer* What is the least positive integer greater than 30 that has exactly 5 factors?

ANSWER: 81

BONUS

15) Math – *Short Answer* When a number is divided by 3, the number is 79 more than if the number was divided by 4. What is the sum of the digits of this number?

ANSWER: 21

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TOSS-UP

16) Chemistry – *Multiple Choice* What is the ratio of effusion in a pinhole leak for molecules of bromine to neon?

W) 2 to 1
X) 2 root 2 to 1
Y) 4 to 1
Z) 4 root 2 to 1

ANSWER: X) 2 ROOT 2 TO 1

BONUS

16) Chemistry – *Short Answer* Identify all of the following three statements that are true regarding ketones: 1) Ketones have no hydrogen atoms directly attached to the carbonyl group; 2) Ketones have lower relative melting and boiling points relative to aldehydes with equal numbers of carbons; 3) They are incapable of forming hydrogen bonds.

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

17) Energy – *Short Answer* Researchers at Thomas Jefferson National Lab are conducting research into how the weak nuclear force affects protons. What other force is the weak nuclear force coupled with?

ANSWER: ELECTROMAGNETIC FORCE

BONUS

17) Energy – *Multiple Choice* Researchers at Princeton Plasma Physics Lab have been conducting research into magnets suitable for use in fusion reactors. In which of the following types of magnetism do the atoms have randomly oriented atomic dipole moments, giving the magnet a net magnetic dipole moment of zero?

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

ANSWER: Y) PARAMAGNETISM

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TOSS-UP

18) Biology – *Multiple Choice* Which of the following statements regarding blood pressure is true?

W) Systolic pressure occurs when arterial blood pressure is the highest
X) During the diastole, the heart's muscles contract and pumps blood into the arteries
Y) Vasoconstriction causes blood pressure in the arteries to fall
Z) Valves are found in both arteries and veins

ANSWER: W) SYSTOLIC PRESSURE OCCURS WHEN ARTERIAL BLOOD PRESSURE IS THE HIGHEST

BONUS

18) Biology – *Short Answer* Identify all of the following 4 processes that are considered anabolic pathways: 1) Beta oxidation; 2) Gluconeogenesis; 3) Glycolysis; 4) Citric acid cycle.

ANSWER: 2 ONLY

19) Earth and Space – *Short Answer* What astronomical feature forms at the surface where solar wind is first deflected by Earth's magnetosphere?
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TOSS-UP

ANSWER: BOW SHOCK

BONUS

19) Earth and Space – *Multiple Choice* Which of the following statements regarding Earth's formation is NOT true?

W) Earth had a primeval atmosphere
X) Earth's secondary atmosphere formed due to outgassing
Y) Due to the greenhouse effect, very little infrared radiation is able to escape Earth's atmosphere
Z) Earth is the standard used in comparative planetology

ANSWER: W) EARTH HAD A PRIMEVAL ATMOSPHERE

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TOSS-UP

20) Math – *Multiple Choice* A rectangle has side lengths of 10 and x. If the area and perimeter of the rectangle are the same, what is the value of x squared?

W) 2.25
X) 6.25
Y) 12.25
Z) 20.25

ANSWER: X) 6.25

BONUS

20) Math – *Short Answer* What is the value of the difference 2018 squared minus 2013 squared?

ANSWER: 20155
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TOSS-UP

21) Physics – *Multiple Choice* What principle do ship-designers primarily rely on to make their boats float?

W) Pascal's
X) Bernoulli's
Y) Archimedes'
Z) Continuity

ANSWER: Y) ARCHIMEDES'

BONUS

21) Physics – *Short Answer* A rocket flying at 33 meters per second with an initial mass of 134 kilograms releases an engine of mass 35 kilograms. The engine falls from the rocket at a speed of 1 meter per second. Rounded up to the nearest whole number, and giving your answer in meters per second, what is the speed of the current rocket?

ANSWER: 44

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TOSS-UP

22) Chemistry – *Multiple Choice* What ion is formed from the redox reaction of the dichromate ion in acidified conditions?

W) Cr O 4 2 minus
X) Cr 2 O 7 2 minus
Y) Cr 3 plus
Z) Cr 6 plus

ANSWER: Y) CR 3 PLUS

BONUS

22) Chemistry – *Short Answer* If the natural log of concentration of a substance is graphed versus time in a graph and forms a straight line, what is the reaction order with respect to that substance?

ANSWER: 1 (ACCEPT: FIRST ORDER)
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TOSS-UP

23) Biology – *Short Answer* The exploratory phase of the shifting balance theory is driven by which phenomenon?

ANSWER: GENETIC DRIFT

BONUS

23) Biology – *Short Answer* The synthesis of which substance occurs via the enzymatic transfer of a phosphocholine [***phos-fuh-KO-leen]*** from phosphatidylcholine ***[phos-fuh-TID-ul-ko-leen]*** to a ceramide?

ANSWER: SPHINGOMYELIN