MEHS ROUND 17

TOSS-UP

1) Physics – *Short Answer* Aldric shoots water from a water gun at a speed of 6.5 m/s holding the hose close to the ground. At what angle should the nozzle of the water gun be pointed to in order so that the water lands 2.5 meters away? Assume that the acceleration due to gravity is 10 m/s^2.

ANSWER: 18 AND 72 DEGREES (INCORRECT IF BOTH DEGREES NOT PRESENT)

BONUS

1) Physics – *Short Answer* A rubix cube is sliding down a ramp which is 9 meters long, and is inclined at 8 degrees. How long does it take the cube to reach the bottom of the ramp? Assume that the coefficient of kinetic friction is 0.060.

ANSWER: 4.8 SECONDS

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

2) Chemistry – *Multiple Choice* Assuming there are no pi interactions, what is the metal-ligand bond order in the hexahydro cobaltate (II) cation?

W) 1/6
X) 4/6
Y) 5/6
Z) 7/6

ANSWER: Y) 5/6

BONUS

2) Chemistry – *Short Answer* What is the name of the process in which carboxylic acid molecules experience hydrogen bonding as a result of deprotonation of their acidic hydrogen?

ANSWER: DIMERIZATION
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

3) Energy – *Multiple Choice* Scientists at Thomas Jefferson National Lab are conducting research on the precise lifespan of neutral pions to help elucidate the theory of quantum chromodynamics. Which of the following statements regarding pions is true?

W) In pions, both the strong and electromagnetic force have infinite ranges due to their masslessness
X) Pions are generally stable, causing the decay to photons, neutrinos, or electrons over long periods of time
Y) Pions can be emitted by neutrons and absorbed by electrons, and vice versa
Z) When put in a cloud chamber, pions in cosmic rays tends to have momentum intermediate between electrons and protons

ANSWER: Z) WHEN PUT IN A CLOUD CHAMBER, PIONS IN COSMIC RAYS TENDS TO HAVE MOMENTUM INTERMEDIATE BETWEEN ELECTRONS AND PROTONS

BONUS

3) Energy – *Short Answer* Scientists at Pacific Northwest National Lab are studying biofuel perennial plants through land surface models. Identify all of the following 3 statements regarding perennial plants that are true: 1) Perennial plants produce small seeds because of the abundant seedlings produced after germination, better ensuring survival; 2) Perennials grow structures that allow them to adapt to living from one year to the next through vegetative reproduction;
3) Perennials produce seeds to continue the species as a new generation when growing conditions are suitable.

ANSWER: 2 ONLY

~~~~~~

TOSS-UP

4) Earth and Space – *Short Answer* What type of equatorially trapped waves rapidly decay as their distance increases away from the equator and have the same rossby deformation radius as kelvin waves?

ANSWER: ROSSBY-GRAVITY WAVE (DO NOT ACCEPT: ROSSBY WAVE OR EQUATORIAL ROSSBY WAVE)

BONUS

4) Earth and Space – *Short Answer* Identify all of the following 5 polymorphs that are quartz polymorphs: 1) Sillimanite; 2) Tridymite; 3) Stishovite; 4) Andalusite; 5) Coesite.

ANSWER: 2, 3, AND 5
5) Math – *Short Answer* What is the shape of the curve defined by the polar equation r squared times the cosine of 2 theta equals 4?
~~~~~~

TOSS-UP

ANSWER: HYPERBOLA

BONUS

5) Math – *Short Answer* What is the value of d squared y over d x squared at the point (1, 2) in the equation 2x cubed plus 3 y squared equals x?

ANSWER: -313/288

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

6) Chemistry – *Multiple Choice* Alec performs an experiment measuring the amount of gas collected from a reaction of Magnesium and Hydrochloric acid over water. If barometric pressure is 101.3 kiloPascals, the vapor pressure of water at 298K is 0.0313 atm, and Alec measures 2.24 liters of gas collected, in atmospheres, what is the partial pressure of Hydrogen gas?

W) 1.0313
X) 0.8687
Y) 0.1313
Z) 0.0687

ANSWER: Z) 0.0687

BONUS

6) Chemistry – *Short Answer* Rank the following three functional groups from lowest to highest pKa: 1) Alpha hydrogen to two ketone carbonyl group; 2) Alpha hydrogen to ketone carbonyl group; 3) Alpha hydrogen to aldehyde carbonyl group.

ANSWER: 1, 3, 2
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

7) Physics – *Short Answer* Edward at soccer practice hits a soccer ball with a force of 500 newtons so it flies off at an initial angle of 45 degrees and then falls to the ground at a distance 40 meters from him. Rounded to the nearest hundredth of a second, how long was his foot in contact with the ball if the mass of the ball is 0.5 kilograms?

ANSWER: 0.02 SECONDS

BONUS

7) Physics – *Multiple Choice* Allison stands 5 meters away from a vertical wall, and kicks the soccer ball so it flies off at an angle of 45 degrees with a speed of 16 m/s. The ball bounces back elastically and flies back towards her. What is the maximum height that the soccer ball will reach?

W) 6.4 meters
X) 9.6 meters
Y) 18.7 meters
Z) 20.6 meters

ANSWER: W) 6.4 METERS

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

8) Biology – *Short Answer* The cortical ER is an extensive network of ER consisting of interconnected cisternae and tubules. What type of ion in the cytosol is the cortical ER responsible for regulating?

ANSWER: CALCIUM IONS (CA2+)

BONUS

8) Biology – *Short Answer* What cranial nerve is a mixed nerve that carries afferent sensory and efferent motor information, exiting out of the brainstem to the vagus nerve?

ANSWER: GLOSSOPHARYNGEAL NERVE
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

9) Earth and Space – *Short Answer* What type of star, with surface temperatures that are hotter than almost all other stars is characterized by an unusual spectra that has thick emission lines of ionized helium and highly ionized nitrogen and carbon?

ANSWER: WOLF-RAYET STAR

BONUS

9) Earth and Space – *Short Answer* Identify all of the 3 following statements regarding advection fogs that are NOT true: 1) Advection fogs are always involved with the movement of air; 2) Two ocean currents with different temperatures that flow next to one another can form an advection fog; 3) Strong temperature differences over water or bare ground can cause advection fogs.

ANSWER: NONE OF THEM

~~~~~~

TOSS-UP

10) Math – *Short Answer* If there are 3 integers such that the product of the first two is 48, the product of the last two is 96, and the product of the first and last integer is 72, what is the sum of all three numbers?

ANSWER: 26

BONUS

10) Math – *Short Answer* Find the area of the zone of a sphere formed by revolving the graph of y equals the square root of the quantity 9 minus x squared between x equals zero and x equals 2 about the y axis.

ANSWER: 6 PI TIMES THE QUANTITY 3 MINUS THE SQUARE ROOT OF 5

11) Physics – *Short Answer* For any series of hydrogen lines, what is the name for the level in a series where the principle quantum number is infinity?
~~~~~~

TOSS-UP

ANSWER: SERIES LIMIT

BONUS

11) Physics – *Multiple Choice* Based on the following descriptions, which of the following devices obey Ohm's law?

W) A device which has a current that increases exponentially as the potential difference applied to it is increased
X) A device which has a resistance dependent on the potential difference applied to the device
Y) A device that is composed of a homogeneous material
Z) All devices obey Ohm's law

ANSWER: Y) A DEVICE THAT IS COMPOSED OF A HOMOGENEOUS MATERIAL

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

12) Energy – *Multiple Choice* Scientists at Ames National Lab are researching the properties of skyrmions, a type of quasiparticle, and how they reproduce by splitting in a way similar to biological cell division. Quasiparticles are important in condensed matter physics because they are one of the few known ways of simplifying which of the following in quantum mechanics?

W) Many-body problem
X) Few-body system
Y) Quantum entanglement
Z) Mean-field theory

ANSWER: W) MANY-BODY PROBLEM

BONUS

12) Energy – *Short Answer* Scientists at Oak Ridge National Lab are using high-performance computing to create protein models to help reveal how the outer membrane is tethered to the cell membrane in certain gram-negative bacteria. What protein family, found in the outer membranes of gram-negative bacteria, act as filters for hydrophilic compounds and form large, water-filled channels which allow the diffusion of hydrophilic molecules into the periplasmic space?

ANSWER: BACTERIAL PORINS
13) Biology – *Short Answer* Order the following 3 layers in tree trunks from the innermost layer to the outermost layer: 1) Vascular cambium; 2) Secondary phloem; 3) Sapwood.

ANSWER: 3, 1, 2

BONUS
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

13) Biology – *Short Answer* In collagen proteins, a triple helix composed of three chains with about 20 amino acids. What 3 amino acids make up the most common motifs in the amino acid sequence of collagen and are abundant on mammal and fish skin?

ANSWER: GLYCINE, PROLINE, AND HYDROXYPROLINE

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

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

W) Blueschist forms from the metamorphism of basalt at low pressures and temperatures
X) Blueschist facies contain minerals such as glaucophane, epidote, and lawsonite
Y) Blueschists have a lepidoblastic and nematoblastic texture
Z) Subduction of blueschist facies in oceanic crust will product eclogite facies

ANSWER: W) BLUESCHIST FORMS FROM THE METAMORPHISM OF BASALT AT LOW PRESSURES AND TEMPERATURES

BONUS

14) Earth and Space – *Short Answer* Identify all of the following 3 groups of minerals that are classified as phyllosilicates; 1) Micas; 2) Pyroxenes; 3) Feldspars.

ANSWER: 1 ONLY
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

15) Math – *Short Answer* What is the sum of the endpoints of the domain of the vector function r of t equals < natural log of the quantity 4 minus t squared comma the square root of the quantity t minus 1?

ANSWER: 1 (-1 TO 2)

BONUS

15) Math – *Short Answer* The average number of cars sold by Aldric at a dealership is 2 cars per day. What is the probability that Aldric will sell exactly 3 cars tomorrow? Express your answer as a fraction in simplest form.

ANSWER: 4 OVER 3 E SQUARED (ACCEPT 4 THIRD E TO THE NEGATIVE 2 OR ANY SIMILAR EXPRESSIONS)

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

16) Chemistry – *Multiple Choice* Which of the following metallic compounds is a liquid at room temperature?

W) SnO2
X) TiCl4
Y) MnF4
Z) WF5

ANSWER: X) TICL4

BONUS

16) Chemistry – *Short Answer* What phenomenon describes the effect when an electron-donating group on a neighboring carbon increases the rate of an SN2 reaction?

ANSWER: NEIGHBORING GROUP PARTICIPATION (ACCEPT: ANCHIMERIC ASSISTANCE)
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

17) Energy – *Short Answer* Researchers at Argonne National lab have been conducting research into nuclear quantum Monte Carlo methods for solving the Schrodinger equation. A random walk Monte carlo algorithm creates what type of chain?

ANSWER: MARKOV CHAIN (ACCEPT: MARKOV)

BONUS

17) Energy – *Multiple Choice* Scientists at Ames National lab are researching methods of propagating light. This requires the independent control of both the electric and magnetic field components of the light. Which of the following aspects of light, when altered, will NOT alter either the electric field or magnetic field components of the light?

W) The intensity of the light
X) The angular frequency of the light
Y) The Poynting vector of the light
Z) The speed of the light

ANSWER: Z) THE SPEED OF THE LIGHT

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

18) Biology – *Short Answer* What chemically resistant biopolymer in bryophyte spores is a major component of the tough walls that enable spores to survive dispersal through the air?

ANSWER: SPOROPOLLENIN

BONUS

18) Biology – *Multiple Choice* Which of the following proteins is involved in the coating of vesicles in receptor-mediated intracellular transport?

W) Caveolin
X) Tubulin
Y) Clusterin
Z) Clathrin

ANSWER: Z) CLATHRIN
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

19) Earth and Space – *Short Answer* What is the name of the nuclear process that occurs when photons present in the core of stars possess energy to destroy heavy nuclei?

ANSWER: PHOTODISINTEGRATION

BONUS

19) Earth and Space – *Short Answer* Cataclysmic variables are stars that irregularly increase in brightness. Identify all of the following 3 statements regarding cataclysmic variable stars that are true: 1) Cataclysmic variables are composed of neutron star binaries; 2) Cataclysmic variables irregularly increase in brightness by a large factor and then fall to a dormant state; 3) Cataclysmic variables emit in the x-ray and gamma-ray ranges.

ANSWER: 2 ONLY

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

20) Math – *Multiple Choice* Which of the following points is closest to the yz plane?

W) (7, 0, -8)
X) (5, 9, 1)
Y) (4, 2, -6)
Z) (-6, 3, 2)

ANSWER: Y) (4, 2, -6)

BONUS

20) Math – *Short Answer* What is the double integral of a solid given the function x comma y equals x times y squared dx dy, between bounds of 0 to 2 for x and 0 to 1 for y?

ANSWER: 2/3
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

21) Physics – *Multiple Choice* Which of the following mathematical objects contains information on the mismatch of quantum states of neutrinos when they propagate freely and when they take part in weak interactions?

W) Weinberg angle
X) Lamb shift
Y) PMNS matrix
Z) Higgs field

ANSWER: Y) PMNS MATRIX

BONUS

21) Physics – *Short Answer* The charm quark, along with the charm antiquark, were first observed in what particle?

ANSWER: J/PSI MESON

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

22) Chemistry – *Multiple Choice* What correction does the b variable make in the Van Der Waals Equation when determining the pressure of a real gas?

W) Adjustment of molecular size
X) Adjustment of intermolecular forces
Y) Adjustment of molecular speed
Z) Adjustment of molar volume

ANSWER: W) ADJUSTMENT OF MOLECULAR SIZE

BONUS

22) Chemistry – *Short Answer* What is the coordination geometry of cobalt in the complex ion Tris(ethylenediamine)cobalt(III) dibromide?

ANSWER: OCTAHEDRAL
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

23) Biology – *Short Answer* What is the name of the veins inside the spongy cancellous bone separating the inner and outer layers of the cortical bone of the skull?

ANSWER: DIPLOIC VEINS (ACCEPT: DIPLOE VIENS)

BONUS

23) Biology – *Short Answer* Identify all of the following 4 conditions in the body that would indicate an increase of white blood cells: 1) Leukemia; 2) Leukocytosis; 3) Leukopenia; 4) Myelofibrosis.

ANSWER: 1, 2, AND 4