MEHS ROUND 14

TOSS-UP

1) Physics – *Short Answer* A particle's Compton wavelength is 257 meters. Assuming that planck's constant is 6.6 * 10^{-34} joules per second, and giving your answer in kilograms, what is the particle's mass?

ANSWER: 8.5 x 10^{-45}

BONUS

1) Physics – *Short Answer* An RL circuit has a current of 5 milliamperes and dissipates power at a rate of 37 watts. Assuming that the current of the RL circuit is always constant, what is the voltage of the circuit?

ANSWER: 7.4 MILLIVOLTS

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TOSS-UP

2) Chemistry – *Multiple Choice* Which of the following molecules has an s-character of 33%

W) NH3
X) CO2
Y) C2O3 2 MINUS
Z) SO3

ANSWER: Y) C2O3 2 MINUS

BONUS

2) Chemistry – *Short Answer* Give the proper name for the coordinated complex with a central atom of iron, 4 CO ligands, and 2 OH minus ligands.

ANSWER: TETRACARBONYL-HYDROXO-IRON (III) ION
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TOSS-UP

3) Energy – *Short Answer* Scientists at Lawrence Berkeley National Lab are using structural biology and the Advanced Light Source to study COVID-19 antibodies. What antibody class is responsible for travelling to cells and releasing chemicals that cause an allergic reaction?

ANSWER: IMMUNOGLOBULIN E (ACCEPT: IGE)

BONUS

3) Energy – *Short Answer* Scientists at Pacific Northwest National Lab are conducting research on how cells regulate enzyme activity to maintain a liquid center. Identify all of the following 3 statements regarding enzymes that are true: 1) The region where the enzyme binds to the substrate is called the enzyme-substrate complex; 2) In catalysis, enzymes change the gibbs free energy for a reaction; 3) Noncompetitive enzyme inhibitors impede enzymatic interaction.

ANSWER: 3 ONLY

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TOSS-UP

4) Earth and Space – *Short Answer* What is the name of the kuiper belt objects which are immune to gravitational influence because of their 3:2 resonance with Neptune?

ANSWER: PLUTINOS

BONUS

4) Earth and Space – *Short Answer* In stratified lakes, what layer is characterized by the presence of a thermocline that changes in depth throughout the day?

ANSWER: METALIMNION
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TOSS-UP

5) Math – *Multiple Choice* A rectangle's base remains 0.5 meters while the height is changing at 1.5 meters per second. At what rate does the area of the rectangle change, in meters per second, when the height is 1.5 meters?

W) 0.5
X) 0.75
Y) 1.5
Z) 2.25

ANSWER: X) 0.75

BONUS

5) Math – *Short Answer* Given an equation y equals u cubed minus u squared plus 1, and u equals 2x squared minus, evaluate dy dx at x equals 2.

ANSWER: 1288

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TOSS-UP

6) Chemistry – *Multiple Choice* Which of the following acids has the lowest pKa1?

W) Acetic acid
X) Bromoacetic acid
Y) Chlorous acid
Z) Chromic acid

ANSWER: Z) CHROMIC ACID

BONUS

6) Chemistry – *Short Answer* Arrange the following 4 elements from greatest to least electron affinity: 1) Fluorine; 2) Chlorine; 3) Boron; 4) Silicon.

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

7) Physics – *Short Answer* A rocket in space naturally oscillates with an amplitude of 3 centimeters, and applies a damping force to that oscillation with a damping constant of 331. As time approaches infinity, what is the amplitude of the oscillation?

ANSWER: 0

BONUS

7) Physics – *Multiple Choice* Valentina wants to circularize the orbit of her satellite rotating the planet Kerbin. Relative to Kerbin, in which of the following directions should she burn the satellite's engines in to most efficiently circularize her orbit?

W) Retrograde
X) Prograde
Y) Normal
Z) Radial

ANSWER: W) RETROGRADE

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TOSS-UP

8) Biology – *Multiple Choice* In the photosystem II, pigments are best at absorbing which of the following colors of lights?

W) Blue
X) Green
Y) Yellow
Z) Red

ANSWER: Z) RED

BONUS

8) Biology – *Multiple Choice* Which of the following cell types is correctly matched with the endocrine product it produces?

W) Alpha cells and insulin
X) Beta cells and glucagon
Y) Delta cells and somatostatin
Z) C cells and gastrin

ANSWER: Y) DELTA CELLS AND SOMATOSTATIN
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TOSS-UP

9) Earth and Space – *Short Answer* What concept describes the floating of the crust in gravitational balance on the deformable rocks in the mantle?

ANSWER: ISOSTASY

BONUS

9) Earth and Space – *Short Answer* What phenomenon explains why old and dense slabs of oceanic lithosphere can plunge into the mantle due to their own weight?

ANSWER: SLAB PULL

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TOSS-UP

10) Math – *Multiple Choice* Which of the following functions is even?

W) sin 3x
X) x squared plus 4x plus 4
Y) x cubed plus 9x
Z) absolute value of cosine x

ANSWER: Z) ABSOLUTE VALUE OF COSINE X

BONUS

10) Math – *Short Answer* What are the rectangular coordinates of a point with polar coordinates (2.4, 5pi/6)?

ANSWER: (1.2 ROOT 3, 1.2)

11) Physics – *Short Answer* A rocket has an initial mass of 31 kilograms and a final mass of 24 kilograms. Rounding your answer to the nearest tenth, If the final mass of the rocket is decreased to 17 kilograms, by what factor will the change in velocity of the rocket increase?

ANSWER: 0.3
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TOSS-UP

BONUS

11) Physics – *Multiple Choice* Annabeth tries pulling a pencil apart. Assuming there are only small changes in heat and temperature, and that there is no net change in internal energy in the pencil, which of the following quantities is indirectly proportional to the inward force from the pencil?

W) The force that Annabeth exerts on the pencil
X) The rate of change of the entropy of the pencil
Y) The change in potential energy of the pencil
Z) The pressure on the pencil

ANSWER: X) THE RATE OF CHANGE OF THE ENTROPY OF THE PENCIL

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TOSS-UP

12) Energy – *Multiple Choice* Researchers at Brookhaven National Lab built the Booster Synchrotron to accelerate ion and proton beams. Which of the following is a valid reason for why the Booster didn't use a cyclotron design?

W) Ions/protons in the Booster are travelling at speeds where their frequency isn't constant
X) Ions/protons are too unstable in a cyclotron
Y) Ions/protons in the booster are traveling at speeds where they can't be accelerated by electric fields
Z) Ions/protons in the Booster are traveling such that they can't be controlled by magnetic fields

ANSWER: W) IONS/PROTONS IN THE BOOSTER ARE TRAVELLING AT SPEEDS WHERE THEIR FREQUENCY ISN'T CONSTANT

BONUS

12) Energy – *Short Answer* Researchers at Fermi Accelerator National Accelerator Lab are conducting research into the applications of Gauss's law to quantum computers. According to Gauss's law for magnetic fields, what quantity must always be zero through a closed Gaussian surface?

ANSWER: NET MAGNETIC FLUX (ACCEPT: MAGNETIC FLUX)
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TOSS-UP

13) Biology – *Short Answer* Identify all of the following 3 organelles that formed in the endosymbiotic theory: 1) Mitochondria; 2) Chloroplasts; 3) Ribosomes.

ANSWER: 1 AND 2

BONUS

13) Biology – *Short Answer* Identify all of the following 3 statements regarding photoperiodism that are true: 1) Short-day plants generally flower in early spring and summer; 2) Long-day plants are controlled by day length; 3) Blue light is the most effective color in interrupting the night length because type II phytochromes are activated by blue light.

TOSS-UP

ANSWER: 1 ONLY

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TOSS-UP

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

W) Globular clusters are more dense with stars compared to open clusters
X) Globular clusters are nearly spherical
Y) Globular clusters are very loosely bound by gravity
Z) Globular clusters are found in the halo of a galaxy

ANSWER: Y) GLOBULAR CLUSTERS ARE VERY LOOSELY BOUND BY GRAVITY

BONUS

14) Earth and Space – *Short Answer* In what season is the productivity in midlatitude oceans the highest?

ANSWER: SPRING
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TOSS-UP

15) Math – *Short Answer* What is the equation of a hyperbola centered at (1,0) with vertices at (-1, 0) and (3, 0)?

ANSWER: X MINUS 1 SQUARED MINUS Y SQUARED EQUALS 4

BONUS

15) Math – *Short Answer* What is the sine of 22.5, given in simplest form with nested radicals?

ANSWER: SQUARE ROOT OF 2 MINUS ROOT, 2 ALL OVER 2, (SQRT(2-SQRT(2))/2)

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TOSS-UP

16) Chemistry – *Multiple Choice* Which of the following is not considered a "noble metal?"

W) Silver
X) Rhenium
Y) Osmium
Z) Iridium

ANSWER: X) RHENIUM

BONUS

16) Chemistry – *Short Answer* In a redox reaction, what are the products when thiosulfate is used to reduce the triiodide anion?

ANSWER: IODIDE AND TETRATHIONATE ANIONS
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TOSS-UP

17) Energy – *Short Answer* Researchers at Argonne National Lab are building mini nuclear reactors for use in the trucking industry. The fuel and moderator are commonly placed in different regions of the reactor volume to minimize what type of capture?

ANSWER: RESONANCE CAPTURE (DO NOT ACCEPT: NONFISSION CAPTURE)

BONUS

17) Energy – *Multiple Choice* Researchers at Thomas Jefferson National Lab are studying the pressure distribution of quarks inside protons. Which of the following classes of particles can not contain a particle containing quarks?

W) Mesons
X) Bosons
Y) Baryons
Z) Leptons

ANSWER: Z) LEPTONS

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TOSS-UP

18) Biology – *Multiple Choice* The nine months of human gestation are divided into three trimesters of equal length. In which of the following trimesters does the main period of organogenesis occur?

W) First
X) Second
Y) Third
Z) Delivery

ANSWER: W) FIRST

BONUS

18) Biology – *Short Answer* What general name is given to genes that can transform cells into tumor cells?

ANSWER: ONCOGENES
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TOSS-UP

19) Earth and Space – *Short Answer* What subclass of active galactic nucleus may be formed by the collision of two galaxies, both containing a large black hole at their centers?

ANSWER: QUASAR

BONUS

19) Earth and Space – *Short Answer* What type of precipitation consist of supercooled drops of water that immediately freeze upon striking a cold object?

ANSWER: GLAZE

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TOSS-UP

20) Math – *Multiple Choice* What is the base 4 representation of 271 in base 10?

W) 10033
X) 10103
Y) 11031
Z) 12011

ANSWER: W) 10033

BONUS

20) Math – *Short Answer* Calculate the derivative of the function f at x=4.2, given that f prime of 4 is -5 and f of 4 is 3.

ANSWER: -4.4
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TOSS-UP

21) Physics – *Multiple Choice* An object with height 6 centimeters is placed 3 centimeters away from a concave lens with focal length 2 cm. Which of the following best describes the image formed by the lens?

W) Real upright image
X) Real inverted image
Y) Virtual upright image
Z) Virtual inverted image

ANSWER: W) REAL UPRIGHT IMAGE

BONUS

21) Physics – *Short Answer* A 2.4 kg mass compresses a spring 40 centimeters from its equilibrium position with a spring constant of 150 Newtons per meter. This spring is then released, causing the mass to move forward with negligible friction. To the nearest second, how long does the mass take to move a distance of 10 meters?

ANSWER: 3

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TOSS-UP

22) Chemistry – *Multiple Choice* What is the acid anhydride for Arsenic Acid?

W) As O3
X) As2 O5
Y) As2 O7
Z) As3 O9

ANSWER: X) AS2 O5

BONUS

22) Chemistry – *Short Answer* When bonded to a central metal atom, cyanide ligands can either donate their lone pair on carbon or nitrogen. What type of isomerism is exhibited due to this effect?

ANSWER: LINKAGE ISOMERISM
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TOSS-UP

23) Biology – *Multiple Choice* Which of the following types of algae includes many seaweeds, are multicellular, and mostly live in marine environments?

W) Green
X) Red
Y) Brown
Z) Yellow-green

ANSWER: Y) BROWN

BONUS

23) Biology – *Short Answer* Identify all of the following types of epithelial tissues that absorb substances in the digestive tract lining: 1) Simple columnar; 2) Stratified squamous; 3) Transitional

ANSWER: 1 ONLY