MHS Round 14

Buzzer test + Ice breaker question:

TOSS-UP

1) Physics – *Short Answer* A spring has a force function of $F(x) = -4x^3$. If a block has a mass of 2 kilograms, and is stretched a distance of 2 meters in the spring, then in meters per second, what will its maximum speed be?

ANSWER: 4

BONUS

1) Physics – *Multiple Choice* Which of the following quasiparticles is not bosonic?

W) Phonon
X) Exciton
Y) Hole
Z) Magnon

ANSWER: Y) HOLE

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TOSS-UP

2) Earth and Space – *Short Answer* The Amalthea and Thebe are both examples of what specific type of ring of Jupiter, extending twice as far from the planet as the main ring?

ANSWER: GOSSAMER RINGS

BONUS

2) Earth and Space – *Short Answer* Starquakes occur on what specific type of stellar object?

ANSWER: MAGNETAR
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TOSS-UP

3) Chemistry – *Short Answer* The face of an Sp2 carbon that has priority of its substituents increasing in a clockwise fashion is known as what in the cahn-Ingolg-Prelog naming system?

ANSWER: RE

BONUS

3) Chemistry – *Multiple Choice* Which of the following best explains why cyclooctatriene is not considered ANTIaromatic.

W) It does not follow Huckle's Law
X) It dimerizes with itself
Y) It is not conjugated
Z) It is not planar.

ANSWER: Z) IT IS NOT PLANAR.

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TOSS-UP

4) Biology – *Multiple Choice* Which would be the most important to produce nucleotides and reducing power required in high concentration in advance of DNA replication?

W) Pentose phosphate, oxidative phase
X) Gluconeogenesis
Y) Lactate fermentation
Z) Pentose phosphate, non-oxidative phase

ANSWER: W) PENTOSE PHOSPHATE, OXIDATIVE PHASE

BONUS

4) Biology – *Multiple Choice* Which of the following is not a function of cytochrome C?

W) It is recycled into aspartate in the Urea cycle.
X) It carries electrons in the electron transport chain.
Y) Aids in the activation of apoptosis.
Z) It functions as a strong antioxidative enzyme in the mitochondria.

ANSWER: W) IT IS RECYCLED INTO ASPARTATE IN THE UREA CYCLE.
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TOSS-UP

5) Math – *Short Answer* .2 repeating in base 5 is equivalent to what value in base 10?

ANSWER: 0.5 (ACCEPT: ½)

BONUS

5) Math – *Short Answer* The point (2, 3) is rotated 60 degrees counterclockwise. What are the new coordinates of this point?

ANSWER: $(1 - 3\sqrt{3}/2, \sqrt{3}/2 + 3/2)$

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TOSS-UP

6) Physics – *Short Answer* What is the name of the class of materials that, when stretched, expand in a perpendicular direction to the stretching force?

ANSWER: AUXETICS

BONUS

6) Physics – *Short Answer* A solid, constant-density cylindrical object of radius 1meter and mass 60kg rolls down a 60 degree incline without slipping. What is the force of static friction the object experiences to the nearest ten newtons?

ANSWER: 170
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TOSS-UP

7) Earth and Space – *Multiple Choice* Which of the following forms of stability occur when the environmental lapse rate is greater than the dry adiabatic rate?

W) Absolute Stability
X) Conditional Instability
Y) Absolute Instability
Z) Wet Stability

ANSWER: Y) ABSOLUTE INSTABILITY

BONUS

7) Earth and Space – *Short Answer* What is the name for the type of waves that are dominated by the effects of wind and surface tension, commonly known as ripples?

ANSWER: CAPILLARY WAVES

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TOSS-UP

8) Chemistry – *Short Answer* A neutral carbon atom that has a valence of 2 is known as what?

ANSWER: CARBENE

BONUS

8) Chemistry – *Short Answer* Order the following 3 crystal systems from increasing order from least symmetric to most symmetric: 1) Cubic; 2) Triclinic; 3) Orthorhombic.

ANSWER: 2, 3, 1
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TOSS-UP

9) Biology – *Multiple Choice* Which of the following is not a factor that contributed to the deadliness of Tuberculosis?

W) They are hidden from the innate defenses
X) They resist breakdown by lysosomes
Y) They grow and reproduce within macrophages
Z) They are retroviruses

ANSWER: Z) THEY ARE RETROVIRUSES

BONUS

9) Biology – *Multiple Choice* Which of the following choices will occur when the F factor is integrated into the genome of a bacterium?

W) The bacterium becomes F- and can only act as the recipient.
X) The bacterium is F+, and is the donor.
Y) The bacterium is F+, and can no longer be the donor.
Z) The bacterium is F+, and is now the recipient.

ANSWER: X) THE BACTERIUM IS F+, AND IS THE DONOR.

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TOSS-UP

10) Math – *Short Answer* Given that the multivariable function $f(x,y) = xy + 3x + 5y + 15$. What is $f(3,4)$?

ANSWER: 56

BONUS

10) Math – *Short Answer* What is the area of the shape formed in the complex plane by the roots of the equation $z^5 + z^4 + z^3 + z^2 + z + 1$?

ANSWER: $5\sqrt{3}/4$
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TOSS-UP

11) Physics – *Short Answer* Will and Leon are flying in separate spaceships in the same direction. Will is directly behind Leon, and observes Leon travelling at a speed of 0.7c. Given that Will is travelling at a speed of 0.3c, what is the speed of Leon measured by a stationary outside observer in terms of c?

ANSWER: 100c/121

BONUS

11) Physics – *Short Answer* An object's potential energy with respect to distance can be modelled by the function $U(x) = x\sin(x)$. How many points of unstable equilibrium exist between $x = 0$ and $x = 12$?

ANSWER: 2

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TOSS-UP

12) Earth and Space – *Multiple Choice* Which of the following oceanic currents is a western boundary current?

W) California Current
X) Canary Current
Y) Kuroshio Current
Z) Benguela Current

ANSWER: Y) KUROSHIO CURRENT

BONUS

12) Earth and Space – *Multiple Choice* Which of the following types of air masses is the least dense?

W) Maritime Tropical
X) Maritime Polar
Y) Continental Tropical
Z) Continental Polar

ANSWER: W) MARITIME TROPICAL
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TOSS-UP

13) Biology – *Short Answer* What term is given for when a bacterial infection induces an overwhelming systemic inflammatory response, often characterized by a high fever, low blood pressure, and poor blood flow?

ANSWER: SEPTIC SHOCK (ACCEPT: SEPSIS)

BONUS

13) Biology – *Short Answer* What plot is created when you take the reciprocal of the Briggs-Haldane equation?

ANSWER: LINEWEAVER-BURK PLOT

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TOSS-UP

14) Chemistry – *Short Answer* Identify all of the following 3 choices that are the same for a hexagonal closed-pack unit cell and a face-centered cubic unit cell: 1) Coordination number; 2) Symmetry; 3) Atomic packing factor.

ANSWER: 1, 3

BONUS

14) Chemistry – *Short Answer* I'm too lazy to think of another question, so uh, tell the person next to you that you love them and then pass go for 10 points.

ANSWER: NEG 5
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TOSS-UP

15) Math – *Short Answer* What is the divergence of the vector field $(x^2 + y^2)\mathbf{i} + (2yz)\mathbf{j} + (4x^2)\mathbf{k}$

ANSWER: $2x + 2z$

BONUS

15) Math – *Short Answer* What is the maximum area of a triangle that can be inscribed in an ellipse with equation $x^2/9 + y^2/16 = 1$?

ANSWER: $9\sqrt{3}$

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TOSS-UP

16) Physics – *Short Answer* When a muon decays into an electron, what two other particles are created to conserve lepton number?

ANSWER: ELECTRON ANTINEUTRINO AND MUON NEUTRINO

BONUS

16) Physics – *Multiple Choice* Which of the following situations describes the Auger effect?

W) A 1*s* electron is ejected from an atom by an X-ray, followed by another 1*s* Auger electron
X) A 2*s* electron is ejected from an atom by an X-ray, followed by a 1*s* Auger electron
Y) A 1*s* electron is ejected from an atom by an X-ray, followed by a 3*s* Auger electron
Z) A 2*s* electron is ejected from an atom by an X-ray, followed by a 2*s* Auger electron

ANSWER: Y) A 1*s* ELECTRON IS EJECTED FROM AN ATOM BY AN X-RAY, FOLLOWED BY A 3*s* AUGER ELECTRON
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TOSS-UP

17) Chemistry – *Short Answer* Identify all of the following 3 reagents that would create a cis epoxide from a cis alkene: 1) mCPBA; 2) MMPP; 3) DMSO.

ANSWER: 1 AND 2

BONUS

17) Chemistry – *Short Answer* Identify all of the following 3 diagrams that can be used for representing redox stability: 1) Pourbaix; 2) Frost; 3) Latimer.

ANSWER: ALL

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TOSS-UP

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

W) Mitochondrial DNA lacks histone proteins.
X) Mitochondria are able to transiently store calcium.
Y) The light strand of the mitochondria produces tRNA.
Z) The TaTa box is the promoter gene for mitochondrial plasmids.

ANSWER: Z) THE TATA BOX IS THE PROMOTER GENE FOR MITOCHONDRIAL PLASMIDS

BONUS

18) Biology – *Short Answer* Which of the following best explains why the addition of a proline in a protein increases stability.

W) Because of the structural rigidity of the pyrrolidine ring, proline decreases the total entropy change between the unfolded and folded state.
X) Proline is a less reactive species because there are no acidic protons making it less electrophilic.
Y) Because of the pyrrolidine ring, proline does not allow conformational changes making it harder for the protein to be folded.
Z) Proline has the highest enthalpy of formation making it the most stable amino acid and helps increase the stability of the proteins it is in.

ANSWER: W) BECAUSE OF THE STRUCTURAL RIGIDITY OF THE PYRROLIDINE RING, PROLINE DECREASES THE TOTAL ENTROPY CHANGES BETWEEN THE UNFOLDED AND FOLDED STATES.
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TOSS-UP

19) Earth and Space – *Short Answer* What is the final nuclide of the CNO cycle, which combines with a proton to generate an alpha particle and a carbon-12 nucleus?

ANSWER: NITROGEN-15

BONUS

19) Earth and Space – *Multiple Choice* Which of the following statements is true of Mercury?

W) It is larger than Ganymede
X) Lobate scarps were generated from the shrinking of Mercury
Y) Mercury does not have a magnetic field
Z) The Caloris impact occurred in the early stage of the cratering of Mercury

ANSWER: X) LOBATE SCARPS WERE GENERATED FROM THE SHRINKING OF MERCURY

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TOSS-UP

20) Math – *Short Answer* What is the smallest number that has 9 factors?

ANSWER: 36

BONUS

20) Math – *Multiple Choice* Which of the following is a valid integrating factor for the differential equation sine of x times y prime + cosine of x times y equals $4x$?

W) $tan(x)$
X) 1
Y) $cos(x)$
Z) $sin(x)$

ANSWER: X) 1
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TOSS-UP

21) Biology – *Multiple Choice* In the process of urea formation, ATP breakdown is required to drive which of the following reactions?

W) Transamination of oxaloacetate to aspartate.
X) Transamination of glutamate to alpha-ketoglutarate
Y) Hydrolysis of urea from arginine
Z) Conversion of bicarbonate to ammonium acceptor

ANSWER: Z) CONVERSION OF BICARBONATE TO AMMONIUM ACCEPTOR

BONUS

21) Biology – *Short Answer* Identify all of the following 4 statements that are true according to the modern synthesis model, but not according to Darwin's model of natural selection: 1) Recombination can be favorable to the organism's reproductive success; 2) Few offspring survive to reproductive age; 3) Some variation within a population is heritable; 4) Adaptive or neutral mutations can become pervasive in the gene pool

ANSWER: 1 AND 4

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TOSS-UP

22) Chemistry – *Short Answer* Order the following 3 pericyclic reactions from least to greatest in the total change of the number of sigma bonds: 1) Sigmatropic; 2) Cycloaddition; 3) Electrocyclic.

ANSWER: 1, 3, 2

BONUS

22) Chemistry – *Multiple Choice* Which of the following hydrogens would be most commonly expected to be furthest downstream on a 1-H NMR spectrum?

W) Methylene hydrogen
X) Ipso hydrogen
Y) Alcohol hydrogen
Z) Aldehyde hydrogen

ANSWER: Z) ALDEHYDE HYDROGEN
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TOSS-UP

23) Earth and Space – *Short Answer* What is the term for when an inferior planet's position is farthest from Earth?

ANSWER: SUPERIOR CONJUNCTION

BONUS

23) Earth and Space – *Short Answer* What is the synodic period, in years, of Mars given that its sidereal period is 17/9 years?

ANSWER: 17/8 YEARS (ACCEPT: 2.125)