MHS Round 11

Buzzer test + Ice breaker question:

TOSS-UP

1) Physics – *Short Answer* Identify all of the following forces that can interact with a sterile neutrino, a possible candidate for dark matter: 1) Gravity; 2) Electromagnetism; 3) Weak

ANSWER: 1 ONLY

BONUS

1) Physics – *Short Answer* A hollow sphere has a radius of 3 kilograms and a radius of 5 meters. If it's radius were to double and its surface area density, measured in kilograms per meters squared, were to remain the same, what would the new moment of inertia, in terms of kilograms meters squared, be for the sphere?

ANSWER: 800

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TOSS-UP

2) Earth and Space - *Multiple Choice* - The rotating nature of an eclipsing binary system's orbit leads to what variation in luminosity plotted by a graph of brightness over time that can reveal stellar diameter and masses?

W) Doppler Shift
X) Light Curve
Y) Spectroscopic Parallax
Z) Flux

ANSWER: X) LIGHT CURVE

BONUS

2) Earth and Space - *Multiple Choice* - Balmer Lines are the strongest in which of the following stellar classes:

W) A type
X) B type
Y) O type
Z) M type

ANSWER: W) A TYPE
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TOSS-UP

3) Chemistry – *Short Answer* What idea in chemistry states that the transition state of a reaction will look like either the reactants or the products depending on which one it is closer to in energy?

ANSWER: HAMMOND'S POSTULATE

BONUS

3) Chemistry – *Short Answer* Identify all of the following 3 molecules that have homotopic hydrogens: 1) Cyclopropane; 2) Fluoro-chloro methane; 3) ®-2-Butanol

ANSWER: 1 ONLY

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TOSS-UP

4) Biology – *Short Answer* Identify all of the following 3 cells that are diploids: 1) Sporophytes; 2) Gametophytes; 3) Integument.

ANSWER: 1 AND 3

BONUS

4) Biology – *Short Answer* Identify all of the following 4 hormones that would increase blood glucose levels: 1) Somatostatin; 2) Glucagon; 3) Thyroxine; 4) Cortisol.

ANSWER: 2, 3, 4
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TOSS-UP

5) Math – *Short Answer* What is the dot product of the vectors $7i + 6j$ and $5i - 2j$?

ANSWER: 23

BONUS

5) Math – *Short Answer* After not talking to a girl in several months, Sanjay is considered "antisocial". The last time he talked to a girl was on March 6th, which was a Friday. Given that it is currently November 24th of the same year, what day of the week is it?

ANSWER: TUESDAY

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TOSS-UP

6) Physics – *Short Answer* What is the magnitude of the centripetal acceleration, in newtons, of a particle with a mass of 2 kilograms and a charge of 3 coulombs, travelling with a velocity of 4 meters per second, at an angle of 30 degrees with respect to a magnetic field of strength 2 teslas?

ANSWER: 6

BONUS

6) Physics – *Multiple Choice* Which of the following describes an ideal voltmeter?

W) Zero resistance, parallel to the circuit
X) Zero resistance, in series with the circuit
Y) Infinite resistance, parallel to the circuit
Z) Infinite resistance, in series with the circuit

ANSWER: Y) INFINITE RESISTANCE, PARALLEL TO THE CIRCUIT
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TOSS-UP

7) Earth and Space - *Short Answer* If you were to fall into a black hole, observers would need to adjust their telescopes to detect different wavelengths of light due to what phenomena, assuming that time dilation is somehow negated?

ANSWER: GRAVITATIONAL REDSHIFT

BONUS

7) Earth and Space - *Multiple Choice* - Theory suggests that a star with a mass greater than 20 solar masses, such as a large supergiant or hypergiant, would collapse very violently, producing gamma ray jets, in an event called a hypernova. Which of the following stars could produce such an explosion, given its size?

W) Vega
X) Sirius
Y) Rigel
Z) Arcturus

ANSWER: Y) RIGEL

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TOSS-UP

8) Energy – *Short Answer* Researchers at Princeton Plasma Physics laboratory are studying the electric currents generated by fusion reactions that could be potentially used for stabilization purposes. The matter used for fusion must have high energies because it must break through what barrier in order for fusion to occur?

ANSWER: COULOMB BARRIER

BONUS

8) Energy – *Multiple Choice* Researchers at Argonne national lab have recently synthesized borophene on a gold surface, which is investigated due to its similarity to graphene. Which of the following statements about graphene is NOT true?

W) All carbons are sp2 hybridized
X) Electron density is distributed evenly throughout the entire graphene surface
Y) Graphene is aromatic
Z) Sheets of graphene interact with each other through London dispersion forces in graphite

ANSWER: X) ELECTRON DENSITY IS DISTRIBUTED EVENLY THROUGHOUT THE ENTIRE GRAPHENE SURFACE
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TOSS-UP

9) Biology – *Short Answer* The Pentose-Phosphate Pathway occurs in what part of the cell?

ANSWER: CYTOPLASM

BONUS

9) Biology – *Short Answer* What type of base pairing is observed when a nucleotide adopts a syn conformation, which allows 3-4 strands to be present in a helix?

ANSWER: HOOGSTEEN

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TOSS-UP

10) Math – *Short Answer* A drawer contains 7 yellow socks, 8 orange socks, 4 red socks, and 2 green socks. John pulls socks randomly from the drawer without looking. How many socks must be pulled out of the drawer to guarantee a pair of orange socks?

ANSWER: 15

BONUS

10) Math – *Multiple Choice* Identify all of the following three functions that have an increasing second derivative over its entire domain: 1) *e* to the negative *x*; 2) cosine of *x* squared; 3) The quantity *x* squared + 1, cubed.

ANSWER: NONE
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TOSS-UP

11) Physics – *Short Answer* A ball is rolling without slipping at a constant velocity on a non-frictionless surface. Assuming no rolling friction, identify all of the following three forces that are acting upon the ball: 1) Gravity; 2) Normal force; 3) Static Friction

ANSWER: 1 AND 2

BONUS

11) Physics – *Short Answer* A 3 volt battery is used to charge a capacitor with an initial capacitance of 25 millifarads. A dielectric with dielectric constant 5 is put in between the capacitor. What is the energy stored in this capacitor, to the nearest tenth of a joule?

ANSWER: 1.1

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TOSS-UP

12) Earth and Space - *Short Answer* Scientists can use ancient, polarized rocks to date strata based on the direction of their grains. What is this technique called?

ANSWER: MAGNETOSTRATIGRAPHY

BONUS

12) Earth and Space - *Short Answer* Order the following extinctions from most recent to least recent in geologic time: 1) Megalodon; 2) Saber toothed tiger; 3) Velociraptor; 4) Trilobite.

ANSWER: 2 1 3 4
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TOSS-UP

13) Energy – *Short Answer* Researchers at the Joint Genome Institute are studying the types of fungi present in the decay of wood. They found that the brown-rot fungi are able to break down cellulose and hemicellulose but are not able to break down what other organic polymer found in the bark of trees?

ANSWER: LIGNIN

BONUS

13) Energy – *Short Answer* Researchers at the Joint Genome Institute are studying the methanogenic bacteria found in various ruminant species. Methanogenic bacteria are able to generate methane through the use of what molecule as the terminal electron acceptor in their respiration pathway?

ANSWER: CARBON DIOXIDE

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TOSS-UP

14) Chemistry – *Multiple Choice* In coordination chemistry, the donor atom of a ligand is described as which of the following?

W) The atom in the ligand that accepts a share in an electron pair from the metal.
X) The atom in the ligand that shares an electron pair with the metal.
Y) The counter ion
Z) Lewis acid

ANSWER: X) THE ATOM IN THE LIGAND THAT SHARES AN ELECTRON PAIR WITH THE METAL.

BONUS

14) Chemistry – *Short Answer* Identify all of the following 3 compounds that are products in the retro Diels Alder reaction: 1) Alkene; 2) Diene; 3) Triene

ANSWER: 2 ONLY
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TOSS-UP

15) Math – *Multiple Choice* A function is characterized by having a y intercept that is both positive and a local minimum. Which of the following functions could this be?

W) $x^3 - 3x$
X) $cos(2x)$
Y) $e^{2x} - 2x$
Z) $1/(x+2)$

ANSWER: Y) $e^{2x} - 2x$

BONUS

15) Math – *Short Answer* Given that two numbers, a and b follow the relationship $a + b = 11$, and $ab = 17$, what is $a^2 - b^2$?

ANSWER: $11\sqrt{53}$

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TOSS-UP

16) Physics – *Short Answer* What orbital shape is taken by an object orbiting a planet with a relative velocity that is always equivalent to the escape velocity?

ANSWER: PARABOLIC

BONUS

16) Physics – *Short Answer* A car is emitting a sound with frequency 540 hertz. Given that the car is moving at a speed of 34.3 meters per second towards a stationary observer, what is the observed frequency ot the nearest hertz?

ANSWER: 600
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TOSS-UP

17) Chemistry – *Multiple Choice* Which of the following functional groups will have the most downfield shift of a proton in 1H NMR?

W) Alcohol
X) Methylene
Y) Amine
Z) Aldehyde

ANSWER: Z) ALDEHYDE

BONUS

17) Chemistry – *Multiple Choice* Which of the following explains why an acid-catalyzed ring-opening of an epoxide can take place on a tertiary carbon:

W) The protonation of the epoxide acts as an electron-donating group.
X) The tertiary carbon holds a partial positive charge.
Y) Sn2 reaction favors the steric hindrance.
Z) An E2 pathway is favored.

ANSWER: X) THE TERTIARY CARBON HOLDS A PARTIAL POSITIVE CHARGE

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TOSS-UP

18) Biology – *Short Answer* The mismatch repair pathway in human DNA adds what functional group to the DNA?

ANSWER: METHYL (ACCEPT: CH3)

BONUS

18) Biology – *Short Answer* In what protein complex of the Electron Transport Chain is responsible for the pumping of protons across the mitochondrial membrane and passing electrons into cytochrome C.

ANSWER: III
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TOSS-UP

19) Earth and Space - *Multiple Choice* - Which of the following minerals does not correspond to its correct mineral family?

W) Amethyst- Quartz
X) Jade- Nephrite
Y) Pearl- Calcite
Z) Sapphire- Corundum

ANSWER: Y) PEARL- CALCITE

BONUS

19) Earth and Space - *Multiple Choice* - If an unknown mineral's streak on a ceramic plate shows a greenish-black color, which of the following is it likely to be?

W) Chalcopyrite
X) Cinnabar
Y) Cassiterite
Z) Corundum

ANSWER: W) Chalcopyrite

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TOSS-UP

20) Math – *Short Answer* What is the sine of arccosine of 1/2?

ANSWER: $\sqrt{3}/2$

BONUS

20) Math – *Short Answer* What is the standard deviation of the set {3, 3, 5, 13}

ANSWER: $\sqrt{17}$
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TOSS-UP

21) Biology – *Multiple Choice* Which of the following processes does the phosphoryl-transfer reaction NOT have a role in?

W) Direct repair of alkylated DNA
X) Sanger sequencing of DNA
Y) DNA Ligation
Z) Mismatch Repair

ANSWER: W) DIRECT REPAIR OF ALKYLATED DNA

BONUS

21) Biology – *Short Answer* Identify all of the following 3 amino acids that have a PROchiral carbon: 1) Glycine; 2) Alanine; 3) Leucine

ANSWER: 1 AND 3

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TOSS-UP

22) Chemistry – *Multiple Choice* A certain metal ejects an electron from a photon that has higher energy than the work function. Which of the following will equal to the y-intercept of a graph with the y-axis being the kinetic energy of the electron, and the x-axis being the frequency of the photon.

W) Work function squared
X) One over the work function
Y) Negative work function
Z) Work function

ANSWER: Y) NEGATIVE WORK FUNCTION

BONUS

22) Chemistry – *Short Answer* What highly reactive nucleophilic reagent can be used to open epoxides and is formed from bromine, magnesium, and an alkyl chain?

ANSWER: GRIGNARD
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TOSS-UP

T21) Energy – *Multiple Choice* Researchers at the Joint Genome Institute have found that for some bacteria, the stop codon encodes for amino acids instead. Which of the following is a stop codon?

W) AUG
X) UAU
Y) UGA
Z) UUA

ANSWER: Y) UGA

BONUS

B21) Energy – *Multiple Choice* Researchers at the Joint Genome Institute have found a class of cellulases that are able to perform well in ionic liquids, allowing for more efficient biofuel treatment. Which of the following class of organisms are these cellulases derived from?

W) Red Algae
X) Methanogens
Y) Thermophiles
Z) Halophiles

ANSWER: Z) HALOPHILES