## MHS Set 2 Round 9

Buzzer test + Ice breaker question: Is writing questions at 5 am a good idea?

**TOSS-UP**

1) Physics – *Short Answer* What quantity measures the third derivative of displacement?

ANSWER: JERK

**BONUS**

1) Physics – *Short Answer* What is the minimum angle of incidence required for a light ray to undergo total internal reflection given that the material's index of refraction is 2?

ANSWER: 30 DEGREES

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**TOSS-UP**

2) Earth and Space – *Short Answer* What part of Earth's interior is noted for causing seismic waves to slow down due to the melting of peridotite?

ANSWER: LOW-VELOCITY ZONE (ACCEPT: LVZ)

**BONUS**

2) Earth and Space – *Short Answer* Identify all of the following three features that can be found on normal faults: 1) Fault scarps; 2) Forearc basin; 3) Horsts

ANSWER: 1 AND 3
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**TOSS-UP**

3) Chemistry – *Multiple Choice* Which of the following most accurately describes the coordination number?

W) It is the number of atoms assigned in a unit cell.
X) It is the number of atoms bonded to another atom in a unit cell.
Y) It is the sum of the sphere volumes in a unit cell.
Z) It is the density of atoms in a unit cell.

ANSWER: X) IT IS THE NUMBER OF ATOMS BONDED TO ANOTHER ATOM IN A UNIT CELL.

**BONUS**

3) Chemistry – *Short Answer* The dissolving metal reduction converts alkynes into E alkenes, this is done in part because group 1A elements dissolve in a liquid form of what molecule most commonly?

ANSWER: AMMONIA (ACCEPT: $NH_3$)

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**TOSS-UP**

4) Biology – *Short Answer* PS bacteria do not use water as their reducing agent but instead, substituted the oxygen for what other element?

ANSWER: SULFUR

**BONUS**

4) Biology – *Multiple Choice* Which of the following sequences in double-stranded DNA is most likely to be recognized as a cutting site for a restriction enzyme?

W) ACCA and TGGT
X) AAGG and TTCC
Y) GGCC and CCGG
Z) AGTC and TCAG

ANSWER: Y) GGCC AND CCGG
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**TOSS-UP**

5) Math – *Short Answer* Out of fear for his security, Sanjay is looking to purchase NordVPN. The amount of money he has to pay can be measured by the function $f(t) = sin(2t) + 10$. How many times from time $t = 0$ to $t = 10$ does Sanjay have the opportunity to pay the smallest amount possible?

ANSWER: 3

**BONUS**

5) Math – *Short Answer* What is the area between the curves $y = x^4$ and $y = 2 - 2x - x^2$ from $x=0$ to $x=1$?

ANSWER: 7/15

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**TOSS-UP**

6) Physics – *Multiple Choice* Which of the following particles obeys Bose-Einstein statistics?

W) Electron
X) Gluon
Y) Neutron
Z) Top quark

ANSWER: X) GLUON

**BONUS**

6) Physics – *Short Answer* A 140 gram ball is thrown at a speed of 18 meters per second. Given that it took 0.8 seconds to throw the ball, what was the average force, in newtons, exerted on the ball during the throw?

ANSWER: 3.15
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**TOSS-UP**

7) Earth and Space – *Short Answer* Rounded to the nearest tenth, if a star has a stellar parallax of 0.5 arcseconds, what is the distance to the star in light years?

ANSWER: 6.5

**BONUS**

7) Earth and Space – *Multiple Choice* Which of the following components of the interstellar medium has the greatest density?

W) Coronal gas
X) Intercloud medium
Y) HI Clouds
Z) Molecular Clouds

ANSWER: Z) MOLECULAR CLOUDS

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**TOSS-UP**

8) Energy – *Short Answer* Researchers at Argonne national lab are using theoretical tools to analyze the crystal distortions in herbertsmithite. These distortions generate what type of liquid crystal that has long-range order but not short-range order?

ANSWER: NEMATIC

**BONUS**

8) Energy – *Short Answer* Researchers at Argonne national lab have doped carbon nanotubes for nanophotonic applications. The doped carbon nanotubes allow for the ultrafast trapping of what quasiparticle, consisting of a bound electron and electron hole?

ANSWER: EXCITON
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**TOSS-UP**

9) Biology – *Short Answer* What term describes the amount of air that moves in and out of the lungs during a normal breath?

ANSWER: TIDAL VOLUME

**BONUS**

9) Biology – *Short Answer* What amino acid contains a pyrrolidine ring?

ANSWER: PROLINE

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**TOSS-UP**

10) Math – *Multiple Choice* Which of the following best describes the domain of the function f of $x$ equals the square root of quantity $x + 2$ divided by the square root of quantity $9 - x^2$?

W) $x$ is greater than -3
X) $x$ is greater than or equal to -2
Y) $x$ is greater than or equal to -2, and less than or equal to 3
Z) $x$ is greater than or equal to -2, and less than 3

ANSWER: Z) $x$ IS GREATER THAN OR EQUAL TO -2, AND LESS THAN 3

**BONUS**

10) Math – *Short Answer* What is the product of the least common multiple and greatest common divisor of 131 and 139?

ANSWER: 18209
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**TOSS-UP**

11) Physics – *Short Answer* The potential energy of a particle with respect to distance can be modelled by the function $U(d) = 3d^2 + 4d + 20$. What is the force acting on the particle at $d = 3$?

ANSWER: -22

**BONUS**

11) Physics – *Short Answer* A sample of radioactive uranium has a mass of 100 grams. Given that it has a half life of 20 seconds, what is the mass of the uranium in the sample, to the nearest gram, after 30 seconds?

ANSWER: 35

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**TOSS-UP**

12) Earth and Space – *Short Answer* What tail of a comet is pushed away by both radiation pressure and solar wind?

ANSWER: GAS TAIL (ACCEPT: TYPE I TAIL)

**BONUS**

12) Earth and Space – *Multiple Choice* Which of the following moons does NOT experience cryovolcanism?

W) Titan
X) Europa
Y) Enceladus
Z) Triton

ANSWER: W) TITAN
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**TOSS-UP**

13) Energy – *Multiple Choice* Researchers at Argonne national lab have discovered a 5d transition metal oxide with a low spin tetrahedrally coordinated metal. Which of the following metals could they be studying?

W) Cobalt
X) Technetium
Y) Iridium
Z) Ruthenium

ANSWER: Y) IRIDIUM

**BONUS**

13) Energy – *Short Answer* Researchers at Brookhaven national lab are studying electron carriers' role in cell wall construction in plants. In plant chloroplasts, what electron carrier is the final acceptor of electrons from photosystem I?

ANSWER: NADP+

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**TOSS-UP**

14) Chemistry – *Short Answer* Order the following 3 lattice systems from lowest to highest on how many atoms an atom in the system would be directly touching: 1) BCC; 2) FCC; 3) Simple Cubic

ANSWER: 3, 1, 2

**BONUS**

14) Chemistry – *Short Answer* Answer the following 2 questions about polymers: 1) What intermolecular force causes straight chain polymers to have higher melting points than branched polymers; 2) What power of distance is your answer from part A inversely proportional to?

ANSWER: 1) LDF (VAN DER WAALS, INDUCED DIPOLES) 2) -6 OR INVERSE 6.
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**TOSS-UP**

15) Math – *Short Answer* A classroom has 40 boys and 30 girls. There are 35 students that play basketball, and the probability that a basketball player is a boy is 80%. How many non-basketball players in the class are girls?

ANSWER: 23

**BONUS**

15) Math – *Short Answer* How many subsets of {0, 2, 5, 6, 7, 8} contain the element 6?

ANSWER: 32

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**TOSS-UP**

16) Physics – *Multiple Choice* Approximately what percent of the kinetic energy of oxygen gas at 20 degrees Celsius is rotational kinetic energy?

W) 20%
X) 40%
Y) 60%
Z) 80%

ANSWER: X) 40%

**BONUS**

16) Physics – *Short Answer* What two fundamental forces were the last to split from each other after the Grand Unification epoch?

ANSWER: ELECTROMAGNETIC AND WEAK
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**TOSS-UP**

17) Chemistry – *Multiple Choice* Which of the following explains why E2 reactions are favored over Sn2 reactions at high temperatures?

W) The activation energy is significantly higher for E2.
X) E2 reactions are more entropically driven.
Y) The heat of formation for the products of Sn2 is higher than that of E2
Z) Sn2 has more steric effects in the intermediate state.

ANSWER: X) E2 REACTIONS ARE MORE ENTROPICALLY DRIVEN.

**BONUS**

17) Chemistry – *Multiple Choice* In an open system, for maximum work, the process must be entirely

W) Isobaric
X) Adiabatic
Y) Reversible
Z) Irreversible

ANSWER: Y) REVERSIBLE

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**TOSS-UP**

18) Biology – *Short Answer* What immune cell process and present antigens to activate T cells, bridging the gap between innate and adaptive immunity?

ANSWER: DENDRITIC CELL

**BONUS**

18) Biology – *Short Answer* A frog who is not poisonous shares the same color pallet as a poison dart frog. What type of mimicry is observed?

ANSWER: BATESIAN MIMICRY
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**TOSS-UP**

19) Earth and Space – *Short Answer* Rank the following three geologic periods in order from least to most recent: 1) Permian; 2) Silurian; 3) Eocene

ANSWER: 2, 1, 3

**BONUS**

19) Earth and Space – *Multiple Choice* Which of the following metamorphic minerals would be most present in the high grade metamorphism of shale?

W) Chlorite
X) Kyanite
Y) Biotite
Z) Sillimanite

ANSWER: Z) SILLIMANITE

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**TOSS-UP**

20) Math – *Short Answer* What is $i^{37}$

ANSWER: $i$

**BONUS**

20) Math – *Short Answer* What is the total distance travelled from time $t = 0$ to $t = 4\pi$ of a particle that can be described by the parametric equations $x = 3\cos(t)$ and $y = 3\sin(t)$?

ANSWER: $12\pi$
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**TOSS-UP**

21) Biology – *Multiple Choice* Which of the following is the organelle that spirochetes use to propel themselves?

W) Plasma membrane
X) Axial filament
Y) Pilum
Z) Fimbria

ANSWER: X) AXIAL FILAMENT

**BONUS**

21) Biology – *Short Answer* The Warburg effect shows that cancer cells tend to go through oxidative phosphorylation less than normal cells, what specific method of cellular respiration do cancer cells go through instead?

ANSWER: GLYCOLYSIS

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**TOSS-UP**

22) Chemistry – *Short Answer* In the reaction with cyclopentadiene and quinone, a bicyclic Diels Alder reaction, what two general types of products will form, where the favored product depends on both the thermodynamics and kinetics of the reaction?

ANSWER: ENDO AND EXO

**BONUS**

22) Chemistry – *Short Answer* One H atom orbital has three planar or conical nodes, no radial nodes, and is cylindrically symmetric about the z axis. What are the values for the n, l, and $m_l$ quantum numbers respectively?

ANSWER: 4, 3, 0
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## TOSS-UP

23) Energy – *Short Answer* Researchers at Lawrence Livermore national lab are looking into the signaling process present when cancer cells propagate throughout the human body. What is the general term for this spread of malignant cancer cells away from the primary cancer site?

ANSWER: METASTASIS

## BONUS

23) Energy – *Short Answer* Researchers at Lawrence Livermore national lab are studying the magnetic fields generated in the aftermath of a supernova. The strong magnetic fields from a supernova lead to the emission of what type of radiation, caused by electrons spiraling through a magnetic field?

ANSWER: SYNCHROTRON RADIATION