# MHS Round 15

Buzzer test + Ice breaker question: Do you forgive us for the excess amounts of organic and biochemistry in these packets?

**TOSS-UP**

1) Physics – *Short Answer* What quantity is defined to be the reciprocal of the impedance of a circuit?

ANSWER: ADMITTANCE

**BONUS**

1) Physics – *Short Answer* By name or number, which of the following four particles are vector bosons? 1) Higgs particle; 2) Pion; 3) Photon; 4) He-4 nucleus

ANSWER: 3 ONLY

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**TOSS-UP**

2) Earth and Space – *Short Answer* Identify all of the following 3 statements that are true of Cepheid variable stars: 1) Classical Cepheids are found on the galactic disk; 2) They can pulsate with a period of 30 days; 3) They can be used as standard candles

ANSWER: ALL

**BONUS**

2) Earth and Space – *Short Answer* What is the name for the currently accepted hypothesis of Moon formation, suggesting that around 4.6 billion years ago, a large object collided with Earth, which generated a disk that coalesced into the Moon?

ANSWER: GIANT-IMPACT HYPOTHESIS
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## TOSS-UP

3) Chemistry – *Short Answer* Order the following 3 alkyl chains from increasing order for their ability to lock a cyclohexane ring in a certain orientation: 1) Tertbutyl; 2) Isopropyl; 3) Ethyl.

ANSWER: 3, 2, 1

## BONUS

3) Chemistry – *Multiple Choice* Which of the following is NOT true regarding the molecule benzyne:

W) The triple bond is part of the conjugated pi system
X) It contains 6 conjugated pi electrons in its ring.
Y) It is an intermediate in the elimination addition reaction.
Z) It is an intermediate of an E1cB type reaction.

ANSWER: W) THE TRIPLE BOND IS PART OF THE CONJUGATED PI SYSTEM.

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## TOSS-UP

4) Biology – *Short Answer* Identify all of the following 3 compound concentrations that when increased, will activate AMPK phosphorylation: 1) AMP; 2) ADP; 3) ATP.

ANSWER: 1 AND 2

## BONUS

4) Biology – *Short Answer* A molecule was found to inhibit an enzyme by binding to the ES complex. Which of the following would best describe its effect on a Lineweaver-Burk plot:

W) A change in both the y-intercept and the slope.
X) No change in the y-intercept but a change in the slope.
Y) A change in only the y-intercept
Z) No change in the x-intercept.

ANSWER: Y) A CHANGE IN ONLY THE Y-INTERCEPT
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**TOSS-UP**

5) Math – *Multiple Choice* Which of the following best describes the graph of the set of parametric equations $x = sin^2(t)$ and $y = cos^2(t)$?

W) Line
X) Circle
Y) Line segment
Z) Hyperbola

ANSWER: Y) LINE SEGMENT

**BONUS**

5) Math – *Short Answer* What is the angle of rotation, in degrees, of the hyperbola with equation $2x^2 - \sqrt{3}xy - y^2 = 1$?

ANSWER: 15

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**TOSS-UP**

6) Physics – *Short Answer* Which of the following is closest to the distance at which two nucleons begin to feel a repulsive force?

W) 1 nanometer
X) 1 picometer
Y) 1 femtometer
Z) 1 attometer

ANSWER: Y) 1 FEMTOMETER

**BONUS**

6) Physics – *Short Answer* Consider a non-rotating uncharged black hole with mass equal to the Earth's mass. To the nearest power of 10, what is the ratio of the Schwarzchild radius of this black hole to the radius of the Earth?

W) 10^-9
X) 10^-10
Y) 10^-11
Z) 10^-12

ANSWER: W) 10^-9
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**TOSS-UP**

7) Earth and Space – *Short Answer* For stars of similar mass to that of the Sun, what stage of stellar evolution is taken immediately after the helium flash?

ANSWER: HORIZONTAL BRANCH

**BONUS**

7) Earth and Space – *Short Answer* If star A has a lifetime of 16 billion years, what will the approximate lifetime be of a star with a mass that is 4 times that of star A?

ANSWER: 500 MILLION YEARS

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**TOSS-UP**

8) Energy – *Multiple Choice* Researchers at Lawrence Livermore national lab are modelling the nuclear fusion of zombie stars for use in detecting black holes. Zombie stars form when the gravitational force of black holes reignite what class of stellar objects?

W) Brown dwarf
X) White dwarf
Y) Neutron star
Z) Black hole accretion disk

ANSWER: X) WHITE DWARF

**BONUS**

8) Energy – *Short Answer* Researchers at Lawrence Livermore national lab are studying the formation of the ice VII phase of water. One process that they are studying is the coalescence of the water molecules to initiate the phase change. What is the name for this process, which is often the first step for a thermodynamic phase transition?

ANSWER: NUCLEATION
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**TOSS-UP**

9) Biology – *Short Answer* Division of the zygote into blastomeres begins about 30 hours after fertilization. These mitotic divisions normally occur as the zygote passes through the fallopian tube toward the uterus. The process by which subsequent divisions form progressively smaller blastomeres is called:

W) Neurulation
X) Compaction
Y) Cleavage
Z) Gastrulation

ANSWER: Y) CLEAVAGE

**BONUS**

9) Biology – *Short Answer* In Cushing's Syndrome, what hormone is in excess in the blood after the pituitary gland secretes excess amounts of ACTH?

ANSWER: CORTISOL

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**TOSS-UP**

10) Math – *Short Answer* One-three-two-one in base 4 is equivalent to what number in base 16?

ANSWER: 79

**BONUS**

10) Math – *Short Answer* Tetrahedron ABCD has a center of mass with coordinates (3,4,-1) and point D with coordinates (4, 8, -3). What is the length of the segment from D to face ABC that passes through the center of mass?

ANSWER: $4\sqrt{21}/3$
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**TOSS-UP**

11) Physics – *Short Answer* In terms of $c$, if an object with a mass of 4 kilograms is moving at a speed of $0.6c$, what is the total energy of the object?

ANSWER: $5c^2$

**BONUS**

11) Physics – *Short Answer* A rectangular prism has sides of length 6, 8, and 12, and a total mass of 4 kilograms. What is the moment of inertia of the rectangular prism about the axis perpendicular to the face with the smallest area, and passing through that face's center?

ANSWER: 100/3

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**TOSS-UP**

12) Earth and Space – *Short Answer* At depths of 410 kilometers and 660 kilometers below Earth's surface, there is a jump in S-wave speed due to the phase transition of what mineral?

ANSWER: OLIVINE

**BONUS**

12) Earth and Space – *Multiple Choice* Which of the following soil types forms in volcanic ash?

W) Oxisol
X) Alfisol
Y) Spodosol
Z) Andisol

ANSWER: Z) ANDISOL
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**TOSS-UP**

13) Energy – *Multiple Choice* Researchers at Lawrence Livermore national lab have recently found that the zirconium-88 isotope undergoes neutron capture very easily compared to other isotopes. Which of the following nuclides are most frequently synthesized via neutron capture?

W) Helium-4
X) Carbon-14
Y) Argon-40
Z) Iron-56

ANSWER: X) CARBON-14

**BONUS**

13) Energy – *Short Answer* Researchers at Lawrence Livermore national lab are studying the applications of neutron capture to controlling nuclear fission reactions. What is the name for the primary two processes that use neutron capture to synthesize nuclides with masses greater than 56 amu?

ANSWER: R AND S PROCESSES

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**TOSS-UP**

14) Chemistry – *Multiple Choice* Which of the following molecules will not experience tautomerization?

W) Butanal
X) Butanone
Y) 3-methyl-2-butanone
Z) 2,2-dimethylbutanal

ANSWER: Z) 2,2-DIMETHYLBUTANAL

**BONUS**

14) Chemistry – *Short Answer* Order the following 4 steps in chronological order for the oxidation of a thiol by hydroxide and bromine: 1) Thiolate ion making an ionic bond with sodium; 2) Protonation of the thiol; 3) Sn2 attack on the bromine; 4) Sn2 attack on the sodium thiolate.

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

15) Math – *Short Answer* A fifth root of complex number $z$ has an argument of 37 degrees in the complex plane. Given that arguments can only take on values from 0 to 360 degrees, what is the largest possible argument of a fifth root of $z$?

ANSWER: 325 DEGREES

**BONUS**

15) Math – *Short Answer* What is the cartesian equation of the figure formed from the spherical equation $r = 3sec(\text{phi})$?

ANSWER: $z = 3$

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**TOSS-UP**

16) Physics – *Short Answer* What particle, which has a lifetime of approximately $10^{-16}$ seconds, often decays into gamma rays and provides an explanation for the residual strong force?

ANSWER: NEUTRAL PION

**BONUS**

16) Physics – *Short Answer* When writing the permittivity of free space in SI base units, what exponent is given to meters?

ANSWER: -3
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**TOSS-UP**

17) Chemistry – *Short Answer* What laboratory technique measures the mass of a sample over time as the temperature increases, and evaluates the thermal stability of a material where it runs concurrently with DSC?

ANSWER: THERMAL GRAVIMETRIC ANALYSIS (ACCEPT: TGA)

**BONUS**

17) Chemistry – *Multiple Choice* In a Beer's Law plot, where the x-axis measures the concentration, and the y-axis measures the absorbance. Which of the following most accurately describes the slope?

W) Molar absorptivity coefficient.
X) Gram equivalent weight
Y) Absorption spectrum
Z) Equimolar equivalence points

ANSWER: W) MOLAR ABSORPTIVITY COEFFICIENT

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**TOSS-UP**

18) Biology – *Short Answer* What type of hair appendage, the rhizoid of a vascular plant, is formed from trichoblasts, and facilitates the absorption of water and minerals from the ground?

ANSWER: ROOT HAIRS

**BONUS**

18) Biology – *Multiple Choice* Which of the following best explains why, in Tauri disease or glycogen storage disease VII, there is an accumulation of glycogen rather than glucose after glycolysis is inhibited by a defective PFK enzyme in muscle cells?

W) Glycogenin is formed from an intermediate of the steps of glycolysis that occurred, causing excess in the enzymes required for glycogenesis.
X) ATP activates glucose-6-phosphatase, however, since glycolysis did not occur, glucose-6-phosphatase is inhibited.
Y) The Hill coefficient for glycogenin is higher than that of glucose-6-phosphatase, meaning there is higher coopertavity and higher velocity of the enzyme.
Z) Glucose-6-phosphatase is a missing enzyme in muscle cells causing the favored reaction pathway to be glycogenesis.

ANSWER: Z) GLUCOSE-6-PHOSPHATASE IS A MISSING ENZYME IN MUSCLE CELLS CAUSING THE FAVORED REACTION PATHWAY TO BE GLYCOGENESIS.
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## TOSS-UP

19) Earth and Space – *Short Answer* Identify all of the following three metamorphic rocks that are foliated: 1) Metaconglomerate; 2) Hornfels; 3) Gneiss

ANSWER: 1 AND 3

## BONUS

19) Earth and Space – *Short Answer* Identify all of the following three minerals that are orthosilicates: 1) Zircon; 2) Beryl; 3) Biotite.

ANSWER: 1 ONLY

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## TOSS-UP

20) Math – *Multiple Choice* What is the Laplace transform of the function $f(t) = t^2$?

W) $1/s$
X) $1/s^2$
Y) $2/s^3$
Z) $6/s^4$

ANSWER: Y) $2/s^3$

## BONUS

20) Math – *Short Answer* What is the line integral of $x^2 + y^2$ along the curve $x^2 + y^2 = 9$, from the point (3,0) to (-3,0)?

ANSWER: $27\pi$
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**TOSS-UP**

21) Biology – *Multiple Choice* A tryptophan auxotroph in corn showed 50 times more accumulation of IAA than the normal amount. Which of the following is the best explanation for this observation:

W) Deconjugation of ester linked IAA does not take place
X) IAA is probably not inhibited by the feedback mechanism
Y) IAA was not oxidized
Z) There may be some other precursors for IAA synthesis

ANSWER: Z) THERE MAY BE SOME OTHER PRECURSORS FOR IAA SYNTHESIS

**BONUS**

21) Biology – *Short Answer* Two human populations have been isolated on islands since their ancestors first arrived. The mtDNAs of the people on one of the islands is more varied in sequence than the other. Which of the following most accurately describes their relative age of repopulation?

W) The less varied sequence is older because the mtDNA has more nucleases that resolve DNA variation.
X) The more varied population is older because the mitochondria has had more time to accumulate mutations.
Y) The more varied population is older because the mtDNA has had more time to diversify from repopulation.
Z) Relative age is not discernable because mtDNA is not associated with cellular DNA and gene pool.

ANSWER: X) THE MORE VARIED POPULATION IS OLDER BECAUSE THE MITOCHONDRIA HAS HAD MORE TIME TO ACCUMULATE MUTATIONS.

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**TOSS-UP**

22) Chemistry – *Multiple Choice* According to Bent's rule, which of the following bonds with carbon has the lowest percent S character in the molecule CFClBrI?

W) F
X) Cl
Y) Br
Z) I

ANSWER: W) F

**BONUS**

22) Chemistry – *Short Answer* What type of cycloaddition is the Diels Alder reaction most commonly known as?

ANSWER: [4+2]
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## TOSS-UP

23) Energy – *Short Answer* Researchers at Lawrence Livermore national lab are studying the zonal flows present in the belts on Jupiter, to better understand the dynamics of the tachocline in stars, which is the barrier between the radiative interior and the convective shell of a star. Identify all of the following three stars that have a tachocline: 1) The Sun; 2) Betelgeuse; 3) Rigel

ANSWER: 1 ONLY

## BONUS

23) Energy – *Short Answer* Researchers at Lawrence Livermore national lab are studying the theoretical neutrinoless double beta decay. Neutrinoless double beta decay is a phenomenon of interest because it violates the conservation of what quantity?

ANSWER: LEPTON NUMBER