MHS Round 13

Buzzer test + Ice breaker question:

TOSS-UP

1) Physics – *Short Answer* A block with a specific gravity of 0.6 is floating on top of water. If its mass were to double, and volume remain the same, by what factor would the buoyant force on the block be multiplied by a few seconds after the change occurs?

ANSWER: 5/3

BONUS

1) Physics – *Short Answer* A protostar has a total energy of -100 gigajoules. If heat is transferred to the protostar such that its total energy doubles, what is the change in kinetic energy, in gigajoules, of the protostar?

ANSWER: 100

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TOSS-UP

2) Earth and Space – *Multiple Choice* According to the Koppen Classification system, particularly dry climates are given what letter?

W) A
X) B
Y) D
Z) E

ANSWER: X) B

BONUS

2) Earth and Space – *Multiple Choice* Which of the following best explains why oceanic pH reaches a minimum at a depth of 1000 meters?

W) Oceanic temperature is maximized at a depth of 1000 meters
X) The rate of photosynthesis is minimized at a depth of 1000 meters
Y) The rate of animal respiration is maximized at a depth of 1000 meters
Z) The acid dissociation constant for bicarbonate is maximized at a depth of 1000 meters

ANSWER: Y) THE RATE OF ANIMAL RESPIRATION IS MAXIMIZED AT A DEPTH OF 1000 METERS
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TOSS-UP

3) Chemistry – *Short Answer* Order the following 3 lactones based on the number of atoms in the ring from lowest to highest stability: 1) 4 atoms; 2) 5 atoms; 3) 6 atoms.

ANSWER: 1, 3, 2

BONUS

3) Chemistry – *Multiple Choice* Which of the following is a reason why cyclooctatetraene is not aromatic.

W) It does not follow Huckel's Law
X) It does not have 6 carbons
Y) It is not cyclic
Z) It is not conjugated.

ANSWER: W) IT DOES NOT FOLLOW HUCKEL'S LAW

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TOSS-UP

4) Biology – *Multiple Choice* The presence of sugars in the urine is abnormal in a healthy patient, and therefore an indicator of diabetes. What mechanism normally accounts for the absence of glucose in the urine?

W) Glucose does not enter the filtrate at the glomerulus because the fenestrae are too small
X) Glucose crystallizes in the urinary bladder and is scavenged by macrophages
Y) Glucose is only actively secreted in the presence of medications for diabetes
Z) Glucose is actively reabsorbed at the proximal convoluted tubule

ANSWER: Z) GLUCOSE IS ACTIVELY REABSORBED AT THE PROXIMAL CONVOLUTED TUBULE.

BONUS

4) Biology – *Multiple Choice* Which of the following coenzymes is NOT required in the production of acetyl CoA?

W) Pantothenate
X) Thiamine
Y) Cobalamin
Z) Riboflavin

ANSWER: Y) COBALAMIN
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TOSS-UP

5) Math – *Short Answer* Sanjay is currently looking so basic that he can be called BBN. Given that BBN is a molecule that can be represented as a graph with 10 vertices and 3 faces, how many edges does this graph have?

ANSWER: 11

BONUS

5) Math – *Short Answer* What is the volume of a frustum with a lower base of radius 9, an upper base of radius 6, and a height of 2?

ANSWER: 114π

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TOSS-UP

6) Physics – *Multiple Choice* Which of the following are the units to Boltzmann's constant?

W) Joules per Kelvin
X) Joule Kelvins
Y) Joules per meter Kelvins
Z) Kelvins per Joule

ANSWER: W) JOULES PER KELVIN

BONUS

6) Physics – *Short Answer* What is the centripetal acceleration of an object that has a radius of rotation of length 10 meters, that is rotating at a rate of 2 revolutions per second?

ANSWER: $40\pi^2$
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TOSS-UP

7) Earth and Space – *Multiple Choice* In which of the following latitudes is the salinity of water the greatest?

W) 0 degrees North
X) 30 degrees South
Y) 60 degrees South
Z) 90 degrees North

ANSWER: X) 30 DEGREES SOUTH

BONUS

7) Earth and Space – *Multiple Choice* The weathering of which of the following would be most likely to produce clay minerals?

W) Quartz
X) Orthoclase
Y) Biotite
Z) Olivine

ANSWER: X) ORTHOCLASE

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TOSS-UP

8) Energy – *Multiple Choice* Researchers at Brookhaven national lab are looking at ways to stabilize the sodium ion battery as a replacement for the lithium ion battery. Which of the following is the reason for why they are looking to use sodium to replace lithium in these ion batteries?

W) Sodium ions have a greater reduction potential than lithium ions
X) Sodium is more widespread than lithium
Y) Sodium has a lower ionization energy than lithium
Z) Sodium ion batteries are expected to last longer than lithium ion batteries

ANSWER: X) SODIUM IS MORE WIDESPREAD THAN LITHIUM

BONUS

8) Energy – *Short Answer* Researchers at Brookhaven national lab have developed a mammalian bonelike structure to enhance the stability of NVP in sodium ion batteries. Given that the chemical formula of NVP is $Na_3V_2(PO_4)_3$, how many *d*-electrons are present in each vanadium atom?

ANSWER: 2
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TOSS-UP

9) Biology – *Short Answer* Order the following 4 plasias from lowest to highest cell density: 1) Metaplasia; 2) Hyperplasia; 3) Hypoplasia; 4) Aplasia

ANSWER: 4, 3, 1, 2

BONUS

9) Biology – *Multiple Choice* Which of the following best explains why ammonia is toxic to humans?

W) Ammonia can absorb a hydrogen creating ammonium which interferes with oxidative phosphorylation.
X) Ammonia takes counter ions away from secondary messengers causing a failed cascade.
Y) Ammonia disrupts membrane fluidity by interacting with cholesterol molecules.
Z) Ammonia mixes with retinol causing decreased production of rhodopsin causing blindness.

ANSWER: W) AMMONIA CAN ABSORB A HYDROGEN CREATING AMMONIUM WHICH INTERFERES WITH OXIDATIVE PHOSPHORYLATION.

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TOSS-UP

10) Math – *Multiple Choice* Which of the following vectors is perpendicular to the plane with equation $4x - 2y + 8z = 12$?

W) $3i - j + 2k$
X) $2i - j + 4k$
Y) $4i - 2j + k$
Z) $i + 2j$

ANSWER: X) $2i - j + 4k$

BONUS

10) Math – *Short Answer* What is the average value of the function $3sin(x) + 2$ from the interval of 0 to π?

ANSWER: $2 + \frac{6}{\pi}$
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TOSS-UP

11) Physics – *Short Answer* A rectangle with a uniform mass distribution has a length of 2 meters and a height of 2 times the square root of 3 meters. What is the maximum angle, in degrees, the rectangle can be tilted with respect to the horizontal such that it does not fall on its longer side?

ANSWER: 30

BONUS

11) Physics – *Short Answer* What is the name of the constant, which is approximately 1/137, that quantifies the electromagnetic strength of the interaction between elementary particles?

ANSWER: FINE-STRUCTURE CONSTANT

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TOSS-UP

12) Earth and Space – *Short Answer* The Bayer process produces aluminum oxide by refining what rock?

ANSWER: BAUXITE

BONUS

12) Earth and Space – *Multiple Choice* Which of the following locations is currently in the terminal stage of the Wilson cycle?

W) Red Sea
X) Atlantic Ocean
Y) Pacific Ocean
Z) Mediterranean Sea

ANSWER: Z) MEDITERRANEAN SEA
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TOSS-UP

13) Energy – *Short Answer* Researchers at Lawrence Livermore national lab are analyzing the volatiles contained within samples of the Moon from the Apollo 17 mission. What part of the lunar surface are they analyzing, composed of fine powder generated from micrometeorite impacts?

ANSWER: REGOLITH

BONUS

13) Energy – *Multiple Choice* Researchers at Lawrence Livermore national lab are studying the mechanisms by which beta decay occurs to better understand why it occurs at a much slower rate compared to the decay of a free neutron. Which of the following is closest to the mean lifetime of a free neutron?

W) 1 minute
X) 15 minutes
Y) 1 hour
Z) 2 hours

ANSWER: X) 15 MINUTES

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TOSS-UP

14) Chemistry – *Multiple Choice* Which of the following choices is a reason as to why aldehydes are generally more susceptible to nucleophilic attack than ketones?

W) The carbonyl carbon in aldehydes is sp2 hybridized.
X) The carbonyl carbon in ketones forms more stable carbocation intermediates.
Y) The carbonyl oxygen in ketones has more steric hindrance.
Z) The carbonyl carbon in ketones has more steric hindrance.

ANSWER: Z) THE CARBONYL CARBON IN KETONES HAS MORE STERIC HINDRANCE.

BONUS

14) Chemistry – *Multiple Choice* Which of the following statements about the hydroboration oxidation reaction is NOT true?

W) The enolate intermediate is formed during the base-catalyzed tautomerization for the hydroboration oxidation of an alkyne.
X) The final product of the hydroboration oxidation of a terminal alkyne is a ketone.
Y) Hydroboration oxidation adds a hydroxyl group to an alkene in an anti-Markovnikov fashion.
Z) A dialkyl borane is used to prevent the second addition on an alkyne.

ANSWER: X) THE FINAL PRODUCT OF THE HYDORBORATION OXIDATION OF A TERMINAL ALKYNE IS A KETONE.
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TOSS-UP

15) Math – *Short Answer* What is the acute angle, in degrees, between the hour hand and the minute hand of a clock at 4:10?

ANSWER: 65

BONUS

15) Math – *Short Answer* The point (3,7) is reflected across the line $y = x + 9$, and then shifted 2 units to the left. What are the coordinates of the new point?

ANSWER: (-4, 12)

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TOSS-UP

16) Physics – *Short Answer* Rank the following three gases in order of increasing root mean square speed: 1) Carbon dioxide; 2) Chlorine gas; 3) Oxygen gas

ANSWER: 2, 1, 3

BONUS

16) Physics – *Short Answer* Identify all of the following three interactions that lead to processes that conserve strangeness: 1) Strong; 2) Electromagnetic; 3) Weak

ANSWER: 1 AND 2
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TOSS-UP

17) Chemistry – *Short Answer* What is the oxidation number and the d electron count of the iron atom in the complex: $[Fe(H_2O)_6]^{+3}$ respectively

ANSWER: +3, 5

BONUS

17) Chemistry – *Multiple Choice* In the molecule Bullvalene, carbon carbon single bonds break and as such carbon carbon double bonds are formed interchangeably. Which of the following best describes the class of molecules like these?

W) Resonant
X) Mesomeric
Y) Tautomeric
Z) Fluxional

ANSWER: Z) FLUXIONAL

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TOSS-UP

18) Biology – *Multiple Choice* Which of the following antibodies is a membrane-bound antibody?

W) iga
X) igd
Y) ige
Z) igg

ANSWER: X) IGD

BONUS

18) Biology – *Short Answer* A shark's tissue can contain high concentration of urea, what organic molecule protects proteins that are damaged by urea?

ANSWER: TMAO (ACCEPT: TRIMETHYLAMINE OXIDE)
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TOSS-UP

19) Earth and Space – *Short Answer* What is the period of rotation of Mercury given that its sidereal period is 90 days?

ANSWER: 60 DAYS

BONUS

19) Earth and Space – *Short Answer* Identify all of the following three objects that are dwarf planets: 1) Eros; 2) Ceres; 3) Charon

ANSWER: 2 ONLY

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TOSS-UP

20) Math – *Short Answer* What is the area enclosed by the polar curve $r = 4sin(\theta)$?

ANSWER: 4π

BONUS

20) Math – *Multiple Choice* Which of the following functions is a valid solution to the differential equation *y* times *y* prime equals *x*?

W) $y = \sqrt{x}$
X) $y = x + 2$
Y) $y = \sqrt{x^2 + 1}$
Z) $y = e^x$

ANSWER: Y) $y = \sqrt{x^2 + 1}$
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TOSS-UP

21) Biology – *Multiple Choice* Which of the following combinations of 2 organs is where glycogen is stored most readily?

W) Liver and skeletal muscle
X) Liver and cardiac muscle
Y) Pancreas and liver
Z) Kidney and pancreas

ANSWER: W) LIVER AND SKELETAL MUSCLE

BONUS

21) Biology – *Multiple Choice* Which of the following options most accurately describes a type 1 survivorship curve?

W) Organisms have similar mortality rates throughout their lives increasing linearly.
X) Organisms have few offspring however they take care of their offspring with great care.
Y) Organisms die early in life and produce a lot of offspring to compensate for the deaths.
Z) Organisms start off with very high mortality rates, however as they mature it decreases quadratically.

ANSWER: X) ORGANISMS HAVE FEW OFFSPRING HOWEVER THEY TAKE CARE OF THEIR OFFSPRING WITH GREAT CARE.

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TOSS-UP

22) Chemistry – *Short Answer* What equation in chemistry is used to calculate the lattice energy of a crystalline ionic compound which builds upon the Born-Lande Equation?

ANSWER: BORN-MAYER EQUATION

BONUS

22) Chemistry – *Multiple Choice* Which of the following terms best describes the D orbitals for a complex with infinite spherical ligands?

W) They will be degenerate
X) Those in the Z axis will be excited
Y) Z and Y axis will be equally excited over the X axis
Z) S orbital will be higher in energy.

ANSWER: W) THEY WILL BE DEGENERATE
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TOSS-UP

23) Energy – *Short Answer* Researchers at Lawrence Livermore national lab have recently 3D printed cells that can convert glucose into carbon dioxide and ethanol. This conversion of glucose is an example of what type of redox reaction, in which a substance is simultaneously oxidized and reduced?

ANSWER: DISPROPORTIONATION

BONUS

23) Energy – *Short Answer* Researchers at Lawrence Livermore national lab are studying the properties of superionic ice as a potential generator for the dynamo effect for certain planets. They believe that superionic ice is responsible for generating the magnetic field on what two planets?

ANSWER: URANUS AND NEPTUNE