MHS Round 16

Buzzer test + Ice breaker question: Hi

TOSS-UP

1) Physics – *Short Answer* A thin conducting ring of radius R carries an anti-clockwise current I. How many times as great is the magnetic field R units above the center of the loop as the magnetic field at the center of the loop?

ANSWER: SQRT(2)/4

BONUS

1) Physics – *Short Answer* A chain of mass 10 kg is hung from two walls with ends at equal heights. If the slope of the chain makes an angle of 45 degrees with the vertical at its ends, and taking g=9.8 m/s^2 what is the tension at the center of the chain?

ANSWER: 49

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

2) Earth and Space – *Short Answer* What rule states that after the runaway fusion of a dying massive star occurs, the amount of even atomic numbered elements are more abundant than both the odd atomic number elements adjacent to that element in mass.

ANSWER: ODDO-HARKINS RULE

BONUS

2) Earth and Space – *Short Answer* For a deep water wave, what is the ratio between the maximum wave height, and the wave base?

ANSWER: 2:7 (ACCEPT: 2/7)
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

3) Chemistry – *Short Answer* What approximation in quantum chemistry allows the computation for the ground state energy of a multi body system by writing the electronic wavefunction as a sum of products of single-particle wavefunctions.

ANSWER: HARTREE FOCK

BONUS

3) Chemistry – *Multiple Choice* Which of the following statements regarding nucleophilic carbonyl addition reactions is NOT true?

W) The Burgi Dunitz describes the optimal angle of attack on a carbonyl by a nucleophile.
X) When THF is used as a solvent for $MgBr_2$ for a carbonyl with an ether attached to the alpha carbon, the alkyl attaches in a syn relationship.
Y) The Cram-Felkin-Ahn model shows that the nucleophile adds in a syn relationship to the largest R group on the alpha carbon.
Z) When Boron is used as the lewis acid for a carbonyl with an ether attached to the alpha carbon, it only coordinates only of the oxygens.

ANSWER: X) WHEN THF IS USED AS A SOLVENT FOR $MgBr_2$ FOR A CARBONYL WITH AN ETHER ATTACHED TO THE ALPHA CARBON, THE NUCLEOPHILE ATTACHES IN A SYN RELATIONSHIP.

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

4) Biology – *Short Answer* Identify all of the following 3 molecules that fatty acid synthesis requires: 1) ATP; 2) NADPH; 3) Biotin.

ANSWER: ALL

BONUS

4) Biology – *Short Answer* A patient with hyperglycemia, and a low blood cortisol level is injected with ACTH. After time passes, the blood is drawn and blood work is conducted showing normal levels of cortisol. Based on this, identify all of the following 4 choices where the deficiency most likely took place. 1) Hypothalamus; 2) Anterior pituitary; 3) Posterior pituitary; 4) Adrenal cortex.

ANSWER: 1 AND 2
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

5) Math – *Short Answer* What is the sum of the squares of the distinct eigenvalues of the matrix with first row, 1, 0, and second row 0, 1.

ANSWER: 1

BONUS

5) Math – *Short Answer* What theorem states that a set being closed and bounded and a set being compact are equivalent?

ANSWER: HEINE-BOREL THEOREM

~~~~~~

TOSS-UP

6) Physics – *Short Answer* What hypothesis states that the microstates of a system are equiprobable over a long time?

ANSWER: ERGODIC HYPOTHESIS

BONUS

6) Physics – *Short Answer* A particle is travelling under a magnetic field and electric field that are perpendicular to each other. What trajectory does the particle move in?

ANSWER: CYCLOID
~~~~~~

TOSS-UP

7) Earth and Space – *Multiple Choice* Which of the following classes of asteroids spend most of their time within Earth's orbit, only crossing Earth's orbit at their aphelion?

W) Main belt asteroids
X) Amor asteroids
Y) Apollo asteroids
Z) Aten asteroids

ANSWER: Z) ATEN ASTEROIDS

BONUS

7) Earth and Space – *Multiple Choice* Which of the following is not a limit on a star's mass?

W) Chandrasekhar Limit
X) Eddington Limit
Y) Tolman-Oppenheimer-Volkoff Limit
Z) Schonberg-Chandrasekhar Limit

ANSWER: X) EDDINGTON LIMIT

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

8) Energy – *Short Answer* Researchers at Brookhaven national lab's heavy ion collider are studying the properties of the fluid generated from high energy collisions. What is the name for this state of matter which is theorized to be the particle soup that originally filled the early universe?

ANSWER: QUARK-GLUON PLASMA

BONUS

8) Energy – *Short Answer* Researchers at Brookhaven national lab have recently developed an invisible glass that effectively eliminates any reflection off of its surface. The material is able to do this because its surface has a gradual change in what property of the material?

ANSWER: INDEX OF REFRACTION
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

9) Biology – *Short Answer* What enzyme in the PDH complex contains a lipoate attached through an amide bond to the epsilon amino group of a lysine residue?

ANSWER: E2 OR DIHYDROLIPOYL TRANSACETYLASE OR DLAT

BONUS

9) Biology – *Short Answer* Insulin signaling in the liver activates phosphoprotein phosphatase-1. Identify all of the following 3 options that this enzyme activates by catalyzing the removal of a phosphate group: 1) Activates glycogen phosphorylase and glycogen breakdown; 2) Activates glycogen synthase and glycogen synthesis; 3) Activates FPBase-2 and gluconeogenesis.

ANSWER: 2 ONLY

~~~~~~

TOSS-UP

10) Math – *Short Answer* What is the coefficient of the fourth non zero term in the Maclauren series for hyperbolic cosine?

ANSWER: 1/720

BONUS

10) Math – *Short Answer* Bill is trying to capture a shiny Skorupi. If there is a 1/100 probability of a given encounter to be a shiny skorupi, what is the expected number of encounters he must do in order to encounter 2 shiny Skorupi in a row?

ANSWER: 10100
~~~~~~

TOSS-UP

11) Physics – *Short Answer* A monatomic gas has a pressure of 3000 pascals and a density of 0.2 kilograms per meter cubed. In meters per second, what is the speed of sound in this gas?

ANSWER: 500 m/s

BONUS

11) Physics – *Short Answer* What is the name of the general method of approximating the wavefunction of a many-body system in a stationary state?

ANSWER: HARTREE-FOCK

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

12) Earth and Space – *Multiple Choice* Which of the following ocean currents is not part of Pacific ocean circulation?

W) Loop Current
X) Kuroshio Current
Y) East Australian Current
Z) California Current

ANSWER: W) LOOP CURRENT

BONUS

12) Earth and Space – *Multiple Choice* Which of the following pressure systems cannot be found in July?

W) Pacific High
X) Icelandic Low
Y) Bermuda High
Z) Siberian High

ANSWER: Z) SIBERIAN HIGH
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

13) Energy – *Short Answer* Researchers at Lawrence Livermore national lab have used machine learning to model the progression of a condition where the body has an extreme reaction infection. What is the name of this condition?

ANSWER: SEPSIS

BONUS

13) Energy – *Multiple Choice* Researchers at Brookhaven national lab are studying low temperature catalysts for the production of hydrogen gas and carbon dioxide from carbon monoxide and water. What is the reducing agent in this reaction?

W) Hydrogen
X) Carbon monoxide
Y) Carbon dioxide
Z) Water

ANSWER: X) CARBON MONOXIDE

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

14) Chemistry – *Multiple Choice* The existence of radicals can be best supported by which of the following spectroscopic methods?

W) Electron spin resonance
X) Proton enhanced nuclear induction spectroscopy
Y) Tandem MS
Z) Time of flight MS

ANSWER: W) ELECTRON SPIN RESONANCE

BONUS

14) Chemistry – *Multiple Choice* In the Lennard-Jones potential, the minimum distance it has is given by which of the following factors?

W) $2^{-1/3}$
X) Pi
Y) $2^{1/2}$
Z) $2^{1/6}$

ANSWER: Z) $2^{1/6}$
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

15) Math – *Short Answer* What is the name for the 3-dimensional shape generated by the equation $z = x^2 - y^2$

ANSWER: HYPERBOLIC PARABOLOID

BONUS

15) Math – *Short Answer* What is the Legendre transform of e^x in terms of a variable p?

ANSWER: P LN(P) - P

~~~~~~

TOSS-UP

16) Physics – *Multiple Choice* Which of the following correctly describes the relationship between the electric displacement field and the electric field and polarization vector?

W) Increases with increasing electric field, decreases with increasing polarization
X) Increases with increasing electric field, increases with increasing polarization
Y) Decreases with increasing electric field, decreases with increasing polarization
Z) Decreases with increasing electric field, increases with increasing polarization

ANSWER: X) INCREASES WITH INCREASING ELECTRIC FIELD, INCREASES WITH INCREASING POLARIZATION

BONUS

16) Physics – *Short Answer* The dielectric constant of a medium is given as 2 epsilon_0. If the dielectric constant is replaced by 6 epsilon_0, and the number density of the atoms in the medium stays the same, by what factor must the polarizability of each atom multiply by?

ANSWER: 20/7
~~~~~~

TOSS-UP

17) Chemistry – *Short Answer* In the organic lithium addition of formic acid, what is the maximum number of negative charges present at a time in the reaction mechanism.

ANSWER: 2

BONUS

17) Chemistry – *Multiple Choice* Which of the following would be the best for the formation of a ketone after the addition of a Grignard?

W) DCC
X) Weinreb Amide
Y) Stryker's Reagent
Z) Evans Oxazolidinone

ANSWER: X) WEINREB AMIDE

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

18) Biology – *Short Answer* When an antibody binds to an antigen of a pathogen, and promotes the phagocytosis by macrophages and neutrophils, what process occurs?

ANSWER: OPSONIZATION

BONUS

18) Biology – *Short Answer* Order the following three steps from first to last to occur in the oxidative decarboxylation of pyruvate to acetyl CoA by the PHD Complex: 1) The SH group of CoA replaces the SH group of E2 to yield acetyl COA; 2) The transfer of two electrons and the acetyl group from TPP to the oxidized form of the lipollysyl group of the core enzyme; 3) Pyruvate reacts with bound TPP of E1, undergoing decarboxylation.

ANSWER: 3, 2, 1
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

19) Earth and Space – *Multiple Choice* Emission spectral line A is formed by an emission from an excited state with a lifetime of 20 nanoseconds. Spectral line B is formed by an emission from a metastable state with a lifetime of 1 second. Which of the following statements is true about the relative widths of the two spectral lines?

W) A is wider than B
X) B is wider than A
Y) A and B have approximately the same width
Z) There is no way to determine their relative widths

ANSWER: W) A IS WIDER THAN B

BONUS

19) Earth and Space – *Short Answer* What equation gives a quantitative expression of a gas's ionization equilibrium at a given temperature, electron density, and ionization potential?

ANSWER: SAHA EQUATION

~~~~~~

TOSS-UP

20) Math – *Short Answer* What is the quadratic with smallest integer coefficients that has the same sum of roots and product of roots as the polynomial $4x^9 + 7x^8 - 6x^3 + 4x - 1/3$?

ANSWER: $12x^2 + 21x + 1$

BONUS

20) Math – *Short Answer* What is the volume of the figure formed by the rotation of the graph with equation $x^2 - 6x + y^2 + 4y = -4$, about the line $x = 0$?

ANSWER: $54\pi^2$
~~~~~~

TOSS-UP

21) Biology – *Short Answer* Order the following 3 structures from earliest to latest, in the path a long-chain fatty acid would take from the small intestine into circulation: 1) Lacteal; 2) Mucosal cell; 3) Thoracic duct.

ANSWER: 2, 1, 3

BONUS

21) Biology – *Short Answer* What percentage of enzyme total is in the enzyme substrate form if the substrate concentration is 3 times greater than the Michaelis constant?

ANSWER: 75%

~~~~~~

TOSS-UP

22) Chemistry – *Short Answer* The beta silicon effect in the intermediate of the Sakurai allylation is analogous to what other effect in organic chemistry that allows the donation of electron density into adjacent orbitals to stabilize them?

ANSWER: HYPERCONJUGATION

BONUS

22) Chemistry – *Short Answer* In the mechanism of the Oppenauer oxidation a secondary alcohol and acetone are converted into a ketone and a side product. In the final step of this oxidation, a transfer of what species occurs?

ANSWER: HYDRIDE
~~~~~~

TOSS-UP

23) Energy – *Short Answer* Scientists at Fermi National Accelerator Laboratory are studying neutrinos by observing their interactions with liquid in large detectors in the Deep Underground Neutrino Experiment. What liquid is used in the detectors to interact with neutrinos?

ANSWER: ARGON

BONUS

23) Energy – *Short Answer* Researchers at Brookhaven National Lab are developing larger quantum computers. Quantum computers are promising as they can solve certain problems exponentially faster than conventional computers. One of these problems is that of factoring large numbers, which has important implications in cryptography. What famous quantum algorithm solves this problem of integer factorization?

ANSWER: SHOR'S ALGORITHM