NNHS ROUND 16

TOSS-UP

1) Physics – *Short Answer* Responsible for the hum of transformers, what effect occurs when ferromagnetic materials change their dimensions in response to an applied magnetic field?

ANSWER: MAGNETOSTRICTION

BONUS

1) Physics – *Short Answer* A circuit consists of a 9 volt battery connected in series to a 2 ohm resistor, an variable resistor, and a 3 ohm resistor. What is the maximum power that the variable resistor can dissipate, to the nearest watt?

ANSWER: 4

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TOSS-UP

2) Biology – *Multiple Choice* Which of the following techniques would be most suitable for analyzing mRNA?

W) Northern Blot
X) Southern Blot
Y) Eastern Blot
Z) Western Blot

ANSWER: W) NORTHERN BLOT

BONUS

2) Biology – *Short Answer* What vitamin is an essential part of Coenzyme A, which is involved in the oxidation of pyruvate in cellular respiration?

ANSWER: VITAMIN B5 (ACCEPT: PANTOTHENIC ACID)
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TOSS-UP

3) Earth and Space – *Multiple Choice* The highest redshift quasar to have ever been observed has a redshift between which of the following?

W) 2 to 4
X) 4 to 6
Y) 6 to 8
Z) 8 to 10

ANSWER: Y) 6 TO 8

BONUS

3) Earth and Space – *Short Answer* Order the following three supercontinents from oldest to youngest: 1) Pangaea; 2) Rodinia; 3) Gondwana.

ANSWER: 2, 3, 1

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TOSS-UP

4) Math – *Short Answer* The first and second terms of an arithmetic and a geometric sequence are both 8 and 12. What is the positive difference between the 4th term of the arithmetic sequence and the 4th term of the geometric sequence?

ANSWER: 7

BONUS

4) Math – *Multiple Choice* Three points in the plane, A, B, and C, form a nondegenerate triangle. Each of the points move in a single, arbitrary direction at different constant speeds. At most how many distinct instances can the three points be collinear?

W) 0
X) 1
Y) 2
Z) 3

ANSWER: Y) 2
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TOSS-UP

5) Chemistry – *Short Answer* What law states that the molar specific heat capacity of any solid is approximately 3 times the ideal gas constant?

ANSWER: DULONG–PETIT LAW

BONUS

5) Chemistry – *Multiple Choice* Which of the following macrocyclic compounds would be the most useful for the preparation of alkyl fluorides?

W) Uroporphyrinogen III
X) Benzene
Y) 18-crown-6
Z) 2,3-epoxy-2-methylpentane

ANSWER: Y) 18-CROWN-6

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TOSS-UP

6) Energy – *Short Answer* Researchers at the Pacific Northwest National Laboratory are studying GDF-15, which can delay the onset of type 1 diabetes. What pancreatic cells does GDF-15 act on?

ANSWER: BETA CELLS

BONUS

6) Energy – *Short Answer* Researchers at Oak Ridge National Laboratory are looking into the use of terpenes as a potential energy source and biofuel. All terpenes are derived from what specific hydrocarbon with chemical formula C_5H_8?

ANSWER: ISOPRENE (ACCEPT: 2-METHYL-1,3-BUTADIENE)
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TOSS-UP

7) Physics – *Multiple Choice* Scientists first discovered CP symmetry violation by studying the decay of which of the following particles?

W) Kaons
X) Pions
Y) Hyperions
Z) Neutrons

ANSWER: W) KAONS

BONUS

7) Physics – *Short Answer* An object is placed 2 meters in front of a diverging lens, producing an image that is 50 centimeters in front of the lens. What is the power of the lens?

ANSWER: -1/3 DIOPTERS

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TOSS-UP

8) Biology – *Short Answer* According to the neutral theory of evolution, what phenomena is the ultimate cause of all variation between species?

ANSWER: GENETIC DRIFT

BONUS

8) Biology – *Short Answer* What abnormal condition is caused by the hypersecretion of growth hormone after the epiphyseal plates close?

ANSWER: ACROMEGALY
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TOSS-UP

9) Earth and Space – *Multiple Choice* According to the Faber-Jackson relation, doubling the velocity dispersion of a galaxy will multiply the luminosity by approximately which of the following?

W) $2\sqrt{2}$
X) 4
Y) 8
Z) 16

ANSWER: W) 16

BONUS

9) Earth and Space – *Short Answer* What term describes alternating light and dark bands found on some glaciers?

ANSWER: OGIVES

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TOSS-UP

10) Math – *Multiple Choice* According to the prime number theorem, the number of primes less than n asymptomatically approaches which of the following functions of n?

W) n
X) n over the natural log of n
Y) n over the natural log of the natural log of n
Z) the natural log of n over n

ANSWER: X) N OVER THE NATURAL LOG OF N

BONUS

10) Math – *Short Answer* What is the curl of the function $f(x, y, z) = (xy, yz, z^2)$?

ANSWER: $(-y, 0, -x)$
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TOSS-UP

11) Chemistry – *Multiple Choice* How many stereoisomers does 2, 3-pentanediol have?

W) 1
X) 2
Y) 3
Z) 4

ANSWER: Z) 4

BONUS

11) Chemistry – *Short Answer* In X-ray spectroscopy, what element is commonly used as a window material due to its low atomic mass, making it nearly transparent to radiation?

ANSWER: BERYLLIUM

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TOSS-UP

12) Energy – *Short Answer* Researchers at Ames National Lab are studying high-entropy alloys. What type of alloy is formed when small atoms fill in the "holes" in metal lattices?

ANSWER: INTERSTITIAL ALLOY (ACCEPT: INTERSTITIAL)

BONUS

12) Energy – *Short Answer* Researchers at Ames National Lab are studying multiple principal element alloys. What rule can be used to determine the mole fraction of each metal in an alloy from its phase diagram?

ANSWER: LEVER RULE
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TOSS-UP

13) Physics – *Short Answer* What type of scattering occurs when light interacts with phonons or other acoustic modes?

ANSWER: BRILLOUIN SCATTERING (ACCEPT: BRILLOUIN)

BONUS

13) Physics – *Short Answer* In degrees, what is the vertex angle of a shock cone produced by an object traveling at 2 times the speed of sound?

ANSWER: 60

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TOSS-UP

14) Biology – *Multiple Choice* In mammals, which of the following molecules does NOT bind to a Toll-like receptor?

W) Flagellin
X) Lipopolysaccharide
Y) CpG DNA
Z) Spectrin

ANSWER: Z) SPECTRIN

BONUS

14) Biology – *Multiple Choice* Which of the following statements is FALSE regarding CRISPR-Cas9 technology?

W) CRISPR was initially discovered in bacteria as a defense against viruses
X) The guide RNA must exactly match the sequence of DNA for the Cas9 protein to bind
Y) The guide RNA only needs to be about 20 base pairs long
Z) CRISPR-Cas9 systems from different bacterial species can have different protospacer-adjacent motifs

ANSWER: X) THE GUIDE RNA MUST EXACTLY MATCH THE SEQUENCE OF DNA FOR THE CAS9 PROTEIN TO BIND
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TOSS-UP

15) Earth and Space – *Multiple Choice* Which of the following types of sand dunes is most likely to migrate slowly with the wind?

W) Barchan
X) Transverse
Y) Longitudinal
Z) Parabolic

ANSWER: W) BARCHAN

BONUS

15) Earth and Space – *Short Answer* To one significant figure, what is the Schwarzchild radius of a 100-solar-mass black hole, given that the mass of the sun is approximately $2*10^{30}$ kg?

ANSWER: $3*10^{5}$ METERS

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TOSS-UP

16) Math – *Short Answer* What is the trace of a six by six matrix, where every element in the matrix is -2?

ANSWER: 12

BONUS

16) Math – *Short Answer* By name or number, identify all of the following four numbers can be written as the sum of two perfect squares: 1) 27; 2) 129; 3) 221; 4) 418

ANSWER: 3 ONLY (ACCEPT: 221)
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TOSS-UP

17) Chemistry – *Multiple Choice* Which of the following statements is FALSE regarding SN1 and SN2 mechanisms?

W) SN1 reactions are first order while SN2 reactions are second order
X) SN2 reactions are characterized by an inversion of stereochemistry
Y) SN1 reactions work best in polar aprotic solution
Z) Primary carbons are more likely to react with a SN2 mechanism than a SN1 mechanism

ANSWER: Y) SN1 REACTIONS WORK BEST IN POLAR APROTIC SOLUTION

BONUS

17) Chemistry – *Short Answer* Toluene is reacted with nitric acid in sulfuric acid solution. By name or number, order the following three products in order of increasing prevalence in the products: 1) Ortho-nitrotoluene; 2) Meta-nitrotoluene; 3) Para-nitrotoluene.

ANSWER: 2, 3, 1 (ACCEPT: META-NITROTOLUENE; PARA-NITROTOLUENE, ORTHO-NITROTOLUENE)

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TOSS-UP

18) Energy – *Short Answer* Researchers at Ames National Laboratory are working to reduce toxic leaching from land-filled electronics waste. They have done this by developing a solder that does not contain what metal?

ANSWER: LEAD

BONUS

18) Energy – *Short Answer* Researchers at Ames National Laboratory are studying organometallic halide perovskites, which are often deployed in solar cells. They experimentally confirmed the presence of what effect in these materials, which is characterized by momentum-dependent splitting of spin bands in bulk crystals?

ANSWER: RASHBA EFFECT
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TOSS-UP

19) Physics – *Short Answer* By name or number, identify all of the following four vector quantities that are pseudovectors: 1) Area vector; 2) Linear momentum; 3) Electric field; 4) Torque.

ANSWER: 1 AND 4 (ACCEPT: AREA VECTOR AND TORQUE)

BONUS

19) Physics – *Short Answer* Scientists have discovered exotic mesons composed of 4 quarks, known as tetraquarks. What is the baryon number of a tetraquark?

ANSWER: 0

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TOSS-UP

20) Biology – *Multiple Choice* Which of the following amino acids is least likely to be phosphorylated?

W) Serine
X) Tryptophan
Y) Threonine
Z) Tyrosine

ANSWER: X) TRYPTOPHAN

BONUS

20) Biology – *Multiple Choice* Which of the following terms describes an indehiscent fruit that is formed from two fused carpels and splits on both sides at maturity?

W) Achene
X) Silique
Y) Cypsela
Z) Lomentum

ANSWER: X) SILIQUE
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TOSS-UP

21) Earth and Space – *Short Answer* What effect describes the imbalance between the concentrations of oxygen-18 and oxygen-16 in the atmosphere as a result of respiration in plants and animals?

ANSWER: DOLE EFFECT

BONUS

21) Earth and Space – *Short Answer* What effect describes the correlation between the widths of certain spectral lines and a star's absolute magnitude?

ANSWER: WILSON-BAPPU EFFECT

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TOSS-UP

22) Math – *Short Answer* What is the second derivative of arctan(x) at x = 1?

ANSWER: -1/2

BONUS

22) Math – *Multiple Choice* Which of the following distributions has a constant failure rate and exhibits the memoryless property?

W) Bernoulli
X) Normal
Y) Logistic
Z) Exponential

ANSWER: Z) EXPONENTIAL
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TOSS-UP

23) Chemistry – *Multiple Choice* Which of the following types of radical halogenation of an alkane is the most selective?

W) Bromination
X) Chlorination
Y) Iodination
Z) Florinaition

ANSWER: W) BROMINATION

BONUS

23) Chemistry – *Short Answer* What process oxidizes tertiary allylic alcohols in the presence of pyridinium chlorochromate?

ANSWER: BABLER OXIDATION