NNHS ROUND 17

TOSS-UP

1) Physics – *Short Answer* What is the color charge of a neutron?

ANSWER: 0 (DO NOT ACCEPT: WHITE)

BONUS

1) Physics – *Multiple Choice* In megaelectronvolts, what is the kinetic energy of an electron with mass 0.5 megaelectronvolts per c squared moving at 0.6 times the speed of light?

W) 0.09
X) 0.125
Y) 0.18
Z) 0.225

ANSWER: X) 0.125

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TOSS-UP

2) Biology – *Multiple Choice* Which of the following best describes the function of dithiothreitol ***[die-THIGH-o-three-it-tol]*** in SDS-PAGE gel electrophoresis?

W) Reducing agent
X) Buffer
Y) Detergent
Z) Protein dye

ANSWER: W) REDUCING AGENT

BONUS

2) Biology – *Short Answer* What class of enzymes catalyze the breakdown of neurotransmitters like norepinephrine, dopamine and serotonin?

ANSWER: MONOAMINE OXIDASES (ACCEPT: MAO)
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TOSS-UP

3) Earth and Space – *Multiple Choice* Which of the following statements is FALSE regarding hydrothermal vents?

W) Hydrothermal vents typically form near mid-ocean ridges
X) The color of white smokers results from iron and sulfur
Y) Black smokers are more common than white smokers
Z) Black smokers are hotter than white smokers

ANSWER: X) THE COLOR OF WHITE SMOKERS RESULTS FROM IRON AND SULFUR

BONUS

3) Earth and Space – *Short Answer* Identify which spectral class each of the following three spectral lines belongs to, according to the Harvard classification system: 1) Strong TiO lines; 2) Strong balmer lines, weak calcium lines; 3) Weak balmer lines, medium calcium lines.

ANSWER: 1) M; 2) A; 3) G

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TOSS-UP

4) Math – *Short Answer* In triangle ABC, D lies on side BC such that AD is an angle bisector, AB = 5, AC = 7, and BC = 8. What is the ratio of the area of triangle DAC to triangle DAB?

ANSWER: 7/5

BONUS

4) Math – *Short Answer* A point in three-dimensional space has distances of 2, 6, 7, 8, and 9 from five of the vertices of a regular octahedron. What is its distance from the sixth vertex?

ANSWER: √21
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TOSS-UP

5) Chemistry – *Multiple Choice* An alkene is reacted with borane, and the product is reacted with hydrogen peroxide in basic solution. Which of the following best describes the favored product of this reaction?

W) Zaitsev
X) Markovnikov
Y) Anti-Markovnikov
Z) Lindlar

ANSWER: Y) ANTI-MARKOVNIKOV

BONUS

5) Chemistry – *Short Answer* Identify all of the following three statements that are true of IR spectroscopy: 1) Triple bonds generally have higher stretching frequencies than double bonds; 2) A bond to a sulfur atom would have a higher stretching frequency than a similar bond to a hydrogen atom; 3) Bending frequencies are generally higher than stretching frequencies.

ANSWER: 1 ONLY

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TOSS-UP

6) Energy – *Short Answer* Scientists at Argonne National Lab are using an analytical local stress model for uranium-molybdenum dispersion fuel. In their model, they used a thick sphere model. Suppose that a thick sphere has an inner radius of 4 and an outer radius of 5. What is the total surface area of the thick sphere in terms of π?

ANSWER: 164π

BONUS

6) Energy – *Short Answer* Scientists at Argonne National Lab are visualizing dynamic fractures in porcine bone. The scientists are studying what type of porous bone, which has a spongy appearance and encloses large spaces?

ANSWER: TRABECULAR (ACCEPT: CANCELLOUS)
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TOSS-UP

7) Physics – *Multiple Choice* Which of the following is responsible for most of the rest mass of a proton?

W) Generation of virtual Higgs bosons
X) Energy of the Higgs field
Y) Mass of constituent quarks
Z) Gluon binding energy

ANSWER: Z) GLUON BINDING ENERGY

BONUS

7) Physics – *Short Answer* Which experiment was the first to measure the effect of time dilation on the Doppler effect, thus providing confirmation for special relativity?

ANSWER: IVES–STILWELL EXPERIMENT

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TOSS-UP

8) Biology – *Short Answer* Dihedral angles in the backbone of a protein can be plotted on what diagram, which has the psi and phi angles as its axes?

ANSWER: RAMACHANDRAN PLOT

BONUS

8) Biology – *Multiple Choice* Which of the following statements regarding the effects of cortisol on the body is FALSE?

W) Cortisol is primarily secreted by the zona fasciculata in the adrenal glands
X) Heightened cortisol levels reduce the symptoms of autoimmune disease
Y) Cortisol increases the plasma concentrations of glucose and fatty acids
Z) Addison's disease leads to decreased bone mass

ANSWER: Z) ADDISON'S DISEASE LEADS TO DECREASED BONE MASS
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TOSS-UP

9) Earth and Space – *Multiple Choice* Which of the following statements is FALSE about Seyfert galaxies?

W) They have a supermassive black hole in the center
X) Look similar to spiral galaxies under visible light
Y) Slow moving gas in Type I Seyfert galaxies produce its narrow core
Z) Type I Seyfert galaxies have narrower emission lines than type II Seyfert galaxies

ANSWER: Z) TYPE I SEYFERT GALAXIES HAVE NARROWER EMISSION LINES THAN TYPE II SEYFERT GALAXIES

BONUS

9) Earth and Space – *Short Answer* Which Polish astronomer first discovered large collections of dust at the 4th and 5th Lagrange points of the Earth-Moon system, after whom the clouds are named?

ANSWER: KAZIMIERZ KORDYLEWSKI (ACCEPT: KORDYLEWSKI)

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TOSS-UP

10) Math – *Multiple Choice* Which of the following is the equation of the perpendicular bisector of the segment with endpoints (1, 2) and (5, -4)?

W) $3x + 2y = 7$
X) $3x - 2y = 11$
X) $2x + 3y = 3$
Z) $2x - 3y = -9$

ANSWER: Z) $2x - 3y = -9$

BONUS

10) Math – *Short Answer* Find all integers n such that $n^2 + 4n + 19$ is a perfect square.

ANSWER: -9, -3, -1, AND 5
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TOSS-UP

11) Chemistry – *Multiple Choice* Which of the following statements is FALSE regarding S_N2 reactions?

W) They do not involve an intermediate
X) They can undergo an inversion of configuration
Y) Backside attack occurs when the front side is blocked by high electron density from the leaving group's lone pairs
Z) The LUMO of the nucleophile overlaps with the HOMO of the electrophile

ANSWER: Z) The LUMO of the nucleophile overlaps with the HOMO of the electrophile

BONUS

11) Chemistry – *Short Answer* Rank the following four carboxylic acid derivatives by decreasing reactivity: 1) Acyl phosphate; 2) Ester; 3) Acid anhydride; 4) Thioester.

ANSWER: 3, 1, 4, 2

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TOSS-UP

12) Energy – *Short Answer* Researchers at Brookhaven National Lab are studying the interaction when two photons collide. They found that the two photons can merge, forming what particle that mediates beta decay?

ANSWER: W BOSON (ACCEPT; W^+ BOSON; W^- BOSON)

BONUS

12) Energy – *Multiple Choice* Researchers at Brookhaven National Lab are studying the decay of the Higgs Boson. They found experimental confirmation that the most common mechanism for the decay of the Higgs Boson produces which of the following quarks?

W) Charm
X) Strange
Y) Top
Z) Bottom

ANSWER: Z) BOTTOM
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TOSS-UP

13) Physics – *Short Answer* Identify all of the following three statements that are true about Cooper pairs: 1) They consist of two bound phonons; 2) They form the basis of the Ginzburg-Landau theory of superconductivity; 3) They obey the Pauli exclusion principle.

ANSWER: NONE

BONUS

13) Physics – *Short Answer* The decrease in strength of the residual strong force is best modeled by what potential?

ANSWER: YUKAWA POTENTIAL

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TOSS-UP

14) Biology – *Multiple Choice* Which of the following chemicals is used to calculate glomerular filtration rate because it is freely filtered but not secreted or reabsorbed by the nephron?

W) Para-aminohippurate
X) Inulin
Y) Creatinine
Z) Galactose

ANSWER: X) INULIN

BONUS

14) Biology – *Short Answer* Identify all of the following three statements that are true regarding DNA: 1) DNA is typically found in the B form in cells; 2) In Hoogsten base pairing, the syn side of the purine binds to the anti side of the pyrimidine; 3) In wobble base pairing, inosine can bond to cytosine, uracil, and adenine.

ANSWER: ALL (ACCEPT: 1, 2 AND 3)
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TOSS-UP

15) Earth and Space – *Short Answer* What element is most often used to determine the age of a T Tauri star?

ANSWER: LITHIUM

BONUS

15) Earth and Space – *Short Answer* Identify all of the following three statements that are true about the Bergerson process: 1) The air is supersaturated with water; 2) It dominates at mid-latitudes; 3) Mixed clouds are primarily composed of water droplets.

ANSWER: 2 AND 3

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TOSS-UP

16) Math – *Multiple Choice* What is the determinant of a 3x3 matrix with eigenvalues of 2, 3, and 5?

W) -30
X) -10
Y) 10
Z) 30

ANSWER: W) -30

BONUS

16) Math – *Short Answer* Compute the sum of the prime factors of $3^8 + 3^4 + 1$.

ANSWER: 93
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TOSS-UP

17) Chemistry – *Short Answer* What boron-containing compound is added in the process of making borosilicate glass?

ANSWER: BORON TRIOXIDE (ACCEPT: DIBORON TRIOXIDE; B_2O_3)

BONUS

17) Chemistry – *Multiple Choice* An aldehyde is reacted with hydroxylamine in an acidic condition. What functional group is produced?

W) Primary amine
X) Secondary amine
Y) Oxime
Z) Hydrazone

ANSWER: Y) OXIME

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TOSS-UP

18) Energy – *Short Answer* Researchers at Lawrence Livermore National Lab are building 3D nanometer-thin membranes inspired by nature. These membranes have a wide range of applications, including what treatment for kidney failure?

ANSWER: DIALYSIS

BONUS

18) Energy – *Multiple Choice* Researchers at Lawrence Livermore National Lab are studying the shock waves produced from exploding stars. In particular, they are studying the injection problem. Which of the following mechanisms is unknown, causing the injection problem?

W) Stabilization of shock waves through intermolecular forces
X) Sustained high speeds of particles in the shock wave
Y) Acquisition of initial energy of particles in the shock wave
Z) Spontaneous absorption and emission of light into the shock waves

ANSWER: Y) ACQUISITION OF INITIAL ENERGY OF PARTICLES IN THE SHOCK WAVE
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TOSS-UP

19) Physics – *Multiple Choice* The first two Bose-Einstein condensates ever created were made from atoms from which of the following groups?

W) Alkali metals
X) Alkali earth metals
Y) Halogens
Z) Noble gases

ANSWER: W) ALKALI METALS

BONUS

19) Physics – *Short Answer* What equation calculates the effective power of a thick lens with respect to a second principle plane?

ANSWER: GULLSTRAND'S EQUATION

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TOSS-UP

20) Biology – *Short Answer* Bees exhibit haplo-diploid sex determination, where an egg that is not fertilized by a male bee will develop into a male, and an egg that is fertilized will develop into a female bee. What is the coefficient of relatedness between a female bee and her brother?

ANSWER: 0.25

BONUS

20) Biology – *Short Answer* Identify all of the following four plant families that exhibit zygomorphic flowers: 1) Fabaceae; 2) Asteraceae; 3) Orchidaceae; 4) Bromeliaceae

ANSWER: 1 AND 3
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TOSS-UP

21) Earth and Space – *Short Answer* After a glacier has melted away from a region, they often leave behind cirque basins. What small lakes sometimes occupy these basins?

ANSWER: TARN

BONUS

21) Earth and Space – *Multiple Choice* A spiral galaxy is classified as E4. Which of the following is closest to its eccentricity?

W) 0.5
X) 0.6
Y) 0.7
Z) 0.8

ANSWER: Y) 0.7

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TOSS-UP

22) Math – *Short Answer* How many positive integers less than 30 are relatively prime to 30?

ANSWER: 8

BONUS

22) Math – *Short Answer* What is the equation of the quadratic with leading coefficient 1 that passes through the points (-1, 1), (2, -5), and (3, -3)?

ANSWER: $x^2 - 3x - 3$
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TOSS-UP

23) Chemistry – *Multiple Choice* Which of the following conformations of cyclohexane is the LEAST stable?

W) Chair
X) Boat
Y) Half-chair
Z) Twist-boat

ANSWER: Y) HALF-CHAIR

BONUS

23) Chemistry – *Short Answer* Identify all of the following three functional groups that are considered meta- directors: 1) Nitrile; 2) Amino; 3) Trifluoromethyl.

ANSWER: 1 AND 3