# NNHS ROUND 12

## TOSS-UP

1) Physics – *Short Answer* What device first demonstrated Earth's rotation?

ANSWER: FOUCAULT PENDULUM

## BONUS

1) Physics – *Short Answer* Identify all of the following three statements that are true regarding the Standard Model: 1) The Higgs boson is the only elementary particle with a spin of 0; 2) Neutrinos have a lepton number of 1; 3) Quarks have a baryon number of 1.

ANSWER: 1 AND 2

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

## TOSS-UP

2) Biology – *Multiple Choice* Which of the following chemicals is NOT needed for Sanger sequencing?

W) dNTPs
X) ddNTPs with fluorescent tags
Y) DNA Ligase
Z) Primer

ANSWER: Y) DNA LIGASE

## BONUS

2) Biology – *Short Answer* What specialized lymph capillaries take up chylomicrons from fat absorption?

ANSWER: LACTEALS
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

**TOSS-UP**

3) Earth and Space – *Multiple Choice* Which of the following is NOT a Milankovitch cycle?

W) Eccentricity
X) Obliquity
Y) Rotation
Z) Precession

ANSWER: Y) ROTATION

**BONUS**

3) Earth and Space – *Short Answer* What term describes circular, nearly-vertical shafts found in glaciers that are formed by meltwater melting a specific region in the ice?

ANSWER: MOULIN

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

**TOSS-UP**

4) Math – *Multiple Choice* Let complex number $z = 3\cos(2\pi/3) + 3\sin(2\pi/3)i$ ***[3 times the cosine of the quantity 2 pi over 3 plus 3 sin of the quantity 2pi over 3 times i]***. Which of the following is a real number?

W) $z$
X) $z^3$
Y) $z^5$
Z) $z^7$

ANSWER: X) $z^3$

**BONUS**

4) Math – *Short Answer* Let A equal the sum of the reciprocals of the perfect fourth powers, and let B equal the sum of the reciprocals of the odd perfect fourth powers. What is the ratio of B to A?

ANSWER: 15/16
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

**TOSS-UP**

5) Chemistry – *Multiple Choice* Which of the following atoms can NOT become hypervalent?

W) Calcium
X) Sulfur
Y) Fluorine
Z) Phosphorous

ANSWER: Y) FLUORINE

**BONUS**

5) Chemistry – *Short Answer* Identify all of the following four bonds that are found in all esters: 1) Carbon-carbon double bond, 2) Carbon-oxygen double bond, 3) Carbon-oxygen single bond, 4) Oxygen-oxygen single bond.

ANSWER: 2 AND 3

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

**TOSS-UP**

6) Energy – *Multiple Choice* Researchers at Oak Ridge National Lab recently discovered a new microbial pathway that produces ethylene and methane. The pathway produces these carbon-containing molecules as byproducts to make what sulfur-containing amino acid?

W) Methionine
X) Alanine
Y) Leucine
Z) Tryptophan

ANSWER: W) METHIONINE

**BONUS**

6) Energy – *Short Answer* Researchers at Oak Ridge National Lab are breaking up biomass using a combination of water and tetrahydrofuran. Identify all of the following four properties that correctly characterize tetrahydrofuran: 1) Heterocyclic; 2) Low boiling point; 3) Polar; 4) Saturated.

ANSWER: 1, 2, 3, AND 4 (ACCEPT: ALL)
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

**TOSS-UP**

7) Physics – *Multiple Choice* Which of the following statements about the Reynolds number is FALSE?

W) A high reynolds number is characteristic of turbulent flow
X) Viscous forces dominate at high Reynolds numbers
Y) It is dimensionless
Z) It is proportional to fluid velocity

ANSWER: X) VISCOUS FORCES DOMINATE AT HIGH REYNOLDS NUMBERS

**BONUS**

7) Physics – *Short Answer* What type of particle is its own antiparticle?

ANSWER: MAJORANA PARTICLE (ACCEPT: MAJORANA FERMION)

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

**TOSS-UP**

8) Biology – Short Answer What hormone, which is a derivative of tryptophan, is produced by the pineal gland?

ANSWER: MELATONIN

**BONUS**

8) Biology – *Multiple Choice* Geoffrey has found a new inhibitor to the hexokinase enzyme. To study its effects, Geoffrey compares the Lineweaver-Burke plot of the original enzyme to the Lineweaver-Burke plot of the enzyme with inhibitor added. He notices that the y-intercept stayed the same, but the slope increased. What type of inhibitor did Geoffrey find?

W) Competitive
X) Noncompetitive
Y) Uncompetitive
Z) Mixed

ANSWER: W) COMPETITIVE
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

**TOSS-UP**

9) Earth and Space – *Multiple Choice* Which of the following drainage patterns would be formed on a surface that is relatively uniform?

W) Dendritic
X) Radial
Y) Rectangular
Z) Trellis

ANSWER: W) DENDRITIC

**BONUS**

9) Earth and Space – *Short Answer* What is the spectral class of the red supergiant Betelgeuse ***[beetle-juice]***, located in the Orion constellation?

ANSWER: M

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

**TOSS-UP**

10) Math – *Multiple Choice* Which of the following could be the length of the hypotenuse of a triangle with positive integer side lengths?

W) 18
X) 19
Y) 20
Z) 21

ANSWER: Y) 20

**BONUS**

10) Math – *Short Answer* A certain ribbons store offers a 2-ribbon package for $3 and a 5-ribbon for $7. What is the maximum number of ribbons that can be bought at this store with $16?

ANSWER: 11
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

**TOSS-UP**

11) Chemistry – *Short Answer* What is the degree of unsaturation of phenol, which has the molecular formula $C_6H_6O$?

ANSWER: 4

**BONUS**

11) Chemistry – *Short Answer* How many signals would be expected in the $^1$H-NMR spectrum of cyclopentadiene?

ANSWER: 3

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

**TOSS-UP**

12) Energy – *Multiple Choice* Researchers at Lawrence Livermore National Lab are studying the structure of neutron stars by looking at the location of high-energy neutrons. Which of the following is closest to the maximum possible solar mass of a neutron star?

W) 3.0
X) 2.2
Y) 1.4
Z) 0.6

ANSWER: X) 2.2

**BONUS**

12) Energy – *Short Answer* Researchers at Lawrence Livermore National Lab are analyzing hadrons composed of what second generation quark with +⅔ charge?

ANSWER: CHARM
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

**TOSS-UP**

13) Physics – *Short Answer* What phenomenon occurs when two particles have quantum properties that are dependent on each other, which Albert Einstein termed "spooky action at a distance"?

ANSWER: QUANTUM ENTANGLEMENT

**BONUS**

13) Physics – *Short Answer* What is the period of an ideal pendulum that consists of a uniform, rigid rod of mass 10 kilograms and length 0.3 meters?

ANSWER: 2π/7 SECONDS

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

**TOSS-UP**

14) Biology – *Multiple Choice* Two toxic species of animals that both have similar bright displays of coloration exhibit which of the following phenomena?

W) Mullerian mimicry
X) Batesian mimicry
Y) Mertensian mimicry
Z) Cryptic coloration

ANSWER: W) MULLERIAN MIMICRY

**BONUS**

14) Biology – *Short Answer* Rank the following three cell types by increasing mitochondria density: 1) Cardiac myocyte; 2) Hepatocyte; 3) Erythrocyte.

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

**TOSS-UP**

15) Earth and Space – *Short Answer* What force supports white dwarfs and prevents them from collapsing due to gravity?

ANSWER: ELECTRON DEGENERACY PRESSURE

**BONUS**

15) Earth and Space – *Multiple Choice* Which of the following is closest to the difference in time between a sidereal year and a tropical year?

W) 2 minutes
X) 20 minutes
Y) 3 hours
Z) 1 day

ANSWER: X) 20 MINUTES

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

**TOSS-UP**

16) Math – *Multiple Choice* Consider the following statement: if n is an integer, then the square root of n is also an integer. Which of the following values of n would disprove this statement?

W) -4
X) 20.25
Y) 25
Z) 0

ANSWER: W) -4

**BONUS**

16) Math – *Short Answer* Three circles, each with radius 4, are externally tangent to each other. A fourth circle is placed in the center of the three circles and is externally tangent to the other three circles. What is the radius of the fourth circle?

ANSWER: $4\sqrt{3} - 6$
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

**TOSS-UP**

17) Chemistry – *Short Answer* Identify all of the following three statements are true about mass spectroscopy: 1) Heavier ions are deflected less than lighter ions; 2) All atoms are ionized into cations; 3) The mass spectrum of chlorine gas has two peaks.

ANSWER: 1 AND 2

**BONUS**

17) Chemistry – *Short Answer* Expressing your answer to two significant figures, what is the osmotic pressure of a solution when 3 moles of sodium chloride are added to 4 kilograms of water, at 23° celsius?

ANSWER: 3700 PASCALS

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

**TOSS-UP**

18) Energy – *Multiple Choice* Researchers at Argonne National Lab are studying conditions on water-rich exoplanets. Which of the following is closest to the albedo of Earth's oceans?

W) 0.1
X) 0.3
Y) 0.7
Z) 0.9

ANSWER: W) 0.1

**BONUS**

18) Energy – *Short Answer* Researchers at Argonne National Lab are studying the catalytic conversion of carbon dioxide and water into ethanol. Suppose that a researcher has 132 grams of carbon dioxide and 36 grams of water. How many moles of ethanol can the research produce?

ANSWER: 2/3
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

**TOSS-UP**

19) Physics – *Short Answer* What quantity equals the time integral of the Lagrangian?

ANSWER: ACTION

**BONUS**

19) Physics – *Multiple Choice* Unpolarized light with an intensity of 200 watts per meter squared travels through two polarizers. The axis of the two polarizers are rotated 60 degrees from each other. What is the intensity of the light, in watts per meter squared, right after it passes through the second polarizer?

W) 200
X) 100
Y) 50
Z) 25

ANSWER: Z) 25

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

**TOSS-UP**

20) Biology – *Short Answer* What is the name of the resident macrophage glial cells in the central nervous system?

ANSWER: MICROGLIA

**BONUS**

20) Biology – *Multiple Choice* Which of the following is NOT an adaptation found in xerophytes to survive in arid environments?

W) Crassulacean acid metabolism
X) Stomata found in crypts with trichomes
Y) Stomata found solely on the adaxial surface of leaves
Z) Thick cuticle

ANSWER: Y) STOMATA FOUND SOLELY ON THE ADAXIAL SURFACE OF LEAVES
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

**TOSS-UP**

21) Earth and Space – *Short Answer* What proposed geological epoch spans from around 1950 to the present day and is characterized by human-induced climate change?

ANSWER: ANTHROPOCENE

**BONUS**

21) Earth and Space – *Short Answer* Telescopes rely on what device, which often consists of an equatorial mounting in combination with a polar axis, to track stars across the sky as Earth rotates?

ANSWER: SIDEREAL DRIVE

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

**TOSS-UP**

22) Math – *Short Answer* What is the sum of the cubes of the first 4 positive integers?

ANSWER: 100

**BONUS**

22) Math – *Short Answer* What is the tangent of the largest angle in a triangle with side lengths of 3, 5, and 7?

ANSWER: $\sqrt{3}$
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

**TOSS-UP**

23) Chemistry – *Multiple Choice* Which of the following is commonly used as a catalyst for the esterification of carboxylic acid and alcohol?

W) Water
X) Methane
Y) Sulfuric Acid
Z) Pentane

ANSWER: Y) SULFURIC ACID

**BONUS**

23) Chemistry – *Multiple Choice* Which of the following compounds will absorb moisture from the atmosphere when exposed to air, forming an aqueous solution?

W) NaOH
X) $AlCl_3$
Y) $H_2SO_4$
Z) $SO_2$

ANSWER: W) NaOH