NNHS ROUND 6

TOSS-UP

1) Physics – *Short Answer* A 60-kilogram block experiences a constant force of 300 Newtons for 4 seconds. What is the impulse experienced by the block?

ANSWER: 1200 KILOGRAM-METERS PER SECOND

BONUS

1) Physics – *Multiple Choice* Block A is launched from the ground at a speed of 10 meters per second at an angle of θ, while Block B is launched from the ground at a speed of 5 meters per second vertically upward. Neglecting air resistance, which of the following statements is true regarding the speeds of the blocks when they both reach a height h?

W) Block A will only have a faster speed when θ is less than 30°
X) Block A will only have a faster speed when θ is greater than 30°
Y) Block A will always have a faster speed
Z) Block B will always have a faster speed

ANSWER: Y) BLOCK A WILL ALWAYS HAVE A FASTER SPEED

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TOSS-UP

2) Biology – *Short Answer* What hormone, secreted by the duodenum in response to acidity, causes the pancreas to secrete bicarbonate?

ANSWER: SECRETIN

BONUS

2) Biology – *Short Answer* In addition to secreting hydrochloric acid, the parietal cells of the stomach also secrete intrinsic factor. Intrinsic factor aids in the absorption of what cobalt-containing B vitamin?

ANSWER: VITAMIN B12 (ACCEPT: COBALAMIN)
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TOSS-UP

3) Earth and Space – *Multiple Choice* Which of the following planets is NOT visible to the naked eye?

W) Mercury
X) Venus
Y) Saturn
Z) Neptune

ANSWER: Z) NEPTUNE

BONUS

3) Earth and Space – *Short Answer* Only two planets in the solar system experience retrograde motion, Venus and Uranus. Both planets likely experienced what event, resulting in this kind of motion?

ANSWER: CATACLYSMIC COLLISION (ACCEPT: COLLISION WITH A PROTOPLANET)

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TOSS-UP

4) Math – *Short Answer* What is the smallest integer greater than 1 that leaves a remainder of 1 when divided by 2, 3, 4, and 5?

ANSWER: 61

BONUS

4) Math – *Short Answer* A positive integer factor of 120 is chosen at random. What is the probability that the chosen factor is even?

ANSWER: 3/4
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TOSS-UP

5) Chemistry – *Multiple Choice* Which of the following is considered a Lewis acid but NOT a Brønsted-Lowry acid?

W) Boron trichloride
X) Carbon dioxide
Y) Ammonium
Z) Hydrochloric acid

ANSWER: W) BORON TRICHLORIDE

BONUS

5) Chemistry – *Short Answer* What method produces alloys by mixing finely powdered metals, and then pressing them into a mold?

ANSWER: SINTERING

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TOSS-UP

6) Energy – *Short Answer* Researchers at Oak Ridge National Laboratory are studying potential applications of starch in the production of biofuels. Starch is composed of what two polysaccharides?

ANSWER: AMYLOSE AND AMYLOPECTIN

BONUS

6) Energy – *Short Answer* Researchers at Oak Ridge National Laboratory are using supercomputing to study potential drugs in the fight against the SARS-CoV-2 virus. In particular, they are looking for compounds that will bind to what transmembrane protein on the virus?

ANSWER: SPIKE PROTEIN (ACCEPT: S PROTEIN)
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TOSS-UP

7) Physics – *Multiple Choice* Which of the following quantities represents how compressible a material is?

W) Young's modulus
X) Shear modulus
Y) Longitudinal modulus
Z) Bulk modulus

ANSWER: Z) BULK MODULUS

BONUS

7) Physics – *Short Answer* Beta-minus decay is mediated through the release of what virtual particle?

ANSWER: W^- BOSON (DO NOT ACCEPT: W BOSON, W^+ BOSON)

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TOSS-UP

8) Biology – *Short Answer* What instrument is used to measure the blood pressure of a patient?

ANSWER: SPHYGMOMANOMETER

BONUS

8) Biology – *Multiple Choice* Which of the following best describes the pH of blood and the affinity of hemoglobin for oxygen during exercise?

W) Blood pH decreases; hemoglobin's affinity for oxygen increases
X) Blood pH decreases; hemoglobin's affinity for oxygen decreases
Y) Blood pH increases; hemoglobin's affinity for oxygen increases
Z) Blood pH increases; hemoglobin's affinity for oxygen decreases

ANSWER: X) BLOOD PH DECREASES; HEMOGLOBIN'S AFFINITY FOR OXYGEN DECREASES
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TOSS-UP

9) Earth and Space – *Short Answer* What term describes the two points where the moon crosses the ecliptic?

ANSWER: LUNAR NODES

BONUS

9) Earth and Space – *Short Answer* Order the following four substances that occur in the metamorphism of mafic volcanics by increasing metamorphic grade: 1) Granulite; 2) Zeolite; 3) Greenschist; 4) Amphibolite.

ANSWER: 2, 3, 4, 1

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TOSS-UP

10) Math – *Multiple Choice* Which of the following is an antiderivative of sec(x)?

W) sec(x)tan(x)
X) $\sec^2(x)$
Y) ln|sin(x) + cos(x)| ***[the natural log of the absolute value of sine of x plus cosine of x]***
Z) ln|sec(x) + tan(x)| ***[the natural log of the absolute value of secant of x plus tangent of x]***

ANSWER: Z) ln|sec(x) + tan(x)|

BONUS

10) Math – *Short Answer* How many ways can a parent give 8 indistinguishable cookies to 3 kids, if each kid must receive at least one cookie?

ANSWER: 21
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TOSS-UP

11) Chemistry – *Short Answer* What is the degree of unsaturation of the compound 2-pentanone, which has the molecular formula $C_5H_{10}O$?

ANSWER: 1

BONUS

11) Chemistry – *Multiple Choice* Approximately how many times larger is the radius of the nucleus of gallium compared to the radius of the nucleus of hydrogen?

W) 2
X) 4
Y) 8
Z) 16

ANSWER: X) 4

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TOSS-UP

12) Energy – *Multiple Choice* Researchers at Oak Ridge National Laboratory are studying solar-energy materials. In the materials, the researchers found a way to slow phonons, which are vibrations that transport which of the following quantities?

W) Heat
X) Sound
Y) Current
Z) Voltage

ANSWER: W) HEAT

BONUS

12) Energy – *Short Answer* Researchers at Oak Ridge National Laboratory are researching the effects of mercury on the ecosystem. Mercury, by itself, is not harmful to the environment. What mercury-containing compound, that is generated by microbes in the presence of mercury, causes the most harm to ecosystems?

ANSWER: METHYLMERCURY (ACCEPT: CH_3Hg)
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TOSS-UP

13) Physics – *Short Answer* What general term refers to a property that is different when measured along different directions?

ANSWER: ANISOTROPIC

BONUS

13) Physics – *Multiple Choice* According to Poiseuille's equation, volumetric flow rate is proportional to what power of radius?

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

ANSWER: Z) 4

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TOSS-UP

14) Biology – *Short Answer* In what section of the chloroplast do the light reactions of photosynthesis occur?

ANSWER: THYLAKOID (ACCEPT: THYLAKOID MEMBRANE)

BONUS

14) Biology – *Multiple Choice* When a plant is exposed to 14 continuous hours of darkness, it flowers. If the plant is exposed to a flash of red light during this 14 hour period, it will not flower. Which of the following terms best describes the photoperiod of the plant?

W) Short day
X) Long day
Y) Day neutral
Z) Seasonal

ANSWER: W) SHORT DAY
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TOSS-UP

15) Earth and Space – *Short Answer* The ionosphere is a result of the interaction between the upper atmosphere and what type of electromagnetic radiation produced by the sun?

ANSWER: ULTRAVIOLET (ACCEPT: UV)

BONUS

15) Earth and Space – *Short Answer* Vega, Altair and Deneb are part of what asterism?

ANSWER: SUMMER TRIANGLE

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TOSS-UP---

16) Math – *Short Answer* Identify all of the following three equations that pass through the point (1, 3): 1) $x^2 - y^2 = -2$; 2) $2x + 4y = 13$; 3) $x^y + y^x = 4$.

ANSWER: 3 ONLY

BONUS

16) Math – *Short Answer* A triangle has two vertices at (-1, 2) and (3, 4), and its centroid is located at (2, 5). What are the coordinates of the triangle's third vertex?

ANSWER: (4, 9)
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TOSS-UP

17) Chemistry – *Short Answer* Identify all of the following three mixtures that exhibit the Tyndall Effect: 1) Salt water; 2) Milk; 3) Whipped cream.

ANSWER: 2 AND 3

BONUS

17) Chemistry – *Short Answer* What region in IR spectroscopy from 1450 to 400 inverse centimeters contains an unusually large number of peaks and is often used to identify compounds?

ANSWER: FINGERPRINT REGION

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TOSS-UP

18) Energy – *Short Answer* Scientists at Argonne National Lab have devised a method to create micro and nanoscale mechanical oscillators with excellent frequency stability. Most current oscillators use a quartz crystal as the resonating element. Quartz exhibits what effect, which produces an electric charge in response to mechanical stress?

ANSWER: PIEZOELECTRICITY (ACCEPT: PIEZOELECTRIC EFFECT)

BONUS

18) Energy – *Multiple Choice* Scientists at Argonne National Lab have devised a method to create micro and nanoscale mechanical oscillators. Which of the following is NOT a major potential application of this technology?

W) NMR spectroscopy
X) Frequency-shift-based detectors
Y) Mechanical energy storage
Z) GPS timing references

ANSWER: W) NMR SPECTROSCOPY
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TOSS-UP

19) Physics – *Multiple Choice* According to Newton's second law, force equals the time derivative of what quantity?

W) Mass
X) Angular momentum
Y) Linear momentum
Z) Linear acceleration

ANSWER: Y) LINEAR MOMENTUM

BONUS

19) Physics – *Short Answer* Henry Cavendish used what device to measure the universal gravitational constant?

ANSWER: TORSION BALANCE

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TOSS-UP

20) Biology – *Multiple Choice* Which of the following ions is used to induce the slow block to polyspermy in sea urchins?

W) K^+
X) Na^+
Y) Cl^-
Z) Ca^{2+}

ANSWER: Z) Ca^{2+}

BONUS

20) Biology – *Short Answer* Identify all of the following four structures that develop from the endoderm: 1) Adrenal cortex; 2) Adrenal medulla; 3) Thyroid; 4) Liver.

ANSWER: 3 AND 4
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TOSS-UP

21) Earth and Space – *Short Answer* What hypothesis states that the mantle is separated into an upper mantle system and a lower mantle system, which convect at different rates?

ANSWER: STRATIFIED CONVECTION

BONUS

21) Earth and Space – *Multiple Choice* Inferior planets can NEVER be at which of the following orientations with the Sun?

W) Opposition
X) Conjunction
Y) Greatest western elongation
Z) Greatest eastern elongation

ANSWER: W) OPPOSITION

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TOSS-UP

22) Math – *Short Answer* A teacher randomly returns the tests of 10 students, one to each student. What is the probability that she returns the right test to exactly 9 of the 10 students?

ANSWER: 0

BONUS

22) Math – *Short Answer* If $\sin(x) = 1/3$, and x is an angle in the first quadrant, then what is the value of $\sin(2x)$?

ANSWER: $\frac{4\sqrt{2}}{9}$
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TOSS-UP

23) Chemistry – *Multiple Choice* 2-methylpropane is an isomer of which of the following alkanes?

W) Ethane
X) Butane
Y) Pentane
Z) Hexane

ANSWER: X) BUTANE

BONUS

23) Chemistry – *Multiple Choice* Maxwell's demon hypothetically violates which law of thermodynamics?

W) Zeroth
X) First
Y) Second
Z) Third

ANSWER: Y) SECOND