NNHS ROUND 11

TOSS-UP

1) Physics – *Short Answer* What principle states that every point on a wavefront is the source of new spherical wavelets?

ANSWER: HUYGENS PRINCIPLE (ACCEPT: HUYGENS–FRESNEL PRINCIPLE)

BONUS

1) Physics – *Multiple Choice* Polarized light travels from glass, with an index of refraction of n = 1.5, to diamond, with an index of refraction of n = 2.4. No reflection will occur closest to which of the following incident angles?

W) 40°
X) 50°
Y) 60°
Z) 70°

ANSWER: Y) 60°

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TOSS-UP

2) Biology – *Short Answer* What metal is found at the center of the porphyrin ring in chlorophyll?

ANSWER: MAGNESIUM

BONUS

2) Biology – *Short Answer* In C4 plants, what enzyme first captures carbon dioxide?

ANSWER: PEP CARBOXYLASE
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TOSS-UP

3) Earth and Space – *Multiple Choice* In which of the following latitudes would you expect to find the most dramatic thermocline?

W) 10 degrees North
X) 20 degrees North
Y) 30 degrees North
Z) 40 degrees North

ANSWER: W) 10 DEGREES NORTH

BONUS

3) Earth and Space – *Short Answer* Approximately 325 million years ago, the Alleghenian orogeny formed which modern mountain range?

ANSWER: THE APPALACHIAN MOUNTAINS

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TOSS-UP

4) Math – *Short Answer* The volume of a cube is decreasing at 4 meters cubed per second. What is the side length of the cube if the side length is decreasing at a rate of 1/3 meters per second?

ANSWER: 2 METERS

BONUS

4) Math – *Short Answer* Evaluate the indefinite integral of 2 times the square root of the quantity $1 - x^2$ dx.

ANSWER: $x\sqrt{x} + \arcsin(x) + C$
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TOSS-UP

5) Chemistry – *Multiple Choice* Which of the following has the largest atomic radius?

W) Iodine
X) Bromine
Y) Manganese
Z) Yttrium

ANSWER: Z) YTTRIUM

BONUS

5) Chemistry – *Short Answer* What is the formal charge of nitrogen in thiocyanate?

ANSWER: –1

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TOSS-UP

6) Energy – *Short Answer* Researchers at Lawrence Livermore National Lab are studying methane hydrates to better understand the seafloor. Rapid release of methane to seawater can cause what effect, which is caused by changes to the bicarbonate buffer system?

ANSWER: OCEAN ACIDIFICATION

BONUS

6) Energy – *Short Answer* Researchers at Lawrence Livermore National Lab have developed a 3D-printed aneurysm to help improve surgical procedures. One non-invasive treatment for aneurysms is to insert a thin metal tube, causing the area to clot. What is the term for the tube?

ANSWER: CATHETER
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TOSS-UP

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

W) Laminar flow is characterized by high viscosity
X) Surface tension increases as temperature increases
Y) A fluid that obeys the continuity equation must have a constant density
Z) In the absence of gravity, bubbles adopt a spherical shape to minimize surface tension

ANSWER: X) SURFACE TENSION INCREASES AS TEMPERATURE INCREASES

BONUS

7) Physics – *Short Answer* Two waves traveling in the same medium have the same speed, but the second wave has three times the amplitude and twice the wavelength of the first wave. If the first wave has intensity I, then in terms of I, what is the intensity of the second wave?

ANSWER: 9I/4 (ACCEPT: 2.25I)

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TOSS-UP

8) Biology – *Short Answer* What cells located in the gastric gland secretes the components of hydrochloric acid?

ANSWER: PARIETAL CELLS

BONUS

8) Biology – *Multiple Choice* Which of the following correctly describes deuterostomes?

W) Cleavage is spiral and determinate, blastopore develops into mouth
X) Cleavage is radial and indeterminate, blastopore develops into mouth
Y) Cleavage is spiral and determinate, blastopore develops into anus
Z) Cleavage is radial and indeterminate, blastopore develops into anus

ANSWER: Z) CLEAVAGE IS RADIAL AND INDETERMINATE, BLASTOPORE DEVELOPS INTO ANUS
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TOSS-UP

9) Earth and Space – *Short Answer* What type of tides occur when the sun and moon's gravitational effects partially cancel, creating weaker high and low tides?

ANSWER: NEAP TIDES

BONUS

9) Earth and Space – *Multiple Choice* Which of the following statements regarding the Bergeron process is FALSE?

W) Supercooled water droplets freeze when they come into contact with freezing nuclei
X) Freezing nuclei are more abundant in the atmosphere than condensation nuclei
Y) At temperatures below 0°C, the relative humidity with respect to ice is more than the relative humidity with respect to water
Z) The Bergeron process cannot sufficiently explain precipitation in the tropics

ANSWER: X) FREEZING NUCLEI ARE MORE ABUNDANT IN THE ATMOSPHERE THAN CONDENSATION NUCLEI

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TOSS-UP

10) Math – *Short Answer* A cone has a height of 12 and the circumference of the base of the cone is 10π. What is the lateral surface area of the cone?

ANSWER: 65π

BONUS

10) Math – *Short Answer* How many ways are there to distribute 16 indistinguishable oranges between Alice, Bob and Carol, if each person must receive at least 2 oranges?

ANSWER: 66
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TOSS-UP

11) Chemistry – *Multiple Choice* Propanal contains which of the following functional groups?

W) Aldehyde
X) Ketone
Y) Ether
Z) Alcohol

ANSWER: W) ALDEHYDE

BONUS

11) Chemistry – *Short Answer* What principle states that the transition state of a reaction will be closer to the species, product or reactants, that it is closer in energy to?

ANSWER: HAMMOND'S POSTULATE

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TOSS-UP

12) Energy – *Short Answer* Researchers at Pacific Northwest National Lab are predicting hurricanes through sensors powered by wave energy. Hurricane strength is typically measured on what scale, which classifies them into five categories based on wind speed?

ANSWER: SAFFIR–SIMPSON SCALE

BONUS

12) Energy – *Short Answer* Researchers at Pacific Northwest National Lab are studying the structure of small crystals. Suppose that a cubic grain of table salt has a side length of 0.1 millimeters, and the density of table salt is 2.2 grams per cubic centimeter. What is the mass, in grams, of 12 grains of table salt?

ANSWER: $2.64 * 10^{-5}$
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TOSS-UP

13) Physics – *Short Answer* The Lorentz transformation in special relativity replaced what transformation used in Newtonian physics?

ANSWER: GALILEAN TRANSFORMATION

BONUS

13) Physics – *Short Answer* A wave's angular frequency is given by the relation $\omega = k^2 + 5k + 4$, where k is the wavenumber of the wave. At what wavenumbers will the wave's phase and group velocity be equal?

ANSWER: -2 AND 2

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TOSS-UP

14) Biology – *Short Answer* What host protein displays an antigen fragment on the cell surface that facilitates recognition by T cells?

ANSWER: MAJOR HISTOCOMPATIBILITY COMPLEX (ACCEPT: MHC)

BONUS

14) Biology – *Multiple Choice* Which of the following is NOT characteristic of Down syndrome?

W) Increasing risk of developing Alzheimer's disease
X) Increased risk of atherosclerosis
Y) Small white spots on the iris
Z) Decreased risk of having high blood pressure

ANSWER: X) INCREASED RISK OF ATHEROSCLEROSIS
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TOSS-UP

15) Earth and Space – *Multiple Choice* A glacier recedes and removes weight from a region of the Earth's crust. As a result, the crust there rises. This process is described by which of the following terms?

W) Decompression melting
X) Exfoliation
Y) Frost wedging
Z) Isostatic rebound

ANSWER: Z) ISOSTATIC REBOUND

BONUS

15) Earth and Space – *Short Answer* Light that hits a ground-based telescope must first pass through miles of turbulent air in Earth's atmosphere, blurring the image. What is the name of this effect?

ANSWER: SEEING

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TOSS-UP

16) Math – *Short Answer* In rectangle ABCD, AB = 8 and BC = 5, and point E is selected uniformly at random from side AB. What is the probability that the area of AECD is greater than 30?

ANSWER: 1/2

BONUS

16) Math – *Short Answer* What is the greatest common factor of $9^6 - 1$ and $27^6 - 1$?

ANSWER: 728
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TOSS-UP

17) Chemistry – *Short Answer* What law states that the amount of dissolved gas in a liquid is proportional to its partial pressure above the liquid?

ANSWER: HENRY'S LAW

BONUS

17) Chemistry – *Short Answer* In x-ray crystallography, what notation system is often used to define planes in crystal lattices?

ANSWER: MILLER INDICES

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TOSS-UP

18) Energy – *Multiple Choice* Researchers at Argonne National Lab are studying the selective growth of aluminum oxide on platinum crystals. Which of the following minerals consists of aluminum oxide?

W) Corundum
X) Schist
Y) Fluorite
Z) Orthoclase

ANSWER: W) CORUNDUM

BONUS

18) Energy – *Multiple Choice* Researchers at Argonne National Lab are using atomic-layer deposition to grow aluminum oxides, which involves depositing a small amount of vapor onto platinum. Which of the following materials can NOT be created by atomic-layer deposition?

W) Thin films
X) Transistors
Y) Nanomaterials
Z) Light emitting diodes

ANSWER: Z) LIGHT EMITTING DIODES
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TOSS-UP

19) Physics – *Multiple Choice* Which of the following has the same units as surface tension?

W) Kilogram-meters per second squared
X) Meters per second
Y) Kilograms per second squared
Z) Meters cubed per second

ANSWER: Y) KILOGRAMS PER SECOND SQUARED

BONUS

19) Physics – *Short Answer* What field of physics studies the magnetic properties of electrically conducting fluids such as plasmas?

ANSWER: MAGNETOHYDRODYNAMICS (ACCEPT: MHD)

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TOSS-UP

20) Biology – *Short Answer* In plants, statoliths help cells sense what phenomenon to determine direction of growth?

ANSWER: GRAVITY (ACCEPT: GRAVITROPISM)

BONUS

20) Biology – *Multiple Choice* Which of the following is a major cause of menopause?

W) Loss of ovary function due to disease
X) Loss of ovary responsiveness to LH and FSH
Y) Breakdown of the endometrium
Z) Loss of function of fallopian tubes

ANSWER: X) LOSS OF OVARY RESPONSIVENESS TO LH AND FSH
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TOSS-UP

21) Earth and Space – *Multiple Choice* Which of the following factors does NOT affect wave formation in the open ocean?

W) Wind duration
X) Wind speed
Y) Fetch
Z) Ocean depth

ANSWER: Z) OCEAN DEPTH

BONUS

21) Earth and Space – *Short Answer* Order the following 4 elements by increasing concentration in the Earth's crust: 1) Oxygen; 2) Aluminum; 3) Silicon; 4) Iron.

ANSWER: 4, 2, 3, 1

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TOSS-UP

22) Math – *Short Answer* A particle has position given by $r(t) = \langle -2t, 8t \rangle$. At $t = 3$, what is the speed of the particle?

ANSWER: $2\sqrt{17}$

BONUS

22) Math – *Short Answer* What is the smallest positive integer n such that $6n - 11$ is divisible by 17?

ANSWER: 16
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TOSS-UP

23) Chemistry – *Multiple Choice* Which of the following physical properties differs for a pair of enantiomers?

W) Solubility in water
X) Boiling point
Y) Direction of rotation of plane-polarized light
Z) Index of refraction

ANSWER: Y) DIRECTION OF ROTATION OF PLANE-POLARIZED LIGHT

BONUS

23) Chemistry – *Multiple Choice* Which of the following is a tertiary alcohol?

W) 2-methyl-2-butanol
X) Ethanol
Y) 2-propanol
Z) 3-pentanol

ANSWER: W) 2-methyl-2-butanol