NNHS ROUND 7

TOSS-UP

1) Physics – *Short Answer* What general term, which encompasses damping, refers to the gradual loss of amplitude of a wave as it propagates through a medium?

ANSWER: ATTENUATION (ACCEPT: EXTINCTION)

BONUS

1) Physics – *Multiple Choice* Which of the following must be constant in coherent light?

W) Frequency
X) Phase difference
Y) Spatial orientation
Z) Photon energy

ANSWER: X) PHASE DIFFERENCE

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TOSS-UP

2) Biology – *Short Answer* Identify all of the following four cells that are considered antigen-presenting cells: 1) Dendritic cell; 2) B cell; 3) Cytotoxic T cell; 4) Macrophage.

ANSWER: 1, 2, AND 4

BONUS

2) Biology – *Short Answer* What immune cells secrete histamine and circulate through the bloodstream?

ANSWER: BASOPHILS
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TOSS-UP

3) Earth and Space – *Short Answer* What is the term for seamounts that are weathered down until they become submerged and flat-topped?

ANSWER: GUYOTS

BONUS

3) Earth and Space – *Short Answer* During the summer, the sun moves through what constellation?

ANSWER: ORION

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TOSS-UP

4) Math – *Multiple Choice* Which of the following equations represents a cardioid?

W) $r = 2$
X) $r = 3 + 2\cos(\theta)$
Y) $r = 4 - 4\sin(\theta)$
Z) $r = 1 + 5\sin(\theta)$

ANSWER: Y) $r = 4 - 4\sin(\theta)$

BONUS

4) Math – *Short Answer* A marble factory adds a red mark to every other marble, a blue mark to every third marble, and a green mark to every fifth marble. After the factory produces 600 marbles, how many marbles will have both a red and a blue mark, but no green mark?

ANSWER: 80
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TOSS-UP

5) Chemistry – *Multiple Choice* In aqueous solution, chloride will form a precipitate with which of the following cations?

W) Cu^{2+}
X) Zn^{2+}
Y) Ni^{3+}
Z) Pb^{2+}

ANSWER: Z) Pb^{2+}

BONUS

5) Chemistry – *Short Answer* What is the name of a cyclic ether with a three membered ring that is highly reactive due to its high ring strain?

ANSWER: EPOXIDE

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TOSS-UP

6) Energy – *Short Answer* Researchers at Argonne National Lab are studying ways to increase the scalability of efficient battery technology. One way they are doing this is by replacing the catalyst in polymer electrolyte membrane fuel cells. What metal typically serves as the catalyst?

ANSWER: PLATINUM

BONUS

6) Energy – *Short Answer* Researchers at Argonne National Lab have developed the Oleo sponge, which has shown promise for cleaning oil spills from bodies of water. In particular, the Oleo sponge can capture what extremely thin layer of oil that coats the water's surface and is traditionally tough to remove?

ANSWER: OIL SHEEN
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TOSS-UP

7) Physics – *Multiple Choice* At high temperatures, how many vibrational degrees of freedom does ozone have?

W) 2
X) 3
Y) 6
Z) 9

ANSWER: X) 3

BONUS

7) Physics – *Short Answer* Identify all of the following four pairs that represent thermodynamic conjugate pairs: 1) Pressure and volume; 2) Enthalpy and Helmholtz free energy; 3) Gibbs free energy and mole number; 4) Chemical potential and particle number.

ANSWER: 1 AND 4

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TOSS-UP

8) Biology – *Short Answer* What enzyme, commonly found in retroviruses, transcribes an RNA template into a DNA strand?

ANSWER: REVERSE TRANSCRIPTASE

BONUS

8) Biology – *Short Answer* Order the following four parts of the circulatory system by the order that oxygenated blood from the lungs will travel: 1) Left atrium; 2) Pulmonary artery; 3) Pulmonary vein; 4) Right ventricle.

ANSWER: 3, 1, 4, 2
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TOSS-UP

9) Earth and Space – *Multiple Choice* According to the no-hair theorem, black holes are characterized by all of the following properties EXCEPT:

W) Mass
X) Angular momentum
Y) Temperature
Z) Electric charge

ANSWER: Y) TEMPERATURE

BONUS

9) Earth and Space – *Short Answer* Rank the following three salts from lowest to highest concentration in ocean water: 1) Sodium chloride; 2) Sodium sulfate; 3) Magnesium chloride.

ANSWER: 2, 3, 1

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TOSS-UP

10) Math – *Multiple Choice* What is the largest number of $3.50 sandwiches that one can buy with $20?

W) 4
X) 5
Y) 6
Z) 7

ANSWER: X) 5

BONUS

10) Math – *Short Answer* A jar contains 4 red marbles and 6 blue marbles. Marbles are randomly removed from the jar, one at a time, until no marbles remain in the jar. What is the probability that the last marble removed is red?

ANSWER: 2/5
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TOSS-UP

11) Chemistry – *Short Answer* What scientist used a cathode ray tube to discover electrons?

ANSWER: J.J. THOMSON (ACCEPT: THOMSON)

BONUS

11) Chemistry – *Short Answer* Osmium is often considered to be one of the densest elements. What is the coordination number of a pure osmium crystal?

ANSWER: 12

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TOSS-UP

12) Energy – *Short Answer* Researchers at Ames National Lab are using low energy electron diffraction to examine the structure of graphene. They found that because the electron position normal to the layer is precisely known, their wave vector must have a spread, which is transferred to the diffracted electrons. What principle is responsible for this effect?

ANSWER: UNCERTAINTY PRINCIPLE (ACCEPT: HEISENBERG UNCERTAINTY PRINCIPLE)

BONUS

12) Energy – *Short Answer* Researchers at Ames National Lab are studying the properties of materials under high pressures. These researchers are part of what field of physics that studies matter where the number of constituents is large and the interaction between them is strong?

ANSWER: CONDENSED MATTER PHYSICS
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TOSS-UP

13) Physics – *Multiple Choice* A positive pion and a proton interact, forming a neutrino and two other particles. Which of the following could be the other two products of this decay?

W) Proton and proton
X) Positron and neutron
Y) Photon and proton
Z) Photon and positron

ANSWER: W) PROTON AND PROTON

BONUS

13) Physics – *Short Answer* Oil with a density of 0.8 grams per cubic centimeter falls at a rate of 2 liters per second from a height of 10 meters onto a cart, which is moving at a constant speed of 5 meters per second in the absence of friction. What force must be applied to the cart to maintain its speed?

ANSWER: 8 NEWTONS

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TOSS-UP

14) Biology – *Short Answer* A mother with blood type A has a child with blood type O. How many possibilities are there for the father's genotype?

ANSWER: 3

BONUS

14) Biology – *Short Answer* What glycoproteins connect integrins to the extracellular matrix?

ANSWER: FIBRONECTINS
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TOSS-UP

15) Earth and Space – *Multiple Choice* Which of the following is NOT considered a mineral due to a lack of a definitive chemical formula and crystal structure?

W) Limonite
X) Hematite
Y) Magnetite
Z) Apatite

ANSWER: W) LIMONITE

BONUS

15) Earth and Space – *Short Answer* Identify all of the following four planets that can NOT be in opposition with the Sun: 1) Mercury; 2) Venus; 3) Mars; 4) Jupiter.

ANSWER: 1 AND 2

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TOSS-UP

16) Math – *Short Answer* A data set has a mean of 30 and a standard deviation of 5. What is the z-score of the data point 37?

ANSWER: 1.4

BONUS

16) Math – *Short Answer* Dan is completing a 300 mile road trip and drives at an average speed of 50 miles per hour for the first 150 miles of the trip. What must his average speed be during the remaining 150 miles of the road trip to average a speed of 60 miles per hour over the course of the entire trip?

ANSWER: 75 MILES PER HOUR
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TOSS-UP

17) Chemistry – *Short Answer* What law states that the rate of effusion is inversely proportional to the square root of the molar mass of a gas?

ANSWER: GRAHAM'S LAW

BONUS

17) Chemistry – *Short Answer* Identify all of the following three statements about acids that are true: 1) Increasing the concentration of a weak acid increases percent dissociation; 2) Phosphoric acid is a triprotic acid; 3) The pH of pure water is independent of temperature.

ANSWER: 2 ONLY

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TOSS-UP

18) Energy – *Multiple Choice* Scientists at Brookhaven National Lab are using the Sloan Digital Sky Survey to examine the expansion of the universe during the middle 11 billion years of its history. The scientists measured a discrepancy in which of the following constants compared to previous surveys?

W) Universal gravitational constant
X) Fine structure constant
Y) Cosmological constant
Z) Hubble's constant

ANSWER: Z) HUBBLE'S CONSTANT

BONUS

18) Energy – *Short Answer* Scientists at Brookhaven National Lab are studying the use of electron shuttle proteins in the construction of plant cell walls. They found that the shuttle proteins delivered electrons to help synthesize the H, G, and S subtypes of what rigid protein?

ANSWER: LIGNIN
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TOSS-UP

19) Physics – *Short Answer* In general relativity, what statement describes the indistinguishability of a gravitational force and a fictitious force caused by a non-inertial reference frame?

ANSWER: EQUIVALENCE PRINCIPLE

BONUS

19) Physics – *Short Answer* Light that consists of two plane waves with equal magnitudes and a phase difference of 90° exhibits what type of polarization?

ANSWER: CIRCULAR (DO NOT ACCEPT: ELLIPTICAL)

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TOSS-UP

20) Biology – *Multiple Choice* In which of the following environments would semelparity be most favored?

W) A relatively constant environment
X) An environment in which offspring survival rate is low
Y) An environment in which adult survival rate is high
Z) An environment with slight consistent annual variations in temperature

ANSWER: X) AN ENVIRONMENT IN WHICH OFFSPRING SURVIVAL RATE IS LOW

BONUS

20) Biology – *Short Answer* What effect states that low population sizes can harm an individual's ability to reproduce or survive?

ANSWER: ALLEE EFFECT
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TOSS-UP

21) Earth and Space – *Multiple Choice* What drainage pattern occurs when the source is a volcanic caldera?

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

ANSWER: Z) RADIAL

BONUS

21) Earth and Space – *Short Answer* The characteristic light curve of type 1a supernovae is generated by the decay of what element?

ANSWER: NICKEL

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TOSS-UP

22) Math – *Short Answer* Triangle ABC has circumcenter O, and angle A equals 40 degrees. What is the degree measure of angle BOC?

ANSWER: 80

BONUS

22) Math – *Short Answer* A sequence is defined by $a_1 = 1$, $a_2 = 2$, and for all n greater than 2, $a_n = 2a_{n-1} + 3a_{n-2}$. What is the value of a_5?

ANSWER: 61
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TOSS-UP

23) Chemistry – *Multiple Choice* What is the maximum number of electrons that can be accommodated in a subshell where $l = 3$?

W) 2
X) 6
Y) 10
Z) 14

ANSWER: Z) 14

BONUS

23) Chemistry – *Short Answer* Rank the following three compounds by increasing oxidation state of oxygen: 1) Sodium bicarbonate; 2) Oxygen difluoride; 3) Hydrogen peroxide.

ANSWER: 1, 3, 2