NNHS ROUND 8

TOSS-UP

1) Physics – *Short Answer* James Maxwell added a term accounting for a changing electric field, the displacement current, thereby modifying which law of electromagnetism?

ANSWER: AMPERE'S LAW

BONUS

1) Physics – *Short Answer* A ball is dropped from a height of 36 meters, and the coefficient of restitution of collisions between the ball and the ground is 0.5. Ignoring air resistance, what is the distance traveled by the ball after a long time?

ANSWER: 60 METERS

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TOSS-UP

2) Biology – *Short Answer* In angiosperms, what term describes the specialized cotyledon of certain grasses like maize?

ANSWER: SCUTELLUM

BONUS

2) Biology – *Multiple Choice* In plant development, the zygote first divides into the basal and terminal cell. Which of the following structures arises from the basal cell?

W) Cotyledons
X) Endosperm
Y) Proembryo
Z) Suspensor

ANSWER: Z) SUSPENSOR
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TOSS-UP

3) Earth and Space – *Short Answer* Identify all of the following four moons of Jupiter that have significant amounts of tectonic activity: 1) Io; 2) Ganymede; 3) Callisto; 4) Europa.

ANSWER: 1 AND 4

BONUS

3) Earth and Space – *Multiple Choice* An oxbow lake most likely to form from which of the following types of streams?

W) Braided
X) Bow
Y) Meandering
Z) Choked

ANSWER: Y) MEANDERING

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TOSS-UP

4) Math – *Short Answer* Kite ABCD has side lengths AB = BC = 8, CD = DA = 15 and angle DAB = 90. What is the radius of the circumcircle of ABCD?

ANSWER: 17/2

BONUS

4) Math – *Multiple Choice* Alice drove from Chicago to New York, a distance of 750 miles, at an average speed of 50 miles per hour. Bob drove from New York to Chicago at an average speed of 40 miles per hour. Given that Bob started driving right after Alice arrived at New York, and Alice left Chicago at 4:00 pm, then at which of the following times will Bob arrive at Chicago?

W) 1:45
X) 9:45
Y) 2:45
Z) 8:45

ANSWER: W) 1:45
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TOSS-UP

5) Chemistry – *Short Answer* What process creates soaps by reacting triglycerides with lye?

ANSWER: SAPONIFICATION

BONUS

5) Chemistry – *Multiple Choice* Grubbs catalysts, which are widely used in olefin metathesis, contain what metal at their center?

W) Silver
X) Palladium
Y) Platinum
Z) Ruthenium

ANSWER: Z) RUTHENIUM

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TOSS-UP

6) Energy – *Short Answer* Researchers at Oak Ridge National Laboratory using neutron analysis to examine glaucoma drugs. Glaucoma is caused by an increase in eye pressure as a result of the buildup of what liquid found anterior to the lens?

ANSWER: AQUEOUS HUMOR

BONUS

6) Energy – *Short Answer* Researchers at Oak Ridge National Laboratory using neutron analysis to examine glaucoma drugs. These drugs act to decrease the production of aqueous humor by reducing the production of bicarbonate through the inhibition of what enzyme?

ANSWER: CARBONIC ANHYDRASE
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TOSS-UP

7) Physics – *Multiple Choice* Which of the following circuit elements consists of exactly one PN junction?

W) Transistor
X) Rectifier
Y) Diode
Z) Resistor

ANSWER: Y) DIODE

BONUS

7) Physics – *Short Answer* What effect occurs when a liquid is placed on an extremely hot surface, creating an insulating vapor layer?

ANSWER: LEIDENFROST EFFECT

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TOSS-UP

8) Biology – *Multiple Choice* Which of the following best explains why birds are able to withstand the lack of oxygen at higher elevation than mammals?

W) The lungs of birds are larger and can carry more oxygen
X) Birds store oxygen in their muscles to decrease oxygen intake at higher altitudes
Y) Air flows unidirectionally in a bird's lungs
Z) Birds can hold their breath longer than most mammals

ANSWER: Y) AIR FLOWS UNIDIRECTIONALLY IN A BIRD'S LUNGS

BONUS

8) Biology – *Short Answer* In Crassulacean ***[crass-a-loosy-an]*** acid metabolism, plants take in CO_2 at night and use it to form what 4-carbon acid, which is then released during the day?

ANSWER: MALIC ACID
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TOSS-UP

9) Earth and Space – *Multiple Choice* Which of the following is the most energy efficient method to travel from one circular orbit to another?

W) Oberth transfer
X) Bi-elliptic transfer
Y) Bi-orbital transfer
Z) Hohmann transfer

ANSWER: Z) HOHMANN TRANSFER

BONUS

9) Earth and Space – *Short Answer* Identify all of the following four sedimentary rocks that are considered biochemical limestones: 1) Crystalline limestone; 2) Chalk; 3) Coquina; 4) Travertine.

ANSWER: 2 AND 3

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TOSS-UP

10) Math – *Short Answer* How many ordered pairs of positive integers (a, b) are there such that $ab = 60$?

ANSWER: 12

BONUS

10) Math – *Short Answer* A square is inscribed in a regular octagon with side length 2. What is the maximum possible area of the square?

ANSWER: $8 + 4\sqrt{2}$
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TOSS-UP

11) Chemistry – *Short Answer* Indicating charge, what is the oxidation state of chromium in the chromate ion?

ANSWER: +6 (DO NOT ACCEPT: 6)

BONUS

11) Chemistry – *Short Answer* How many signals are expected in the ^{1}H-NMR spectrum of benzene?

ANSWER: 1

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TOSS-UP

12) Energy – *Multiple Choice* Researchers at Fermilab are studying the origins of dark matter in the universe. Dark matter consists of what percentage of the known mass-energy of the universe?

W) 5%
X) 27%
Y) 68%
Z) 84%

ANSWER: X) 27%

BONUS

12) Energy – *Short Answer* Researchers at Fermilab are collaborating with CERN to study modes of Higgs boson decay. They detected that the Higgs Boson could rarely decay into two muons. In the standard model, the muon is classified as what generation of matter?

ANSWER: SECOND
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TOSS-UP

13) Physics – *Multiple Choice* A satellite in an elliptical orbit around the Earth loses 1 joule of kinetic energy. Which of the following must also occur?

W) The satellite loses 1 joule of potential energy
X) The satellite gains 1 joule of potential energy
Y) The satellite's total energy decreases by 1 joule
Z) The satellite's total energy increases by 1 joule

ANSWER: Z) THE SATELLITE'S TOTAL ENERGY INCREASES BY 1 JOULE

BONUS

13) Physics – *Short Answer* The Right-Leduc effect creates a thermal gradient against an applied magnetic field. This is the thermal analog of what electrical effect?

ANSWER: HALL EFFECT

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TOSS-UP

14) Biology – *Multiple Choice* Which of the following would most likely occur if you moved the operator of the lac operon in between the lacZ gene and the lacY gene?

W) The LacZ gene will be continuously transcribed
X) The LacY gene will be continuously transcribed
Y) There will be a significant decrease in transcription of both the lacZ and lacY genes
Z) There will not be a notable change in the expression of the lac operon

ANSWER: W) THE LACZ GENE WILL BE CONTINUOUSLY TRANSCRIBED

BONUS

14) Biology – *Short Answer* Identify all of the following three clades that have a tracheal system: 1) Insecta; 2) Chelicerata; 3) Annelida.

ANSWER: 1 ONLY
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TOSS-UP

15) Earth and Space – *Short Answer* What triangular shaped oceanic plate lies between the Pacific Plate and Caribbean Plate?

ANSWER: COCOS PLATE

BONUS

15) Earth and Space – *Short Answer* Kramers' opacity law states that opacity is proportional to what power of temperature?

ANSWER: -7/2

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TOSS-UP

16) Math – *Multiple Choice* Which of the following lines is parallel to $4x - y = 10$?

W) $y = -4x + 2$
X) $y = -0.25x + 5$
Y) $y = 0.25x - 6$
Z) $y = 4x + 3$

ANSWER: Z) $y = 4x + 3$

BONUS

16) Math – *Short Answer* A bug starts at one vertex of a cube. Each minute, the bug picks one of the vertices of the cube at random, besides the one it is currently standing on and the vertex that is opposite the bug, and walks there in one minute. After two minutes, what is the probability that the bug will be back where it started?

ANSWER: 1/6
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TOSS-UP

17) Chemistry – *Multiple Choice* Which of the following pairs of compounds is NOT miscible?

W) Ethanol and hexane
X) Water and ethanol
Y) Tetrahydrofuran and water
Z) Hexane and water

ANSWER: Z) HEXANE AND WATER

BONUS

17) Chemistry – *Short Answer* Certain acids cannot be effectively used in water because they immediately react with water to form hydronium ions. What is the name of this phenomenon?

ANSWER: LEVELING EFFECT

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TOSS-UP

18) Energy – *Short Answer* Researchers at the neutron division of Oak Ridge National Lab have discovered a new method to modify benzene for drug use. Specifically, they are introducing what isotope, found in heavy water, to possibly increase the safety of benzene inside the body?

ANSWER: DEUTERIUM (ACCEPT: HYDROGEN-2; HEAVY HYDROGEN; DO NOT ACCEPT: HYDROGEN)

BONUS

18) Energy – *Multiple Choice* Researchers at Pacific Northwest National Lab are using the otoliths of fish to determine both their age and their birthplace. In the human body, otoliths can be found in which of the following structures?

W) Cochlea
X) Utricle
Y) Semicircular canals
Z) Eustachian tube

ANSWER: X) UTRICLE
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TOSS-UP

19) Physics – *Multiple Choice* A cannonball is launched off of a 200-meter high cliff at a speed of 5 meters per second. Which of the following angles above the horizontal should the cannonball be launched to maximize its range, assuming air resistance is negligible?

W) 0°
X) 20°
Y) 45°
Z) 65°

ANSWER: X) 20°

BONUS

19) Physics – *Short Answer* Identify all of the following four quantities that changes as light travels from glass, with an index of refraction of n = 1.5, to air, with an index of refraction of n = 1.0: 1) Speed of light; 2) Wavelength; 3) Frequency; 4) Phase.

ANSWER: 1 AND 2

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TOSS-UP

20) Biology – *Short Answer* Order the following three steps of the polymerase chain reaction: 1) Annealing; 2) Extension; 3) Denaturation.

ANSWER: 3, 1, 2

BONUS

20) Biology – *Short Answer* What type of skin gland secretes thick sweat in densely hairy areas?

ANSWER: APOCRINE
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TOSS-UP

21) Earth and Space – *Short Answer* Identify all of the following three statements that accurately describe the cosmic microwave background: 1) Uniform; 2) Anisotropic; 3) Studied by WMAP.

ANSWER: 2 AND 3

BONUS

21) Earth and Space – *Multiple Choice* In what direction does longshore transport occur along the western and eastern American coasts, respectively?

W) North, north
X) North, south
Y) South, north
Z) South, south

ANSWER: Z) SOUTH, SOUTH

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TOSS-UP

22) Math – *Short Answer* How many positive integers less than 100 are both perfect squares and perfect cubes?

ANSWER: 2

BONUS

22) Math – *Short Answer* Alex wants to walk from (0,0) to the point (3, 3) by only moving 1 unit in the +x direction or 1 unit in the +y direction. However, Harry planted a land mine at (1,1), which Alex cannot step on. How many paths can Alex take that avoid Harry's land mine?

ANSWER: 8
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TOSS-UP

23) Chemistry – *Short Answer* What are the two primary constituents of syngas?

ANSWER: CARBON MONOXIDE AND HYDROGEN

BONUS

23) Chemistry – *Multiple Choice* Which of the following statements is FALSE?

W) Increasing temperature will always decrease the forward rate of an exothermic reaction
X) Catalysts can appear in the rate law of a reaction
Y) In a zeroth-order reaction, doubling the initial concentration will double the half life of the reaction
Z) The Eyring equation can be used to calculate the rate of a reaction across different temperatures

ANSWER: W) INCREASING TEMPERATURE WILL ALWAYS DECREASE THE FORWARD RATE OF AN EXOTHERMIC REACTION