NNHS ROUND 14

TOSS-UP

1) Physics – *Short Answer* What theory of physics proposes that every fermion and boson will have a corresponding partner from the other group whose spin differs by exactly 1/2?

ANSWER: SUPERSYMMETRY (ACCEPT: SUSY)

BONUS

1) Physics – *Multiple Choice* An observer travels at 0.8 times the speed of light away from a source emitting light with a wavelength of 240 nanometers. What wavelength light will the observer detect?

W) 48 nanometers
X) 80 nanometers
Y) 540 nanometers
Z) 720 nanometers

ANSWER: Z) 720 NANOMETERS

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TOSS-UP

2) Biology – *Short Answer* What eye condition, often found in older people, is characterized by the loss of elasticity of the lens?

ANSWER: PRESBYOPIA

BONUS

2) Biology – *Short Answer* Order the following four steps of long term potentiation in chronological order: 1) Mg^{2+} is displaced from NMDA receptors; 2) The presynaptic neuron releases glutamate; 3) The postsynaptic membrane is depolarized; 4) Stored AMPA receptors are inserted into the postsynaptic membrane.

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

3) Earth and Space – *Multiple Choice* When the first miners arrived at a particular volcano tuff cone on the island of Oahu, they mistakenly thought it contained diamond, leading to the name Diamond Head. What mineral did Diamond Head actually contain?

W) Talc
X) Gypsum
Y) Calcite
Z) Zircon

ANSWER: Y) CALCITE

BONUS

3) Earth and Space – *Short Answer* Super Kamiokande detects what particle to monitor for the presence of supernovae?

ANSWER: NEUTRINO

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TOSS-UP

4) Math – *Short Answer* In 2 dimensions, what is the kissing number?

ANSWER: 6

BONUS

4) Math – *Multiple Choice* A cube is formed by connecting the centers of adjacent faces of a regular octahedron of side length 12. What is the ratio of the volume of the cube to the volume of the octahedron?

W) 2/9
X) $\sqrt{2}/6$
Y) $\sqrt{6}/8$
Z) 1/3

ANSWER: W) 2/9
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TOSS-UP

5) Chemistry – *Multiple Choice* Which of the following is FALSE regarding Grignard reagents?

W) Undergoes electrophilic attack of ketones
X) Contains an ionic carbon-magnesium bond
Y) Used in the preparation of alcohols
Z) Rapidly reacts with water to produce alkanes

ANSWER: W) UNDERGOES ELECTROPHILIC ATTACK OF KETONES

BONUS

5) Chemistry – *Short Answer* What reaction, similar to the Clasien condensation, produces 5 or 6 membered cyclic β-keto esters?

ANSWER: DIECKMANN CONDENSATION

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TOSS-UP

6) Energy – *Short Answer* Researchers at Lawrence Berkeley National Laboratory have discovered a connection between the gut microbiome and memory in mice. In particular, scientists believe that a certain three-carbon product of fermentation is involved in this connection. What is this molecule?

ANSWER: LACTATE (ACCEPT: LACTIC ACID)

BONUS

6) Energy – *Short Answer* Researchers at Lawrence Berkeley National Laboratory are studying the protein XPG, which is involved in nucleotide excision repair. Individuals with a mutation in this protein typically exhibit what condition, characterized by extreme sensitivity to the sun and increased risk of skin cancer?

ANSWER: XERODERMA PIGMENTOSUM
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TOSS-UP

7) Physics – *Short Answer* What method, used in old quantum theory, found the allowed states of a particle by forcing the angular momentum to be a multiple of reduced Planck's constant?

ANSWER: BOHR–SOMMERFELD QUANTIZATION

BONUS

7) Physics – *Short Answer* In string theory, what object generalizes the notion of a point particle to higher dimensions?

ANSWER: BRANE

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TOSS-UP

8) Biology – *Multiple Choice* Both the swallowing center and the vomiting center can be found in which of the following parts of the brain?

W) Hypothalamus
X) Thalamus
Y) Pons
Z) Medulla oblongata

ANSWER: Z) MEDULLA OBLONGATA

BONUS

8) Biology – *Short Answer* Identify all of the following four cell types that a lymphoid stem cell could differentiate into: 1) T cell; 2) Natural killer cell; 3) Basophil; 4) Erythrocyte.

ANSWER: 1 AND 2
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TOSS-UP

9) Earth and Space – *Short Answer* The Eddington valve mechanism, which causes the pulsations of Mira variable stars, primarily results from the ionization of what element?

ANSWER: HYDROGEN

BONUS

9) Earth and Space – *Short Answer* What two atmospheric processes are responsible for precipitation on Earth?

ANSWER: BERGERON PROCESS AND COLLISION–COALESCENCE PROCESS

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TOSS-UP

10) Math – *Multiple Choice* Which of the following is equal to the partial derivative with respect to x of the function f of x comma y equals sine of the quantity xy plus cosine of the quantity xy at the point (1, 2)?

W) sin(2) + cos(2)
X) 2sin(2) + 2cos(2)
Y) -sin(2) + cos(2)
Z) -2sin(2) + 2cos(2)

ANSWER: Z) -2sin(2) + 2cos(2)

BONUS

10) Math – *Short Answer* What theorem states that over any commutative ring, every square matrix satisfies its own characteristic equation?

ANSWER: CAYLEY–HAMILTON THEOREM
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TOSS-UP

11) Chemistry – *Short Answer* What diagram is used to show the relative stability of different oxidation states of an element?

ANSWER: FROST DIAGRAM

BONUS

11) Chemistry – *Multiple Choice* Which of the following best explains how aqua regia dissolves platinum?

W) Hydrochloric acid oxidizes platinum, which is stabilized by nitrate ions
X) Nitric acid oxidizes platinum, which then forms a complex ion with chloride ions
Y) Platinum forms a complex ion with nitrate ions, which is then stabilized by chloride ions
Z) Platinum forms a complex ion with chloride ions, which is then stabilized by nitrate ions

ANSWER: X) NITRIC ACID OXIDIZES PLATINUM, WHICH THEN FORMS A COMPLEX ION WITH CHLORIDE IONS

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TOSS-UP

12) Energy – *Short Answer* Researchers at the National Energy Technology Laboratory are optimizing coal sources with consumer needs and identifying key coal properties for end products. By removing the extraneous matter, they are using what general process on the raw coal, improving its quality?

ANSWER: BENEFICIATION

BONUS

12) Energy – *Short Answer* Researchers at the National Energy Technology Laboratory are studying solid oxide fuel cells, or SOFCs. Identify all of the following three statements that are true regarding SOFCs: 1) The electrolyte is typically a ceramic; 2) Air is typically delivered to the anode; 3) Fuel reacts catalytically with the hydrogen, releasing electrons.

ANSWER: 1 ONLY
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TOSS-UP

13) Physics – *Short Answer* What motion is caused by the change in the second Euler angle of a rotating body?

ANSWER: NUTATION (DO NOT ACCEPT: PRECESSION)

BONUS

13) Physics – *Short Answer* What term is given to birefringent crystals that induce quarter-cycle phase differences on incident polarized light?

ANSWER: QUARTER WAVE PLATE

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TOSS-UP

14) Biology – *Short Answer* Patients with cystic fibrosis have defects in ion channels known as cystic fibrosis transmembrane conductance regulator proteins. What ion do the functional form of these proteins transport?

ANSWER: CHLORIDE (ACCEPT: Cl^-)

BONUS

14) Biology – *Multiple Choice* Which of the following hormones inhibits the secretion of hydrochloric acid from parietal cells in the stomach?

W) Gastrin
X) Acetylcholine
Y) Somatostatin
Z) Histamine

ANSWER: Y) SOMATOSTATIN
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TOSS-UP

15) Earth and Space – *Multiple Choice* Alan Guth proposed what commonly accepted idea to modify prior theories to the expansion of the universe?

W) The universe would eventually stop expanding
X) The universe would expand at an accelerating rate
Y) The universe's expansion is due to dark energy
Z) Early periods in the universe's expansion included an inflationary period.

ANSWER: Z) EARLY PERIODS IN THE UNIVERSE'S EXPANSION INCLUDED AN INFLATIONARY PERIOD

BONUS

15) Earth and Space – *Short Answer* Order the following four planets in terms of decreasing obliquity: 1) Mercury; 2) Earth; 3) Jupiter; 4) Uranus.

ANSWER: 4, 2, 3, 1

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TOSS-UP

16) Math – *Short Answer* What is the greatest common divisor of 1136 and 4512?

ANSWER: 16

BONUS

16) Math – *Short Answer* A point inside an equilateral triangle has distances of 3, 5, and 7 from the three sides of the triangle. What is the area of the equilateral triangle?

ANSWER: $75\sqrt{3}$
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TOSS-UP

17) Chemistry – *Short Answer* What compound is used as a standard in ^{1}H NMR spectroscopy for calibrating chemical shifts in organic solvents?

ANSWER: TETRAMETHYLSILANE (ACCEPT: TMS; $Si(CH_3)_4$)

BONUS

17) Chemistry – *Short Answer* Identify all of the following three statements that are true of crystalline solids: 1) Ionic solids that have similar cation and anion radii will have a coordination number of 8; 2) Magnesium oxide adopts a face-centered cubic structure; 3) Zinc sulfide has a coordination number of 6.

ANSWER: 1 AND 2

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TOSS-UP

18) Energy – *Short Answer* Researchers at Brookhaven National Laboratory are studying instabilities in inorganic perovskite cells by using X-ray diffraction. By studying these instabilities, the researchers are hoping to create highly efficient versions of what devices?

ANSWER: SOLAR CELLS (ACCEPT: SOLAR PANELS, PHOTOVOLTAIC CELLS)

BONUS

18) Energy – *Short Answer* Researchers at Brookhaven National Laboratory are studying instabilities in $CsPbI_3$, an inorganic perovskite. To do this, they coupled X-ray diffraction with what other technique, which is used to gain quantitative insight into the structure of materials where the structural coherence extends over only a few nanometers?

ANSWER: PAIR DISTRIBUTION FUNCTION TECHNIQUE (ACCEPT: PDF)
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TOSS-UP

19) Physics – *Short Answer* A pendulum consists of a massless rope attached to a point mass. Identify all of the following three changes that would increase the period of the pendulum: 1) Increasing the starting angle from 10° to 20°; 2) Increasing the length of the rope; 3) Replacing the pendulum with a uniform rigid rod of the same length.

ANSWER: 1 AND 2

BONUS

19) Physics – *Short Answer* What effect, predicted by quantum electrodynamics, produces matter from a strong electric field?

ANSWER: SCHWINGER EFFECT

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TOSS-UP

20) Biology – *Multiple Choice* Which of the following processes is mediated primarily by cryptochromes, NOT phytochromes?

W) Opening of stomata
X) Seed germination
Y) Flowering in short day plants
Z) Flowering in long day plants

ANSWER: W) OPENING OF STOMATA

BONUS

20) Biology – *Short Answer* In plants, ethylene is synthesized from what amino acid?

ANSWER: METHIONINE
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TOSS-UP

21) Earth and Space – *Multiple Choice* Which of the following correctly describes the orbits of Mars's two moons, Phobos and Deimos?

W) Phobos is gradually spiralling inward and Deimos is gradually spiralling outward
X) Phobos is gradually spiralling outward and Deimos is gradually spiralling inward
Y) Both moons are spiralling inwards
Z) Both moons are spiralling outward

ANSWER: W) PHOBOS IS GRADUALLY SPIRALLING INWARD AND DEIMOS IS GRADUALLY SPIRALLING OUTWARD

BONUS

21) Earth and Space – *Short Answer* The inverse Compton scattering of cosmic microwave background radiation is often used to understand density fluctuations in the universe. What is the name of this effect?

ANSWER: SUNYAEV-ZELDOVICH EFFECT (ACCEPT: SZ EFFECT)

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TOSS-UP

22) Math – *Multiple Choice* What is the sample standard deviation of the data set 1, 1, 2, 4?

W) 1
X) $\sqrt{6}/3$
Y) $\sqrt{6}/2$
Z) $\sqrt{2}$

ANSWER: Z) $\sqrt{2}$

BONUS

22) Math – *Short Answer* What is the average value of the function $f(x) = 2x^2 + 3x + 3$ from $x = 0$ to $x = 3$?

ANSWER: 27/2
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TOSS-UP

23) Chemistry – *Short Answer* What statement states that the transition state more closely resembles either the reactants or the products, depending on which one it is closer in energy to?

ANSWER: HAMMOND'S POSTULATE

BONUS

23) Chemistry – *Multiple Choice* Which of the following statements about oxymercuration-demercuration is FALSE?

W) The mercurinium ion undergoes electrophilic attack, leading to Markovnikov addition
X) Sodium borohydride reduces the mercury rearrangement, removing the mercury atom
Y) The mercuric cation acts as a strong electrophile and is attacked by the π bond of the alkene
Z) It produces an OH group at the more substituted carbon

ANSWER: W) THE MERCURINIUM ION UNDERGOES ELECTROPHILIC ATTACK, LEADING TO MARKOVNIKOV ADDITION