HIGH SCHOOL - ROUND 11A

TOSS-UP

1) Physics − *Short Answer* For a closed curve on a pressure-volume diagram, what specific thermodynamic quantity is best represented by the enclosed area inside the curve?

ANSWER: WORK (DO NOT ACCEPT: HEAT OR ENERGY)

BONUS

1) Physics − *Short Answer* Identify all of the following three changes that would increase the capacitance of a parallel plate capacitor in a circuit: 1) Increasing the potential difference in the circuit; 2) Increasing the plate area; 3) Increasing the distance between plates.

ANSWER: 2

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TOSS-UP

2) Energy − *Short Answer* Scientists at Oak Ridge National Lab have developed a method to use nanoscale spikes of carbon atoms to reduce gaseous nitrogen to ammonia. In nitrogen-fixing bacteria, what molybdenum- ***[muh-LIB-den-um]*** and iron-containing enzyme catalyzes this same reaction?

ANSWER: NITROGENASE

BONUS

2) Energy – *Short Answer* Researchers at Fermi National Accelerator Lab were the first to observe the production of the top quark. In the decay pathway that produced the first-observed top quark, the decay was mediated by what fundamental force?

ANSWER: STRONG (ACCEPT: STRONG NUCLEAR FORCE)
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TOSS-UP

3) Biology − *Short Answer* Two groups of the same species of monkey develop different mating rituals and eventually become reproductively incompatible. If this occurs while they occupy the same geographic region, what is the adjective for the type of speciation that has occurred?

ANSWER: SYMPATRIC

BONUS

3) Biology – *Short Answer* What zipper-like protein structure holds homologs together during synapsis?

ANSWER: SYNAPTONEMAL COMPLEX

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TOSS-UP

4) Chemistry – *Multiple Choice* Which of the following elements has the largest first ionization energy?

W) Sodium
X) Aluminum
Y) Argon
Z) Chlorine

ANSWER: Y) ARGON

BONUS

4) Chemistry – *Short Answer* Identify all of the following three numbers of pi ***[pie]*** electrons that, according to Huckel's ***[HAH-kulz]*** rule, can occupy an aromatic system: 1) 4; 2) 8; 3) 10.

ANSWER: 3
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TOSS-UP

5) Math − *Short Answer* What is the 5/3 power of –8?

ANSWER: –32

BONUS

5) Math − *Short Answer* A jar contains 9 coins: 8 fair coins and 1 double-headed coin. If a random coin is selected from the jar, is flipped, and comes up heads, what is the probability that the double-headed coin was the one selected?

ANSWER: 1/5 (ACCEPT: 0.20, 20%)

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TOSS-UP

6) Earth and Space − *Multiple Choice* Where on the H-R diagram can one find red dwarf stars?

W) Top right
X) Bottom right
Y) Bottom left
Z) Top left

ANSWER: X) BOTTOM RIGHT

BONUS

6) Earth and Space − *Short Answer* Identify all of the following three positions on the celestial sphere that have a declination of zero: 1) Summer solstice; 2) Autumnal equinox; 3) Winter solstice.

ANSWER: 2
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TOSS-UP

7) Physics − *Multiple Choice* Which of the following best describes the shape of the graph of potential energy as a function of position for a constant force?

W) Linear
X) Quadratic
Y) Logarithmic
Z) Exponential

ANSWER: W) LINEAR

BONUS

7) Physics − *Short Answer* Identify all of the following three statements that are always true regarding motion in a closed path: 1) If no displacement occurs, zero work was done; 2) Going around a closed path requires negative work; 3) Mechanical energy is conserved.

ANSWER: NONE OF THEM

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TOSS-UP

8) Chemistry − *Short Answer* Cyclohexene undergoes hydrogenation with hydrogen gas. What is the molecular formula of the product of the reaction?

ANSWER: C_6H_{12}

BONUS

8) Chemistry − *Short Answer* Rank the following three electronic transitions in monatomic hydrogen in terms of increasing change in energy: 1) Electron jumps from 1s to 2p; 2) Electron is ionized from the 3s orbital; 3) Electron jumps from 2s to 4p.

ANSWER: 2, 3, 1
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TOSS-UP

9) Energy – *Multiple Choice* Oak Ridge National Lab scientists are studying bacteria that have penicillin resistance. Penicillin and similar drugs inhibit what process in the bacteria?

W) DNA replication
X) Translation
Y) Cell wall biosynthesis
Z) Ribosome assembly

ANSWER: Y) CELL WALL BIOSYNTHESIS

BONUS

9) Energy − *Short Answer* Scientists at Pacific Northwest National Lab are studying the production of lipid metabolites by fungi. These metabolites are produced by the oxidation of simpler lipids by cytochrome ***[SIGH-tow-krohm]*** P450 enzymes in what double-membrane-bound organelle?

ANSWER: SMOOTH ENDOPLASMIC RETICULUM (ACCEPT: ENDOPLASMIC RETICULUM, ER; DO NOT ACCEPT: ROUGH ER)

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TOSS-UP

10) Biology – *Multiple Choice* What mammalian characteristic do Echidnas ***[eh-KID-nahs]*** lack?

W) Hair
X) Milk production
Y) Nipples
Z) Temporal fenestra

ANSWER: Y) NIPPLES

BONUS

10) Biology − *Multiple Choice* Spiracles on the surface of insects function as part of which of the following organ systems?

W) Circulatory
X) Digestive
Y) Reproductive
Z) Respiratory

ANSWER: Z) RESPIRATORY
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TOSS-UP

11) Earth and Space − *Multiple Choice* Increasing the silica content in rock melts results in an increase in the melt viscosity. Which of the following SI derived units would be used to describe melt viscosity?

W) Newtons per meter
X) Pascal seconds
Y) Newton meters
Z) Pascals per second

ANSWER: X) PASCAL SECONDS

BONUS

11) Earth and Space − *Short Answer* Identify all of the following three metamorphic rocks that are considered foliated: 1) Phyllite ***[FILL-lite]***; 2) Quartzite; 3) Schist.

ANSWER: 1, 3

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TOSS-UP

12) Math − *Multiple Choice* Which of the following types of figures must have line symmetry but not necessarily turn symmetry?

W) Isosceles triangle
X) Parallelogram
Y) Rectangle
Z) Rhombus

ANSWER: W) ISOSCELES TRIANGLE

BONUS

12) Math − *Short Answer* Jack is asked by his teacher to subtract 4 from a number and multiply the result by 3. Instead, he subtracts 3 and then multiplies the result by 4, giving him 176. What is the correct answer to the teacher's question?

ANSWER: 129
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TOSS-UP

13) Physics − *Short Answer* If a given artery requires a pressure *P* to sustain a flow rate, then, in terms of *P*, how much pressure is required to maintain the flow rate if the artery shrinks to half of its original radius?

ANSWER: 16*P*

BONUS

13) Physics − *Short Answer* Identify all of the following three changes that would increase the distance between intensity maxima in a single-slit diffraction setup: 1) Increasing the wavelength of light; 2) Increasing the width of the single slit; 3) Increasing the distance to the screen.

ANSWER: 1, 3

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TOSS-UP

14) Math − *Short Answer* If *f* of *x* equals the fifth root of <u>open parenthesis *x* + 10 close parenthesis</u>, what is *f* inverse of 2?

ANSWER: 22

BONUS

14) Math − *Short Answer* For integers *a* and *b*, define the binary operation "star" by <u>*a* "star" *b*</u> is equal to 2 less than <u>the product of *a* and *b*</u>. What is <u>3 "star" open parenthesis 4 "star" 5 close parenthesis</u>?

ANSWER: 52
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TOSS-UP

15) Chemistry – *Multiple Choice* Which of the following best describes the ground state electron configuration of chromium?

W) A fully-filled 4s orbital and five half-filled 3d orbitals
X) A half-filled 4s orbital and five fully-filled 3d orbitals
Y) A half-filled 4s orbital and five half-filled 3d orbitals
Z) An empty 4s orbital and five fully-filled 3d orbitals

ANSWER: Y) A HALF-FILLED 4S ORBITAL AND FIVE HALF-FILLED 3D ORBITALS

BONUS

15) Chemistry – *Short Answer* To the nearest gram per mole, what is the molar mass of bauxite?

ANSWER: 138

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TOSS-UP

16) Earth and Space − *Short Answer* A large number of Kuiper ***[KYE-pur]*** Belt objects possess a 3-to-2 orbital resonance with what planet?

ANSWER: NEPTUNE

BONUS

16) Earth and Space − *Short Answer* Rank the following three planets in order of increasing length of day: 1) Jupiter; 2) Saturn; 3) Uranus.

ANSWER: 1, 2, 3
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TOSS-UP

17) Biology – *Multiple Choice* A population of actively dividing cells contains, on average, 30 femtograms of DNA per cell. After some period of time, you make another measurement and observe that the cells now have 60 femtograms of DNA per cell. Which of the following is the most reasonable conclusion to make about these cells?

W) They are going to perform meiosis ***[my-OH-sis]***
X) They are going to perform mitosis
Y) S phase has occurred
Z) They are in G1 phase

ANSWER: Y) S PHASE HAS OCCURRED

BONUS

17) Biology − *Multiple Choice* You cross a female, red-eyed, short-winged fly with a male, white-eyed, long-winged fly. Out of 100 offspring, 45 have red eyes and short wings, 45 have white eyes and long wings, and the remaining 10 offspring have a non-parental phenotype. Which of the following statements correctly describes the eye color and wing length loci?

W) Both loci are X-linked
X) The loci epistatically interact with one another
Y) Both loci are autosomal but are located on different chromosomes
Z) Both loci are autosomal and are located on the same chromosome

ANSWER: Z) BOTH LOCI ARE AUTOSOMAL AND ARE LOCATED ON THE SAME CHROMOSOME

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TOSS-UP

18) Energy – *Short Answer* Scientists at Brookhaven National Lab are developing software to streamline data acquisition at the NSLS-II, which is a circular light source. The light is generated by accelerating what subatomic particles?

ANSWER: ELECTRONS

BONUS

18) Energy – *Multiple Choice* Pacific Northwest National Lab scientists are studying the virus that causes Middle East respiratory syndrome. This virus is most closely related to the virus that causes what other disease?

W) Influenza
X) Common cold
Y) Sleeping sickness
Z) SARS

ANSWER: Z) SARS
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TOSS-UP

19) Math − *Short Answer* What are the coordinates of the image of the point $(2, 2\sqrt{3})$ when it is rotated 60 degrees counter-clockwise about the origin?

ANSWER: $(-2, 2\sqrt{3})$ (ACCEPT: $x = -2$ AND $y = 2\sqrt{3}$)

BONUS

19) Math − *Short Answer* A particle's position x at time t is defined by the equation x of $t = 2t^3 - 33t^2 + 144t - 48$. At what time or times t is the particle at rest?

ANSWER: 3 AND 8

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TOSS-UP

20) Physics − *Multiple Choice* If one takes the line integral of an electric field over a particular path, the answer can be expressed in which of the following units?

W) Coulombs
X) Volts
Y) Amperes
Z) Newtons

ANSWER: X) VOLTS

BONUS

20) Physics − *Short Answer* A damped harmonic oscillator's position function is x of t equals A times e to the minus t. At what time t does the oscillator reach one-half of its original amplitude?

ANSWER: NATURAL LOG OF 2 (ACCEPT: LN2, LOG BASE e OF 2; DO NOT ACCEPT: LOG OF 2)
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TOSS-UP

21) Earth and Space − *Short Answer* The Canary current flows primarily in which cardinal direction?

ANSWER: SOUTH

BONUS

21) Earth and Space − *Short Answer* Acid rain can result from gases released to the atmosphere by natural or anthropogenic***[an-throw-poh-JEN-ic]*** activity. Identify all of the following three acids that are commonly found in acid rain: 1) Hydrochloric acid; 2) Nitric acid; 3) Sulfuric acid.

ANSWER: 2, 3

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TOSS-UP

22) Chemistry − *Short Answer* Rank the following four single bonds in increasing order of polarity: 1) Carbon-carbon; 2) Carbon-hydrogen; 3) Nitrogen-hydrogen; 4) Fluorine-hydrogen.

ANSWER: 1, 2, 3, 4

BONUS

22) Chemistry − *Short Answer* Identify all of the following three molecules that would be expected to have a delocalized pi ***[pie]*** bond system: 1) Benzene;
2) 1,4-pentadiene ***[one-four-penta-DYE-een]***; 3) 1,3-butadiene ***[one-three-BYU-tah-DYE-een]***.

ANSWER: 1, 3
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TOSS-UP

23) Biology – *Short Answer* The bacterial cell wall is primarily composed of what polymer that consists of sugars cross-linked by short amino acid chains?

ANSWER: PEPTIDOGLYCAN (ACCEPT: MUREIN)

BONUS

23) Biology – *Short Answer* For a protein secreted by a eukaryotic cell, put the following three locations in chronological order from synthesis to secretion: 1) Rough ER; 2) Cytoplasm; 3) Extracellular space.

ANSWER: 2, 1, 3