

HIGH SCHOOL - ROUND 11A

TOSS-UP

1) Physics – *Short Answer* A 50-kilogram mass is sliding at an initial speed of 5.25 meters per second on ice, coming to rest uniformly in 3.5 seconds due to friction. In newtons, what is the magnitude of the force of friction on the mass due to the ice?

ANSWER: 75

BONUS

1) Physics – *Short Answer* Gloria is preparing to image a biological sample, so she places it underneath a 50-millimeter glass slide. Given that the index of refraction of the glass is 1.2 and that she is viewing the sample from directly overhead, then, to the nearest whole millimeter, what is the apparent depth of the sample?

ANSWER: 42

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### TOSS-UP

2) Energy – *Short Answer* Berkeley Lab researchers used broad-spectrum infrared light to determine the reactivity of a heterogeneous [*hetero-JEE-nyus*] catalyst at different points on the surface of the catalyst. What user facility at Lawrence Berkeley National Lab did they use to generate the infrared light?

ANSWER: ALS (ACCEPT: ADVANCED LIGHT SOURCE)

### BONUS

2) Energy – *Short Answer* Scientists at Oak Ridge National Lab have discovered a new method to filter out heavy isotopes of hydrogen using a functionalized form of what class of polymeric [*paw-lih-MARE-ik*] compounds, which consist of artificially-constructed porous carbon-based scaffolds ligating [*LYE-gating*] metal ions?

ANSWER: METAL-ORGANIC FRAMEWORK (ACCEPT: MOF)

### TOSS-UP

3) Biology – *Short Answer* When fermentation occurs in humans, pyruvate [*pie-ROO-vate*] is reduced by NADH to form what molecule?

ANSWER: LACTATE (ACCEPT: LACTIC ACID)

### BONUS

3) Biology – *Short Answer* What flexible amino acid is present on nearly every third residue of collagen, due to its ability to fit on the inside of the triple helix?

ANSWER: GLYCINE

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TOSS-UP

4) Chemistry – *Short Answer* What is the hybridization [*HIGH-brih-dye-ZAY-shun*] of the central atom in bromine [*BROH-meen*] trifluoride?

ANSWER: SP3D (ACCEPT: DSP3)

BONUS

4) Chemistry – *Short Answer* Consider the combustion reaction of solid graphite with gaseous [*gah-shus*] oxygen to generate gaseous carbon monoxide. Identify all of the following three changes that would shift the equilibrium of this reaction to the right: 1) Adding more solid carbon; 2) Increasing the temperature; 3) Compressing the reaction vessel.

ANSWER: NONE

TOSS-UP

5) Math – *Multiple Choice* According to the rational root theorem, which of the following is NOT a possible solution to the equation $8x^3 - 2x^2 + x - 12 = 0$?

- W) 2
- X) 4
- Y) 6
- Z) 8

ANSWER: Z) 8

BONUS

5) Math – *Short Answer* A line contains five points *A, B, C, D,* and *E.* A second line contains four other points *W, X, Y,* and *Z.* What is the maximum possible number of lines that contain at least two of these 9 points?

ANSWER: 22

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**TOSS-UP**

6) Earth and Space – *Short Answer* What isotope accounts for approximately 7 parts per trillion of the Earth's atmosphere, and can be formed from the radioactive decay of tritium [*TRIH-tee-um*]?

ANSWER: HELIUM-3

**BONUS**

6) Earth and Space – *Short Answer* Identify all of the following three minerals that have cubic crystal structure: 1) Calcite; 2) Galena [*gah-LEE-nah*]; 3) Mica.

ANSWER: 2

**TOSS-UP**

7) Physics – *Short Answer* Steve is constructing an array from two antennas. He sets them to transmit in phase at 30 kilohertz, and he wants to place them in such a way that no destructive interference occurs at any location. To the nearest kilometer, what is the maximum separation distance between the antennas?

ANSWER: 5

**BONUS**

7) Physics – *Short Answer* A 7.2-kilogram box is sliding along a frictionless surface at 3 meters per second when it runs into a spring of spring constant 8,000 newtons per meter. In meters, how much will the spring be compressed?

ANSWER: 0.09

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TOSS-UP

8) Chemistry – *Multiple Choice* Which of the following ions has the smallest radius?

- W) Magnesium two plus
- X) Fluorine minus
- Y) Aluminum three plus
- Z) Sodium plus

ANSWER: Y) ALUMINUM THREE PLUS

BONUS

8) Chemistry – *Short Answer* Identify all of the following three orbitals that have two or more radial nodes: 1) 4d-xy; 2) 5p-x; 3) 3s.

ANSWER: 2 AND 3

TOSS-UP

9) Energy – *Multiple Choice* Scientists at Brookhaven National Lab are studying molecular [*moh-LEK-yoo-lur*] wires as a potential polymeric replacement for silicon-based technologies. Which of the following polymers could behave as a molecular wire without any other functional groups?

- W) Polyester
- X) Polyphenylene [*polly-FEH-nil-een*] vinylene
- Y) Polyamide [*polly-AM-ide*]
- Z) Polystyrene [*polly-STYE-reen*]

ANSWER: X) POLYPHENYLENE VINYLENE

BONUS

9) Energy – *Short Answer* To better understand matter-antimatter asymmetry in the universe, scientists at SLAC [*slack*] are studying the CP-violating decays of what particle in the BaBar experiment?

ANSWER: B MESON (ACCEPT: B PARTICLE)

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### TOSS-UP

10) Biology – *Short Answer* What part of a myelinated [*MY-ah-lin-ay-did*] neuron is covered by myelin sheaths?

ANSWER: AXON

### BONUS

10) Biology – *Short Answer* When triggered by inositol triphosphate, ions of what element are released as second messengers?

ANSWER: CALCIUM

**TOSS-UP**

11) Earth and Space – *Short Answer* The core of what planet in our solar system constitutes the largest fraction of the planet’s volume?

ANSWER: MERCURY

**BONUS**

11) Earth and Space – *Short Answer* What type of star is thought to be massive enough to fuse deuterium [*doo-TEER-ee-um*] and lithium, but cannot sustain hydrogen fusion?

ANSWER: BROWN DWARF

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TOSS-UP

12) Math – *Short Answer* An arithmetic sequence has fourth term 9 and ninth term 29. What is the positive difference between consecutive terms for the sequence?

ANSWER: 4

BONUS

12) Math – *Short Answer* Suppose that x is congruent to 3 mod 7. In the integers mod 7, what is x^7 ?

ANSWER: 3

TOSS-UP

13) Physics – *Short Answer* In a heavy-water-moderated reactor, what is the momentum of a neutron, as a fraction of its original momentum, after it collides with the deuterium atom in a stationary heavy-water molecule?

ANSWER: 1/3

BONUS

13) Physics – *Short Answer* A beam of light whose wavelength is 600 nanometers in a vacuum passes into a medium with an index of refraction of 1.333. To the nearest integer multiple of ten nanometers, what is the new wavelength of the light?

ANSWER: 450

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**TOSS-UP**

14) Math – *Short Answer* What is the limit as  $x$  approaches 6 of the function with numerator  $x - 6$  and denominator  $x^2 - 36$ ?

ANSWER: 1/12

**BONUS**

14) Math – *Short Answer* Given that log base 10 of 2 is 0.301 and log base 10 of 3 is 0.477. Giving your answer to three decimal places, what is log base 10 of 45?

ANSWER: 1.653

**TOSS-UP**

15) Chemistry – *Multiple Choice* A student prepares a saturated sodium chloride solution and then adds a few drops of 12-molar hydrochloric acid. Which of the following will occur?

- W) No visible changes will occur
- X) A large amount of gas will be evolved
- Y) A hydrogen chloride precipitate will form
- Z) A sodium chloride precipitate will form

ANSWER: Z) A SODIUM CHLORIDE PRECIPITATE WILL FORM

**BONUS**

15) Chemistry – *Multiple Choice* Which of the following best explains why mercury in a glass tube forms a convex meniscus?

- W) Mercury is repelled by the negatively-charged glass surface
- X) Mercury is more polar than the glass surface
- Y) Mercury is highly viscous
- Z) Mercury's cohesive forces are stronger than its adhesive forces

ANSWER: Z) MERCURY'S COHESIVE FORCES ARE STRONGER THAN ITS ADHESIVE FORCES

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TOSS-UP

16) Earth and Space – *Multiple Choice* Which of the following correctly describes the weather phenomenon rime?

- W) Frozen fog deposit
- X) A tornado that spins clockwise in the Northern Hemisphere
- Y) High altitude lightning
- Z) Out-of-season hurricane

ANSWER: W) FROZEN FOG DEPOSIT

BONUS

16) Earth and Space – *Multiple Choice* In which of the following locations could a paleontologist hope to find sedimentary rocks containing trilobites ?

- W) Iceland
- X) The Canary Islands
- Y) Southern Florida
- Z) Manitoba

ANSWER: Z) MANITOBA

TOSS-UP

17) Biology – *Multiple Choice* The common dandelion, which is fluorescent under UV light, is pollinated by what?

- W) Bees
- X) Wind
- Y) Butterflies
- Z) Moths

ANSWER: W) BEES

BONUS

17) Biology – *Short Answer* Your dog is suffering from chronic kidney disease. Identify all of the following that you would expect to see in his urine: 1) White blood cells; 2) Glia; 3) Protein.

ANSWER: 3



TOSS-UP

18) Energy – *Short Answer* Researchers at Lawrence Berkeley National Lab recently demonstrated that certain pore complexes can recognize and block aberrant strands of mRNA from entering the cytosol [*SIGH-toh-sol*]. In what membrane do these pore complexes reside?

ANSWER: NUCLEAR MEMBRANE (ACCEPT: NUCLEAR LAMIN)

BONUS

18) Energy – *Short Answer* In order to image subsurface features, such as volcanic magma chambers, scientists at Pacific Northwest National Lab are investigating a strategy to use detectors for what high-energy leptons produced in cosmic ray showers?

ANSWER: MUONS

TOSS-UP

19) Math – *Short Answer* What is the complex conjugate of $-7i$?

ANSWER: $7i$ (ACCEPT: $0 + 7i$)

BONUS

19) Math – *Short Answer* If a spherical balloon is inflated at a rate of π cubic centimeters per second, at what rate in centimeters per second is the radius changing when the radius is 3 centimeters?

ANSWER: $1/36$

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**TOSS-UP**

20) Physics – *Short Answer* If the multiplicity of a system increases from 10 to 1000, by what factor is the entropy [*EN-troh-pee*] of the system multiplied?

ANSWER: 3

**BONUS**

20) Physics – *Short Answer* Kevin, who has mass 50 kilograms, is standing motionless on a skating rink when he throws the 10-kilogram rock he is holding at a velocity of 15 meters per second at an angle 45 degrees above the horizontal. What is his speed, to the nearest meter per second, after he does this?

ANSWER: 2

**TOSS-UP**

21) Earth and Space – *Short Answer* What constellation contains the celestial South Pole?

ANSWER: OCTANS (ACCEPT: L'OCTANS DE REFLEXION; OCTANS HADLEIANUS)

**BONUS**

21) Earth and Space – *Short Answer* Rank the following three planets in increasing order of equatorial magnetic field strength: 1) Mars; 2) Jupiter; 3) Earth.

ANSWER: 1, 3, 2

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TOSS-UP

22) Chemistry – *Short Answer* What is the IUPAC name for the compound with the chemical formula $K_2[Cu(CN)_4]$?

ANSWER: POTASSIUM TETRACYANOCUPRATE (II) **[TWO]**

BONUS

22) Chemistry – *Short Answer* Nitric oxide contains 10 electrons in bonding orbitals and 5 electrons in antibonding orbitals. What is its bond order?

ANSWER: 2.5

TOSS-UP

23) Biology – *Multiple Choice* When viewed in cross-section, in which plant organ would you find a star-shaped zone of xylem [**ZYE-lum**]?

- W) Monocot stem
- X) Gymnosperm [**JIM-no-sperms**] stem
- Y) Dicot [**DYE-kawt**] root
- Z) Dicot stem

ANSWER: Y) DICOT ROOT

BONUS

23) Biology – *Short Answer* Identify all of the following three locations in a dNTP that, when radioactively labeled, will be retained in the final DNA molecule: 1) Alpha phosphate; 2) Beta phosphate; 3) Gamma phosphate.

ANSWER: 1