

HIGH SCHOOL - ROUND 16A

TOSS-UP

1) Chemistry – *Short Answer* Identify all of the following three statements that are true of cyclohexane:
1) It is miscible with benzene; 2) The bond angles in the ring are sixty degrees; 3) It is more strained than cyclooctane.

ANSWER: 1

BONUS

1) Chemistry – *Multiple Choice* Lithium aluminum hydride would likely be used by a synthetic chemist for what type of reaction?

- W) Amide [**AM-ide**] bond formation
- X) Nucleophilic substitution
- Y) Reduction
- Z) Aromatic substitution

ANSWER: Y) REDUCTION

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### TOSS-UP

2) Math – *Short Answer* A bag contains three red and three blue marbles. One marble is drawn, and then a second, without replacement. What is the probability of drawing one marble of each color?

ANSWER: 3/5 (ACCEPT: 0.6, 60%)

### BONUS

2) Math – *Short Answer* Solve the following system of three equations in three unknowns:  
 $x + y = 4$ ,  $y + z = 1$ , and  $x + z = 13$ ?

ANSWER:  $x = 8$ ;  $y = -4$ ;  $z = 5$  (ACCEPT: (8, -4, 5))

### TOSS-UP

3) Biology – *Multiple Choice* In humans, hyperfunctioning of the thyroid gland can result from which of the following conditions?

- W) Cushing's syndrome
- X) Addison's disease
- Y) Cretinism [**KREE-tin-izm**]
- Z) Graves' disease

ANSWER: Z) GRAVES' DISEASE

### BONUS

3) Biology – *Short Answer* Identify all of the following three statements that are true of lancelets:  
1) They possess a post-anal tail; 2) They possess pharyngeal [**fair-in-JEE-ul**] slits; 3) Their musculature derives from mesoderm.

ANSWER: ALL

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TOSS-UP

4) Earth and Space – *Multiple Choice* Widmanstätten [**WIHD-mahn-STAH-ten**] patterns are most commonly found in which of the following objects?

- W) Stony meteorites
- X) Iron meteorites
- Y) Moon rocks
- Z) Carbonaceous [**car-bon-AY-shus**] chondrites [**KON-drytes**]

ANSWER: X) IRON METEORITES

BONUS

4) Earth and Space – *Multiple Choice* Lobate scarps on the surface of Mercury are a result of which of the following processes?

- W) Cooling
- X) Plate tectonics [**tek-TAWN-iks**]
- Y) Volcanism
- Z) Land tides

ANSWER: W) COOLING

TOSS-UP

5) Physics – *Short Answer* To the nearest whole number of joules, how much work is done by a 4-newton-meter torque applied over one full revolution to a 3-kilogram wheel with radius 7 meters?

ANSWER: 25

BONUS

5) Physics – *Short Answer* The potential energy of the two atoms in a diatomic molecule is defined by the Lennard-Jones potential, or U equals A over d to the twelfth minus B over d to the sixth, where A and B are positive constants and d is distance. Identify all of the following three statements that are true of this system: 1) At equilibrium, force is minimized; 2) At equilibrium, potential energy is zero; 3) At equilibrium, force is zero.

ANSWER: 3

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### TOSS-UP

6) Energy – *Short Answer* Researchers at SLAC [*slack*] lab are operating and collecting data from the orbiting Fermi [*FUR-mee*] telescope, which captures light from what region of the electromagnetic spectrum that is useful for studying Type II supernovae [*SUper-noh-vee*] and pulsars?

ANSWER: GAMMA RAYS

### BONUS

6) Energy – *Multiple Choice* Scientists at Ames Lab have recently released a study of the various parameters of superconductors, including the superconducting transition temperature and the London Penetration Depth. The London Penetration Depth best measures the penetration of which of the following quantities?

- W) Current
- X) External magnetic field
- Y) Alternating current
- Z) An external electric field

ANSWER: X) EXTERNAL MAGNETIC FIELD

**TOSS-UP**

7) Math – *Short Answer* What is 69 times 13?

ANSWER: 897

**BONUS**

7) Math – *Short Answer* What is the cross product of vectors  $\mathbf{i} + 2\mathbf{j} + 3\mathbf{k}$  cross  $\mathbf{j}$ ?

ANSWER:  $-3\mathbf{i} + \mathbf{k}$  (ACCEPT:  $-3\mathbf{i} + 0\mathbf{j} + 1\mathbf{k}$ ,  $-3\mathbf{i} + 1\mathbf{k}$ )

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TOSS-UP

8) Physics – *Short Answer* An astronaut, who is 60 kilograms and initially at rest, is approached by a crate of supplies that is moving at 4 meters per second. When the crate is close, the astronaut pushes against it, accelerating him to 2 meters per second and slowing the crate down to 2.5 meters per second. What is the mass, in kilograms, of the crate?

ANSWER: 80

BONUS

8) Physics – *Short Answer* A 4-kilogram block is placed on top of a spring with a spring constant of 100 kilograms per second squared. To the nearest joule, how much energy will be released by the spring when the block is removed?

ANSWER: 8

TOSS-UP

9) Earth and Space – *Multiple Choice* Tephrochronology [*TEF-roh-krah-NAWL-ah-jee*] deals with age-dating what type of material?

- W) Carbonate shells
- X) Dead organisms
- Y) Volcanic ash
- Z) Ice-rafted debris

ANSWER: Y) VOLCANIC ASH

BONUS

9) Earth and Space – *Short Answer* Identify all of the following three statements that are true of fossil fuels: 1) Good reservoir rocks have high permeability; 2) Good cap rocks have low permeability; 3) Natural gas tends to form at shallower depths than oil.

ANSWER: 1 AND 2

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### TOSS-UP

10) Chemistry – *Multiple Choice* Methanol has a more negative standard change in enthalpy [*EN-thul-pee*] of formation than methane. Which of the following is true regarding their relative chemical stabilities?

- W) Methanol is more stable than methane
- X) Methanol is less stable than methane
- Y) Because both are composed of the same atoms, they are equally stable
- Z) Their stabilities cannot be compared with standard enthalpy [*EN-thul-pee*] changes

ANSWER: Z) THEIR STABILITIES CANNOT BE COMPARED WITH STANDARD ENTHALPY CHANGES

### BONUS

10) Chemistry – *Multiple Choice* Acetone cyanohydrin [*sigh-ANN-oh-HIGH-drin*] is formed when a cyanide ion reacts with acetone. What atom is the electrophile in this reaction?

- W) Nitrogen on the cyanide ion
- X) Carbon at the 2 position on acetone
- Y) Carbon at the 1 position on acetone
- Z) Oxygen on acetone

ANSWER: X) CARBON AT THE 2 POSITION ON ACETONE

### TOSS-UP

11) Energy – *Multiple Choice* De novo phasing is a technique that structural biologists at SLAC [*slack*] use to gather information about a new protein's 3D shape. This technique involves the replacement of a single atom inside the protein with a traditionally non-proteinogenic [*pro-teen-oh-JEN-ik*] atom with similar chemical behavior. In one example, the researchers replaced a sulfur atom with what?

- W) Nitrogen
- X) Selenium
- Y) Phosphorus
- Z) Arsenic

ANSWER: X) SELENIUM

### BONUS

11) Energy – *Multiple Choice* Los Alamos National Lab scientists are studying how microbes in the soil can slow down the spread of what long-lived radioisotope that is readily absorbed in the thyroid?

- W) Strontium-90 [*STRAWNCH-ee-um-90*]
- X) Iodine-131
- Y) Cesium-137 [*SEEZ-ee-um-one-thirty-seven*]
- Z) Iodine-129

ANSWER: Z) IODINE-129

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TOSS-UP

12) Biology – *Multiple Choice* Which of the following forms of nitrogenous [*nye-TRAW-jen-us*] waste excretion is most energetically costly to produce?

- W) Ammonia
- X) Urea
- Y) Ammonium
- Z) Uric acid

ANSWER: Z) URIC ACID

BONUS

12) Biology – *Multiple Choice* During Western blotting, a blocking solution is often prepared. What is the primary function of the blocking solution?

- W) Conditioning of the PVDF membrane
- X) Limiting non-specific binding of antibodies
- Y) Preserving antibody-protein interactions
- Z) Quenching protein denaturation

ANSWER: X) LIMITING NON-SPECIFIC BINDING OF ANTIBODIES

TOSS-UP

13) Earth and Space – *Multiple Choice* What class of meteorites is composed of undifferentiated, spherical particles that are believed to contain primitive material from which rocky planets formed?

- W) Achondrites [*ay-KAWN-drites*]
- X) Chondrites [*KON-drite*]
- Y) Iron meteorites
- Z) Pallasites

ANSWER: X) CHONDRITES

BONUS

13) Earth and Space – *Short Answer* What is the spin-to-orbit resonance ratio of Mercury?

ANSWER: 3 TO 2 (ACCEPT: 1.5, 3/2, 1½; DO NOT ACCEPT: 2 TO 3)

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**TOSS-UP**

14) Math – *Short Answer* If the graph of  $y$  equals open parenthesis  $x + 4$  close parenthesis squared + 3 is translated 2 units to the right and 4 units down, what are the coordinates of the vertex of the image?

ANSWER:  $(-2, -1)$  (ACCEPT:  $x = -2$  AND  $y = -1$ )

**BONUS**

14) Math – *Short Answer* A 5-digit palindrome has 3 different digits and is divisible by 8. What is the largest such number?

ANSWER: 86,968

### TOSS-UP

15) Physics – *Short Answer* Plane polarized light with an intensity of  $I$  passes through a filter that makes a 30-degree angle with respect to the angle of polarization. In terms of  $I$ , what is the intensity of the light after it passes through the filter?

ANSWER:  $0.75 I$  (ACCEPT:  $(3/4) I$ )

### BONUS

15) Physics – *Short Answer* Identify all of the following three statements that are true regarding RLC circuits with an AC source: 1) At resonance, the source voltage and current are in phase; 2) The circuit's  $Q$  factor is inversely proportional to its bandwidth; 3) At resonance, the voltage across the resistor equals the source voltage.

ANSWER: ALL

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TOSS-UP

16) Energy – *Multiple Choice* Researchers at SLAC [*slack*] developed a microscopic rake that enables better mixing of deposited materials on surfaces, resulting in more efficient solar cells. Which of the following solar cells benefit from this invention?

- W) Polymer cell
- X) Thin-film cell
- Y) Wafer cell
- Z) Organic cell

ANSWER: W) POLYMER CELL

BONUS

16) Energy – *Short Answer* Due to the desire for extremely low neutron-absorption cross sections in nuclear-fuel-rod cladding, they are primarily composed of what metal?

ANSWER: ZIRCONIUM

TOSS-UP

17) Biology – *Multiple Choice* What type of phagocytic cell can primarily be found under mucosal [*myoo-KOH-sul*] surfaces and plays a primary role in responding to multicellular pathogens?

- W) Neutrophils [*NEW-troh-fill*]
- X) Eosinophils [*ee-oh-SIN-oh-filz*]
- Y) Dendritic cells [*den-DRIH-dik*]
- Z) Macrophages [*MACRO-fay-jiz*]

ANSWER: X) EOSINOPHILS

BONUS

17) Biology – *Short Answer* A scientist is separating proteins using size-exclusion chromatography [*crow-mah-TAW-grah-fee*]. Identify the relative order of elution from earliest to latest of the following proteins from the column: 1) Titin; 2) Myoglobin [*MY-oh-glow-bin*]; 3) Hemoglobin; 4) Cytochrome [*SIGH-tow-krome*] c.

ANSWER: 1, 3, 2, 4

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### TOSS-UP

18) Chemistry – *Multiple Choice* Which of the following functional groups can be found in sucrose?

- W) Alcohol
- X) Amine
- Y) Amino
- Z) Carboxyl

ANSWER: W) ALCOHOL

### BONUS

18) Chemistry – *Multiple Choice* Which of the following techniques would most unambiguously determine the structure of a compound that contains stereocenters?

- W) Mass spectrometry [*spek-TRAW-metry*]
- X) X-ray crystallography [*crystal-AW-graphy*]
- Y) 1D NMR spectroscopy [*spek-TRAW-scu-h-pee*]
- Z) Atomic absorption spectroscopy

ANSWER: X) X-RAY CRYSTALLOGRAPHY

**TOSS-UP**

19) Math – *Short Answer* What is the determinant of the 2-by-2 matrix with first row  $-3, -5$  and second row  $8, -2$ ?

ANSWER: 46

**BONUS**

19) Math – *Short Answer* Find the volume of the solid obtained by rotating about the  $y$ -axis the region bounded by  $y = x^2 - x^3$  and  $y = 0$ .

ANSWER:  $\pi/10$  (ACCEPT:  $0.1\pi$ )

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TOSS-UP

20) Biology – *Short Answer* Fairy rings are associated with what division of fungi?

ANSWER: BASIDIOMYCOTA (ACCEPT: BASIDIOMYCETES)

BONUS

20) Biology – *Short Answer* A patient presents with the ability to understand language, but the inability to speak. What small region of the left frontal lobe might be damaged?

ANSWER: BROCA'S AREA

TOSS-UP

21) Physics – *Short Answer* A 9-volt battery with internal resistance of 1 ohm is connected to a lightbulb. If the potential drop across the lightbulb is 6 volts, then in watts, how much power is dissipated by the lightbulb?

ANSWER: 18

BONUS

21) Physics – *Short Answer* Water flows through a horizontally-level pipe at 4 meters per second, until it encounters a section where its static pressure decreases by 10 kilopascals. To the nearest whole number of meters per second, what is its new flow speed?

ANSWER: 6

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### TOSS-UP

22) Earth and Space – *Short Answer* Identify all of the following three rocks that would be classified as aphanitic [*AFF-in-it-ik*]: 1) Andesite [*ANN-deh-site*]; 2) Basalt [*bah-SALT*]; 3) Diorite.

ANSWER: 1 AND 2

### BONUS

22) Earth and Space – *Short Answer* Place the following three rock types in increasing order of distance from shore at the time of deposition in a typical sedimentary sequence: 1) Shale; 2) Limestone; 3) Sandstone.

ANSWER: 3, 1, 2

### TOSS-UP

23) Chemistry – *Short Answer* Aspartame is an artificial sweetener composed of amino acids linked by what type of chemical bond?

ANSWER: AMIDE (ACCEPT: PEPTIDE)

### BONUS

23) Chemistry – *Short Answer* Identify all of the following three chemical moieties that are capable of having cis **[sis]** -trans isomerism **[eye-SAW-mer-izm]**: 1) Tetrahedral **[tetrah-HEE-drul]** complex; 2) Alkene; 3) Square planar **[PLAY-nar]** complex.

ANSWER: 2 AND 3