

HIGH SCHOOL - ROUND 6A

TOSS-UP

1) Energy – *Multiple Choice* The National Energy Technology Lab is leading a project that gasifies coal and coal-biomass blends to form syngas, which is primarily a mixture of hydrogen and what other chemical compound?

- W) Carbon monoxide
- X) Carbon dioxide
- Y) Methane
- Z) Sulfur dioxide

ANSWER: W) CARBON MONOXIDE

BONUS

1) Energy – *Short Answer* Berkeley lab scientists produced the first 3D images of a protein that is important in DNA replication and presents a target for antibiotic and anticancer drugs. What class of proteins, which are responsible for untangling DNA strands and changing DNA linking number, did they image?

ANSWER: TOPOISOMERASES

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### TOSS-UP

2) Earth and Space – *Short Answer* In what corner of a Hertzsprung-Russell diagram can one find an O-class supergiant?

ANSWER: TOP LEFT

### BONUS

2) Earth and Space – *Multiple Choice* A certain O-class star appears red from the Earth's surface. The absorption lines, however, do not look shifted towards red. Based on these observations, which of the following is a reasonable conclusion about this star?

- W) It is moving away from the Earth very quickly
- X) It is moving towards the Earth very quickly
- Y) There is dust between Earth and the star
- Z) There is dark matter between Earth and the star

ANSWER: Y) THERE IS DUST BETWEEN EARTH AND THE STAR

### TOSS-UP

3) Math – *Short Answer* Giving your answer in standard form, what is the equation of the circle with center at (0, 0) and diameter 28?

ANSWER:  $x^2 + y^2 = 196$

### BONUS

3) Math – *Short Answer* What is the x-coordinate of the solution of the following system of two equations in two unknowns:  $5x - 3y = 6$  and  $4x - 7y = 5$ ?

ANSWER: 27/23 (ACCEPT: 1 4/23)

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TOSS-UP

4) Biology – *Short Answer* Deficiency of what vitamin is linked to the connective-tissue disorder scurvy?

ANSWER: VITAMIN C

BONUS

4) Biology – *Short Answer* Identify all of the following three statements that are true of eukaryotic **[YOU-care-ee-AW-tic]** cell structures: 1) The cilia **[SILL-ee-ah]** has a characteristic 9 plus 2 arrangement of microtubules **[micro-TUBE-yules]**; 2) Lysosomes **[LYE-soh-sohms]** are responsible for assembling ribosomes; 3) The endoplasmic reticulum **[reh-TIK-yoo-lum]** plays a role in synthesizing lipids.

ANSWER: 1 AND 3

TOSS-UP

5) Chemistry – *Short Answer* What is the oxidation state of copper in Cu_2O ?

ANSWER: 1+

BONUS

5) Chemistry – *Multiple Choice* Di-iodine gas can dissociate into two atoms of iodine gas. At 1200 kelvins, the forward reaction has an equilibrium constant of approximately 10. In kilojoules [**KILL-oh-joules**] per mole, which of the following is closest to the standard change in Gibbs free energy of this reaction?

- W) -20
- X) -2
- Y) +2
- Z) +20

ANSWER: W) -20

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### TOSS-UP

6) Physics – *Short Answer* What is the term for the point on a pressure-temperature diagram at which a substance can exist in three phases of matter simultaneously?

ANSWER: TRIPLE POINT

### BONUS

6) Physics – *Short Answer* A circuit consists of a 10-volt battery connected to a parallel branch of three 90-ohm resistors. Expressing your answer in amperes and as a decimal with one significant figure, what is the total current flow through the circuit?

ANSWER: 0.3

### TOSS-UP

7) Energy – *Short Answer* Scientists at Ames Lab are developing methods to encapsulate catalysts inside porous glass nanoparticles to offer exquisite control of stability and reactivity. What is the chemical formula of the encapsulating material they are using?

ANSWER: SiO<sub>2</sub>

### BONUS

7) Energy – *Short Answer* Fermilab scientists collaborate on the Cryogenic [**cry-oh-JEN-ik**] Dark Matter Search experiment to detect certain types of dark matter. Identify all of the following three proposed types of dark matter this experiment is designed to detect: 1) WIMPs [**wimps**]; 2) Axions; 3) Baryonic [**bare-ee-ON-ik**] dark matter.

ANSWER: 1

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TOSS-UP

8) Earth and Space – *Multiple Choice* A sedimentary deposit consists of three layers: a base layer of gravel-sized grains, an intermediate layer of sand, and a top layer of silt and other fine particles. Assuming the deposit has not been overturned, what type of grading does the deposit represent?

- W) Normal
- X) Inverse
- Y) Coarse tail
- Z) Debris flow

ANSWER: W) NORMAL

BONUS

8) Earth and Space – *Short Answer* Identify all of the following three actions that would decrease the temperature at which a subducting rock becomes a magma: 1) Increase pressure; 2) Increase water content; 3) Increase silica content.

ANSWER: 2, 3

TOSS-UP

9) Chemistry – *Short Answer* What constant, which appears in the denominator of the Nernst equation, is the amount of charge present in one mole of electrons?

ANSWER: FARADAY (ACCEPT: F)

BONUS

9) Chemistry – *Short Answer* For the gas-phase reaction of hydrogen and bromine [**BROH-meen**] to generate HBr, identify all of the following three changes that would shift the equilibrium towards products: 1) Adding more hydrogen gas; 2) Increasing the volume of the container; 3) Adding a catalyst to the reaction.

ANSWER: 1

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### TOSS-UP

10) Biology – *Multiple Choice* A plant loses the greatest amount of water through what structures?

- W) Root cuticle
- X) Leaf cuticle
- Y) Lenticels
- Z) Stomata

ANSWER: Z) STOMATA

### BONUS

10) Biology – *Multiple Choice* A flower that has four stamens, one pistil, four petals, and no sepals would be considered which of the following?

- W) Complete
- X) Incomplete
- Y) Monoecious
- Z) Imperfect

ANSWER: X) INCOMPLETE

**TOSS-UP**

11) Math – *Short Answer* What is the expected value when rolling a single ten-sided die?

ANSWER: 5.5 (ACCEPT:  $11/2$ ,  $5\frac{1}{2}$ )

**BONUS**

11) Math – *Short Answer* If the third derivative of a position function can be described by the function  $6t^3$ , what is the coefficient of the highest-order term in the position function?

ANSWER:  $1/20$  (ACCEPT: 0.05)

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TOSS-UP

12) Physics – *Short Answer* Currents induced inside conductors due in the presence of a time-varying magnetic field are called what?

ANSWER: EDDY CURRENTS (ACCEPT: FOUCAULT CURRENTS)

BONUS

12) Physics – *Multiple Choice* Which of the following mathematical representations is commonly used to model AC voltages and currents as a rotating vector in the complex plane?

- W) Wavefunction
- X) Phasor
- Y) Cosine vector
- Z) Tangent vector

ANSWER: X) PHASOR

TOSS-UP

13) Energy – *Short Answer* Alkaline batteries are a common type of commercialized battery that involves the reaction of manganese [**MAYN-gan-eez**] dioxide and what other metal?

ANSWER: ZINC

BONUS

13) Energy – *Short Answer* Scientists studying photoredox chemistry at Brookhaven National Lab have turned their attention to the molecule ICN. When this molecule absorbs light, it breaks up into two radicals, one of them a halide [**HAY-lide**]. What functional group does the other radical resemble?

ANSWER: CYANO (ACCEPT: CYANIDE or NITRILE)

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### TOSS-UP

14) Earth and Space – *Multiple Choice* The inner core of the Earth is most similar in composition to which of the following?

- W) Meteoric iron
- X) Chondrites [**KON-drytes**]
- Y) Stony meteorites
- Z) Achondrites [**ay-KAWN-drites**]

ANSWER: W) METEORIC IRON

### BONUS

14) Earth and Space – *Short Answer* An amateur astronomer observes 61 Cygni [**SIG-nye**] and determines that it has a parallax angle of 0.333 arcseconds. To the nearest whole number of light years, how far away is 61 Cygni from the Earth?

ANSWER: 10

**TOSS-UP**

15) Physics – *Short Answer* If one wants to change the period of a simple pendulum so that it oscillates at three fourths of the original period, what ratio of new-to-old length is required?

ANSWER: 9/16 (ACCEPT: 9 TO 16)

**BONUS**

15) Physics – *Short Answer* Identify all of the following three features that were in Bohr's model of the atom: 1) Energy levels; 2) Orbitals; 3) Electrons.

ANSWER: 1 AND 3

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TOSS-UP

16) Biology – *Short Answer* What cluster of electrically active cells in the human heart sets the rate at which all cardiac muscle cells contract?

ANSWER: SINOATRIAL NODE (ACCEPT: SA NODE)

BONUS

16) Biology – *Multiple Choice* Which of the following fossils is representative of the transition from fish to tetrapods?

- W) Tiktaalik [*tik-TAH-lik*]
- X) Archaeopteryx [*ark-ee-AWP-tur-ix*]
- Y) Megalosaurus [*mega-ZAWS-roh-don*]
- Z) Ambulocetus [*am-byoo-loh-SEE-tus*]

ANSWER: W) TIKTAALIK

TOSS-UP

17) Math – *Short Answer* What is the antilog base 9 of 2?

ANSWER: 81

BONUS

17) Math – *Short Answer* Each day, Sue eats 25% of the cookies left in a jar. At the end of the second day, there are 36 cookies left in the jar. How many cookies were in the jar originally?

ANSWER: 64

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**TOSS-UP**

18) Chemistry – *Multiple Choice* Which of the following statements is true regarding a gas-phase reaction at chemical equilibrium?

- W) The forward and reverse reactions stop at equilibrium
- X) Adding reactant will increase the concentration of product
- Y) Adding reactant will increase the equilibrium constant
- Z) The reverse reaction only begins at equilibrium

ANSWER: X) ADDING REACTANT WILL INCREASE THE CONCENTRATION OF PRODUCT

**BONUS**

18) Chemistry – *Short Answer* How many three-center two-electron bonds are present in the compound with formula  $B_2H_6$ ?

ANSWER: 2

**TOSS-UP**

19) Earth and Space – *Short Answer* What substance serves as a lubricant in glacier basal slip?

ANSWER: WATER

**BONUS**

19) Earth and Space – *Short Answer* Rank the following three components of the ocean's dissolved inorganic carbon in increasing order: 1) Carbonic [*car-BAWN-ik*] acid; 2) Carbonate ion; 3) Bicarbonate ion.

ANSWER: 1, 2, 3

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TOSS-UP

20) Physics – *Short Answer* The uranium-238 decay series terminates at the 206 isotope of what element?

ANSWER: LEAD

BONUS

20) Physics – *Short Answer* A 6-centimeter tall object is placed 15 centimeters from a double convex lens with a 9-centimeter focal length. In centimeters, what is the height of the image, and is this image upright or inverted?

ANSWER: 9 AND INVERTED (ACCEPT: -9 AND INVERTED)

TOSS-UP

21) Math – *Short Answer* What is the sum of the two vectors $8\mathbf{i} + 3\mathbf{j}$ and $-6\mathbf{i} - 7\mathbf{j}$?

ANSWER: $2\mathbf{i} - 4\mathbf{j}$

BONUS

21) Math – *Short Answer* A square has sides of length 12 centimeters. In square centimeters, what is the difference between the areas of its circumscribing circle and its inscribed circle?

ANSWER: 36π

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### TOSS-UP

22) Chemistry – *Short Answer* What is the name given to a special mixture of liquids whose composition cannot be changed by simple distillation, such as 95% ethanol to 5% water?

ANSWER: AZEOTROPEs

### BONUS

22) Chemistry – *Short Answer* Rank the following three diatomic [*dye-ah-TOM-ik*] molecules in increasing order of bond energy: 1) Bromine [*BROH-meen*]; 2) Iodine; 3) Chlorine.

ANSWER: 2, 1, 3

### TOSS-UP

23) Biology – *Short Answer* Pneumatophores [*new-MAT-ah-forz*] and beets are modified versions of what plant organ?

ANSWER: ROOTS

### BONUS

23) Biology – *Short Answer* What molecule, when present in small quantities in the cell membrane, increases fluidity at low temperatures and decreases fluidity at high temperatures?

ANSWER: CHOLESTEROL