

HIGH SCHOOL - ROUND 5A

TOSS-UP

1) Math – *Multiple Choice* The tangent of open parenthesis pi + theta close parenthesis is equal to which of the following?

- W) Tangent theta
- X) Negative tangent theta
- Y) Cotangent theta
- Z) Negative cosecant theta

ANSWER: W) TANGENT THETA

BONUS

1) Math – *Short Answer* Special water for a 650-liter aquarium is only sold in 42-liter containers. What is the minimum number of these 42-liter containers you would need to buy to be able to completely fill the tank?

ANSWER: 16 (DO NOT ACCEPT: 15 10/21 or 325/21)

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### TOSS-UP

2) Biology – *Short Answer* What is the term for infections or diseases that are naturally transmissible from vertebrate animals to humans?

ANSWER: ZOONOSES (ACCEPT: ZOONOTIC)

### BONUS

2) Biology – *Short Answer* Identify all of the following three plants that associate parasitically with other plants: 1) Vanilla; 2) Mistletoe; 3) Venus flytrap.

ANSWER: 2

**TOSS-UP**

3) Earth and Space – *Multiple Choice* Which of the following is NOT among the criteria that define a substance as a mineral?

- W) Specific chemical composition
- X) Specific crystal structure
- Y) Specific melting point
- Z) Naturally-occurring

ANSWER: Y) SPECIFIC MELTING POINT

**BONUS**

3) Earth and Space – *Short Answer* Identify all of the following three statements that are true about the positions of American cities relative to tectonic [*tek-TAWN-ik*] plates: 1) San Francisco is located on the North American Plate; 2) Los Angeles is located on the Pacific Plate; 3) Seattle is located on the Pacific Plate.

ANSWER: 1 AND 2 ONLY

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TOSS-UP

4) Physics – *Short Answer* The conversion of carbon-14 into nitrogen-14 is an example of what type of radioactive decay?

ANSWER: BETA DECAY (ACCEPT: BETA MINUS DECAY)

BONUS

4) Physics – *Short Answer* A construction worker accidentally drops a hammer off the roof of a building. If it takes 4 seconds for the hammer to hit the ground, then, how tall, to the nearest meter, is the building?

ANSWER: 78

TOSS-UP

5) Chemistry – *Multiple Choice* In which of the following compounds is the oxidation state of oxygen equal to zero?

- W) CuO
- X) H₂O
- Y) O₂
- Z) H₃PO₄

ANSWER: Y) O₂

BONUS

5) Chemistry – *Multiple Choice* A chemist adds ethylenediamine [*eh-thil-eeen-DYE-ah-meen*], methylamine, and EDTA to an aqueous [*AY-kwee-us*] solution of cadmium (II). Which of the following ligands [*LIH-gundz*] will form the most stable complex in this solution?

- W) Water
- X) Ethylenediamine
- Y) Methylamine
- Z) EDTA

ANSWER: Z) EDTA

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### TOSS-UP

6) Energy – *Short Answer* Scientists at Lawrence Berkeley National Lab recently studied the effect of variation in genes regulating genomic [*jeh-NOH-mik*] integrity in a myriad of cancers. What specific complex of proteins, to which spindle fibers attach during mitosis, was coded for by many of these genes?

ANSWER: KINETOCHORE

### BONUS

6) Energy – *Short Answer* Jefferson Lab researchers are performing experimental tests to better understand the effects of virtual quark/anti-quark pairs inside the proton. What second-generation quark, the third lightest of all quarks, is the most likely to be found as a virtual pair in the proton?

ANSWER: STRANGE QUARK

**TOSS-UP**

7) Physics – *Short Answer* When used as adjectives, Fresnel [*freh-NELL*] and Fraunhofer [*FRAWN-hofer*] are examples of what property of waves that results in them bending around obstacles?

ANSWER: DIFFRACTION

**BONUS**

7) Physics – *Short Answer* What quark, discovered in 1995, is the most massive known quark?

ANSWER: TOP (ACCEPT: T or TRUTH)

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TOSS-UP

8) Math – *Multiple Choice* Which of the following is true regarding the graph of $y = -x^5$ at $x = -4$?

- W) Increasing and concave up
- X) Increasing and concave down
- Y) Decreasing and concave up
- Z) Decreasing and concave down

ANSWER: Y) DECREASING AND CONCAVE UP

BONUS

8) Math – *Short Answer* What are the radius and the coordinates of the center, respectively, of the circle with equation $x^2 + 12x + y^2 - 4y - 81 = 0$?

ANSWER: RADIUS 11; CENTER (-6, 2) (ACCEPT: $x = -6$ AND $y = 2$ for center)

TOSS-UP

9) Earth and Space – *Short Answer* What type of tide occurs when the Moon is at first or third quarter?

ANSWER: NEAP

BONUS

9) Earth and Space – *Multiple Choice* A moon with a small mass is orbiting a large planet of unknown mass with an orbital period of ten to the fifth seconds and with a semimajor axis of ten to the eighth meters. Which of the following values is closest to the mass, in kilograms, of the planet?

- W) 6 times 10 to the 15th
- X) 6 times 10 to the 20th
- Y) 6 times 10 to the 25th
- Z) 6 times 10 to the 30th

ANSWER: Y) 6 TIMES 10 TO THE 25TH



TOSS-UP

10) Energy – *Short Answer* In the uranium fuel cycle, mined ore is milled and uranium is precipitated using solvent extraction or trituration. The precipitate is formed into bricks known as what?

ANSWER: YELLOWCAKE (ACCEPT: URANIA)

BONUS

10) Energy – *Short Answer* The Dark Energy Camera was built at Fermilab to image the universe from an observatory in Chile. Identify all of the following three statements that are true of the Dark Energy Camera: 1) It uses charge-coupled devices to detect light; 2) It is better at detecting red and near-infrared light than violet and ultraviolet light; 3) It is part of an interferometer.

ANSWER: 1 AND 2

TOSS-UP

11) Chemistry – *Short Answer* Identify all of the following three acids that are polyprotic [*polly-PRO-tic*]: 1) Phosphorous acid; 2) Hydroiodic [*HIGH-droh-eye-AW-dik*] acid; 3) Selenic acid.

ANSWER: 1 AND 3

BONUS

11) Chemistry – *Short Answer* Consider the dehydration of isopropanol by sulfuric acid to form propene. What is the mechanism of this reaction?

ANSWER: E1 (ACCEPT: ELIMINATION UNIMOLECULAR, UNIMOLECULAR ELIMINATION, ELIMINATION 1)

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### TOSS-UP

12) Biology – *Short Answer* What structures at the ends of eukaryotic [*YOU-care-ee-AW-tic*] chromosomes prevent their degradation?

ANSWER: TELOMERES

### BONUS

12) Biology – *Multiple Choice* In DNA replication, which of the following components is necessary for the synthesis of the lagging strand but not the leading strand?

- W) Helicase [*HEEL-ih-case*]
- X) Ligase [*LYE-gase*]
- Y) Primase
- Z) Single-strand binding proteins

ANSWER: X) LIGASE

### TOSS-UP

13) Physics – *Short Answer* What is the thermodynamic efficiency of a Carnot [**CAR-noh**] engine whose hot source is at 2000 kelvins and whose cold sink is at 250 kelvins?

ANSWER: 87.5% (ACCEPT: 87 1/2%, 0.875, 7/8)

### BONUS

13) Physics – *Short Answer* An earthquake occurs, causing a tsunami [**su-NAH-mee**]. A satellite observes that the distance between wave peaks is 540 kilometers and the waves are hitting the shore once per hour. What is the speed, in meters per second, of these waves?

ANSWER: 150

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TOSS-UP

14) Chemistry – *Multiple Choice* The molecular mass of atomic oxygen is expressed as 15.9994 plus or minus 0.0003. Which of the following best explains the source of the error?

- W) Human error from measurement to measurement
- X) Lack of precision in ultra-low weighing techniques
- Y) Minute differences in measurement equipment used by different research groups
- Z) Isotopic variation in different samples of oxygen

ANSWER: Z) ISOTOPIC VARIATION IN DIFFERENT SAMPLES OF OXYGEN

BONUS

14) Chemistry – *Short Answer* Consider the interaction between two rotating dipoles [**DYE-poles**] in the gas phase. If the distance between the dipoles is doubled, by what factor is the dipole-dipole potential energy multiplied?

ANSWER: 1/64

TOSS-UP

15) Earth and Space – *Short Answer* What layer of the Earth’s interior accounts for the largest percentage of the Earth's total mass?

ANSWER: MANTLE

BONUS

15) Earth and Space – *Multiple Choice* At which of the following times, in millions of years ago, was Pangaea [*pan-JEE-ah*] intact?

- W) 240
- X) 458
- Y) 650
- Z) 750

ANSWER: W) 240

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**TOSS-UP**

16) Biology – *Short Answer* The neurons found in humans require nourishment from supporting cells known as what?

ANSWER: GLIA (ACCEPT: NEUROGLIA, GLIAL CELLS)

**BONUS**

16) Biology – *Short Answer* In land plants, what is the term for the male gametangia [*gam-ih-TAN-jee-ah*]?

ANSWER: ANTHERIDIA (ACCEPT: ANTHERIDIUM)



**TOSS-UP**

17) Math – *Short Answer* What is the distance between the points (0, 5) and (4, 9)?

ANSWER:  $4\sqrt{2}$

**BONUS**

17) Math – *Short Answer* Three coplanar circles with radii of lengths 3, 5, and 7, respectively, have the same center, forming a shape consisting of two annuluses and a circle that are nonoverlapping. What is the ratio of the area of the smaller annulus to that of the larger annulus?

ANSWER: 2/3 (ACCEPT: 2 TO 3)

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TOSS-UP

18) Energy – *Short Answer* Gaseous [*gah-shus*] diffusion is currently the most common method used in the United States for the enrichment of uranium. What is the chemical formula of the gaseous uranium compound in this stage?

ANSWER: UF_6

BONUS

18) Energy – *Short Answer* Scientists at SLAC [*slack*] are studying how heat and compression result in the formation of different minerals. They have demonstrated their technique in the lab by growing stishovite, which is an extremely dense mineral related to quartz. What is the chemical formula of stishovite?

ANSWER: SiO_2

TOSS-UP

19) Earth and Space – *Short Answer* The 21-centimeter radio emission line is due to a transition in what element?

ANSWER: HYDROGEN

BONUS

19) Earth and Space – *Short Answer* The Kirkwood gaps in the asteroid belt are due to orbital resonance with what body?

ANSWER: JUPITER

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**TOSS-UP**

20) Chemistry – *Short Answer* A reaction has a rate constant with units of liters to the 3rd, moles to the negative 3rd, and seconds to the negative 1. What is the order of this reaction?

ANSWER: 4

**BONUS**

20) Chemistry – *Short Answer* Identify all of the following three statements that are true about intermolecular [*inter-moh-LEK-yoo-lur*] forces and phase diagrams: 1) Dinitrogen has a high critical temperature relative to water; 2) Substances with higher vapor pressures have lower boiling points; 3) Substances with stronger intermolecular forces have lower vapor pressures.

ANSWER: 2 AND 3

**TOSS-UP**

21) Math – *Short Answer* What is the slope of the line with equation  $4x - 7y = 8$ ?

ANSWER: 4/7

**BONUS**

21) Math – *Short Answer* What is the average value of the function  $f(x) = x^2$  over the interval  $-1$  to  $3$ ?

ANSWER: 7/3 (ACCEPT: 2 1/3)



**TOSS-UP**

22) Biology – *Short Answer* One common method of cloning DNA is incorporating a small loop of DNA containing the gene of interest into *E. coli* [*ee COLE-eye*]. What is the term for these small loops?

ANSWER: PLASMIDS

**BONUS**

22) Biology – *Short Answer* Insulin is secreted by what structures in the pancreas?

ANSWER: ISLETS OF LANGERHANS (ACCEPT: BETA CELLS OF THE ISLETS OF LANGERHANS, PANCREATIC ISLETS, BETA CELLS)

### TOSS-UP

23) Physics – *Short Answer* What set of rules states that for an electron configuration, the term with maximum multiplicity has the lowest energy?

ANSWER: HUND'S RULES

### BONUS

23) Physics – *Short Answer* A beam of light whose wavelength is 600 nanometers [*NAN-oh-meters*] in a vacuum passes into a medium with an index of refraction of four-thirds. To the nearest integer multiple of a thousand kilometers per second, what is the speed of the light in this medium?

ANSWER: 225,000