

HIGH SCHOOL - ROUND 17A

TOSS-UP

1) Earth and Space – *Multiple Choice* Which of the following ocean currents does NOT flow from higher latitudes toward the equator?

- W) The California Current
- X) The Peru Current
- Y) The Brazil Current
- Z) The Benguela [*ben-GWAY-la*] Current

ANSWER: Y) THE BRAZIL CURRENT

BONUS

1) Earth and Space – *Multiple Choice* Which of the following events occurred in the Late Mississippian?

- W) Breakup of Rodinia
- X) Collision of Gondwana with Laurasia
- Y) Collision of Laurentia with Baltica
- Z) Breakup of Pangaea

ANSWER: X) COLLISION OF GONDWANA WITH LAURASIA

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**TOSS-UP**

2) Math – *Short Answer* What are the  $x$ -coordinates of the intersections of the graphs of the equations  $y = 9x^2 + 3$  and  $y = -27x + 3$ ?

ANSWER: 0 AND -3

**BONUS**

2) Math – *Short Answer* What is the cube of the complex number  $3 + 5i$ ?

ANSWER:  $-198 + 10i$

### TOSS-UP

3) Chemistry – *Multiple Choice* A student wishes to convert an aldehyde to a secondary alcohol. Which of the following reagents would be most useful?

- W) Alkyl [*AL-keel*] Grignard [*GRIN-yerd*] reagent
- X) Lithium aluminum hydride
- Y) Sodium borohydride
- Z) Sodium hydride

ANSWER: W) ALKYL GRIGNARD REAGENT

### BONUS

3) Chemistry – *Short Answer* Andrew synthesizes a compound that consists of a benzene ring with an alcohol group in the one position and a primary amine in the four position. Identify all of the following three names that unambiguously represent the structure of this compound: 1) P-aminophenol; 2) 4-aminophenol; 3) 4-hydroxyaniline.

ANSWER: ALL

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TOSS-UP

4) Physics – *Multiple Choice* Planck resolved the ultraviolet catastrophe for black bodies by postulating the quantization of photon energies to derive an expression showing that the modal energies obey which of the following statistical distributions?

- W) Fermi-Dirac
- X) Maxwell-Boltzmann
- Y) Bose-Einstein
- Z) Gaussian

ANSWER: Y) BOSE-EINSTEIN

BONUS

4) Physics – *Short Answer* A spinning dancer draws her arms inwards until she rotates at 3 times her original velocity. In terms of her original kinetic energy E , how much energy did this maneuver require?

ANSWER: $2E$

TOSS-UP

5) Biology – *Short Answer* Identify all of the following four phyla [**FYE-lah**] that exhibit radial symmetry: 1) Porifera [**poor-IH-fer-ah**]; 2) Cnidaria [**nye-DARE-ee-ah**]; 3) Mollusca [**mull-US-kah**]; 4) Echinodermata [**eh-kye-noh-der-MAH-tah**].

ANSWER: 2, 4

BONUS

5) Biology – *Short Answer* In humans, circadian [**sir-KAY-dee-an**] rhythms are controlled by a specific group of neurons in the hypothalamus [**high-poh-THAL-ah-mus**] called what?

ANSWER: SCN (ACCEPT: SUPRACHIASMATIC NUCLEUS)

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**TOSS-UP**

6) Energy – *Multiple Choice* Scientists at Lawrence Berkeley National Lab recently captured images of a Type one-A supernova in a galaxy four billion light-years away that appeared 50 times brighter than normal and in four different places in the sky. Which of the following did the scientists discover?

- W) A Type-one-A supernova with a progenitor that was 20-50 times more massive than normal
- X) An anomalous type-two supernova with a light curve resembling type Ia
- Y) A light echo of a type-one-A supernova
- Z) A type-one-A supernova whose image was strongly gravitationally lensed

ANSWER: Z) A TYPE-ONE-A SUPERNOVA WHOSE IMAGE WAS STRONGLY GRAVITATIONALLY LENSED

**BONUS**

6) Energy – *Multiple Choice* One of the most promising generation IV nuclear reactor designs involves the use of supercritical water as the coolant. What is the main reason to use supercritical water?

- W) It has a higher neutron absorption cross section
- X) It has a lower neutron absorption cross section
- Y) It is fissile
- Z) It allows for a higher thermal efficiency

ANSWER: Z) IT ALLOWS FOR A HIGHER THERMAL EFFICIENCY

### TOSS-UP

7) Earth and Space – *Multiple Choice* Which of the following drainage patterns would likely be visible on jointed, rocky terrain?

- W) Dendritic [*den-DRIH-dik*]
- X) Trellis
- Y) Radial
- Z) Rectangular

ANSWER: Z) RECTANGULAR

### BONUS

7) Earth and Space – *Short Answer* Identify all of the following three latitudes that trade winds can be found in: 1) Between 60 and 30 degrees south; 2) Between 30 degrees south and the equator; 3) Between the equator and 30 degrees north.

ANSWER: 2 AND 3

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TOSS-UP

8) Biology – *Multiple Choice* A patient is demonstrating loss in bone density. Which of the following hormones would be most useful in treating this symptom?

- W) Parathyroid hormone
- X) Vasopressin
- Y) Calcitonin [*kal-sih-TOE-nin*]
- Z) Mineralocorticoid [*mineralo-CORE-deh-KOYD*]

ANSWER: Y) CALCITONIN

BONUS

8) Biology – *Short Answer* Identify all of the following three statements that are true of nitrogenous [*nye-TRAW-jen-us*] waste excretion: 1) Ammonia excretion results in more water loss than an equivalent amount of urea excretion; 2) Urea is more energetically expensive to excrete than an equivalent amount of uric [*YUR-ik*] acid; 3) Humans produce a small amount of uric acid.

ANSWER: ALL

TOSS-UP

9) Energy – *Multiple Choice* DOE scientists are using the Advanced Light Source to study atmospheric reentry heat shields, including PICA [*PEE-kah*], the type currently used by NASA and SpaceX. Which of the following best describes PICA?

- W) A silicone-based heating pad
- X) A highly-thermally-conductive epoxy
- Y) A carbon fiber that slowly ablates
- Z) Titanium shingles with heat sinks

ANSWER: Y) A CARBON FIBER THAT SLOWLY ABLATES

BONUS

9) Energy – *Multiple Choice* Scientists at SLAC [*slack*] recently demonstrated that coating the gold tip of an electron gun with nanodiamonds resulted in a higher electron flux through the gun. This is because the diamonds changed what property of the electron gun tip?

- W) Conductance
- X) Electron density
- Y) Voltage
- Z) Work function

ANSWER: Z) WORK FUNCTION

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**TOSS-UP**

10) Math – *Short Answer* What is the product of the three different prime factors of 315?

ANSWER: 105

**BONUS**

10) Math – *Short Answer* What is the approximation for the sine of 2 that results from using the first three nonzero terms of the Taylor series for sine  $x$  centered at 0?

ANSWER: 14/15

### TOSS-UP

11) Physics – *Short Answer* In terms of the elementary charge  $e$ , what is the electric charge of an up quark?

ANSWER: POSITIVE  $(2/3)e$  (ACCEPT:  $(2/3)e$ ,  $2e/3$ )

### BONUS

11) Physics – *Short Answer* An excess charge is distributed over the surface of a solid metal sphere that has a radius of one meter. Identify all of the following three distances from the center of the sphere at which the electrical potential relative to infinity is maximized: 1) 50 centimeters; 2) 100 centimeters; 3) 150 centimeters.

ANSWER: 1 AND 2

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TOSS-UP

12) Chemistry – *Multiple Choice* The precipitation reaction caused by the addition of potassium chloride to aqueous [*AY-kwee-us*] silver nitrate is an example of which of the following types of reactions?

- W) Metathesis [*meh-TATH-uh-sis*]
- X) Decomposition
- Y) Synthesis
- Z) Redox

ANSWER: W) METATHESIS

BONUS

12) Chemistry – *Multiple Choice* Copper (II) hydroxide is insoluble in water. However, upon the addition of excess ammonia, it dissolves and changes to a deep blue color. Which of the following statements best explains this observation?

- W) The rise in pH solubilized the copper hydroxide
- X) The drop in pH solubilized the copper hydroxide
- Y) The copper reacted with ammonia, forming a soluble species
- Z) The ammonia neutralized the hydroxide, releasing soluble copper (II)

ANSWER: Y) THE COPPER REACTED WITH AMMONIA, FORMING A SOLUBLE SPECIES

TOSS-UP

13) Biology – *Short Answer* The five-prime cap added to mRNA is a modified version of what nucleotide base?

ANSWER: GUANINE

BONUS

13) Biology – *Short Answer* Identify all of the following three statements that are true regarding a neuron at rest: 1) Voltage-gated sodium channels are mostly open; 2) Voltage-gated potassium channels are mostly open; 3) The sodium-potassium pump is hydrolyzing [*HIGH-droh-lyzing*] ATP.

ANSWER: 3

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**TOSS-UP**

14) Physics – *Short Answer* When looking at it through a plane mirror, a flagpole appears to be 10 centimeters tall. Given that the eye-to-mirror distance is 0.4 meters and the total eye-to-mirror-to-pole distance is 30 meters, what is the actual height, in meters, of the flagpole?

ANSWER: 7.5 (ACCEPT: 15/2, 7½ )

**BONUS**

14) Physics – *Short Answer* A cannon fires several cannonballs at the same initial speed but at several different angles, the furthest landing 100 meters away. What is the slowest possible speed, in meters per second and to the nearest ten, at which these cannonballs could have been fired?

ANSWER: 30

### TOSS-UP

15) Energy – *Multiple Choice* Lithium-ion batteries are generally built in the discharged state, then recharged after construction. Which of the following best explains why this is done?

- W) The materials in the discharged state can be exposed to the atmosphere safely
- X) In the charged state, the raw materials pose a risk of dendrite formation
- Y) Lithium dendrites cannot form in the discharged state
- Z) Lithiated manganese materials are particularly unstable in the presence of humidity

ANSWER: W) THE MATERIALS IN THE DISCHARGED STATE CAN BE EXPOSED TO THE ATMOSPHERE SAFELY

### BONUS

15) Energy – *Short Answer* Scientists at Pacific Northwest National Lab are studying how the El Nino Southern Oscillation, or ENSO is changing over time. Identify all of the following three statements that are TRUE concerning their findings: 1) El Nino is accompanied by increased likelihood of rainfall over California; 2) The intensity of ENSO events will likely increase due to climate change; 3) The variability in yearly rainfall will likely increase globally due to ENSO events.

ANSWER: ALL

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TOSS-UP

16) Chemistry – *Multiple Choice* Which of the following substances is more soluble in toluene than in water?

- W) Carbon tetrachloride
- X) Sodium chloride
- Y) Acetic acid
- Z) Sodium methoxide

ANSWER: W) CARBON TETRACHLORIDE

BONUS

16) Chemistry – *Multiple Choice* A physical chemist has determined the vapor pressure of a liquid at multiple temperatures and wants to determine the standard entropy of vaporization. Which of the following sets of axes will enable the chemist to graph the data as a line and determine the entropy from the y-intercept?

- W) Pressure on y, temperature on x
- X) One over pressure on y, temperature on x
- Y) Natural log of pressure on y, temperature on x
- Z) Natural log of pressure on y, one over temperature on x

ANSWER: Z) NATURAL LOG OF PRESSURE ON Y, ONE OVER TEMPERATURE ON X

TOSS-UP

17) Math – *Short Answer* What is the integral with respect to x from 9 to 64 of the derivative of the square root of x ?

ANSWER: 5

BONUS

17) Math – *Short Answer* The graph of the polar equation $r = 6 \cos \theta$ is a circle. What are its radius and cartesian-coordinate center, respectively?

ANSWER: RADIUS 3, CENTER (3, 0) (ACCEPT: $x = 3$ AND $y = 0$ for center)

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**TOSS-UP**

18) Earth and Space – *Multiple Choice* A soil sample is extracted from a soil monolith in a temperate forest environment. The sample contains a relatively high concentration of sand and silt as well as leached minerals. What soil horizon does the sample represent?

- W) A
- X) B
- Y) C
- Z) E

ANSWER: Z) E

**BONUS**

18) Earth and Space – *Short Answer* What is the name for a location on Earth that does not have tides?

ANSWER: AMPHIDROMIC POINT (ACCEPT: TIDAL NODES)

**TOSS-UP**

19) Physics – *Short Answer* What quantity, inversely related to compressibility, measures a material’s ability to resist pressures coming from all sides, such as when underwater?

ANSWER: BULK MODULUS

**BONUS**

19) Physics – *Short Answer* Identify all of the following three quantities that are dimensionless:  
1) Tensile [*TEN-sile*] stress; 2) Tensile strain; 3) Young’s Modulus.

ANSWER: 2

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TOSS-UP

20) Math – *Short Answer* How many terms does the binomial expansion of open parenthesis $8x^3 + 5y^2$ close parenthesis to 18th power contain?

ANSWER: 19

BONUS

20) Math – *Short Answer* What are the coordinates of the image of the point $(-1, 4)$ when it is rotated about the point $(3, 2)$ by 90 degrees counterclockwise?

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

TOSS-UP

21) Biology – *Short Answer* What is the name of the jelly-like fluid that fills the human eye?

ANSWER: VITREOUS HUMOR (ACCEPT: VITREOUS BODY)

BONUS

21) Biology – *Short Answer* Identify all of the following three vitamins that are considered fat-soluble:

1) Biotin; 2) Cobalamin [*koh-BALL-ah-min*]; 3) Niacin.

ANSWER: NONE

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### TOSS-UP

22) Chemistry – *Short Answer* Identify all of the following three statements that are true regarding the denticity of ligands [*LIH-gundz*]: 1) Bromine [*BROH-meen*] is a monodentate ligand;

2) Diethylenetriamine [*dye-ethileen-tri-ah-meen*] is a bidentate ligand; 3) EDTA is a quadridentate [*kwah-trah-DEN-tate*] ligand.

ANSWER: 1

### BONUS

22) Chemistry – *Short Answer* Identify all of the following three molecules that have the chemical formula  $C_4H_8O$ : 1) Acetone; 2) Butanone; 3) Butyraldehyde.

ANSWER: 2 AND 3

### TOSS-UP

23) Earth and Space – *Short Answer* What spectral class of stars possesses the strongest Balmer lines?

ANSWER: A (ACCEPT: A-ZERO)

### BONUS

23) Earth and Space – *Short Answer* When a muon [*MYOO-on*] is created in a laboratory setting, it has a lifetime of approximately 2.2 microseconds. When muons are created by cosmic rays, they have speeds of 99.5% of the speed of light relative to observers on Earth. For an observer on Earth, how long, to two significant figures and in microseconds, will the lifetime of the cosmic ray muon be?

ANSWER: 22