

HIGH SCHOOL - ROUND 4A

TOSS-UP

1) Physics – *Short Answer* During a Science Bowl study session, the team captain pushed a textbook across a frictionless table with a force of 1.8 newtons. If the distance she pushed the book is 1.5 meters, how much work, in joules, did she do on the book?

ANSWER: 2.7

BONUS

1) Physics – *Short Answer* A 15-kilogram fish is swimming at 2 meters per second and eats a smaller, 5-kilogram fish that is stationary. What is the final velocity, in meters per second, of the two-fish system?

ANSWER: 1.5

~~~~~

### TOSS-UP

2) Earth and Space – *Multiple Choice* What type of volcano is characterized by gentle eruptions and large, gently-sloped landforms?

- W) Composite
- X) Lava dome
- Y) Cinder cone
- Z) Shield

ANSWER: Z) SHIELD

### BONUS

2) Earth and Space – *Short Answer* Order the following three cloud types in increasing order of elevation in the Earth's atmosphere: 1) Altocumulus; 2) Cirrocumulus; 3) Stratocumulus.

ANSWER: 3, 1, 2

**TOSS-UP**

3) Math – *Short Answer* An artist creates the background for a painting by placing a circle in a square frame so that their centers coincide. If the radius of the circle is 7 inches, and the minimum distance from the circle to the square is 5 inches, what is the perimeter, in inches, of the inside of the frame?

ANSWER: 96

**BONUS**

3) Math – *Short Answer* Solve the following equation for  $x$  over the real numbers: 32 to the power open parenthesis  $2x$  close parenthesis equals 4 to the power open parenthesis  $2x$  minus 1 close parenthesis.

ANSWER:  $-1/3$

~~~~~  
TOSS-UP

4) Chemistry – *Short Answer* How many electrons does the beryllium [*beh-RILL-ee-um*] two plus cation [*CAT-eye-on*] have in its valence [*VAY-lence*] shell?

ANSWER: TWO

BONUS

4) Chemistry – *Short Answer* What element is formed when nitrogen-13 decays by positron emission?

ANSWER: CARBON

TOSS-UP

5) Energy – *Short Answer* Fermilab’s [*FUR-mee-labs*] MicroBooNE collaboration is currently operating a 170-ton Liquid Argon Time Projection Chamber that is used to detect what class of leptons?

ANSWER: NEUTRINO

BONUS

5) Energy – *Short Answer* Scientists at Los Alamos National Lab are currently using computational models to study the astrophysical processes that produced the lanthanide and actinide elements. Identify all of the following three situations that produce rare-earth elements: 1) Big-bang nucleosynthesis; 2) The core of a four solar-mass main-sequence star; 3) The collision of two neutron stars.

ANSWER: 3

~~~~~  
**TOSS-UP**

6) Biology – *Multiple Choice* Bacteria at deep sea vents obtain energy by oxidizing hydrogen sulfide. They would be classified as which of the following?

- W) Photoautotrophic [*photo-auto-TROH-fik*]
- X) Chemoautotrophic [*kee-moh-auto-TROH-fik*]
- Y) Photoheterotrophic [*photo-hetero-TROW-fik*]
- Z) Chemoheterotrophic [*kee-moh-hetero-TROH-fik*]

ANSWER: X) CHEMOAUTOTROPHIC

**BONUS**

6) Biology – *Short Answer* Human vision occurs due to the photoisomerization [*photo-eye-saw-mer-ih-ZAY-shun*] of what molecule?

ANSWER: RETINAL (ACCEPT: RETINALDEHYDE, DO NOT ACCEPT: RETINOL – *if you can tell the difference*)

**TOSS-UP**

7) Chemistry – *Short Answer* How many aluminum atoms are in one formula unit of the compound aluminum sulfate?

ANSWER: 2

**BONUS**

7) Chemistry – *Multiple Choice* Which of the following statements concerning pressure-temperature phase diagrams is NOT TRUE?

W) The slope of the liquid-solid coexistence curve is positive if the solid floats on the liquid

X) Fluids at a pressure above the critical pressure cannot be boiled

Y) Gases are found in the low-pressure, high-temperature regime

Z) It is not possible for four phases of the same substance to be in equilibrium

ANSWER: W) THE SLOPE OF THE LIQUID-SOLID COEXISTENCE CURVE IS POSITIVE IF THE SOLID FLOATS ON THE LIQUID



**TOSS-UP**

8) Math – *Short Answer* A segment has its midpoint at (4, 2) and one endpoint at (1, 7). What are the coordinates of the other endpoint?

ANSWER: (7, -3) (ACCEPT:  $x = 7$  AND  $y = -3$ )

**BONUS**

8) Math – *Short Answer* What is the sum from  $n = 1$  to 6 of  $3n^2$ ?

ANSWER: 273

**TOSS-UP**

9) Biology – *Multiple Choice* What is the function of the operculum [*oh-PURR-kyoo-lum*] in fish?

- W) Propulsion
- X) Protection of gills
- Y) Sensing predators
- Z) Decreasing drag when swimming

ANSWER: X) PROTECTION OF GILLS

**BONUS**

9) Biology – *Short Answer* What is the percent probability that a child inherits a mitochondrial [*my-tow-KON-dree-ul*] disorder from her father?

ANSWER: 0

~~~~~  
TOSS-UP

10) Energy – *Short Answer* Lead-acid batteries are commonly found in cars. In these batteries, what substance serves as the electrolyte?

ANSWER: SULFURIC ACID (ACCEPT: H₂SO₄)

BONUS

10) Energy – *Short Answer* The Fermilab PICO [*PEE-koh*] collaboration is currently studying the hypothesized spin-dependent scattering of WIMPs [*wimps*] off nuclei [*NEW-klee-eye*]. Identify all of the following three nuclei with which WIMPs could hypothetically interact in this manner: 1) Carbon-12; 2) Fluorine-18 [*FLOOR-een eighteen*]; 3) Fluorine-19.

ANSWER: 3

TOSS-UP

11) Earth and Space – *Short Answer* The Dalton minimum and Modern maximum all correspond to the occurrence of what?

ANSWER: SUNSPOTS

BONUS

11) Earth and Space – *Short Answer* What is the term for a spherically-shaped, dense group of up to a million stars that are thought to share a common origin?

ANSWER: GLOBULAR CLUSTER



TOSS-UP

12) Physics – *Short Answer* What scientist is famous for discovering X-rays?

ANSWER: WILHELM ROENTGEN (ACCEPT: ROENTGEN)

BONUS

12) Physics – *Short Answer* A meteor strikes the Earth and ejects a rock to a final speed of 8 kilometers per second, accelerating it over the course of 5 meters. Assuming the acceleration is constant and in kilometers per second squared, what is the magnitude of the acceleration upon the rock?

ANSWER: 6,400

TOSS-UP

13) Biology – *Short Answer* What animal phylum [*FYE-lum*] has the greatest number of identified species?

ANSWER: ARTHROPODA

BONUS

13) Biology – *Multiple Choice* Which of the following is not a characteristic of paedomorphic [*ped-oh-MOOR-fik*] amphibians?

- W) Delayed sexual maturity
- X) Aquatic life
- Y) External gills
- Z) Tadpole-like tail

ANSWER: W) DELAYED SEXUAL MATURITY

~~~~~  
**TOSS-UP**

14) Earth and Space – *Short Answer* What is the term for the steady downhill flow of soil?

ANSWER: CREEP

**BONUS**

14) Earth and Space – *Short Answer* What is the name for the area of low pressure encircling Earth near the equator where the northeast and southeast trade winds come together?

ANSWER: INTERTROPICAL CONVERGENCE ZONE (ACCEPT ITCZ)

### TOSS-UP

15) Energy – *Short Answer* Researchers at the Advanced Photon Source have been studying a class of high-temperature superconductors based on a barium-arsenic crystal structure. These materials can demonstrate certain hallmarks of superconductivity when the material is ferromagnetic. What is the term for the transition temperature at which these materials will become paramagnetic?

ANSWER: CURIE TEMPERATURE

### BONUS

15) Energy – *Short Answer* Researchers at Ames Lab have made a double salt consisting of two anions [*AN-eye-ons*], platinum two minus and hydride, and one very large cation [*CAT-eye-on*]. What 6th-row s-block element was used as the cation in this salt?

ANSWER: CESIUM [*SEEZ-ee-um*]

~~~~~

TOSS-UP

16) Chemistry – *Multiple Choice* According to Boyle's Law, the volume of a gas is linearly related to what quantity?

- W) Pressure
- X) Pressure squared
- Y) One over pressure
- Z) One over pressure squared

ANSWER: Y) ONE OVER PRESSURE

BONUS

16) Chemistry – *Multiple Choice* Which of the following statements is the best explanation for why the atomic radius decreases across a period to the right?

- W) Increase in ionization [*eye-on-ih-ZAY-shun*] energy at the valence [*VAY-lence*] shell
- X) Increase in effective nuclear charge at the valence shell
- Y) Increase in atomic polarizability [*POH-lah-rize-ah-BIL-itee*] at the valence shell
- Z) Increase in electron affinity at the valence [*VAY-lence*] shell

ANSWER: X) INCREASE IN EFFECTIVE NUCLEAR CHARGE AT THE VALENCE SHELL

TOSS-UP

17) Math – *Short Answer* What is the second derivative with respect to x of $6x^2 - 15$ evaluated at $x = 7$?

ANSWER: 12

BONUS

17) Math – *Short Answer* How many points of intersection are there for the graphs of $y = 3^x$ and $y = x^2 - 3$?

ANSWER: 1



TOSS-UP

18) Physics – *Multiple Choice* Which of the following is an example of an action that demonstrates negative work?

- W) Lifting a book
- X) Holding a book
- Y) Throwing a book to the ground
- Z) Gently lowering a book to the ground

ANSWER: Z) GENTLY LOWERING A BOOK TO THE GROUND

BONUS

18) Physics – *Short Answer* A hunter fires a bullet at 300 meters per second at an angle 30 degrees above the horizontal. To two significant figures and in seconds, how long does it take for the bullet to reach its highest point?

ANSWER: 15

TOSS-UP

19) Biology – *Short Answer* Mast cells are responsible for releasing what important signaling molecule that triggers vasodilation [*vay-zoh-dye-LAY-shun*] and inflammation?

ANSWER: HISTAMINE

BONUS

19) Biology – *Short Answer* In order for an animal to be classified as a coelomate [*SEEL-oh-mate*], it must have a body cavity that is completely lined with tissue from what germ layer?

ANSWER: MESODERM



TOSS-UP

20) Earth and Space – *Short Answer* How many known objects in our solar system have a radius that is larger than that of Earth?

ANSWER: FIVE

BONUS

20) Earth and Space – *Short Answer* Identify all of the following three types of objects that could be considered meteors: 1) Fragments of asteroids; 2) Fragments of comets; 3) Impact debris from Mars.

ANSWER: ALL

TOSS-UP

21) Chemistry – *Short Answer* In the Clemmensen reduction, zinc amalgam is used to reduce ketones [*KEE-tones*] and aldehydes to alkanes. In the preparation of zinc amalgam, in what substance is zinc dissolved?

ANSWER: MERCURY

BONUS

21) Chemistry – *Short Answer* Identify all of the following three statements that are true regarding enthalpies of reaction: 1) For the formation of water from oxygen and hydrogen, the enthalpy [*EN-thul-pee*] change depends on the final phase of the water; 2) For the combustion of methane, the forward reaction and the reverse reaction have the same enthalpy; 3) Enthalpy is an intensive property.

ANSWER: 1

~~~~~

### TOSS-UP

22) Physics – *Multiple Choice* Hubble's law states that there is a direct correlation between the distance to a galaxy and which of the following quantities:

- W) Recessional velocity
- X) Total mass
- Y) Blue-shift wavelength
- Z) Precession period

ANSWER: W) RECESSIONAL VELOCITY

### BONUS

22) Physics – *Short Answer* A track star runs exactly one lap around a circular track at a constant speed. Identify all of the following three statements that are true of this system: 1) Her average speed is greater than the magnitude of her average velocity; 2) Her velocity is constant; 3) The magnitude of her average velocity after half of her journey is equal to her average speed at that time.

ANSWER: 1

**TOSS-UP**

23) Math – *Short Answer* Solve the following equation for  $x$ : the absolute value of open parenthesis  $x - 3$  close parenthesis is equal to 5.

ANSWER:  $-2$  AND  $8$

**BONUS**

23) Math – *Short Answer* What is the derivative evaluated at  $x = 5$  of the fraction with numerator  $x^3 - 8$  and denominator  $x - 2$ ?

ANSWER:  $12$