

## HIGH SCHOOL - ROUND 2A

---

### TOSS-UP

1) Chemistry – *Multiple Choice* A student is holding two balloons, one containing one mole of hydrogen gas and the other containing one mole of helium gas. What is the ratio of the volume of the helium balloon to that of the hydrogen balloon?

- W) 1/2
- X) 1
- Y) 2
- Z) 4

ANSWER: X) 1

### BONUS

1) Chemistry – *Short Answer* Rank the following three elements in increasing order of atomic radius:  
1) Calcium; 2) Chlorine; 3) Magnesium.

ANSWER: 2, 3, 1

~~~~~

### TOSS-UP

2) Physics – *Short Answer* The radioactive decay of magnesium-23 to sodium-23 is mediated by which fundamental force?

ANSWER: WEAK FORCE (ACCEPT: WEAK NUCLEAR FORCE)

### BONUS

2) Physics – *Short Answer* A block rests on an inclined plane angled at 30 degrees from the horizontal. What is the ratio of the normal force to the force down the surface of the plane?

ANSWER:  $\sqrt{3}$  (ACCEPT:  $\sqrt{3}$  TO 1)

**TOSS-UP**

3) Energy – *Short Answer* Researchers at Lawrence Berkeley National Lab are studying a tunable, hypersensitive form of MRI that could present a breakthrough in cancer diagnostics. Typically, MRI machines use radio frequency pulses to measure the distribution of what element?

ANSWER: HYDROGEN

**BONUS**

3) Energy – *Short Answer* Identify all of the following three fuels that could be used in a fuel cell:

1) Methane; 2) Hydrogen; 3) Carbon monoxide.

ANSWER: ALL

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

4) Biology – *Short Answer* Glucagon [*GLUE-kah-gon*] is primarily manufactured in the alpha cells of what human organ?

ANSWER: PANCREAS

**BONUS**

4) Biology – *Short Answer* A molecular biologist wishes to move a section of DNA from one plasmid to another. After cutting the first plasmid with restriction enzymes and isolating the band of DNA of interest, she mixes together the second, already-cleaved plasmid and the DNA of interest. What enzyme must she add to finish incorporating the gene into the plasmid?

ANSWER: LIGASE (ACCEPT: DNA LIGASE, RECOMBINASE)

**TOSS-UP**

5) Math – *Short Answer* In the expansion of the cube of  $a + 2b$ , what is the coefficient of the  $ab^2$  term?

ANSWER: 12

**BONUS**

5) Math – *Short Answer* Solve the following system of 2 equations:  $2x + y = 5$  and  $x - y = 1$ .

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



**TOSS-UP**

6) Earth and Space – *Short Answer* What technique is employed by astronomers to study the ways in which matter interacts with or emits electromagnetic radiation?

ANSWER: SPECTROSCOPY

**BONUS**

6) Earth and Space – *Short Answer* What prominent meteor shower is active from mid-July to late-August, and is associated with Comet Swift-Tuttle?

ANSWER: PERSEID

**TOSS-UP**

7) Chemistry – *Short Answer* How many ligands [*LIH-gundz*] does a molecule with octahedral geometry possess?

ANSWER: SIX

**BONUS**

7) Chemistry – *Short Answer* Rank the following three elements in increasing order of first ionization energy: 1) Magnesium; 2) Phosphorus; 3) Chlorine.

ANSWER: 1, 2, 3

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

8) Physics – *Short Answer* A car is uniformly accelerating in a straight line, traveling 120 meters in 12 seconds. If its velocity as it reaches the end of the 120 meters is 13 meters per second, then, in meters per second, what was its initial velocity?

ANSWER: 7

**BONUS**

8) Physics – *Short Answer* What is the equivalent resistance, in ohms, of a circuit composed of a 2-ohm, a 10-ohm, and a 40-ohm resistor connected in parallel?

ANSWER: 8/5 (ACCEPT 1 3/5 or 1.6)

**TOSS-UP**

9) Energy – *Short Answer* The Deep Underground Neutrino [*new-TREE-no*] Experiment is an effort at Fermilab to send neutrinos between two points separated by a large distance to give them time to undergo what unique behavior of neutrinos?

ANSWER: OSCILLATION

**BONUS**

9) Energy – *Multiple Choice* Which of the following is the most important difference between fast nuclear reactors and thermal nuclear reactors?

- W) They use different fuel configurations
- X) Unlike thermal reactors, fast reactors do not use a moderator
- Y) Thermal reactors have a higher neutron flux than fast reactors
- Z) Thermal reactors run at higher temperatures than fast reactors

ANSWER: X) UNLIKE THERMAL REACTORS, FAST REACTORS DO NOT USE A MODERATOR



**TOSS-UP**

10) Math – *Short Answer* What is the arc length of a sector of a circle with radius 2 and central angle pi over three?

ANSWER:  $2\pi/3$  (ACCEPT:  $(2/3)\pi$ )

**BONUS**

10) Math – *Short Answer* A student has a paper cup in the shape of a right circular cone, with a height of 5 inches and an opening diameter of 3 inches. How many of these paper cups of water will it take the student to fill a cylindrical container of diameter 3 inches and height 10 inches?

ANSWER: 6

**TOSS-UP**

11) Earth and Space – *Short Answer* What is the term for the point of origin within the Earth of seismic waves in an earthquake?

ANSWER: FOCUS (ACCEPT: HYPOCENTER)

**BONUS**

11) Earth and Space – *Short Answer* What name is given to the boundary between the Earth's crust and mantle where P-wave velocity jumps from approximately 6 kilometers per second to approximately 8 kilometers per second?

ANSWER: MOHO (ACCEPT: MOHOROVIČIĆ DISCONTINUITY)

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

12) Biology – *Multiple Choice* Beadle and Tatum's one gene-one enzyme hypothesis was formed from the results of their investigation of which of the following biological processes?

- W) Operon inhibition
- X) Amino acid biosynthesis
- Y) DNA replication
- Z) Limited proteolysis [*pro-tee-AW-lih-sis*]

ANSWER: X) AMINO ACID BIOSYNTHESIS

**BONUS**

12) Biology – *Short Answer* Identify all of the following three plant nutrients that are required for the light reactions of photosynthesis to occur: 1) Iron; 2) Nickel; 3) Molybdenum [*muh-LIB-den-um*].

ANSWER: 1

**TOSS-UP**

13) Math – *Short Answer* If  $f$  of  $x$  is equal to  $5x^2 - 6x + 2$ , what is  $f$  of 3?

ANSWER: 29

**BONUS**

13) Math – *Short Answer* What is the limit as  $x$  approaches 0 of the fraction with numerator  $x + \sin x$  and denominator  $e$  to the  $x$  power minus 1?

ANSWER: 2

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

14) Physics – *Short Answer* What physical quantity is defined as the rate of change of a particle's energy with respect to time?

ANSWER: POWER

**BONUS**

14) Physics – *Short Answer* A linear spring is hung from the ceiling. When a 1-kilogram block is hung from the spring, the spring's length increases by 2 meters. If another 1-kilogram block is hung from 8 similar springs connected in parallel, then, in meters, what will be the change in length of each of the springs?

ANSWER: 0.25 (ACCEPT: ¼)

**TOSS-UP**

15) Energy – *Short Answer* The first useful nuclear-generated electricity was produced in Idaho in 1951. The nuclear reactor was designed and built by what DOE national laboratory?

ANSWER: ARGONNE NATIONAL LAB (ACCEPT: ARGONNE)

**BONUS**

15) Energy – *Short Answer* The electrodes in hydrogen fuel cells are generally composed of what catalytically-active element?

ANSWER: PLATINUM

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

16) Earth and Space – *Multiple Choice* Which of the following minerals would be found in least abundance in a typical gabbro [*gab-roh*]?

- W) Muscovite
- X) Plagioclase [*PLAY-jee-oh-klaze*]
- Y) Augite [*AW-jite*]
- Z) Hornblende

ANSWER: W) MUSCOVITE

**BONUS**

16) Earth and Space – *Short Answer* Identify all of the following three features that are associated with karst landscapes. 1) Disappearing streams; 2) Stalagmites [*stah-LAG-mites*]; 3) Sinkholes.

ANSWER: ALL



### TOSS-UP

17) Chemistry – *Short Answer* What is the hybridization [**HIGH-brih-dye-ZAY-shun**] of the carbon atoms in polyethylene?

ANSWER: sp<sup>3</sup>

### BONUS

17) Chemistry – *Short Answer* Rank the following three elements in increasing order of boiling point:  
1) Tellurium [**te-LOOR-ee-um**]; 2) Sulfur; 3) Selenium.

ANSWER: 2, 3, 1

~~~~~

### TOSS-UP

18) Biology – *Short Answer* Sand dollars belong to what phylum [**FYE-lum**]?

ANSWER: ECHINODERMATA

### BONUS

18) Biology – *Short Answer* Identify all of the following three statements that are true regarding polysaccharides: 1) Cellulose microfibrils [**micro-FYE-brils**] are unbranched; 2) Glycogen [**GLYE-koh-jen**] granules are unbranched; 3) Amylopectin [**AM-il-oh-pek-tin**] granules are unbranched.

ANSWER: 1

**TOSS-UP**

19) Math – *Short Answer* What is the slope of the line that passes through the points (6, 2) and (2, 1)?

ANSWER: 1/4 (ACCEPT: 0.25)

**BONUS**

19) Math – *Short Answer* What is the units digit of 3 raised to the 33<sup>rd</sup> power?

ANSWER: 3



**TOSS-UP**

20) Physics – *Multiple Choice* Which of the following length scales best describes the spatial distortion resolution of the Laser Interferometer Gravitational-wave Observatory?

- W) Length of the interferometer arm
- X) Wavelength of the helium-neon laser
- Y) Radius of a silver atom
- Z) Thousandth of a proton diameter

ANSWER: Z) THOUSANDTH OF A PROTON DIAMETER

**BONUS**

20) Physics – *Multiple Choice* The spin quantum number is so named because spin can be expressed in which of the following units?

- W) Kilogram-meters-squared per second
- X) Pascal [*Pass-KAL*]-meters cubed
- Y) Coulomb [*KOO-lawm*]-volt
- Z) Watt-second

ANSWER: W) KILOGRAM-METERS-SQUARED PER SECOND

**TOSS-UP**

21) Earth and Space – *Short Answer* What is the brightest star in the constellation Orion?

ANSWER: RIGEL

**BONUS**

21) Earth and Space – *Short Answer* What is the term for objects that revolve around the Sun between the orbits of Jupiter and Neptune and are thought to be scattered Kuiper [**KYE-pur**] Belt objects?

ANSWER: CENTAURS (DO NOT ACCEPT: NEPTUNE TROJANS)



**TOSS-UP**

22) Biology – *Short Answer* In order for tropomyosin [**troh-poh-MY-oh-sin**] to be removed from the myosin-binding sites on actin, troponin [**TROH-poh-nin**] must bind to what second messenger?

ANSWER: CALCIUM (ACCEPT: CALCIUM TWO PLUS)

**BONUS**

22) Biology – *Short Answer* Cerebrospinal [**seh-REE-broh-SPY-nul**] fluid is produced by ependymal cells that line what brain cavities?

ANSWER: VENTRICLES (ACCEPT: LATERAL VENTRICLE, FOURTH VENTRICLE)

### TOSS-UP

23) Chemistry – *Short Answer* According to VSEPR theory, what is the electron-pair geometry of the central atom in the compound iodine trichloride?

ANSWER: TRIGONAL BIPYRAMIDAL

### BONUS

23) Chemistry – *Short Answer* Identify all of the following three properties of a liquid that decrease with increasing temperature: 1) Vapor pressure; 2) Viscosity; 3) Surface tension.

ANSWER: 2 AND 3