

## ROUND 14

### TOSS-UP

1) CHEMISTRY *Multiple Choice* Which of the following molecules has an electron pair geometry that matches its molecular geometry:

- W) H<sub>2</sub>O
- X) NH<sub>3</sub>
- Y) SO<sub>2</sub>
- Z) PCl<sub>5</sub>

ANSWER: Z) PCl<sub>5</sub>

### BONUS

1) CHEMISTRY *Multiple Choice* Which of the following is NOT a constitutional isomer of the organic compound whose molecular formula is C<sub>4</sub>H<sub>8</sub>:

- W) 1-butene
- X) 2-butene
- Y) 2-methyl-1-butene
- Z) 2-methyl-1-propene

ANSWER: Y) 2-METHYL-1-BUTENE

(Solution: 2-methyl-1-butene has a molecular formula of C<sub>5</sub>H<sub>10</sub>)

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### TOSS-UP

2) PHYSICS *Short Answer* Within the Standard Model of Particle Physics what particle is responsible for carrying the strong nuclear force?

ANSWER: GLUON

### BONUS

2) PHYSICS *Short Answer* What is the principle or law that fundamentally limits the accuracy of specifying at the same time the momentum and position of a particle?

ANSWER: HEISENBERG UNCERTAINTY PRINCIPLE (ACCEPT: UNCERTAINTY PRINCIPLE)

**TOSS-UP**

3) BIOLOGY *Multiple Choice* Which of the following occurs during synapsis of meiosis:

- W) non-sister chromatids of homologous chromosomes cross over
- X) sister chromatids of homologous chromosomes cross over
- Y) non-sister chromatids of non-homologous chromosomes cross over
- Z) sister chromatids of non-homologous chromosomes cross over

ANSWER: W) NON-SISTER CHROMATIDS OF HOMOLOGOUS CHROMOSOMES CROSS OVER

**BONUS**

3) BIOLOGY *Short Answer* If  $2n$  is the number of chromosomes and  $2s$  is the DNA content of a diploid human cell in G1 of the cell cycle, what are the  $n$  and  $s$  values, respectively, of a human spermatogonia at the end of telophase one of meiosis?

ANSWER: 1N AND 2S

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**TOSS-UP**

4) MATH *Short Answer* In simplest radical form, give the cosecant of a  $135^\circ$  angle:

ANSWER:  $\sqrt{2}$

**BONUS**

4) MATH *Short Answer* Find the value of  $k$  that will result in a unique, real solution for the following equation:  $kx^2 + 10x + 25 = 0$

ANSWER: 1

(Solution:  $b^2 - 4ac = 0$ ;  $100 - 4(k)(25) = 0$ ;  $k = 1$ )

### TOSS-UP

5) EARTH SCIENCE *Multiple Choice* Groundwater flows according to what law that, in its simplest form, is given by the equation  $Q = kIA$ :

- W) Darcy's Law
- X) Law of Superposition
- Y) Law of Original Horizontality
- Z) Ekman's Law

ANSWER: W) DARCY'S LAW

### BONUS

5) EARTH SCIENCE *Multiple Choice* Which of the following is a type of inland fog that occurs more often in spring when warm, moist air is cooled below its dew point as it moves over a cooler surface:

- W) advection fog
- X) radiation fog
- Y) reflection fog
- Z) steam fog

ANSWER: W) ADVECTION FOG

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### TOSS-UP

6) GENERAL SCIENCE *Multiple Choice* A primary consequence of acid rain in the northeast U.S. has been:

- W) salt-water intrusion in coastal wells
- X) the leaching out of toxic heavy metals in lakes and streams
- Y) increase in radioactive decay of parent bedrock
- Z) increased algal growth to cause eutrophication in lakes

ANSWER: X) THE LEACHING OUT OF TOXIC HEAVY METALS IN LAKES AND STREAMS

### BONUS

6) GENERAL SCIENCE *Short Answer* About two-thirds of the cause of acid precipitation is the production of sulfuric acid in the atmosphere. The production of what acid accounts for about the other one-third of acid rain?

ANSWER: NITRIC ACID (ACCEPT: NITROUS)

### TOSS-UP

7) ASTRONOMY *Multiple Choice* If an astronomer photographed a massive cloud of ionized hydrogen in space that was emitting all of the Balmer wavelengths, what color would it typically appear to us:

- W) white
- X) green
- Y) pink
- Z) blue

ANSWER: Y) PINK

### BONUS

7) ASTRONOMY *Multiple Choice* Which of the following was discovered in the 1600's about Venus that was strong evidence that the planets orbited the Sun:

- W) Venus's cloud cover reverses its direction in the sky at certain times of the year
- X) Venus has phases varying from crescent to full
- Y) Venus has an axial motion opposite to that of the Earth
- Z) Venus is the brightest planet in the sky only part of the year

ANSWER: X) VENUS HAS PHASES VARYING FROM CRESCENT TO FULL

### TOSS-UP

8) CHEMISTRY *Multiple Choice* For a given chemical reaction at constant temperature and pressure, if the value for Gibbs free-energy change is a negative, the reaction is always:

- W) endothermic
- X) exothermic
- Y) spontaneous
- Z) nonspontaneous

ANSWER: Y) SPONTANEOUS

### BONUS

8) CHEMISTRY *Multiple Choice* In a phase diagram, the solid-liquid line has a negative slope for which of the following pure substances:

- W) carbon dioxide
- X) water
- Y) ammonia
- Z) argon

ANSWER: X) WATER

(Solution: solid water is less dense than liquid water)

### TOSS-UP

9) PHYSICS *Multiple Choice* Which of the following was the big surprise in the classic gold foil experiments of Rutherford, Geiger and Marsden:

- W) alpha particles sometimes disappeared
- X) electrons would not penetrate the nucleus
- Y) the atom was mostly space as supported by the finding that most alpha particles continued on a straight path and hit the rear of the detection screen
- Z) some alpha particles left evidence of having returned almost straight back to hit the front part of the detection screen

ANSWER: Z) SOME ALPHA PARTICLES LEFT EVIDENCE OF HAVING RETURNED ALMOST STRAIGHT BACK TO HIT THE FRONT PART OF THE DETECTION SCREEN

### BONUS

9) PHYSICS *Short Answer* Most of the early classical experiments with alpha particles were done by Rutherford and co-workers using a simple scintillation detector, which was a screen most commonly coated with what substance?

ANSWER: ZINC SULFIDE (ACCEPT: ZnS)

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### TOSS-UP

10) BIOLOGY *Multiple Choice* Which of the following is NOT true of chloroplasts:

- W) they are relatively large organelles and can exceed 3 microns long
- X) they have smaller ribosomes than are found in the plant cytosol
- Y) they contain thylakoid (read as: THY-la-koid) stacks
- Z) their numbers are controlled primarily by the cell's nuclear genes that control division

ANSWER: Z) THEIR NUMBERS ARE CONTROLLED PRIMARILY BY THE CELL'S NUCLEAR GENES THAT CONTROL DIVISION

### BONUS

10) BIOLOGY *Short Answer* By number or name, identify all of the following 4 areas of plants where you would be MOST likely to see meristematic tissue:

- 1) longitudinal section of a terminal bud
- 2) cross-section of the pith of a sunflower stem
- 3) transverse section of a lateral root tip
- 4) cross-section of central parenchymal cells of a corn stem

ANSWER: 1 AND 3 (ACCEPT: 1 - LONGITUDINAL SECTION OF A TERMINAL BUD AND 3 - TRANSVERSE SECTION OF A LATERAL ROOT TIP)

**TOSS-UP**

11) MATH *Short Answer* Giving your answer as one, two, three, or four, in what quadrant will theta terminate if sine  $\theta$  and secant  $\theta$  are both negative?

ANSWER: 3

**BONUS**

11) MATH *Short Answer* Differentiate and simplify the following with respect to  $x$ :  $y = \ln |x|$   
(read as:  $y =$  natural log of absolute value of  $x$ )

ANSWER:  $\frac{1}{x}$

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**TOSS-UP**

12) EARTH SCIENCE *Multiple Choice* Which of the following is the global wind system that most influences weather in the West Indies and Central America:

- W) northeast trade winds
- X) prevailing westerlies
- Y) southeast trade winds
- Z) polar westerlies

ANSWER: W) NORTHEAST TRADE WINDS

**BONUS**

12) EARTH SCIENCE *Multiple Choice* Which of the following is the soil horizon that contains a mixture of organic matter and highly altered mineral matter and is dark in color:

- W) O-horizon
- X) A-horizon
- Y) C-horizon
- Z) R-horizon

ANSWER: X) A-HORIZON

### TOSS-UP

13) GENERAL SCIENCE *Multiple Choice* Which of the following statements is LEAST accurate:

- W) the molecular formula for dimethyl sulfoxide is C<sub>2</sub>H<sub>6</sub>SO
- X) black smokers are a type of hydrothermal vent found on the ocean floor
- Y) Io is the most volcanically active body in our Solar System
- Z) on a weather map, an adjacent series of closed half-circles along a line represents a cold front

ANSWER: Z) ON A WEATHER MAP, AN ADJACENT SERIES OF CLOSED HALF-CIRCLES ALONG A LINE REPRESENTS A COLD FRONT

### BONUS

13) GENERAL SCIENCE *Multiple Choice* Which of the following is NOT generally true regarding the hydrologic cycle world-wide:

- W) glaciers are shrinking
- X) river discharge is decreasing
- Y) precipitation at high altitudes is increasing
- Z) the thickness of sea ice over the Arctic Ocean is decreasing

ANSWER: X) RIVER DISCHARGE IS DECREASING

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### TOSS-UP

14) ASTRONOMY *Multiple choice* According to the location in the H-R diagram, which of the following stars has the highest absolute visual magnitude and is also the hottest:

- W) one located in the upper left of the diagram
- X) one located in the upper right of the diagram
- Y) one located in the lower left of the diagram
- Z) one located in the lower right of the diagram

ANSWER: W) ONE LOCATED IN THE UPPER LEFT OF THE DIAGRAM

### BONUS

14) ASTRONOMY *Short Answer* What is the MOST common scientific term for the specific spectral line-splitting effect resulting when atoms absorb or emit radiation in the presence of a magnetic field?

ANSWER: ZEEMAN EFFECT

### TOSS-UP

15) CHEMISTRY *Multiple Choice* In order to find the heat of reaction, or delta H naught, for a reaction using standard enthalpies of formation, the working formula is:

- W) delta H products minus delta H reactants
- X) delta H reactants minus delta H products
- Y) delta H reactants plus delta H products
- Z) delta H products plus delta H reactants

ANSWER: W) DELTA H PRODUCTS MINUS DELTA H REACTANTS

### BONUS

15) CHEMISTRY *Short answer* In crystallography, what is the coordination number, or number of nearest neighbors, of an atom in the simple cubic unit cell structure?

ANSWER: 6

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### TOSS-UP

16) PHYSICS *Multiple Choice* Which of the following is NOT true:

- W) the hydrogen nucleus has a lower binding energy per nucleon than the helium nucleus
- X) the tritium nucleus contains 3 nucleons
- Y) it is typically easier to fission U-238 than U-235 with slow neutrons
- Z) fission fragments of a nucleus are more often about 60% and 40% of the original mass of the atom than 50% and 50%

ANSWER: Y) IT IS TYPICALLY EASIER TO FISSION U-238 THAN U-235 WITH SLOW NEUTRONS

### BONUS

16) PHYSICS *Short Answer* In the Standard Model of particle physics, all forces arise because of the exchange of what fundamental class of particles?

ANSWER: BOSONS

### TOSS-UP

17) BIOLOGY *Multiple Choice* If the human SRY gene is inactivated in the first week of gestation, which of the following will occur:

- W) the embryo will die
- X) the embryo will remain female
- Y) the embryo will continue as a male
- Z) the embryo will remain in a quiescent state

ANSWER: X) THE EMBRYO WILL REMAIN FEMALE

### BONUS

17) BIOLOGY *Multiple Choice* Which of the following functions primarily by cutting RNA strands at specific sites:

- W) micro RNA
- X) episome
- Y) ribozyme
- Z) ligase

ANSWER: Y) RIBOZYME

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### TOSS-UP

18) MATH *Short Answer* Simplify the following trigonometric expression completely:  $\cos \theta \tan \theta$  (read as: cosine theta tangent theta)

ANSWER:  $\sin \theta$

### BONUS

18) MATH *Short Answer* In how many ways can 4 green, 2 yellow, and 2 red tee-shirts be given to 8 soccer players standing in a row if each player receives only one tee-shirt?

ANSWER: 420

(Solution:  $P = n!/(n_1! n_2! n_3! \dots)$ ;  $P = 8!/(4! 2! 2!) = 420$ )

### TOSS-UP

19) EARTH SCIENCE *Multiple Choice* Which of the following is a glacial feature that is NOT caused by the deposition of sediments:

- W) kame
- X) kettle
- Y) drumlin
- Z) bergshrund

ANSWER: Z) BERGSHRUND

### BONUS

19) EARTH SCIENCE *Multiple Choice* Analysis of which of the following isotopes is most commonly used because it gives the BEST indication of historical temperatures at different latitudes worldwide:

- W) oxygen
- X) carbon
- Y) nitrogen
- Z) potassium

ANSWER: W) OXYGEN

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### TOSS-UP

20) GENERAL SCIENCE *Short Answer* What is the SI unit for absorbed dose of ionizing radiation?

ANSWER: GRAY

### BONUS

20) GENERAL SCIENCE *Multiple Choice* Nisin is an antibiotic currently being studied because it has not yet induced widespread biological resistance. Which of the following is its mode of action:

- W) directly inhibits the electron transport system in bacteria
- X) inhibits in vivo endotoxin formation
- Y) binds to a bacterial cell wall precursor to form damaging pores in the plasma membrane
- Z) binds to 30-S ribosomal subunit

ANSWER: Y) BINDS TO A BACTERIAL CELL WALL PRECURSOR TO FORM DAMAGING PORES IN THE PLASMA MEMBRANE

**TOSS-UP**

21) ASTRONOMY *Short Answer* What is the most common astronomical term for the geometrical configuration where Venus is between the Earth and the Sun?

ANSWER: INFERIOR CONJUNCTION

**BONUS**

21) ASTRONOMY *Short Answer* How many degrees of arc are in 4 hours and 20 minutes of right ascension?

ANSWER: 65 DEGREES

(Solution: 15 degrees per hour)

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**TOSS-UP**

22) PHYSICS *Short Answer* What is the focal length, in centimeters and giving the proper sign, of a convex mirror that has a radius of curvature of 12 centimeters?

ANSWER: -6

(Solution: radius of curvature =  $2 \times$  focal length)

**BONUS**

22) PHYSICS *Short Answer* Rutherford and coworkers in the early 20<sup>th</sup> century found that when alpha particles strike nitrogen-14 nuclei, they most commonly produce what element?

ANSWER: OXYGEN (ACCEPT: OXYGEN-17 or O-17)

(Solution:  $\text{He-4} + \text{N-14} \rightarrow \text{O-17} + \text{proton}$ )

### TOSS-UP

23) CHEMISTRY *Short Answer* Predict the bond angles, in degrees, for atoms in a molecule of boron trichloride:

ANSWER: 120° (ACCEPT: THREE 120°)

### BONUS

23) CHEMISTRY *Short Answer* Consider a flexible balloon filled with 3.0 moles of helium at a temperature of 27°C and at a pressure of 101.3 kilopascals. What is the volume in the balloon, in liters to the nearest whole number?

ANSWER: 74

(Solution:  $V = (nRT)/P = [(3.0 \text{ mol})(0.0821 \text{ L}\cdot\text{atm}/\text{mol}\cdot\text{K})(300\text{K})]/1 \text{ atm} = 73.89\text{L}$ )

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### TOSS-UP

24) BIOLOGY *Short Answer* In which of the following 4 phases of cell cycle would a chemical that causes mispairing of bases during replication do the most damage: G-1; G-2; S; M

ANSWER: S

### BONUS

24) BIOLOGY *Short Answer* For a dihybrid cross between parent plants that are each heterozygous for both traits, if there is complete dominance and independent assortment, what is the total fraction of the offspring that will have a recessive phenotype for either trait and the dominant for the other?

ANSWER: 6/16 (ACCEPT: 3/8)

(Solution:  $3/16 + 3/16$ )

### TOSS-UP

25) PHYSICS *Short Answer* What is the angular velocity, in radians per second, of a wagon wheel with a diameter of 2 meters and a surface velocity of 3 meters per second?

ANSWER: 3

(Solution:  $T = v/r = 3/1 = 3$  rad/sec)

### BONUS

25) PHYSICS *Short Answer* The dread pirate Roberts orders his crew into a 100 kilogram rowboat to sail to an island to look for buried treasure. If the rowboat has a capacity of 1.10 cubic meters and is in freshwater, how many 50 kilogram pirates can board the rowboat before it would sink?

ANSWER: 20

(Solution:  $F_b = DgV = (1000 \text{ kg/m}^3)(9.8\text{m/s}^2)(1.10\text{m}^3) = 10,780\text{N}$ ;  $10,780\text{N} - (100\text{kg})(9.8\text{m/s}^2) = 9,800\text{N}$ . Each person weighs  $(50\text{kg})(9.8\text{m/s}^2) = 490\text{N}$ ;  $9800\text{N}/490\text{N} = 20$  pirates)