

## ROUND 14

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### TOSS-UP

1) EARTH AND SPACE *Multiple Choice* *Isotelus rex* [***i-SOH-te-luhs REKS***] was discovered in 1998 and is the largest found fossil of what organism?

- W) Dinosaur
- X) Whale
- Y) Fish
- Z) Trilobite

ANSWER: Z) TRILOBITE

### BONUS

1) EARTH AND SPACE *Short Answer* Winds aloft tend to form into longwaves. Assuming there is no divergence or convergence and the column of air cannot stretch or contract, as we follow the air at a constant speed and a constant 500 millibar level, it begins to flow southeastward, where the value of Earth's vorticity decreases. The conservation of what factor then causes the air to head northeastward?

ANSWER: ABSOLUTE VORTICITY

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### TOSS-UP

2) BIOLOGY *Multiple Choice* Which of the following fish is endemic to the island of Cozumel?

- W) Splendid toadfish
- X) Coelacanth [***SEE-luh-kanth***]
- Y) Mola mola
- Z) Orange roughy

ANSWER: W) SPLENDID TOADFISH

### BONUS

2) BIOLOGY *Short Answer* Arrange proximally to distally the following four components of a bird's contour feather: 1) superior umbilicus [***uhm-BIL-i-kuhs***], 2) rachis [***RAY-kis***], 3) calamus, 4) inferior umbilicus.

ANSWER: 4, 3, 1, 2 (ACCEPT: INFERIOR UMBILICUS, CALAMUS, SUPERIOR UMBILICUS, RACHIS)

### TOSS-UP

3) MATH *Short Answer* Given  $g(x) = 5 + \frac{x^2}{\sin(x^2)}$  [***g of x equals 5 plus the fraction with numerator x squared and denominator sine of the quantity x squared***], find  $\lim_{x \rightarrow 0} g(x)$  [***the limit as x approaches zero of g of x***].

ANSWER: 6

### BONUS

3) MATH *Multiple Choice* What is  $dy/dx$  for  $x^2 + y^2 = 2$  at the point with coordinates (1, 1)?

- W) -1
- X) -1/2
- Y) 0
- Z) 3/2

ANSWER: W) -1

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### TOSS-UP

4) ENERGY *Multiple Choice* Judged to be an intervention that delivers high impact per development dollar, improved cooking stoves aim to reduce greenhouse gas contribution by reducing the amount of what substance?

- W) Carbon dioxide
- X) Black carbon
- Y) Methane
- Z) Nitrous oxide

ANSWER: X) BLACK CARBON

### BONUS

4) ENERGY *Multiple Choice* Which of the following is NOT a common use for flue gas desulfurization [***dee-suhl-fuh-ri-ZAY-shuhn***] products?

- W) Raw material for drywall
- X) Raw material for plywood
- Y) Fill for structural applications
- Z) Feed stock in cement production

ANSWER: X) RAW MATERIAL FOR PLYWOOD

### TOSS-UP

5) CHEMISTRY *Short Answer* What simple system is used to describe molecular vibrations in quantum mechanics?

ANSWER: HARMONIC OSCILLATOR (ACCEPT: BALL AND SPRING)

### BONUS

5) CHEMISTRY *Short Answer* In free-radical polymerization [*puh-lim-er-uh-ZAY-shuhn*], there are two possible termination steps. One is combination of free radicals. What is the other?

ANSWER: DISPROPORTIONATION

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### TOSS-UP

6) PHYSICS *Multiple Choice* Which of the following quark compositions does NOT have a total of zero strangeness quantum number?

- W) Up, down
- X) Up, strange
- Y) Strange, antiparticle strange
- Z) Down, down

ANSWER: X) UP, STRANGE

### BONUS

6) PHYSICS *Multiple Choice* A concave spherical mirror has a radius of 200 centimeters. What object distance in centimeters from this mirror is needed to form a real image that is one fourth of the size of the object?

- W) 100
- X) 125
- Y) 250
- Z) 500

ANSWER: Z) 500

### TOSS-UP

7) EARTH AND SPACE *Multiple Choice* Which of the following organisms were NOT extinct by the end of the Cretaceous [**kri-TAY-shuhs**] period?

- W) Ichthyosaurs [**IK-thee-uh-sawrs**]
- X) Cyclophora [**sy-KLEEUH-fruh**]
- Y) Quetzalcoatlus [**ket-sahl-koh-AHT-luhs**]
- Z) Plesiosaurs [**PLEE-see-uh-sawrs**]

ANSWER: X) CYCLIOPHORA

### BONUS

7) EARTH AND SPACE *Short Answer* The orbit of an asteroid in our solar system has a semi-major axis of 4 AU. To the nearest integer, and in years, what is its period?

ANSWER: 8

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### TOSS-UP

8) BIOLOGY *Multiple Choice* The following are examples of proteins that are not functional because of some problem. In which of the following examples does the problem result from damage primarily to the secondary structure of the protein?

- W) The protein has been exposed to urea, which has disrupted its hydrogen bonds
- X) A mutation is at the active site of a protein and the protein has lost catalytic activity
- Y) A mutation is at the dimer [**DY-mer**] interface of a protein and prevents its dimerization
- Z) A protein has been exposed to an oily chemical that disrupts its hydrophobic core

ANSWER: W) THE PROTEIN HAS BEEN EXPOSED TO UREA, WHICH HAS DISRUPTED ITS HYDROGEN BONDS

### BONUS

8) BIOLOGY *Short Answer* Arrange the following six layers found in a one-year old woody sapling from most lateral to most medial: 1) Cortex, 2) Phloem [**FLOH-em**] fibers, 3) Pith, 4) Secondary phloem, 5) Periderm, 6) Secondary xylem [**ZY-luhm**].

ANSWER: 5, 1, 2, 4, 6, 3 (ACCEPT: PERIDERM, CORTEX, PHLOEM FIBERS, SECONDARY PHLOEM, SECONDARY XYLEM, PITH)

### TOSS-UP

9) MATH *Multiple Choice* What is the principal value in radians for  $\cos^{-1}\left(-\frac{\sqrt{3}}{2}\right)$  [**inverse cosine of negative square root of 3 over 2**]?

W)  $-\frac{\pi}{6}$

X)  $-\frac{\pi}{3}$

Y)  $\frac{5\pi}{6}$

Z)  $\frac{11\pi}{6}$

ANSWER: Y)  $\frac{5\pi}{6}$

### BONUS

9) MATH *Short Answer* Find  $\tan(\arccos(2x))$  [**the tangent of the arc-cosine of 2x**] in terms of  $x$ .

ANSWER:  $\sqrt{1-4x^2}/2x$

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### TOSS-UP

10) ENERGY *Multiple Choice* Roughly what percentage of the energy density of the universe is dark energy?

W) 13%

X) 35%

Y) 72%

Z) 99%

ANSWER: Y) 72%

### BONUS

10) ENERGY *Multiple Choice* Which of the following does NOT help explain why the theoretical yield of cellular respiration is never actually achieved?

W) Pyruvate [**py-ROO-vayt**] must be actively transported out of the mitochondria [**my-tuh-KON-dree-uh**]

X) Phosphate is actively transported into the mitochondria

Y) ADP and ATP are actively exchanged across the inner mitochondrial membrane

Z) The inner mitochondrial membrane leaks protons

ANSWER: W) PYRUVATE MUST BE ACTIVELY TRANSPORTED OUT OF THE MITOCHONDRIA

### TOSS-UP

11) CHEMISTRY *Short Answer* What is the relationship of the organic compounds diethyl ether, n-butyl alcohol, and methyl propyl ether?

ANSWER: STRUCTURAL ISOMERS (ACCEPT: CONSTITUTIONAL ISOMERS)

### BONUS

11) CHEMISTRY *Multiple Choice* Which of the following types of electrodes can cause problems because it is time-sensitive and its measurements result in a cumulative response?

- W) Enzyme
- X) Gas sensing
- Y) Solid state
- Z) Liquid membrane

ANSWER: W) ENZYME

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### TOSS-UP

12) PHYSICS *Multiple Choice* A body with a 2 kilogram mass has position vector  $r = 3i + 2t^2j$  meters. What is the velocity at  $t = 1$  second?

- W)  $1j$
- X)  $4j$
- Y)  $3i + 4j$
- Z)  $1i + 1j$

ANSWER: X)  $4j$

### BONUS

12) PHYSICS *Multiple Choice* Two objects with masses  $m_1$  and  $m_2$  are hanging vertically by different springs of spring constants  $k_1$  and  $k_2$ . If  $m_1 = 3m_2$  and  $k_1 = 2k_2$ , what is the ratio  $x_1/x_2$  of their stretches?

- W)  $2/3$
- X)  $3/2$
- Y) 4
- Z) 6

ANSWER: X)  $3/2$

### TOSS-UP

13) EARTH AND SPACE *Multiple Choice* Where do the strongest winds in Antarctica, which can reach 200 miles per hour, originate?

- W) Antarctic east coast
- X) Antarctic polar plateau
- Y) Antarctic circumpolar wave
- Z) Weddell Sea

ANSWER: X) ANTARCTIC POLAR PLATEAU

### BONUS

13) EARTH AND SPACE *Short Answer* By number, put the following four Earth events in chronological order from earliest to most recent: 1) first evidence of ice at the poles, 2) opening of the Red Sea, 3) separation of Australia and Antarctica post-Pangaea [*pan-JEE-uh*], 4) collision of India with Asia.

ANSWER: 3, 4, 1, 2

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### TOSS-UP

14) BIOLOGY *Short Answer* In muscle cells, the sarcoplasmic reticulum [*sahr-kuh-PLAHZ-mik-ri-TIK-yuh-luhm*] is an important organelle that permits the muscle cell to contract. It acts to store a particular chemical until it is electrically excited. What chemical is stored in the sarcoplasmic reticulum?

ANSWER: CALCIUM (ACCEPT: CALCIUM ION OR CA+2)

### BONUS

14) BIOLOGY *Multiple Choice* Which of the following microscopy methods would be most appropriate for observing the distribution of GFP in a cell?

- W) Simple light microscope
- X) Atomic force microscope
- Y) Fluorescence light microscope
- Z) Transmission electron microscope

ANSWER: Y) FLUORESCENCE LIGHT MICROSCOPE

### TOSS-UP

15) CHEMISTRY *Multiple Choice* Which of the following molecules has a permanent dipole moment?

- W) Carbon dioxide
- X) Methane
- Y) Hydrogen sulfide
- Z) Molecular nitrogen

ANSWER: Y) HYDROGEN SULFIDE

### BONUS

15) CHEMISTRY *Short Answer* List the five halogens in order of increasing first ionization energy.

ANSWER: ASTATINE, IODINE, BROMINE, CHLORINE, FLUORINE (DO NOT ACCEPT ANOTHER ORDER)

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### TOSS-UP

16) MATH *Short Answer* Solve for  $x$ :  $14 - \sqrt{3 - x} = 9$  [**14 minus the square root of the quantity 3 minus x equals 9**].

ANSWER: -22

### BONUS

16) MATH *Short Answer* A circle of radius 2 is centered at the point (2, 3). What is the slope of the line tangent to the circle at the point where  $x = 3$  and  $y$  is greater than 3?

ANSWER:  $\frac{-\sqrt{3}}{3}$  (DO NOT ACCEPT:  $\frac{-1}{\sqrt{3}}$ )



### TOSS-UP

17) CHEMISTRY *Multiple Choice* What is the change in the parent atom atomic number upon alpha particle emission?

- W) It decreases by 2
- X) It decreases by 1
- Y) It increases by 1
- Z) It increases by 2

ANSWER: W) IT DECREASES BY 2

### BONUS

17) CHEMISTRY *Short Answer* Providing your answer in proper point group abbreviation, to what point group does the molecule 1, 2-difluoroethane [**1 comma 2-di-floo-uh-roh-ETH-ayn**] belong?

ANSWER: C<sub>2h</sub>

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### TOSS-UP

18) PHYSICS *Multiple Choice* If the tension in a stretched string is multiplied by a factor of 9, the speed of the transverse wave is multiplied by what factor?

- W) 1/9
- X) 1/3
- Y) 3
- Z) 9

ANSWER: Y) 3

### BONUS

18) PHYSICS *Multiple Choice* Assuming the Boltzmann constant  $k = 1.38 \times 10^{-23}$  joules per Kelvin, what is the average translational kinetic energy in joules of molecules of an ideal gas at 127° Celsius?

- W)  $2.6 \times 10^{-21}$
- X)  $8.28 \times 10^{-21}$
- Y)  $2.6 \times 10^{-22}$
- Z)  $8.28 \times 10^{-22}$

ANSWER: X)  $8.28 \times 10^{-21}$

### TOSS-UP

19) BIOLOGY *Multiple Choice* When two pyrimidine [**py-RIM-i-deen**] bases are adjacent on a DNA strand, exposure to UV light will commonly lead to formation of a cyclobutane ring between them, resulting in a bulky lesion in the DNA. The normal replicative polymerases [**pol-uh-muh-RAYS-uhs**] cannot use this as a template, and the lesion often results in mutation if it cannot be repaired. Which of the following is an example of this lesion formed by UV exposure of neighboring pyrimidines [**py-RIM-i-deens**]?

- W) Transversion
- X) Cytosine deamination [**SY-tuh-seen**]
- Y) Thymine dimer [**THY-meen DY-mer**]
- Z) Intercalation

ANSWER: Y) THYMINE DIMER

### BONUS

19) BIOLOGY *Multiple Choice* Which of the following statements is true regarding the mechanism of infection in prion diseases?

- W) Prions invade the cell nucleus, altering DNA transcription processes
- X) Prions induce abnormal folding in normal protein molecules
- Y) Prions bind to specific sites on a ribosome [**RY-buh-sohm**], rendering them useless
- Z) Prions bind to mRNA, leaving the nucleus, inducing post-transcriptional changes before translation

ANSWER: X) PRIONS INDUCE ABNORMAL FOLDING IN NORMAL PROTEIN MOLECULES

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### TOSS-UP

20) EARTH AND SPACE *Multiple Choice* Which of the following features forms because parts of a glacier move at varying speeds and in different directions?

- W) Moraines
- X) Moulan
- Y) Crevasses
- Z) Arêtes [**uh-REYTS**]

ANSWER: Y) CREVASSES

### BONUS

20) EARTH AND SPACE *Short Answer* Order the following four steps that are theorized to have occurred in the formation of our atmosphere: 1) plants evolve and oxygen increases dramatically; 2) the atmosphere gradually becomes rich in nitrogen; 3) outgassing leads to abundant water vapor; 4) photodissociation increases oxygen gradually.

ANSWER: 3, 2, 4, 1

### TOSS-UP

21) MATH *Short Answer* What is the scalar product of the vectors  $2i - 3j + 2k$  and  $i + 2j + 2k$ ?

ANSWER: 0

### BONUS

21) MATH *Short Answer* What are the equations of all asymptotes -- vertical, horizontal, or oblique -- for the graph of the function  $f(x) = \frac{x^2 - 3x}{x - 1}$  [**f of x equals the fraction with numerator x squared minus 3x and denominator x minus 1**]?

ANSWER:  $x = 1$ ,  $y = x - 2$

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### TOSS-UP

22) ENERGY *Multiple Choice* When dealing with a tank of 150 pounds of water on a platform, it is most energy intensive to do which of the following?

- W) Lift the 150 pounds of water 2 feet in the air
- X) Lower the 150 pounds of water by 2 feet
- Y) Decrease the temperature of the water by 2° Fahrenheit
- Z) Increase the temperature of the water by 1° Fahrenheit

ANSWER: Y) DECREASE THE TEMPERATURE OF THE WATER BY 2° FAHRENHEIT

### BONUS

22) ENERGY *Short Answer* What process accounts for most of the Earth's geothermal energy?

ANSWER: RADIOACTIVE DECAY

**TOSS-UP**

23) BIOLOGY *Multiple Choice* Which of the following is NOT a point mutation?

- W) Missense
- X) Transversion
- Y) Inversion
- Z) Transition

ANSWER: Y) INVERSION

**BONUS**

23) BIOLOGY *Multiple Choice* The cotyledon [*kot-uhl-EED-uhn*] is which of the following?

- W) Primary embryonic leaf
- X) Primary embryonic petal
- Y) Secondary embryonic leaf
- Z) Secondary embryonic petal

ANSWER: W) PRIMARY EMBRYONIC LEAF

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**TOSS-UP**

24) CHEMISTRY *Multiple Choice* Who was the inventor of the first electrochemical cell?

- W) Michael Faraday
- X) Alessandro Volta
- Y) James Maxwell
- Z) Benjamin Franklin

ANSWER: X) ALESSANDRO VOLTA

**BONUS**

24) CHEMISTRY *Short Answer* A plastic undergoes deformation at 740° Celsius. Given that its original cross-sectional area is 70 centimeters, its cross-sectional area after deformation is 62 centimeters, and its yield strength is 300 megapascals, determine the percent cold work to the nearest whole number.

ANSWER: 11%

### TOSS-UP

25) PHYSICS *Multiple Choice* What physical unit is the product of velocity, magnetic field, and length?

- W) Volt
- X) Newton meter per ampere second squared
- Y) Joule per second squared
- Z) Newton per ampere

ANSWER: W) VOLT

### BONUS

25) PHYSICS *Short Answer* A 1 meter long wire lying along the  $x$ -axis carries a current of 10.0 amperes in the negative  $x$  direction. The wire is in a uniform magnetic field  $1.0 \times 10^{-3}$  teslas per square meter. Expressing your answer in scientific notation with one significant figure, what is the magnitude of the magnetic force on the wire in newtons?

ANSWER:  $1 \times 10^{-2}$