

## ROUND 14

---

### TOSS-UP

1) CHEMISTRY *Short Answer* To identify the chemical compounds dissolved in a sample, a student dips a clean piece of nichrome wire into the sample and burns it in a flame. The flame burns red. What metal does the mixture probably contain?

ANSWER: CALCIUM (ACCEPT: LITHIUM, STRONTIUM, RUBIDIUM)

### BONUS

1) CHEMISTRY *Short Answer* What are the decay mode and the daughter nuclide, respectively, of potassium-37?

ANSWER: ELECTRON CAPTURE, ARGON-37

---

### TOSS-UP

2) MATH *Short Answer* What is the maximum number of spheres with a radius of 1 that can fit inside a cube with edge lengths of 6?

ANSWER: 27

### BONUS

2) MATH *Short Answer* Find all points of inflection and extrema, including type, of the function

$$f(x) = \frac{e^x + e^{-x}}{2}.$$

ANSWER: RELATIVE MINIMUM (ACCEPT: MINIMUM) AT (0, 1)

[DO NOT ACCEPT: (0, 1) ALONE]

### TOSS-UP

3) PHYSICS *Short Answer* What is the phrase that describes the process of producing an electron and a positron when a high-energy photon travels through matter, directly converting radiant energy into matter?

ANSWER: PAIR PRODUCTION

### BONUS

3) PHYSICS *Short Answer* A living room has floor dimensions of 3.5 meters by 4.2 meters and a height of 2.4 meters. Given air density of 1.2 kilograms per cubic meter,  $g$  of 10 meters per second squared, and providing your answer to the nearest ten, what does the air in the room weigh in newtons?

ANSWER: 420

---

### TOSS-UP

4) BIOLOGY *Multiple Choice* Which of the following are NOT found in the thylakoid membranes of the chloroplast?

- W) Carotenoids
- X) Rubisco
- Y) Water
- Z) ADP

ANSWER: X) RUBISCO

### BONUS

4) BIOLOGY *Short Answer* By name or number, order the following five cell layers in a eudicot (read as: yuh-DY-koht) root from most lateral to most medial: 1) pericycle, 2) epidermis, 3) endodermis, 4) phloem, 5) cortex.

ANSWER: EPIDERMIS, CORTEX, ENDODERMIS, PERICYCLE, PHLOEM (ACCEPT: 2, 5, 3, 1, 4)

### TOSS-UP

5) CHEMISTRY *Short Answer* Give the specific name for the following functional group: a nitrogen atom bonded to two carbon chains and a hydrogen atom?

ANSWER: SECONDARY AMINE

### BONUS

5) CHEMISTRY *Short Answer* At 25° Celsius, the vapor pressure of water is about 3 kilopascals and the vapor pressure of methanol is about 15 kilopascals. Assuming no deviation from Raoult's law, determine the vapor pressure, in kilopascals, of a mixture of 1 mole of methanol and 2 moles of water.

ANSWER: 7

---

### TOSS-UP

6) PHYSICS *Short Answer* The period of revolution of a particle traveling in uniform circular motion is a function of what two variables?

ANSWER: VELOCITY (ACCEPT: CENTRIPETAL FORCE) AND RADIUS (ACCEPT: CIRCUMFERENCE, DIAMETER)

### BONUS

6) PHYSICS *Short Answer* You are asked to determine whether a king's crown is really made of gold. You weigh the crown; it weighs 8 newtons in air and 7 newtons in water. Its volume is 0.0001 cubic meters. Given that the density of gold is 19,000 kilograms per cubic meter, the density of lead is 11,000 kilograms per cubic meter, and the density of iron is 8,000 kilograms per cubic meter, the king's crown is made of which material?

ANSWER: IRON

### TOSS-UP

7) EARTH AND SPACE *Short Answer* The freshwater and saltwater zones within coastal aquifers are separated by a transition zone, also called the zone of dispersion, within which there is mixing between freshwater and saltwater. Which state of the Northern Atlantic Coastal Plain Aquifer System has the shallowest depth to the top of the transition zone?

ANSWER: NORTH CAROLINA

### BONUS

7) EARTH AND SPACE *Short Answer* In a stratified period of a lake, oxygen supplied directly by the atmosphere and photosynthetic organisms replenishes the dissolved oxygen of which of the following three choices: 1) epilimnion (read as: eh-pi-LIM-nee-ohn), 2) hypolimnion (read as: hy-pōe-LIM-nee-ohn), or 3) thermocline?

ANSWER: EPILIMNION (ACCEPT: 2)

---

### TOSS-UP

8) PHYSICS *Short Answer* Neglecting friction, a 33-kilogram cart rolls down a slope that is 20 meters high and 60 meters long. Using 10 meters per second squared for g, what is the velocity in meters per second at the base of the slope?

ANSWER: 20

### BONUS

8) PHYSICS *Short Answer* A long straight wire carries a 10 ampere current north. Give the magnitude in teslas and the direction of the magnetic field induced at a point 10 centimeters directly under the wire?

ANSWER:  $2 \times 10^{-5}$  WEST

### TOSS-UP

9) ENERGY *Multiple Choice* Approximately how much energy does the Sun generate in joules per hour if it converts about 4 billion kilograms of mass into pure energy every second?

- W)  $10^9$
- X)  $10^{18}$
- Y)  $10^{30}$
- Z)  $10^{33}$

ANSWER: Y)  $10^{30}$

### BONUS

9) ENERGY *Multiple Choice* In the presence of alcohol dehydrogenase, the rate of reduction of acetaldehyde to ethanol increases as you increase the concentration of acetaldehyde. Eventually, the rate of reaction reaches a maximum, where further increases in the concentration of acetaldehyde have no effect. Which of the following BEST explains this result?

- W) All of the alcohol dehydrogenase molecules are bound to acetaldehyde molecules
- X) At high concentrations of acetaldehyde, the activation energy of the reaction decreases
- Y) The enzyme is no longer specific for acetaldehyde
- Z) At high concentrations of acetaldehyde, the change in free energy of the reaction decreases

ANSWER: W) ALL OF THE ALCOHOL DEHYDROGENASE MOLECULES ARE BOUND TO ACETALDEHYDE MOLECULES

---

### TOSS-UP

10) MATH *Multiple Choice* Populations P1 and P2 are normally distributed and have identical means; however, the standard deviation of P1 is twice the standard deviation of P2. Which of the following is TRUE about the percentage of observations falling within two standard deviations of the mean for each population?

- W) The percentage for P1 is twice the percentage for P2
- X) The percentage for P1 is greater, but not twice as great, as the percentage for P2
- Y) The percentage for P2 is twice the percentage for P1
- Z) The percentages are identical

ANSWER: Z) THE PERCENTAGES ARE IDENTICAL

### BONUS

10) MATH *Short Answer* Find the second derivative of the function  $f(x) = (3 + 2x)e^{3x}$ .

ANSWER:  $3(6x + 5)e^{3x}$  [ACCEPT:  $(18x + 15)e^{3x}$ ]

### TOSS-UP

11) EARTH AND SPACE *Multiple Choice* Which of the following compounds is NOT a common cement in sedimentary rocks?

- W)  $\text{SiO}_2$
- X)  $\text{Fe}_2\text{O}_3$
- Y)  $\text{Mg}_2\text{SiO}_3$
- Z)  $\text{CaCO}_3$

ANSWER: Y)  $\text{Mg}_2\text{SiO}_3$

### BONUS

11) EARTH AND SPACE *Short Answer* The Ghyben-Herzberg relation characterizes the relationship between the depth of freshwater occurring above and below sea level in the presence of a saltwater intrusion. What physical property determines this relationship?

ANSWER: DENSITY

---

### TOSS-UP

12) PHYSICS *Multiple Choice* If the coulomb constant is  $9 \times 10^9$  newton meters squared per coulomb squared, what force, in newtons, will two particles with charges of +2 and -2 coulombs kept 2 meters apart exert on each other?

- W)  $4.5 \times 10^9$  away from each other
- X)  $4.5 \times 10^9$  toward each other
- Y)  $9.0 \times 10^9$  toward each other
- Z)  $1.8 \times 10^{10}$  toward each other

ANSWER: Y)  $9.0 \times 10^9$  TOWARD EACH OTHER

### BONUS

12) PHYSICS *Short Answer* Pam buys a pendulum clock at a discount store and discovers when she gets home that it loses 6 minutes each day. If the pendulum has a period of 2 seconds, by how much must the length be changed, to the nearest centimeter, so that the clock keeps accurate time?

ANSWER: 1

### TOSS-UP

13) EARTH AND SPACE *Multiple Choice* Which of the following statements is TRUE about Population I stars and II stars?

- W) Population I stars tend to be older than Population II stars
- X) Population I stars of a given mass tend to be more luminous than Population II stars of the same mass
- Y) Population I stars tend to be found in the spiral arms of galaxies, while Population II stars tend to be found in globular clusters
- Z) Population I stars tend to have fewer heavy elements than Population II stars

ANSWER: Y) POPULATION I STARS TEND TO BE FOUND IN THE SPIRAL ARMS OF GALAXIES, WHILE POPULATION II STARS TEND TO BE FOUND IN GLOBULAR CLUSTERS

### BONUS

13) EARTH AND SPACE *Short Answer* Eclipsing binaries are binary star systems whose members eclipse each other, blocking one another's light and thereby causing the system to look fainter to observers on Earth. Assuming that the eclipsing binary stars are spherical with circular orbits, by number, identify all of the following 5 choices which could influence the light curve of an eclipsing binary: 1) orbital inclination, 2) luminosities of the stars, 3) orbital period, 4) radii of the stars, 5) spectral type of the stars.

ANSWER: 1, 2, 3 AND 4

---

### TOSS-UP

14) ENERGY *Short Answer* What is the term for a kind of landfill technology, currently in research and development, that accelerates the biological decomposition of organic wastes in a landfill by promoting the conditions necessary for the microorganisms that degrade the waste?

ANSWER: BIOREACTOR

### BONUS

14) ENERGY *Short Answer* When water levels drop in a spent nuclear fuel pool, temperatures in the fuel assembly rise, accelerating the oxidation of the material that encases uranium oxide pellets. If the oxidation reactions become self-sustaining, a fire can form that proceeds as a burn front along the axis of the fuel rod toward the source of the oxidant. What is the name of the encasing material that is burning?

ANSWER: ZIRCONIUM CLADDING (ACCEPT: ZIRCONIUM)

**TOSS-UP**

15) BIOLOGY *Short Answer* Cowbirds, common cuckoos, and African honeyguides lay their eggs in the nests of other birds. As a result, what term is typically used to describe these birds?

ANSWER: BROOD PARASITE

**BONUS**

15) BIOLOGY *Short Answer* By name or number, identify all of the following five choices that are NOT essential amino acids for humans: 1) phenylalanine, 2) alanine, 3) tryptophan, 4) histidine, 5) aspartate?

ANSWER: ALANINE AND ASPARTATE (ACCEPT: 2 AND 5)

---

**TOSS-UP**

16) MATH *Short Answer* If  $x^2 + y^2 = 5^2$ , find  $\frac{dy}{dx}$  in terms of  $x$  and  $y$  in simplest form.

ANSWER:  $\frac{-x}{y}$

**BONUS**

16) MATH *Short Answer* A rectangle has both a changing height and a changing width, but the height and width change so that the area of the rectangle is always 200 square feet. What is the rate of change of the width of the rectangle in feet per second when the height is 5 feet, if the height is decreasing at that moment at the rate of 0.5 feet per second?

ANSWER: 4



### TOSS-UP

17) BIOLOGY *Multiple Choice* Which of the following organelles would you expect to be MOST active during apoptosis of the cells that contain them?

- W) Endoplasmic reticulum
- X) Golgi bodies
- Y) Lysosomes
- Z) Ribosomes

ANSWER: Y) LYSOSOMES

### BONUS

17) BIOLOGY *Short Answer* What is the scientific name for a type of skin growth that looks different than a common mole? It is usually larger, with borders that are not easy to see, uneven colors, and is partially raised above the skin surface.

ANSWER: DYSPLASTIC NEVUS (ACCEPT: DYSPLASTIC MELANOCYTIC NEVUS)

---

### TOSS-UP

18) ENERGY *Multiple Choice* Roughly, which of the following BEST represents the solar energy intensity in watts per square meter incident on the Earth?

- W) 200
- X) 1,400
- Y) 3,000
- Z) 10,000

ANSWER: X) 1,400

### BONUS

18) ENERGY *Short Answer* Companies A, B, and C are forced to pay one dollar of tax per ton of carbon dioxide equivalent emissions. If Company A emits 100 tons of carbon dioxide and 4 tons of nitrous oxide, Company B emits 10 tons of carbon dioxide and 5 tons of nitrous oxide, and Company C emits 200 tons of carbon dioxide and no nitrous oxide, which company has to pay the largest tax?

ANSWER: COMPANY B

### TOSS-UP

19) PHYSICS *Short Answer* By number, identify all of the following four situations in which an object is NOT in equilibrium: 1) when moving to the right with a constant velocity; 2) when slowing to a stop; 3) when moving with a constant speed in a circle; 4) when in free fall.

ANSWER: 2, 3, AND 4

### BONUS

19) PHYSICS *Short Answer* A brass ball with a mass of 200 grams at 20° Celsius is placed in boiling water until it reaches equilibrium. Given that the specific heat of brass is 0.094 kilocalories per kilogram degree Celsius, and providing your answer as a decimal to the nearest tenth, how much thermal energy in kilocalories is absorbed by the ball?

ANSWER: 1.5

---

### TOSS-UP

20) BIOLOGY *Short Answer* What is the name of a highly contagious, infectious viral disease in cows that causes symptoms such as respiratory disease, conjunctivitis, encephalitis, and brain infections?

ANSWER: INFECTIOUS BOVINE RHINOTRACHEITIS (ACCEPT: IBR) (DO NOT ACCEPT: MAD COW DISEASE)

### BONUS

20) BIOLOGY *Short Answer* By name or number, identify all of the following five choices that are NOT arthropods: 1) trilobites, 2) chelicerates (read as: ki-LI-keh-rah-tehs), 3) crustaceans, 4) ictnerids (read as: ik-TEHR-ids), 5) polyplacophores (read as: poh-lee-PLAH-koh-fors).

ANSWER: ICTERIDS AND POLYPLACOPHORES (ACCEPT: 4 AND 5)

### TOSS-UP

21) MATH *Multiple Choice* Which of the following series converges?

W)  $\sum_{n=1}^{\infty} \frac{1}{n^{0.5}}$

X)  $\sum_{n=1}^{\infty} \frac{1}{n+1}$

Y)  $\sum_{n=1}^{\infty} \frac{n}{e^n}$

Z)  $\sum_{n=1}^{\infty} \frac{e^n}{n}$

ANSWER: Y)  $\sum_{n=1}^{\infty} \frac{n}{e^n}$

### BONUS

21) MATH *Short Answer* What is the limit of  $x^x$  as  $x$  approaches 0 from the positive side?

ANSWER: 1

---

### TOSS-UP

22) CHEMISTRY *Short Answer* By name or number, identify all of the following four substances that are substitutional alloys: 1) brass, 2) steel, 3) sterling silver, 4) pewter.

ANSWER: BRASS, STERLING SILVER, AND PEWTER (ACCEPT: 1, 3, AND 4)

### BONUS

22) CHEMISTRY *Short Answer* A chemist is trying to identify a chemical by determining its molar mass. A sample weighing 0.75 grams was dissolved in 0.10 kilograms of benzene and the freezing point depression was determined to be 0.50° Celsius. Given the  $K_f$  for benzene of 5° Celsius kilograms per mole, what is the molar mass of the chemical in grams per mole to the nearest whole number?

ANSWER: 75

### TOSS-UP

23) EARTH AND SPACE *Multiple Choice* Which of the following is the closest to the maximum solar altitude for Barrow, Alaska in the course of a year?

- W) 90°
- X) 45°
- Y) 20°
- Z) 0°

ANSWER: X) 45°

### BONUS

23) EARTH AND SPACE *Short Answer* By name or number, identify all of the following three properties that Zeeman splitting can be used to determine: 1) presence of a magnetic field, 2) strength of a magnetic field, 3) metal abundances?

ANSWER: PRESENCE OF A MAGNETIC FIELD, STRENGTH OF A MAGNETIC FIELD  
(ACCEPT: 1 AND 2)

---

### TOSS-UP

24) CHEMISTRY *Multiple Choice* A well near the beach is suspected to be contaminated with chloride ions from sea water. If chloride is present, which of the following will produce a cloudy suspension when mixed with the water?

- W) Silver nitrate
- X) Sodium nitrate
- Y) Potassium acetate
- Z) Calcium bromide

ANSWER: W) SILVER NITRATE

### BONUS

24) CHEMISTRY *Short Answer* The molar mass of carbon dioxide is 44 grams. Providing your answer to the nearest integer, if 88 grams of solid carbon dioxide sublimates, how many liters of carbon dioxide gas will be formed at standard temperature and pressure?

ANSWER: 45

### TOSS-UP

25) BIOLOGY *Short Answer* Amebocytes from *Limulus* organisms are currently used in the medical field to test for the presence of what substances?

ANSWER: BACTERIAL TOXINS (ACCEPT: TOXINS)

### BONUS

25) BIOLOGY *Short Answer* By name or number, identify all of the following five molecules that function as vertebrate neurotransmitters: 1) endorphins, 2) serotonin, 3) biotin, 4) enkephalins, 5) dopamine.

ANSWER: ENDORPHINS, SEROTONIN, ENKEPHALINS, DOPAMINE (ACCEPT: 1, 2, 4, AND 5)