

ROUND 14

TOSS-UP

1) CHEMISTRY *Multiple Choice* Consider the closed equilibrium [**ee-kwuh-LIB-ree-uhm**] system of calcium carbonate, carbon dioxide, and water, which yields calcium ions and bicarbonate ions. Adding sodium bicarbonate to the solution will make which of the following true in the reaction?

- W) Q will be greater than K
- X) Q will be less than K
- Y) Q will be equal to K
- Z) Q and K both increase

ANSWER: W) Q WILL BE GREATER THAN K

BONUS

1) CHEMISTRY *Short Answer* What is the electron configuration of bromine in noble gas notation?

ANSWER: [Ar] 4s² 3d¹⁰ 4p⁵ (ACCEPT: [Ar] 3d¹⁰ 4s² 4p⁵)

TOSS-UP

2) EARTH AND SPACE *Multiple Choice* Which of the following changes has NOT contributed to the current warming trend for Earth's atmosphere?

- W) Greenhouse gas concentrations
- X) Global deforestation
- Y) Incoming solar energy
- Z) Farming practices

ANSWER: Y) INCOMING SOLAR ENERGY

BONUS

2) EARTH AND SPACE *Short Answer* The composition of what objects led to the inference that the core of the Earth is made of iron?

ANSWER: METEORITES OR CHONDRITES

TOSS-UP

3) PHYSICS *Short Answer* Two charges, Q and $-Q$, are placed at $x = -3$ and $x = +1$ on the x -axis. Where on the x -axis between $+Q$ and $-Q$ can another charge be placed so that it experiences no net force?

ANSWER: NOWHERE, DOES NOT EXIST

BONUS

3) PHYSICS *Short Answer* Suppose that you support a meter stick horizontally by positioning one finger under one of the ends and the other finger about one-quarter of the way from the opposite end. Now suppose you move your fingers slowly together until they touch. By number, identify what will most likely happen to the meter stick: 1) it will fall off the side with the finger under the end; 2) it will fall off the side with the finger about one quarter of the way from the end; or 3) it will stay balanced on your fingers.

ANSWER: 3

TOSS-UP

4) MATH *Short Answer* What is the determinant of the 2 by 2 matrix $\begin{bmatrix} 2 & -3 \\ -8 & -4 \end{bmatrix}$ [*such that row one includes 2 and negative 3, and row 2 includes negative 8 and negative 4*]?

ANSWER: -32

BONUS

4) MATH *Short Answer* A coin is tossed 10 times. Providing your answer as a fraction in lowest terms, what is the probability that there are 3 heads and 7 tails?

ANSWER: 15/128

TOSS-UP

5) BIOLOGY *Multiple Choice* An animal's respiratory tidal volume is 500 milliliters and its cardiac output is 250 milliliters per minute with a stroke volume of 5 milliliters. Which of the following is its heart rate in beats per minute?

- W) 10
- X) 20
- Y) 50
- Z) 100

ANSWER: Y) 50

BONUS

5) BIOLOGY *Multiple Choice* In humans, which of the following structures is NOT derived from myeloid [**MY-uh-loid**] stem cells?

- W) Lymphocytes [**LIM-fuh-syts**]
- X) Eosinophils [**ee-uh-SIN-uh-fils**]
- Y) Basophils [**BAY-suh-fils**]
- Z) Platelets [**PLAYT-lits**]

ANSWER: W) LYMPHOCYTES

TOSS-UP

6) MATH *Short Answer* What is the limit of x^x as x approaches 0?

ANSWER: 1

BONUS

6) MATH *Short Answer* Given the equation $9x^2 + 4y^2 + 54x - 8y + 49 = 0$, what kind of shape is its graph, and what are the coordinates of its center?

ANSWER: ELLIPSE, (-3, 1)

TOSS-UP

7) CHEMISTRY *Multiple Choice* Which of the following pairings of quantum numbers n , l , and m CANNOT be correct?

- W) An electron in nickel's 3d orbital: 3, 2, 2
- X) An electron in phosphorus's 2s orbital: 2, 0, 0
- Y) An electron in potassium's 3p orbital: 3, 2, -1
- Z) An electron in oxygen's 2p orbital: 2, 1, +1

ANSWER: Y) AN ELECTRON IN POTASSIUM'S 3P ORBITAL: 3, 2, -1

BONUS

7) CHEMISTRY *Short Answer* According to valence bond theory, what is the hybridization of the central atom of xenon oxytetrafluoride?

ANSWER: sp^3d^2

TOSS-UP

8) EARTH AND SPACE *Short Answer* What type of event marks the end of major geologic eras such as the Paleozoic and Mesozoic?

ANSWER: MASS EXTINCTION (ACCEPT: MAJOR EXTINCTION)

BONUS

8) EARTH AND SPACE *Short Answer* What seismologic feature led scientists to identify the Earth's liquid outer core?

ANSWER: S-WAVE SHADOW ZONE

TOSS-UP

9) PHYSICS *Multiple Choice* A source travelling towards us at $(3/5)c$ emits photons in a direction perpendicular to its velocity. If the source emits photons with energy of 0.5 electron volts in its own rest frame, which of the following energies, in electron volts, do the photons have in our rest frame?

- W) 0.3
- X) 0.4
- Y) 0.5
- Z) 0.6

ANSWER: X) 0.4

BONUS

9) PHYSICS *Short Answer* An unknown particle with rest energy of 1 mega-electron volt is traveling with a speed of $(3/5)c$ along the x -axis in our rest frame when it decays into two photons, also travelling along the x -axis. What are the energies of the photons in mega-electron volts?

ANSWER: 0.25 (ACCEPT: $\frac{1}{4}$) AND 1

TOSS-UP

10) ENERGY *Multiple Choice* Which of the following statements about the mass of atoms in a nuclear fission reaction is true?

- W) The mass of the products is less than the original mass
- X) The mass of the products is equal to the original mass
- Y) There is no change in the original mass
- Z) The mass of the products is more than the original mass

ANSWER: W) THE MASS OF THE PRODUCTS IS LESS THAN THE ORIGINAL MASS

BONUS

10) ENERGY *Multiple Choice* Diesel fuel does not need a spark to ignite like gasoline does. Diesel can rely on compression to heat the fuel for which of the following reasons?

- W) It has a lower molecular weight than gasoline
- X) It has a lower flash point than gasoline
- Y) It has a lower auto ignition temperature than gasoline
- Z) It has a lower spark point than gasoline

ANSWER: Y) IT HAS A LOWER AUTO IGNITION TEMPERATURE THAN GASOLINE

TOSS-UP

11) BIOLOGY *Multiple Choice* Which of the following is necessary for the evolution of pesticide resistance?

- W) A population that is highly susceptible to the pesticide
- X) An extremely lethal pesticide
- Y) Genetic variation in susceptibility to the pesticide
- Z) Heterogeneous [*het-er-uh-JEE-nee-uhs*] application of pesticide

ANSWER: Y) GENETIC VARIATION IN SUSCEPTIBILITY TO THE PESTICIDE

BONUS

11) BIOLOGY *Short Answer* Order the following three human oxygen-binding proteins from highest to lowest affinity for oxygen: 1) fetal hemoglobin, 2) myoglobin [*my-uh-GLOH-bin*], 3) maternal hemoglobin.

ANSWER: 2, 1, 3 (ACCEPT: MYOGLOBIN, FETAL HEMOGLOBIN, MATERNAL HEMOGLOBIN)

TOSS-UP

12) MATH *Multiple Choice* Given that a second degree polynomial function $f(x)$ has a zero at $x = 3$ with multiplicity 2, which of the following is true?

- W) The graph of $f(x)$ crosses the y -axis at 3
- X) As x approaches infinity, $f(x)$ approaches infinity
- Y) The graph of $f(x)$ crosses the x -axis at 3
- Z) The graph of $f(x)$ touches but does not cross the x -axis at 3

ANSWER: Z) THE GRAPH OF $f(x)$ TOUCHES BUT DOES NOT CROSS THE x -AXIS AT 3

BONUS

12) MATH *Short Answer* Expressing your answer in simplest form, find the derivative with respect to x of $y = \frac{x^3 - 8}{x - 2}$ [*the fraction with numerator x cubed minus 8 and denominator x minus 2*] for all values for which y is defined.

ANSWER: $y' = 2x + 2$ (ACCEPT: $2x + 2$)

TOSS-UP

13) EARTH AND SPACE *Multiple Choice* Which of the following is true about the sediments found at the farthest edges of an alluvial fan?

- W) They are metal rich
- X) They are relatively fine-grained
- Y) They are the most angular
- Z) They are chemically altered by their unique environment

ANSWER: X) THEY ARE RELATIVELY FINE-GRAINED

BONUS

13) EARTH AND SPACE *Short Answer* What is observed to reconstruct paleoclimate **[pay-lee-oh-kly-mit]** information, specifically based on historical concentrations of carbon dioxide gas?

ANSWER: ICE CORES

TOSS-UP

14) BIOLOGY *Multiple Choice* Which of the following pairs are the most likely hydrogen-bonding partners?

- W) Water and ammonia
- X) Water and estrogen
- Y) Water and carbonate
- Z) Water and methane

ANSWER: W) WATER AND AMMONIA

BONUS

14) BIOLOGY *Short Answer* Name the structure to which the following terms refer: stylate **[STY-layt]**, lamellate **[luh-MEL-ayt]**, filiform **[FIL-uh-fohrm]**, clavate **[KLAY-vayt]** and plumose **[PLOO-mohs]**.

ANSWER: ANTENNA

TOSS-UP

15) CHEMISTRY *Multiple Choice* Identify which of the following types of copolymer [*koh-POL-uh-mer*] would be represented by a molecule with the linkage pattern FGGFFFGFG?

- W) Statistical
- X) Block
- Y) Graft
- Z) Alternating

ANSWER: W) STATISTICAL

BONUS

15) CHEMISTRY *Multiple Choice* Which of the following is true about benzene?

- W) The carbons are alternately sp^2 and sp^3 hybridized
- X) The carbon atoms are all sp^2 hybridized with an unhybridized p orbital
- Y) Some of the carbon atoms exhibit tetrahedral geometries
- Z) The carbon atoms are all sp^3 hybridized

ANSWER: X) THE CARBON ATOMS ARE ALL SP^2 HYBRIDIZED WITH AN UNHYBRIDIZED P ORBITAL

TOSS-UP

16) EARTH AND SPACE *Multiple Choice* Which of the following causes basal sliding of glaciers?

- W) Melting of basal ice due to heat from friction as the glacier moves along bedrock
- X) Changes in gravity as the glacier increases in mass
- Y) Differences in the amount of friction linked to variable surface conditions under the glacier
- Z) Decrease in friction due to melting from pressure of overlying ice

ANSWER: Z) DECREASE IN FRICTION DUE TO MELTING FROM PRESSURE OF OVERLYING ICE

BONUS

16) EARTH AND SPACE *Multiple Choice* Which of the following drives the volcanism on Jupiter's moon, Io?

- W) Solar radiation
- X) Plate tectonics
- Y) Meteor impacts
- Z) Tidal forces

ANSWER: Z) TIDAL FORCES

TOSS-UP

17) PHYSICS *Multiple Choice* As a photon travels from water to air, which of the following quantities changes?

- W) Frequency
- X) Wavelength
- Y) Energy
- Z) Phase

ANSWER: X) WAVELENGTH

BONUS

17) PHYSICS *Multiple Choice* A starship is heading towards Earth at $0.7c$. To begin slowing down, it enables a forward thruster that emits fuel at $0.8c$ in the direction of Earth. Relative to Earth, which of the following is the approximate speed of the fuel?

- W) $0.8c$
- X) $0.96c$
- Y) $0.99c$
- Z) $1.5c$

ANSWER: X) $0.96c$

TOSS-UP

18) ENERGY *Multiple Choice* Which of the following nuclides is both fissile and fissionable only with high energy bombardment?

- W) U-233
- X) U-235
- Y) U-238
- Z) Pu-239

ANSWER: Y) U-238

BONUS

18) ENERGY *Short Answer* Name the process, suggested as a possible avenue for cold fusion to occur, in which a sound wave is passed through a bubble in a jar, causing the bubble to expand and collapse.

ANSWER: SONOLUMINESCENCE

TOSS-UP

19) BIOLOGY *Multiple Choice* Which of the following molecules are NOT covalently attached to proteins as post-translational modifications?

- W) Ubiquitins
- X) Phosphates
- Y) Ions such as Ca^{+2} and Mg^{+2}
- Z) Carbohydrate groups

ANSWER: Y) IONS SUCH AS Ca^{+2} AND Mg^{+2}

BONUS

19) BIOLOGY *Multiple Choice* Which of the following statements is NOT correct regarding prions?

- W) They can cause scrapie and Creutzfeldt-Jakob diseases [**KROYTS-felt Jakob**]
- X) They infect the same taxa [**TAK-suh**] as viroids [**VY-roids**]
- Y) They can cause degenerative brain diseases
- Z) They are an infectious agent comprised entirely of protein

ANSWER: X) THEY INFECT THE SAME TAXA AS VIROIDS

TOSS-UP

20) MATH *Short Answer* If the height of a cone is equal to the diameter of its base, express the volume of the cone in terms of its radius r and as a fraction in terms of pi.

ANSWER: $(2/3) \pi r^3$ (ALSO ACCEPT: $2\pi r^3/3$)

BONUS

20) MATH *Multiple Choice* Which of the following is the volume of the solid created by revolving the area bounded by semicircle $y = \sqrt{16 - (x - 4)^2}$ [**y equals the square root of open bracket 16 minus open parenthesis x minus 4 close parenthesis squared close brackets**] and the x-axis around the x-axis?

- W) 16π
- X) $64\pi/3$
- Y) 64π
- Z) $256\pi/3$

ANSWER: Z) $256\pi/3$

TOSS-UP

21) CHEMISTRY *Multiple Choice* Which of the following is true for the isotopes of an element?

- W) They cannot be separated at all
- X) They have equal masses
- Y) They have similar chemical behavior
- Z) They cannot be separated by physical methods

ANSWER: Y) THEY HAVE SIMILAR CHEMICAL BEHAVIOR

BONUS

21) CHEMISTRY *Short Answer* The equilibrium constant K for the following reaction is 6×10^{-4} :
 $(\text{CH}_3)_2\text{NH} + \text{H}_2\text{O} \rightarrow (\text{CH}_3)_2\text{NH}_2^+ + \text{OH}^-$ [**CH 3 2 NH plus H 2 O yields star C H 3 2 N H 2 plus plus O H minus**].

Providing your answer in scientific notation, find K for the reaction $(\text{CH}_3)_2\text{NH}_2^+ \rightarrow (\text{CH}_3)_2\text{NH} + \text{H}^+$ [**C H 3 2 N H 2 plus yields star C H 3 2 N H plus H plus**].

ANSWER: 1.7×10^{-11}

TOSS-UP

22) EARTH AND SPACE *Multiple Choice* Which of the following minerals is white or colorless, has a hardness of 2.5, and splits with cubic cleavage?

- W) Calcite
- X) Pyrite
- Y) Halite
- Z) Mica [**MY-kuh**]

ANSWER: Y) HALITE

BONUS

22) EARTH AND SPACE *Short Answer* What is the largest sediment particle type a wind of 10 meters per second could transport?

ANSWER: SAND

TOSS-UP

23) PHYSICS *Short Answer* Three masses are arranged at the vertices of an equilateral triangle and are connected by springs along the edges of the equilateral triangle. How many normal modes for vibration does this mass-spring system have?

ANSWER: THREE

BONUS

23) PHYSICS *Short Answer* When a charged particle moves in a dielectric medium at a speed greater than the speed of light in that medium, what kind of radiation do the atoms in the medium emit?

ANSWER: CHERENKOV

TOSS-UP

24) BIOLOGY *Short Answer* What class of hormone, often produced in a plant's roots, induces cell division in plant roots and shoots?

ANSWER: CYTOKININ

BONUS

24) BIOLOGY *Multiple Choice* Which of the following is NOT true regarding human myoglobin [*my-uh-GLOH-bin*]?

- W) It is a monomer
- X) It exhibits higher affinity for oxygen than hemoglobin
- Y) It exhibits a sigmoidal [*SIG-moid-uhl*] saturation curve
- Z) It is primarily an oxygen storage protein

ANSWER: Y) IT EXHIBITS A SIGMOIDAL SATURATION CURVE

TOSS-UP

25) ENERGY *Multiple Choice* When the spent fuel is removed from a nuclear power plant, which of the following immediately occurs?

- W) It is placed in dry cask storage at the nuclear reactor site until it is safe to handle, and then it is sent to the permanent storage facility
- X) It is sent to Yucca Mountain to be stored in the National Repository
- Y) It is stored under water in a spent fuel pool at the reactor for several years
- Z) It is sealed in 50 gallon drums and allowed to cool

ANSWER: Y) IT IS STORED UNDER WATER IN A SPENT FUEL POOL AT THE REACTOR FOR SEVERAL YEARS

BONUS

25) ENERGY *Multiple Choice* Which of the following statements is NOT true about bubble chambers?

- W) They consist of tanks of superheated transparent liquid
- X) As charged beam particles pass through the liquid, the liquid boils along their paths
- Y) When the pressure is decreased, the bubbles clear
- Z) The bubbles are allowed to grow until they have a diameter of about 1 millimeter

ANSWER: Y) WHEN THE PRESSURE IS DECREASED, THE BUBBLES CLEAR