

ROUND 5

TOSS-UP

1) CHEMISTRY *Multiple Choice* You are given a particular polymer to study, and you notice that it can endure an extremely high amount of stress, but only a very small amount of strain. Which of the following types of polymer is it?

- W) Brittle plastic
- X) Tough fiber
- Y) Elastomer
- Z) Plastic with yield

ANSWER: X) TOUGH FIBER

BONUS

1) CHEMISTRY *Multiple Choice* The measured bond angle in ammonia is 107.3° , whereas the bond angles in phosphine [**FOS-feen**] are 93.7° . Which of the following facts correctly identifies the atomic property that makes the two angles different?

- W) Ammonia and phosphine have different expected VSEPR geometries
- X) Nitrogen is more electronegative than phosphorus
- Y) The bonding orbitals of phosphine have more s and less p character than those of ammonia
- Z) The phosphorus atom is much larger than the nitrogen atom

ANSWER: Z) THE PHOSPHORUS ATOM IS MUCH LARGER THAN THE NITROGEN ATOM

TOSS-UP

2) MATH *Short Answer* If $f(x) = x^2 - 1$ and $g(x) = x - 1$, what is the composite function $f(g(x))$ [**f of g of x**]?

ANSWER: $x^2 - 2x$

BONUS

2) MATH *Short Answer* Given 2 two by two matrices $A = \begin{bmatrix} 1 & 3 \\ 2 & 1 \end{bmatrix}$ [**row one: 1, 3; row two: 2, 1**]

and $B = \begin{bmatrix} 3 & 4 \\ 1 & 0 \end{bmatrix}$ [**row 1: 3, 4; row 2: 1, 0**]. Find the determinant of the product AB.

ANSWER: 20

TOSS-UP

3) EARTH AND SPACE *Multiple Choice* Which of the following rocks would most likely be created within a fluvial environment?

- W) Dolostone
- X) Granite
- Y) Conglomerate
- Z) Limestone

ANSWER: Y) CONGLOMERATE

BONUS

3) EARTH AND SPACE *Multiple Choice* Which of the following scenarios could strengthen a hurricane?

- W) It travels over Hispaniola
- X) It moves into a region with strong upper-level winds
- Y) It passes over an area of warm surface waters
- Z) It encounters a polar front

ANSWER: Y) IT PASSES OVER AN AREA OF WARM SURFACE WATERS

TOSS-UP

4) PHYSICS *Short Answer* Which law of physics explains how a changing magnetic field can produce an electric current?

ANSWER: FARADAY'S (ACCEPT: FARADAY'S LAW OF INDUCTION)

BONUS

4) PHYSICS *Multiple Choice* A wireless router transmits an 802.11a Wi-Fi radio signal at 5 megahertz with a speed up to 54 megabits of data per second. What is the wavelength of the router's signal in meters?

- W) 10
- X) 15
- Y) 60
- Z) 150

ANSWER: Y) 60

TOSS-UP

5) ENERGY *Multiple Choice* Which of the following is the least promising method of large-scale oil extraction in the next several decades?

- W) Drilling access to underground oil reservoirs [**REZ-er-vwahrs**]
- X) Acquiring oil from whales
- Y) Acquiring oil from algae
- Z) Acquiring oil produced by genetically re-engineered *Escherichia coli* [**e-schuh-ri-KEE-uh koh-LY**]

ANSWER: X) ACQUIRING OIL FROM WHALES

BONUS

5) ENERGY *Multiple Choice* Coal combustion products (CCPs) are solid materials produced when coal is burned to generate electricity. Which of the following is NOT a sustainable way to recycle CCPs?

- W) Adding CCP to biodiesel
- X) Using CCP as an agricultural fertilizer
- Y) Adding CCP to concrete
- Z) Adding CCP to asphalt

ANSWER: W) ADDING CCP TO BIODIESEL

TOSS-UP

6) BIOLOGY *Multiple Choice* The taxonomic class Myxini [**MIK-suh-nee**] contains which of the following fish?

- W) Wolf eels
- X) Hagfish
- Y) Chimaeras [**ki-MEER-uhs**]
- Z) Bowfin

ANSWER: X) HAGFISH

BONUS

6) BIOLOGY *Short Answer* In fruit flies, one gene called *fruitless* is responsible for male courtship behavior. The gene is transcribed in both males and females, but due to differences in intron usage, is only translated as a full-length protein in males. A genetic XX female will attempt to court other females if she expresses the male form of the *fruitless* gene. What molecular process would have to be accurately executed to assure that the male form of the gene is expressed only in males?

ANSWER: ALTERNATIVE SPLICING (ACCEPT: ALTERNATIVE RNA PROCESSING OR SPLICING)

TOSS-UP

7) CHEMISTRY *Short Answer* What is the irreducible representation for the atomic orbital s for a molecule with C_{2v} symmetry?

ANSWER: a_1

BONUS

7) CHEMISTRY *Short Answer* For 680 milligrams of tannic acid, which has a molar mass of 1700 grams per mole, dissolved in water, it takes 40.00 milliliters of 0.25 molar sodium hydroxide to titrate the solution to a pH of 13. Based on this data, how many acidic protons does tannic acid have?

ANSWER: 25

TOSS-UP

8) MATH *Short Answer* How many subsets are there of a set whose elements are the composite numbers less than 9?

ANSWER: 8

BONUS

8) MATH *Multiple Choice* A balloon is being filled with water. Its volume in gallons is given by the function $V(r) = r^3/10$ [**V of r equals r cubed over 10**], where r is the radius of the balloon in inches. What is the average rate of change in gallons per inch of the volume of the balloon as the radius is increased from 1 to 2 inches?

- W) 0.3
- X) 0.7
- Y) 0.8
- Z) 1.2

ANSWER: X) 0.7

TOSS-UP

9) EARTH AND SPACE *Multiple Choice* Which of the following minerals has four planes of cleavage?

- W) Fluorite
- X) Calcite
- Y) Augite [**AW-jyt**]
- Z) Muscovite [**MUHS-kuh-vyt**]

ANSWER: W) FLUORITE

BONUS

9) EARTH AND SPACE *Short Answer* What physical law, which ice skaters utilize to increase their rate of spin, is critical in the formation of dust devils, water spouts, and hurricanes?

ANSWER: LAW OF CONSERVATION OF ANGULAR MOMENTUM

TOSS-UP

10) PHYSICS *Multiple Choice* A slingshot stretched by a distance x gives a pebble speed v . What is the speed of the same pebble if a slingshot, obeying Hooke's law, is stretched by a distance $2x$?

- W) $v/2$
- X) v
- Y) $2v$
- Z) $4v$

ANSWER: Y) $2v$

BONUS

10) PHYSICS *Multiple Choice* Free neutrons decay to protons, electrons, and antineutrinos. What fundamental force is responsible for this decay?

- W) Weak nuclear
- X) Strong nuclear
- Y) Electromagnetic
- Z) Gravitational

ANSWER: W) WEAK NUCLEAR

TOSS-UP

11) BIOLOGY *Short Answer* What is the name of the process in which the female gametes are formed in an animal?

ANSWER: OOGENESIS

BONUS

11) BIOLOGY *Multiple Choice* Which of the following terms indicates centromere [**SEN-truh-meer**] placement at the end of the chromosome?

- W) Metacentric
- X) Acrocentric
- Y) Telocentric
- Z) Submetacentric

ANSWER: Y) TELOCENTRIC

TOSS-UP

12) CHEMISTRY *Multiple Choice* Which of the following statements about ferrimagnetic solids is true?

- W) Magnetic moments are on different sublattices and are antiparallel
- X) Magnetic moments are on different sublattices and are parallel
- Y) Magnetic moments are on the same sublattices and are parallel
- Z) Magnetic moments are on the same sublattices and are antiparallel

ANSWER: W) MAGNETIC MOMENTS ARE ON DIFFERENT SUBLATTICES AND ARE ANTIPARALLEL

BONUS

12) CHEMISTRY *Short Answer* What is the major product formed at the conclusion of the following two-step reaction sequence: Step 1) Methylmagnesium bromide, ethylene oxide, and tetrahydrofuran [**te-truh-hy-druh-FYOOR-an**]; Step 2) Ethyl iodide.

ANSWER: ETHYL N-PROPYL ETHER (ACCEPT: 1-ethoxy-propan;Ether, ethyl propyl;ether,ethylpropyl;n-C3H7OC2H5;propane,1-ethoxy-;Propyl ethyl ether;ETHYL PROPYL ETHER)

TOSS-UP

13) PHYSICS *Multiple Choice* A particle is constrained to move in one dimension according to the relation $x = 3t^3$ [***x equals 3 t cubed***], where x is the position from the origin in meters and t is time in seconds. What is the acceleration in meters per second squared of the particle at $t = 7$ seconds?

- W) 18
- X) 126
- Y) 441
- Z) 1029

ANSWER: X) 126

BONUS

13) PHYSICS *Multiple Choice* An RLC circuit consists of a 2 henry inductor, a 1000 ohm resistor, an 8 farad capacitor, and a power supply in series. With what frequency in hertz must the power supply operate in order to establish resonance in the circuit?

- W) $1/8\pi$
- X) $1/4$
- Y) 4
- Z) 8π

ANSWER: W) $1/8\pi$

TOSS-UP

14) MATH *Short Answer* What is the next number in the arithmetic sequence that has first three terms of 17, 31, and 45?

ANSWER: 59

BONUS

14) MATH *Short Answer* A card is drawn at random from a standard deck of 52 cards. Given that the card drawn is a face card, what is the probability that the drawn card is a Jack?

ANSWER: $1/3$

TOSS-UP

15) EARTH AND SPACE *Multiple Choice* In which of the following locations is it possible to find an esker formed during the Pleistocene **[PLY-stuh-seen]** epoch?

- W) Maryland
- X) West Virginia
- Y) Tennessee
- Z) Iowa

ANSWER: Z) IOWA

BONUS

15) EARTH AND SPACE *Multiple Choice* Why do tornadoes occur with the lowest frequency near dawn?

- W) The ground surface is moist, cooling the ground
- X) The differential between land and air temperatures is at its peak
- Y) Cloud formation in the early morning hours is rare
- Z) Air temperature is lowest and radiation deficits are highest

ANSWER: Z) AIR TEMPERATURE IS LOWEST AND RADIATION DEFICITS ARE HIGHEST

TOSS-UP

16) ENERGY *Short Answer* Bond energy measures the strength of a chemical bond. Providing your answer in kilojoules per mole, what is the average bond energy of the C-H bonds in methane if it takes 1600 kilojoules to break up 1 mole of methane into 1 mole of carbon and 4 moles of hydrogen?

ANSWER: 400

BONUS

16) ENERGY *Multiple Choice* Organisms are sometimes assigned fractional trophic levels. Which of the following factors is least likely to complicate trophic level assignment?

- W) Female black widow spiders cannibalize male black widow spiders after mating
- X) Bullfrogs eat crayfish while crayfish eat bullfrog tadpoles
- Y) Bobcats eat rabbits while mountain lions eat both bobcats and rabbits
- Z) Gorillas eat both bamboo and fruit

ANSWER: Z) GORILLAS EAT BOTH BAMBOO AND FRUIT

TOSS-UP

17) PHYSICS *Multiple Choice* A 1 kilogram object is travelling to the left at 3 meters per second when it explodes into 2 equal pieces. One piece is travelling at 7 meters per second to the left after the explosion. What is the velocity in meters per second of the other piece after the explosion?

- W) 1 to the right
- X) 1 to the left
- Y) 4 to the right
- Z) 4 to the left

ANSWER: W) 1 TO THE RIGHT

BONUS

17) PHYSICS *Short Answer* What is the root mean square voltage of a power supply that outputs a sinusoidal voltage with a frequency of 60 hertz and peak voltage of 120 volts?

ANSWER: 85

TOSS-UP

18) BIOLOGY *Multiple Choice* Bacteria are classified as Gram positive or Gram negative based on several characteristics, including which of the following?

- W) Genome size
- X) Cell wall structure
- Y) Degree of virulence
- Z) Reproduction rate

ANSWER: X) CELL WALL STRUCTURE

BONUS

18) BIOLOGY *Short Answer* Which actin-associated motor protein generates the force for muscle contraction?

ANSWER: MYOSIN

TOSS-UP

19) CHEMISTRY *Short Answer* Carbon dioxide has a boiling point of -57° Celsius, whereas sulfur dioxide has a boiling point of -10° Celsius. This difference is most likely due to the fact that sulfur dioxide exhibits which intermolecular force, while carbon dioxide does not?

ANSWER: DIPOLE-DIPOLE (ACCEPT: DIPOLE FORCES)

BONUS

19) CHEMISTRY *Short Answer* The family of olefin metathesis catalysts developed by Grubbs employs which metallic element?

ANSWER: RUTHENIUM

TOSS-UP

20) MATH *Short Answer* A graph has symmetry with respect to the origin and passes through the point $(-2, 3)$. What other point must be on this graph?

ANSWER: $(2, -3)$

BONUS

20) MATH *Short Answer* A line in parametric mode is given by the equations: $x = \frac{1}{2}t + 2$ and $y = 2t$. What is the slope of this line?

ANSWER: 4

TOSS-UP

21) BIOLOGY *Multiple Choice* Approximately how often is the entire stomach lining in a human replaced?

- W) Every three days
- X) Every five days
- Y) Every week
- Z) Every month

ANSWER: W) EVERY THREE DAYS

BONUS

21) BIOLOGY *Short Answer* Polymerase [**POL-uh-muh-rays**] chain reaction (PCR) is a widely used method to rapidly clone pieces of DNA. Place the following three steps of PCR in order for a single amplification cycle: 1) Annealing, 2) Denaturation, 3) Elongation.

ANSWER: 2, 1, 3 (ACCEPT: DENATURATION, ANNEALING, ELONGATION)

TOSS-UP

22) EARTH AND SPACE *Multiple Choice* Thermohaline [**thuhr-moh-HAY-lyn**] circulation in the ocean is controlled most by which of the following?

- W) Temperature and pressure
- X) Temperature and salinity
- Y) Salinity and precipitation
- Z) Salinity and sea ice formation

ANSWER: X) TEMPERATURE AND SALINITY

BONUS

22) EARTH AND SPACE *Multiple Choice* Why did Charles Keeling's carbon dioxide graphs show an up and down pattern each year?

- W) More carbon dioxide was generated by heating processes during the winter
- X) The air is denser in the winter, causing carbon dioxide to become diluted
- Y) Carbon dioxide is absorbed during the growth season and released through decay during the fall and winter
- Z) Warmer summer continents release more carbon dioxide than during colder winters

ANSWER: Y) CARBON DIOXIDE IS ABSORBED DURING THE GROWTH SEASON AND RELEASED THROUGH DECAY DURING THE FALL AND WINTER

TOSS-UP

23) PHYSICS *Multiple Choice* An electron is travelling due north when it experiences a magnetic field that is pointing vertically upward. In what direction will the electron be deflected when it initially encounters the field?

- W) North
- X) South
- Y) East
- Z) West

ANSWER: Z) WEST

BONUS

23) PHYSICS *Short Answer* A 35.4×10^{-11} coulomb charge is placed into a spherical Gaussian **[GOUS-ee-uhn]** surface with a radius of 5 meters. Given that epsilon naught is 8.85×10^{-12} farads per meter, what is the electric flux through this surface in newton meters squared per coulomb?

ANSWER: 40

TOSS-UP

24) ENERGY *Short Answer* Which type of metabolic pathway uses ATP to build macromolecules, such as proteins, out of smaller components?

ANSWER: ANABOLIC METABOLISM

BONUS

24) ENERGY *Multiple Choice* Although coal formed throughout many geological periods, coal from the Lower Triassic period is quite rare. Which of the following is the best possible explanation?

- W) Terrestrial plants had not yet evolved
- X) Large animals had not yet evolved
- Y) A mass extinction occurred
- Z) Soil density was too low

ANSWER: Y) A MASS EXTINCTION OCCURRED

TOSS-UP

25) BIOLOGY *Multiple Choice* The 2011 Nobel Prize in Physiology or Medicine was awarded to three researchers, including Jules Hoffman and Bruce Beutler, for their discoveries leading to the characterization of the Toll-like receptor (TLR) family of molecules. This family of molecules is encoded by genes in a wide variety of eukaryotes [**yoo-KAR-ee-ohs**], ranging from flies to humans, and plays an important role in which of the following processes?

- W) Recognizing pathogens in the immune system
- X) Breaking down lipids in the digestive system
- Y) Regulating neurotransmitters in the nervous system
- Z) Enabling meiosis [**my-OH-sis**] in the reproductive system

ANSWER: W) RECOGNIZING PATHOGENS IN THE IMMUNE SYSTEM

BONUS

25) BIOLOGY *Multiple Choice* Assume you would like to isolate a specific membrane protein from a cell. How could you best remove the protein from the membrane?

- W) Disrupt the lipid bilayer with detergents
- X) Grind the cells using a pestle
- Y) Stain the target protein with fluorescing antibodies
- Z) Centrifuge the cells to separate the lipid bilayer from other cellular components

ANSWER: W) DISRUPT THE LIPID BILAYER WITH DETERGENTS