

## ROUND 15

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### TOSS-UP

1) CHEMISTRY *Multiple Choice* Which of the following is a proper comparison between ductile and brittle fracture?

- W) Ductile has an unstable crack and brittle has a stable crack
- X) Brittle has relatively little plastic deformation, while ductile has extensive deformation
- Y) Brittle doesn't occur in cold metals while ductile does
- Z) Brittle fracture is preferred in most applications

ANSWER: X) BRITTLE HAS RELATIVELY LITTLE PLASTIC DEFORMATION, WHILE DUCTILE HAS EXTENSIVE DEFORMATION

### BONUS

1) CHEMISTRY *Short Answer* The generation of proteolytic [*proh-tee-uh-LIT-ik*] fragments is essential to protein purification. Chymotrypsin [*ky-moh-TRIP-sin*] is an endopeptidase [*en-doh-PEP-ti-days*] that will cleave peptide amide bonds. Name two of the four amino acids this enzyme cleaves.

ANSWER: (ACCEPT TWO) PHENYLALANINE, TYROSINE, TRYPTOPHAN, METHIONINE

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### TOSS-UP

2) MATH *Short Answer* What is the slope-intercept form of the equation of the line that is tangent to the circle with equation  $x^2 + y^2 = 25$  at the point  $(-3, 4)$ ?

ANSWER:  $y = (\frac{3}{4})x + 25/4$

### BONUS

2) MATH *Multiple Choice* Given the two sequences  $s_1$  with nth term  $\frac{2}{n+6}$  and  $s_2$  with nth term  $\frac{n}{5+n}$ , which of the following statements is correct?

- W)  $s_1$  and  $s_2$  are both increasing
- X)  $s_1$  is increasing and  $s_2$  is decreasing
- Y)  $s_1$  is decreasing and  $s_2$  is increasing
- Z)  $s_1$  and  $s_2$  are both decreasing

ANSWER: Y)  $s_1$  IS DECREASING AND  $s_2$  IS INCREASING

### TOSS-UP

3) EARTH AND SPACE *Multiple Choice* Which of the following pairs of metamorphic rocks both result from the parent rock shale?

- W) Slate and hornfels
- X) Greenstone and phyllite
- Y) Quartzite and amphibolite [*am-FIB-uh-lyt*]
- Z) Marble and gneiss [*NYS*]

ANSWER: W) SLATE AND HORNFELS

### BONUS

3) EARTH AND SPACE *Short Answer* Wolf-Rayet stars are young, massive stars with prodigious mass loss rates. What force drives their strong stellar winds?

ANSWER: RADIATION PRESSURE

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### TOSS-UP

4) PHYSICS *Short Answer* According to the Standard Model, protons and neutrons are made of quarks. What are the quark constituents of protons?

ANSWER: TWO UPS AND ONE DOWN

### BONUS

4) PHYSICS *Short Answer* What famous nuclear reaction bypasses the "mass 8 gap" in stellar burning and proceeds mainly through the Hoyle state in carbon-12?

ANSWER: TRIPLE-ALPHA PROCESS

### TOSS-UP

5) ENERGY *Short Answer* In northern climates, which component of a residential home, if properly insulated, will lead to maximal energy savings?

ANSWER: ATTIC (ACCEPT: ROOF)

### BONUS

5) ENERGY *Multiple Choice* In string theory, in the absence of external interactions, string dynamics are governed by tension and which of the following types of energy?

- W) Kinetic
- X) Chemical
- Y) Electrostatic potential
- Z) Gravitational potential

ANSWER: W) KINETIC

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### TOSS-UP

6) BIOLOGY *Multiple Choice* The basal lamina is a long thin structure that is essential for the stability of body cells. Which of the following cell classes is NOT typically underlain or surrounded by the basal lamina?

- W) Epithelial
- X) Muscle
- Y) Nerve
- Z) Cartilage

ANSWER: Z) CARTILAGE

### BONUS

6) BIOLOGY *Multiple Choice* When using a light microscope to view a stained cross section of a dorsal root ganglion, which of the following structures are you most likely to see?

- W) Cell bodies of sensory neurons
- X) Axons of sensory neurons
- Y) Axons of motor neurons
- Z) Cell bodies of motor neurons

ANSWER: W) CELL BODIES OF SENSORY NEURONS

### TOSS-UP

7) CHEMISTRY *Short Answer* Bottom-up approaches to nanotechnology generally involve microscopy. What technique is primarily involved in the top-down approach?

ANSWER: LITHOGRAPHY (ACCEPT: SMALL-SCALE LITHOGRAPHY, MICRON-SCALE LITHOGRAPHY, AND ELECTRON-BEAM LITHOGRAPHY)

### BONUS

7) CHEMISTRY *Short Answer* The molecule (2E, 4Z, 6E)-2,4,6-octatriene [**2 comma 4 comma 6 -ok-tuh-TRY-eeen**] can isomerize to cis-5,6-dimethyl-1,3-cyclohexadiene [**cis-5 comma 6-dy-METH-uhl-1 comma 3-sy-kloh-HEK-suh-deen**]. Identify: 1) The family of pericyclic reactions for this particular isomerization; 2) The mode of activation; and 3) The direction of stereochemical rotation.

ANSWER: 1) ELECTROCYCLIC; 2) THERMAL; 3) DISROTATORY

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### TOSS-UP

8) MATH *Short Answer* If the graph of the complex number  $z = 3 + 4i$  is rotated  $90^\circ$  counterclockwise, what complex number is represented by the result?

ANSWER:  $-4 + 3i$

### BONUS

8) MATH *Multiple Choice* Which of the following is a solution for  $x$  of the equation  $2^{x-2} = \pi^x$  [**2 to the quantity x minus 2 equals pi to the x**]?

W)  $\frac{\log(4)}{\log(2) - \log(\pi)}$  [**the fraction with numerator log of 4 and denominator log of 2 minus log of pi**]

X)  $\frac{\log(4)}{\log(\pi) - \log(2)}$  [**the fraction with numerator log of 4 and denominator log of pi minus log of 2**]

Y)  $\frac{\log(\pi) - \log(2)}{\log(4)}$  [**the fraction with numerator log of pi minus log of 2 and denominator log of 4**]

Z)  $\frac{\log(2) - \log(\pi)}{\log(4)}$  [**the fraction with numerator log of 2 minus log of pi and denominator log of 4**]

ANSWER: W)  $\frac{\log(4)}{\log(2) - \log(\pi)}$

### TOSS-UP

9) EARTH AND SPACE *Multiple Choice* A halo around the Sun or Moon is different than a corona around the Moon in that the halo is produced by what?

- W) Water droplets in a cloud
- X) Ice crystals in a cloud
- Y) Reflection of sunlight
- Z) Refraction of sunlight

ANSWER: X) ICE CRYSTALS IN A CLOUD

### BONUS

9) EARTH AND SPACE *Multiple Choice* Radial velocity surveys are biased towards discovering which of the following kinds of exoplanets?

- W) Face-on systems close to the Earth
- X) High albedo planets with large semi-major axes
- Y) Systems with large mass ratios that are close to the Earth
- Z) Edge-on systems with small semi-major axes

ANSWER: Z) EDGE-ON SYSTEMS WITH SMALL SEMI-MAJOR AXES

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### TOSS-UP

10) PHYSICS *Multiple Choice* If 500 joules of energy are required to move a 20-coulomb charge from point A to point B, what must be the potential difference, in volts, between A and B?

- W) 0
- X) 25
- Y) 1000
- Z) 10000

ANSWER: X) 25

### BONUS

10) PHYSICS *Short Answer* A child is playing on a straight metal slide which is at 45° to the level ground. The child slides down the slide in twice the time it would take if the slide was completely frictionless. What is the coefficient of kinetic friction of the slide?

ANSWER:  $\frac{3}{4}$  (ACCEPT: 0.75)

### TOSS-UP

11) BIOLOGY *Short Answer* In mammals, B cells are produced in the bone marrow. What cloacal [*kloh-AY-kuhl*] organ in birds produces these cells and is the source of their name?

ANSWER: BURSA OF FABRICIUS (ACCEPT: BURSA)

### BONUS

11) BIOLOGY *Short Answer* You are walking at night on a sandy beach in southern California during a high tide that followed the last full moon. What fish will you most likely see mating in the sand on the beach during your walk?

ANSWER: GRUNION (ACCEPT: *LEURESTHES*)

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### TOSS-UP

12) CHEMISTRY *Multiple Choice* Which of the following is NOT a method to separate two liquids?

- W) Fractional distillation
- X) Chromatography
- Y) Sonication
- Z) Extraction

ANSWER: Y) SONICATION

### BONUS

12) CHEMISTRY *Multiple Choice* The intensity of absorption maxima in a visible spectrum depends upon which of the following characteristics?

- W) Ligand field splitting parameter
- X) Allowedness of the transitions
- Y) Electron configuration of the metal center
- Z) Degree of inter-electron repulsion

ANSWER: X) ALLOWEDNESS OF THE TRANSITIONS

### TOSS-UP

13) PHYSICS *Multiple Choice* Which of the following is a consequence of Gauss's law for magnetism?

- W) A changing magnetic flux through a loop creates an electric current around the loop
- X) Charges must be moving to produce magnetic fields
- Y) A time-varying electric flux acts as a current and produces a magnetic field
- Z) Magnetic monopoles do not exist

ANSWER: Z) MAGNETIC MONOPOLES DO NOT EXIST

### BONUS

13) PHYSICS *Short Answer* Which of the following three choices has the longest period: 1) a pendulum [**PEN-juh-luhm**] on Earth with a cord length of 3 meters, 2) a pendulum on the Moon, where the acceleration due to gravity is roughly 1.6 meters per second squared, with a cord length of 1 meter, or 3) a pendulum on Jupiter, where acceleration due to gravity is 26 meters per second squared, with a cord length of 10 meters?

ANSWER: 2 (ACCEPT: PENDULUM ON THE MOON)

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### TOSS-UP

14) MATH *Multiple Choice* A jar contains 500 jellybeans, 100 each of red, white, blue, orange, and green. If you reach in without looking, how many jellybeans must you grab to be certain that at least five are of the same color?

- W) 6
- X) 21
- Y) 25
- Z) 26

ANSWER: X) 21

### BONUS

14) MATH *Short Answer* Find  $h(t)$  if  $2h'(t) - h(t) = 0$  [**2h prime of t minus h of t equals zero**] and  $h(0) = 10$ .

ANSWER:  $h(t) = 10 e^{(1/2)t}$  (ACCEPT:  $10 e^{(1/2)t}$ )

### TOSS-UP

15) EARTH AND SPACE *Short Answer* What is the term for the process through which precipitation forms in water vapor clouds?

ANSWER: COLLISION-COALESCENCE (ACCEPT: COALESCENCE or BERGERON PROCESS)

### BONUS

15) EARTH AND SPACE *Short Answer* Imagine a parcel of air forced upward. If the environmental lapse rate is greater than the dry adiabatic [*ad-ee-uh-BAT-ik*] rate, what is the vertical motion of the parcel?

ANSWER: IT WILL RISE

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### TOSS-UP

16) ENERGY *Multiple Choice* What is the process by which lithium enters electrodes in a lithium-ion battery?

- W) Intercalation
- X) Precipitation
- Y) Hydration
- Z) Bombardment

ANSWER: W) INTERCALATION

### BONUS

16) ENERGY *Multiple Choice* While walking down the street, an open wire falls on you and you receive an instantaneous alternating current electric shock. Where did most of the electrons come from that “shocked” you?

- W) The ground
- X) The wire
- Y) The air
- Z) Your body

ANSWER: Z) YOUR BODY

### TOSS-UP

17) PHYSICS *Multiple Choice* A square loop of wire with a resistance of 2 ohms and a side length of 2 meters has a magnetic field of 5 teslas passing straight through it. If the field is uniformly reduced to zero in 10 seconds, what is the magnitude of the current generated in the loop in amperes?

- W) 0.5
- X) 1
- Y) 2
- Z) 4

ANSWER: X) 1

### BONUS

17) PHYSICS *Short Answer* A rod of length 1 meter and mass 2 kilograms is pivoted perpendicularly to its length and through its center of mass. If two point masses, each with a mass of 1 kilogram, are attached to each end of the rod, what is the total moment of inertia in kilogram meters squared of this collection of objects?

ANSWER: 2/3

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### TOSS-UP

18) BIOLOGY *Multiple Choice* Which of the following proteins would likely be synthesized by a cytosolic ribosome instead of an ER-bound ribosome?

- W) Insulin
- X) Actin
- Y) Subunits for a potassium channel
- Z) G protein-coupled receptor

ANSWER: X) ACTIN

### BONUS

18) BIOLOGY *Multiple Choice* The mechanism of action of the antiviral drugs zanamivir [**za-NUHM-i-veer**] and oseltamivir [**oh-sel-TUHM-i-veer**] is to inhibit what virally encoded enzymes expressed on the surface of influenza virions [**VY-ree-ons**]?

- W) Neuraminidase [**nyoor-uh-MIN-uh-days**]
- X) Hemagglutinin [**he-muh-GLU-ti-nin**]
- Y) Nonspecific protease
- Z) Reverse transcriptase

ANSWER: W) NEURAMINIDASE

### TOSS-UP

19) CHEMISTRY *Multiple Choice* Which of the following reactions would be most expected to form a racemic [*ray-SEE-mik*] product mixture?

- W) E1
- X) E2
- Y) S<sub>N</sub>1
- Z) S<sub>N</sub>2

ANSWER: Y) S<sub>N</sub>1

### BONUS

19) CHEMISTRY *Short Answer* At the beginning of an experiment measuring the phosphorescence produced by a phosphorescent substance, the brightness is measured at 12 lumens. After five minutes, the brightness is 6 lumens. After 10 minutes, it is 4 lumens. What brightness, in lumens, would you expect to find after 15 minutes?

ANSWER: 3

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### TOSS-UP

20) MATH *Multiple Choice* Box A contains 4 chips numbered 1 through 4 and Box B contains 5 chips numbered 1 through 5. A chip is drawn from each box and the product of the two values drawn is denoted by  $x$ . What is the probability that  $x$  is even?

- W) 1/2
- X) 2/3
- Y) 7/10
- Z) 3/4

ANSWER: Y) 7/10

### BONUS

20) MATH *Short Answer* Find an antiderivative for  $y = xe^{-x}$ .

ANSWER:  $-(x + 1)e^{-x}$  (ACCEPT:  $-xe^{-x} - e^{-x}$ , OR EITHER ANSWER +/- ANY CONSTANT)

### TOSS-UP

21) BIOLOGY *Multiple Choice* In the lipid membranes of cells, there are multipass proteins that are partly within the lipid bilayer and partly outside of the lipid bilayer. Through which of the following forces do these proteins achieve this position relative to the membrane?

- W) Covalent linkages to lipid molecules
- X) Disulfide bonds to lipid molecules
- Y) Hydrophobic and hydrophilic interactions
- Z) Physical connections to the cytosol

ANSWER: Y) HYDROPHOBIC AND HYDROPHILIC INTERACTIONS

### BONUS

21) BIOLOGY *Short Answer* What is the term for the pattern of arrangement of embryonic leaves within the bud?

ANSWER: VERNATION

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### TOSS-UP

22) EARTH AND SPACE *Multiple Choice* Which of the following volcanic hazards can have worldwide climatic consequences?

- W) Lahars
- X) Pyroclastic flows
- Y) Volcanic tremors
- Z) Volcanic tephra

ANSWER: Z) VOLCANIC TEPHRA

### BONUS

22) EARTH AND SPACE *Multiple Choice* Plate tectonics have often been linked to changes in global climate. During the middle Cenozoic era, South America became separated from Antarctica and a circumpolar current formed. Which of the following was NOT caused by this separation?

- W) A permanent ice cap formed on Antarctica
- X) The temperature gradient lessened between the South Pole and the Equator
- Y) Earth's average temperature decreased
- Z) Thermohaline [*thuhr-moh-HAY-lyn*] circulation of the southern hemisphere Atlantic Ocean intensified

ANSWER: X) THE TEMPERATURE GRADIENT LESSENERED BETWEEN THE SOUTH POLE AND THE EQUATOR

### TOSS-UP

23) PHYSICS *Multiple Choice* A simple pendulum [*PEN-juh-luhm*] is pulled back to a large angle less than  $90^\circ$ , so that the small angle approximation is no longer valid for this situation. Which of the following statements is true about the period of oscillation of the pendulum?

- W) It is independent of the amplitude
- X) It is larger than the small angle approximation
- Y) It is smaller than the small angle approximation
- Z) It depends on the square root of the amplitude

ANSWER: X) IT IS LARGER THAN THE SMALL ANGLE APPROXIMATION

### BONUS

23) PHYSICS *Multiple Choice* A motor has a DC resistance of 5 ohms. The motor operates on 220 volt AC, and when running at full speed, it generates a back electromotive force of 200 volts. What is the current, in amperes, drawn when the motor operates at top speed?

- W) 0.4
- X) 4
- Y) 40
- Z) 44

ANSWER: X) 4

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### TOSS-UP

24) ENERGY *Multiple Choice* Whose equation describes the relationship between the concentration of an electro-active species and electric potential?

- W) Ohm
- X) Joule
- Y) Nernst
- Z) Bode

ANSWER: Y) NERNST

### BONUS

24) ENERGY *Short Answer* Arrange the following four substances in order of decreasing energy content in kilocalories per gram: 1) proteins, 2) organic acids, 3) fats, 4) ethanol.

ANSWER: 3, 4, 1, 2 (ACCEPT: FATS, ETHANOL, PROTEINS, ORGANIC ACIDS)

### TOSS-UP

25) BIOLOGY *Multiple Choice* What chemicals do peroxisomes [**pe-ro-KSI-sohms**] use to oxidize other compounds?

- W) Mono-diglyceride [**dy-GLIS-uh-ryd**]
- X) Nitrogen dioxide
- Y) Hydrogen peroxide
- Z) Dihydrogen monoxide

ANSWER: Y) HYDROGEN PEROXIDE

### BONUS

25) BIOLOGY *Short Answer* Name all of the following five insect orders that have adults with chewing mouthparts: 1) Hemiptera [**hi-MIP-ter-uh**], 2) Strepsiptera [**strep-sip-TER-uh**], 3) Homoptera, 4) Lepidoptera [**lep-i-DOP-ter-uh**], 5) Coleoptera [**koh-lee-OP-ter-uh**].

ANSWER: COLEOPTERA (ACCEPT: 5)