

ROUND 16

TOSS-UP

1) BIOLOGY *Multiple Choice* In which of the following wavelengths does DNA absorb the best:

- W) 3,900 angstroms
- X) 260 nanometers
- Y) 340 nanometers
- Z) 540 nanometers

ANSWER: X) 260 NANOMETERS

BONUS

1) BIOLOGY *Multiple Choice* Which of the following is closest to the diameter of a plasmodesmata (read as: PLAS-mo-dez-MAH-tah):

- W) 2 angstroms
- X) 60 nanometers
- Y) 80 microns
- Z) 180 microns

ANSWER: X) 60 NANOMETERS

(Solution: this is the only logical size considering the average plant cell size and the size of transported molecules)

TOSS-UP

2) CHEMISTRY *Short Answer* Name the 2 different bond angles present in a molecule with octahedral geometry, such as in SF₆:

ANSWER: 90; 180

BONUS

2) CHEMISTRY *Short Answer* In a titration experiment, it takes 20.0 milliliters of a 0.05 molar barium hydroxide, Ba(OH)₂, solution to neutralize 40 milliliters of a nitric acid, or HNO₃, solution to the equivalence point. Calculate the molarity of HNO₃, rounded to the second decimal place:

ANSWER: 0.05

(Solution: $0.05 \text{ mol Ba(OH)}_2/\text{L} \times 0.02\text{L} = 0.001 \text{ mol Ba(OH)}_2 \times 2 = 0.002 \text{ mol}$; $0.002 \text{ mol} \div 0.04\text{L} = 0.05\text{M}$)

TOSS-UP

3) PHYSICS *Short Answer* By words or numbers, identify all of the following 4 choices that **MUST** be true for 2 objects in thermal equilibrium:

- 1) they both must radiate no energy in any direction
- 2) they must be at the same temperature
- 3) they both must have the same thermal expansion coefficients
- 4) they must have the same internal energy

ANSWER: 2

BONUS

3) PHYSICS *Short Answer* How many kilojoules of thermal energy, rounded to the first decimal place, must be lost from a 250-gram block of Teflon with a specific heat of 1 kilojoule per kilogram kelvin, to lower the block's temperature from 125° C to 75° C?

ANSWER: 12.5 (ACCEPT: -12.5)

(Solution: $(1000 \text{ J/kg.K})(0.25 \text{ Kg})(-50\text{K}) = -12,500 \text{ joules} = -12.5 \text{ kJ}$)

TOSS-UP

4) MATH *Short Answer* If a point has polar coordinates $(3, \pi)$, what are the rectangular coordinates?

ANSWER: $(-3, 0)$

(Solution: $x = 3 \cos \pi = -3$ and $y = 3 \sin \pi = 0$)

BONUS

4) MATH *Short Answer* The graph of the polar equation, $r = 5 - 5 \cos \theta$, is a cardioid. In which two quadrants is most of the area of this cardioid?

ANSWER: II AND III (ACCEPT: 2 AND 3 or SECOND AND THIRD)

TOSS-UP

5) EARTH SCIENCE *Multiple Choice* Which of the following is a coarse-grained igneous rock primarily containing plagioclase feldspar, amphibole and biotite:

- W) gabbro
- X) basalt
- Y) diorite
- Z) granite

ANSWER: Y) DIORITE

BONUS

5) EARTH SCIENCE *Short Answer* Of the 3 basic types of magma on Earth, which one generally has the LOWEST eruptive temperature?

ANSWER: RHYOLITIC (ACCEPT: RHYOLITE)

(Solution: basaltic ~ 1000° – 1200°C, andesitic ~ 800° – 1000°C, rhyolitic ~ 650° – 800°C)

TOSS-UP

6) GENERAL SCIENCE *Multiple Choice* Which of the following is the source of alpha radiation most often used in household ionization smoke detectors:

- W) americium-241
- X) uranium-238
- Y) radium-226
- Z) iron-59

ANSWER: W) AMERICIUM-241

BONUS

6) GENERAL SCIENCE *Short Answer* Calculate the heating degree day in the U.S. if the day's high temperature is 70°F and the low is 30°F:

ANSWER: 15

(Solution: $(70^\circ + 30^\circ)/2 = 50^\circ$; $65^\circ - 50^\circ = 15$ HDD)

TOSS-UP

7) ASTRONOMY *Short Answer* Order the following 3 stages from the EARLIEST to the LATEST in the evolution of a G-type star of 2 solar masses: red giant; T-auri; white dwarf

ANSWER: T-TAURI; RED GIANT; WHITE DWARF

BONUS

7) ASTRONOMY *Short Answer* If a star has a surface temperature of 3,000 degrees kelvin, a core temperature of 100 million Kelvin, and a luminosity of 2,000-times our Sun, choosing from upper right, upper left, lower left, and lower right, where on an H-R diagram would it most likely be found?

ANSWER: UPPER RIGHT

(Solution: this describes a red giant)

TOSS-UP

8) BIOLOGY *Short Answer* What reduced coenzyme donates its electrons to complex-one in the electron transport system?

ANSWER: NADH

BONUS

8) BIOLOGY *Multiple Choice* In a double reciprocal plot of Michaelis-Menton kinetics, what is the effect of a competitive inhibitor:

- W) change in the vertical axis intercept
- X) change in the slope only
- Y) change in the horizontal axis intercept only
- Z) change in both vertical and horizontal axes intercepts

ANSWER: X) CHANGE IN THE SLOPE ONLY

TOSS-UP

9) CHEMISTRY *Short Answer* What is the bond order for each oxygen-oxygen bond in the ozone or O₃ molecule?

ANSWER: $\frac{3}{2}$ (ACCEPT: 1.5)

BONUS

9) CHEMISTRY *Multiple Choice* Hydrogen gas effuses through a pinhole opening from one compartment to another about how many times as fast as nitrogen gas:

- W) 2.4-times
- X) 3.7-times
- Y) 5.3-times
- Z) 8.2-times

ANSWER: X) 3.7-TIMES

(Solution: $\frac{r_{H_2}}{r_{N_2}} = \sqrt{\frac{28g/mol}{2g/mol}} = 3.7$)

TOSS-UP

10) PHYSICS *Multiple Choice* Which of the following best describes why the optical spectrum of an atom exists as discrete lines and not as a continuous spectrum:

- W) atoms have electrons with unit charge
- X) all atoms when excited emit light
- Y) all energy levels of atoms are quantized
- Z) all electrons have spin

ANSWER: Y) ALL ENERGY LEVELS OF ATOMS ARE QUANTIZED

BONUS

10) PHYSICS *Multiple Choice* Which of the following BEST describes one of Maxwell's equations that is a mathematical conceptualization of Faraday's law:

- W) a magnetic B-field is a solenoid vector field
- X) an EMF induced in a conductor opposes that motion
- Y) induced currents are caused by the magnetic field and in opposition to the opposed flux
- Z) a time-varying B-field produces an E-field

ANSWER: Z) A TIME-VARYING B-FIELD PRODUCES AN E-FIELD

TOSS-UP

11) MATH *Multiple Choice* At $x = -\frac{1}{2}$, the graph of $y = x^3$ is:

- W) increasing and concave up
- X) increasing and concave down
- Y) decreasing and concave up
- Z) decreasing and concave down

ANSWER: X) INCREASING AND CONCAVE DOWN

(Solution: at the indicated value the 1st derivative is positive (implying increasing) and the 2nd derivative is negative (implying concave down))

BONUS

11) MATH *Short Answer* The point (3, 2) is reflected across the graph of $y = 6$ and the resulting point is then reflected across the graph of $y = x$. What are the coordinates of the final point?

ANSWER: (10, 3)

(Solution: the 1st reflection \rightarrow (3,10); 2nd reflection interchanges the x and y coordinates)

TOSS-UP

12) GENERAL SCIENCE *Multiple Choice* According to EPA nationwide emission trends for common air pollutants and excluding fires and dust, which of the following accounted for the least amount of emissions in the past 5 years:

- W) volatile organic compounds
- X) carbon monoxide
- Y) sulfur dioxide
- Z) particulate matter

ANSWER: Z) PARTICULATE MATTER

(Solution: VOC ~ 15; CO ~ 81 mT/yr; SO₂ ~ 13; particulates ~ 3)

BONUS

12) GENERAL SCIENCE *Short Answer* Without leap days every 4 years, the winter solstice would start on what month and day after 70 years?

ANSWER: JANUARY 7 (ACCEPT: JANUARY 6 TO 8)

(Solution: 17 days later)

TOSS-UP

13) EARTH SCIENCE *Short Answer* In what layer of Earth's atmosphere do most meteors experience the most heating?

ANSWER: MESOSPHERE

BONUS

13) EARTH SCIENCE *Short Answer* Name all of the following 4 layers of the atmosphere where temperature typically increases as altitude increases: troposphere; stratosphere; mesosphere; thermosphere

ANSWER: STRATOSPHERE; THERMOSPHERE

TOSS-UP

14) ASTRONOMY *Multiple Choice* Which of the following is LEAST likely to occur when viewed from mid-northern latitudes in the month of August:

- W) Venus passing within 2° of Saturn
- X) Neptune at opposition
- Y) the Moon at apogee on the 1st of the month and perigee at the 29th of the month
- Z) the Moon passing within 5° of Uranus

ANSWER: Y) THE MOON AT APOGEE ON THE 1ST OF THE MONTH AND PERIGEE AT THE 29TH OF THE MONTH

(Solution: apogee and perigee are separated by about 14-15 days)

BONUS

14) ASTRONOMY *Multiple Choice* Which of the following was seen from mid-northern latitudes by casual stargazers as a bright light in August of 2008 at midnight, about 1/2 way up the southern horizon:

- W) Venus
- X) Vega
- Y) Jupiter
- Z) Uranus

ANSWER: Y) JUPITER

(Solution: Venus and Vega are not there at this time of year and Uranus is never that bright)

TOSS-UP

15) BIOLOGY *Short Answer* What is the primary calcium-binding protein in eukaryotic cells, that is about 148 amino acids long, and has a wide variety of functions often through kinases and phosphatases (read as: foss-fah-TAY-sis)?

ANSWER: CALMODULIN

BONUS

15) BIOLOGY *Multiple Choice* Which of the following is the RNA complementary sequence of the following sequence: 5'CCGCGA 3' (read as: 5-prime, CCGCGS, 3-prime)

W) 5' UCGCGG 3' (read as: 5-prime, UCGCGG, 3-prime)

X) 5' GGCGCU 3'

Y) 5' GGCGCT 3'

Z) 5' TCGCGG 3'

ANSWER: W) 5' UCGCGG 3'

TOSS-UP

16) CHEMISTRY *Short Answer* For the following 3 processes, predict whether the change in enthalpy, or ΔS° (read as: delta S naught), is positive or negative, respectively:

1) decomposition of ammonium nitrate

2) sublimation of dry ice

3) condensation of gaseous iodine to liquid iodine

ANSWER: 1) +; 2) +; 3) -

BONUS

16) CHEMISTRY *Short Answer* Consider the following equilibrium reaction, $\text{PCl}_{5(\text{gas})} \leftrightarrow \text{PCl}_{3(\text{gas})} + \text{Cl}_{2(\text{gas})}$. If a 1-liter flask contains 0.02 moles of PCl_3 and 0.02 moles of Cl_2 at equilibrium, how many moles of PCl_5 are in the flask. Assume the equilibrium constant is 5×10^{-2} .

ANSWER: 8×10^{-3} (ACCEPT: 0.008)

(Solution: $K_c = [\text{PCl}_3][\text{Cl}_2]/[\text{PCl}_5] = (0.02)(0.02)/(0.05) = 0.008$ moles)

TOSS-UP

17) PHYSICS *Short Answer* During beta minus decay, what nucleon type is reduced by one?

ANSWER: NEUTRON

BONUS

17) PHYSICS *Multiple Choice* Which of the following is NOT true of the Hall effect:

W) it can be used to measure the strength of a magnetic field

X) it is a consequence of a current carrying wire in a magnetic field

Y) it was one of the first direct indications that negative charges are what move in conductors

Z) it cannot distinguish between positive and negative particles

ANSWER: Z) IT CANNOT DISTINGUISH BETWEEN POSITIVE AND NEGATIVE PARTICLES

TOSS-UP

18) GENERAL SCIENCE *Short Answer* What are the Ice Cube observatory under construction at the South Pole and the ANTARES telescope off the coast of France primarily designed to detect?

ANSWER: NEUTRINOS

BONUS

18) GENERAL SCIENCE *Multiple Choice* During the winter solstice in the northern hemisphere, which of the following northern latitude positions will have a day length of 10.1 hours:

W) 30°

X) 40°

Y) 50°

Z) 60°

ANSWER: W) 30°

TOSS-UP

19) EARTH SCIENCE *Multiple Choice* During the past 500,000 years, there have been how many periods of major glaciation on Earth:

- W) 2
- X) 3
- Y) 4
- Z) 5

ANSWER: Z) 5

BONUS

19) EARTH SCIENCE *Multiple Choice* A rising parcel of air reaches the lifting condensation level at 2,000 meters at a dew point temperature of 15°C. At 3,000 meters, the temperature of this parcel of air will on average be:

- W) 15°C
- X) 10°C
- Y) 6°C
- Z) 3°C

ANSWER: X) 10°C

(Solution: wet-adiabatic lapse rate ~ 5°C/1000 meters)

TOSS-UP

20) MATH *Short Answer* Of the following 5 functions identify all that are NOT differentiable for all real numbers: $|x|$ (read as: absolute value of x); $\cos(x)$; $\tan(x)$; e^x ; the greatest integer function

ANSWER: $|x|$; $\tan(x)$; THE GREATEST INTEGER FUNCTION

BONUS

20) MATH *Short Answer* The curve defined by the equation, $Ax^2 + Bx + Cy^2 + Dy + E = 0$, can be an ellipse if which of the constants are positive?

ANSWER: A AND C

TOSS-UP

21) ASTRONOMY *Short Answer* What 3 elements are most prominent in the carbon fusion cycle?

ANSWER: CARBON; NITROGEN; OXYGEN

BONUS

21) ASTRONOMY *Short Answer* If the surface of a star is 15,000 kelvin, at what wavelength, in nanometers rounded to the nearest whole number, does it emit its maximum energy?

ANSWER: 200

(Solution: $\lambda_{\max} = 3 \times 10^6 / 15,000 \text{ K} = 200 \text{ nm}$)

TOSS-UP

22) BIOLOGY *Short Answer* What cell type is MOST directly responsible for secreting the bone matrix in developing humans?

ANSWER: OSTEOLASTS (DO NOT ACCEPT: OSTEOCYTE)

BONUS

22) BIOLOGY *Short Answer* What specific human bone cell is antagonistic to osteoblasts and is known to cause apoptosis (read as: A-pop-TOE-sis) of osteoblasts in vitro?

ANSWER: OSTEOCLASTS

TOSS-UP

23) CHEMISTRY *Short Answer* Of the following 5 alkanes, which one has the LEAST combined strain energy from angle strain and torsional strain: [read slowly] cyclopropane; cyclobutane; cyclopentane; cyclohexane; cyclo-octane

ANSWER: CYCLOHEXANE

BONUS

23) CHEMISTRY *Short Answer* What is the most common name for the conformation that the ring structure of cyclohexane adopts to reach a strain-free value?

ANSWER: CHAIR

TOSS-UP

24) PHYSICS *Short Answer* What is the name of the universal constant that relates atomic spectra of elements to that of hydrogen?

ANSWER: RYDBERG CONSTANT (ACCEPT: RYDBERG)

BONUS

24) PHYSICS *Short Answer* Assuming the universal gravitational constant is 6.67×10^{-11} newton-meters squared per kilogram squared, what is the gravitational attraction, in newtons, between two, 10-kilogram perfectly uniform spheres separated by a center-to-center distance of 10 meters?

ANSWER: 6.67×10^{-11}

(Solution: $F = [(6.67 \times 10^{-11})(10)(10)]/10^2 = 6.67 \times 10^{-11}$ NEWTONS)

TOSS-UP

25) BIOLOGY *Short Answer* Intestinal absorption of what vitamin is most directly dependent on intrinsic factor?

ANSWER: B₁₂

BONUS

25) BIOLOGY *Short Answer* What plant hormone is primarily responsible for apical dominance in angiosperms?

ANSWER: AUXIN (ACCEPT: INDOLE-ACETIC ACID or IAA)