

ROUND 14

TOSS-UP

1) CHEMISTRY *Short Answer* Name the elements in the following reaction that have been oxidized and reduced, respectively: $\text{Zn}_{(\text{solid})} + \text{CuSO}_{4(\text{aqueous})} \rightarrow \text{ZnSO}_{4(\text{aqueous})} + \text{Cu}_{(\text{solid})}$

ANSWER: OXIDIZED = Zn (ACCEPT: ZINC); REDUCED = Cu (ACCEPT: COPPER)

BONUS

1) CHEMISTRY *Multiple Choice* Which of the following is closest to the pK_a of an acid whose $\text{K}_a = 5.0 \times 10^{-4}$:

- W) 2.3
- X) 3.3
- Y) 4.0
- Z) 5.0

ANSWER: X) 3.3

(Solution: $\text{pK}_a = -\log_{10}\text{K}_a = 3.3$)

TOSS-UP

2) BIOLOGY *Multiple Choice* Which of the following best describes the repressor protein in the lac (read as: LACK) operon:

- W) uncompetitive inhibitor
- X) structural protein
- Y) regulatory protein
- Z) transcriptional factor

ANSWER: Y) REGULATORY PROTEIN

BONUS

2) BIOLOGY *Multiple Choice* Through which of the following mechanisms do allosteric inhibitors typically operate:

- W) binding the substrate
- X) binding to an enzyme's active site
- Y) binding to a site other than the active site and changing the shape of an enzyme
- Z) acting as a competitive inhibitor and overpowering the active sites of enzymes

ANSWER: Y) BINDING TO A SITE OTHER THAN THE ACTIVE SITE AND CHANGING THE SHAPE OF AN ENZYME

TOSS-UP

3) PHYSICS *Short Answer* In the radioactive decay scheme of uranium, what is the final stable element produced?

ANSWER: LEAD

BONUS

3) PHYSICS *Short Answer* Consider an astronaut on the Moon and g is exactly $1/6^{\text{th}}$ of g on Earth. If he threw an object vertically upwards with an initial velocity of 1.6 meters per second, how many meters up would it be after 1 second, rounding your answer to the first decimal place?

ANSWER: 0.8

TOSS-UP

4) MATH *Multiple Choice* Which of the following represents the inverse function of $f(x) = x^3 + 5$:

W) $(x - 5)^3$

X) $x^3 - 5$

Y) $(x - 5)^{\frac{1}{3}}$

Z) $\left(\frac{1}{x - 5}\right)^3$

ANSWER: Y) $(x - 5)^{\frac{1}{3}}$

BONUS

4) MATH *Short Answer* Giving your answer in meters squared, find the total surface area of a right prism whose base is a right triangle with legs of length 3 meters and 4 meters and whose altitude is 2 meters:

ANSWER: 36

(Solution: 3:4:5; $P_{\text{base}} = 3+4+5 = 12\text{m}$; $A = \frac{1}{2}bh = 6 \text{ m}^2$; $TA = LA + 2B = (12)(2) + 2(6) = 36 \text{ m}^2$)

TOSS-UP

5) EARTH SCIENCE *Multiple Choice* Which of the following is a tree that is very well-adapted to surviving above shallow permafrost:

- W) cottonwood
- X) white pine
- Y) aspen
- Z) black spruce

ANSWER: Z) BLACK SPRUCE

BONUS

5) EARTH SCIENCE *Multiple Choice* Which of the following BEST describes a small lake in an arctic environment that is likely to be surrounded by a ring of so-called drunken trees leaning toward the lake:

- W) paternoster lake
- X) thermokarst
- Y) tarn
- Z) fen

ANSWER: X) THERMOKARST

TOSS-UP

6) GENERAL SCIENCE *Short Answer* Order the following 3 hexadecimal numbers from SMALLEST to LARGEST: 3E8; BB8; 1F4;

ANSWER: 1F4; 3E8; BB8

(Solution: $1F4 = 500$; $3E8 = 1000$; $BB8 = 3000$)

BONUS

6) GENERAL SCIENCE *Multiple Choice* An experiment aboard a recent Space Shuttle mission exposed *Salmonella typhimurium* (read as: TIE-fee-muhr-EE-um) to a space environment. Which of the following resulted when the bacteria came back to Earth:

- W) they were more virulent
- X) they were less virulent
- Y) they had about the same virulence
- Z) they changed into a new but similar species of bacteria

ANSWER: W) THEY WERE MORE VIRULENT

(Solution: NASA's Space Shuttle mission STS-115)

TOSS-UP

7) ASTRONOMY *Multiple Choice* Which of the following is TRUE of red supergiants:

- W) some form Cepheid variables
- X) most end as nova stars
- Y) most have luminosities about 10 to 100 times that of our Sun
- Z) most have surface temperatures at least 2-times that of our Sun

ANSWER: W) SOME FORM CEPHEID VARIABLES

BONUS

7) ASTRONOMY *Multiple Choice* Which of the following is NOT characteristic of B-type stars like Rigel or Spica (read as: SPY-kah):

- W) very luminous
- X) apparent blue color
- Y) medium strength hydrogen spectral lines
- Z) average solar mass of about 3.2

ANSWER: Z) AVERAGE SOLAR MASS OF ABOUT 3.2

(Solution: solar mass of about 16-18)

TOSS-UP

8) CHEMISTRY *Multiple Choice* According to VSEPR bonding theory, if 2 of the bonded atoms in an octahedral molecule are replaced by 2 electron pairs, the molecule will assume what geometric shape, such as in XeF_4 :

- W) linear
- X) trigonal bipyramidal
- Y) square planar
- Z) square pyramidal

ANSWER: Y) SQUARE PLANAR

BONUS

8) CHEMISTRY *Multiple Choice* According to VSEPR bonding theory, if one of the bonded atoms in a trigonal bipyramidal molecule is replaced by 2 electron pairs, the molecule will assume what geometric shape, such as in ClF_3 :

- W) t-shaped
- X) see-saw
- Y) linear
- Z) bent

ANSWER: W) T-SHAPED

TOSS-UP

9) **BIOLOGY** *Multiple Choice* Which of the following mutations would most likely affect a gene the LEAST:

- W) single base deletion
- X) single base substitution
- Y) single base insertion
- Z) quadruple base deletion

ANSWER: X) SINGLE BASE SUBSTITUTION

BONUS

9) **BIOLOGY** *Multiple Choice* Which of the following BEST explains why a single base substitution in a gene-coding region for amino acids will sometimes lead to no change in amino acid sequence:

- W) all nucleotides are subject to the same mutation rate
- X) some nucleotide bases are covalently joined by stronger bonds
- Y) the code is degenerate with more than one triplet coding for the same amino acid
- Z) some amino acids act in the same fashion in determining the tertiary structure of a protein

ANSWER: Y) THE CODE IS DEGENERATE WITH MORE THAN ONE TRIPLET CODING FOR THE SAME AMINO ACID

TOSS-UP

10) **PHYSICS** *Multiple Choice* Which of the following experimental approaches was used by scientists to discover that the atomic nucleus held most of the atom's mass and a positive charge:

- W) directing alpha particles at thin metal strips
- X) finding the amount of magnetic deflection in cathode rays within a well-evacuated tube
- Y) exposing photographic film to certain radium salts
- Z) using a crude cyclotron to disintegrate large nuclei

ANSWER: W) DIRECTING ALPHA PARTICLES AT THIN METAL STRIPS

BONUS

10) **PHYSICS** *Short Answer* Name all of the following 4 sub-atomic particles that are never found in isolation: electrons; protons; quarks; positrons

ANSWER: QUARKS

TOSS-UP

11) MATH *Multiple Choice* Which of the following is a quadratic equation with a root of multiplicity of 2:

W) $9x^2 - 30x^2 + 25 = 0$

X) $x^2 + 2x - 15 = 0$

Y) $6x^2 - 11x - 2 = 0$

Z) $4x^2 - 1 = 0$

ANSWER: W) $9x^2 - 30x^2 + 25 = 0$

(Solution: $x = 5/3$)

BONUS

11) MATH *Short Answer* Given $f(x) = x^2 + 2x + 3$, express $f(x + 1)$ in standard polynomial form:

ANSWER: $x^2 + 4x + 6$

TOSS-UP

12) EARTH SCIENCE *Multiple Choice* Placodonts, which lived during the Triassic Period, were a group of:

W) meat-eating land reptiles

X) flying reptiles

Y) small, lightweight, plant-eating reptiles

Z) marine reptiles

ANSWER: Z) MARINE REPTILES

BONUS

12) EARTH SCIENCE *Multiple Choice* Which of the following is NOT true regarding seismic waves through the Earth:

W) P-waves travel through the mantle

X) S-waves travel through the mantle

Y) P-waves travel through the outer core

Z) S-waves travel through the outer core

ANSWER: Z) S-WAVES TRAVEL THROUGH THE OUTER CORE

(Solution: S-waves cannot travel through liquids and the outer core is liquid)

TOSS-UP

13) PHYSICS *Multiple Choice* Which of the following would a Leyden jar most likely be considered:

- W) an electroscope
- X) a capacitor
- Y) a resistor
- Z) a Tesla cage

ANSWER: X) A CAPACITOR

BONUS

13) PHYSICS *Short Answer* How many joules of energy are used by an electrical appliance operating on 8 amps of current flowing through a 20-ohm resistance circuit for 5 minutes?

ANSWER: 384,000

(Solution: $E = I^2 R \times T = (8A)^2 \times 20 \text{ ohms} \times 300 \text{ s} = 384,000 \text{ joules}$)

TOSS-UP

14) ASTRONOMY *Multiple Choice* Which of the following BEST describes where the zodiacal light is brightest to a stargazer at mid-northern latitudes:

- W) within about 20 degrees of the ecliptic
- X) at the western horizon at sunrise
- Y) at right angles to the Milky Way
- Z) parallel with the Milky Way

ANSWER: W) WITHIN ABOUT 20 DEGREES OF THE ECLIPTIC

BONUS

14) ASTRONOMY *Multiple Choice* Which of the following is the BEST explanation for what causes zodiacal light:

- W) reflection of moonlight off the Earth's surface
- X) dispersion of the Earth's radiant heat off the troposphere
- Y) sunlight reflected off interplanetary dust particles
- Z) radiation from the Van Allen belts

ANSWER: Y) SUNLIGHT REFLECTED OFF INTERPLANETARY DUST PARTICLES

TOSS-UP

15) CHEMISTRY *Short Answer* How many quantum numbers are required to completely describe a specific electron in a multi-electron atom?

ANSWER: 4

BONUS

15) CHEMISTRY *Multiple Choice* Which of the following describes the quantum number that indicates the direction in space of the electron cloud surrounding the nucleus of an atom:

- W) magnetic quantum number
- X) principle quantum number
- Y) angular momentum quantum number
- Z) spin quantum number

ANSWER: W) MAGNETIC QUANTUM NUMBER

TOSS-UP

16) BIOLOGY *Multiple Choice* Which of the following BEST explains why leaves fall off trees in the autumn:

- W) the leaves die and passively fall off
- X) an abscission layer forms at the base of the leaf stem causing it to fall off
- Y) the leaves slowly dry out from the bottom up because of abscisic acid that prevents phloem from delivering nutrients
- Z) the vascular tissue of the leaves fill up with resin increasing their stiffness and causing them to become brittle

ANSWER: X) AN ABSCISSION LAYER FORMS AT THE BASE OF THE LEAF STEM CAUSING IT TO FALL OFF

BONUS

16) BIOLOGY *Multiple Choice* Which of the following will most likely result from a single base deletion in DNA:

- W) nonsense mutation
- X) stop codon
- Y) frame shift mutation
- Z) inversion mutation

ANSWER: Y) FRAME SHIFT MUTATION

TOSS-UP

17) GENERAL SCIENCE *Multiple Choice* Because of its linear-temperature relationship and its chemical inertness, which of the following materials is almost always used in resistance temperature detectors:

- W) mercury
- X) platinum
- Y) iron
- Z) brass

ANSWER: X) PLATINUM

BONUS

17) GENERAL SCIENCE *Multiple Choice* Which of the following is the main advantage for the use of geothermal heat pumps in the U.S.:

- W) geothermal steam reservoirs can be tapped almost anywhere in the U.S.
- X) heat can be delivered directly for its intended use
- Y) steam can be used to directly generate electricity
- Z) all areas of the U.S. have nearly constant shallow-ground temperatures

ANSWER: Z) ALL AREAS OF THE U.S. HAVE NEARLY CONSTANT SHALLOW-GROUND TEMPERATURES

TOSS-UP

18) MATH *Short Answer* In the algebra of real-valued functions, give the name or number of all of the following 3 choices that the implied domain usually excludes:

- 1) numbers causing division by zero
- 2) numbers causing imaginary numbers in the range
- 3) numbers causing irrational numbers in the range

ANSWER: 1 AND 2

BONUS

18) MATH *Short Answer* Add the following rational expressions and give your answer in fully

factored form: $\frac{x}{(x+2)} + \frac{4x}{(x-6)}$

ANSWER: $\frac{x(5x+2)}{(x-6)(x+2)}$ (ACCEPT: $\frac{x(5x+2)}{(x+2)(x-6)}$)

TOSS-UP

19) EARTH SCIENCE *Short Answer* The aurora occur high in what layer of Earth's atmosphere?

ANSWER: THERMOSPHERE

BONUS

19) EARTH SCIENCE *Multiple Choice* During a Nor'easter, areas far to the east of the storm center will feel which of the following storm-generated winds:

- W) northeasterly
- X) southeasterly
- Y) southwesterly
- Z) northwesterly

ANSWER: Y) SOUTHWESTERLY

TOSS-UP

20) GENERAL SCIENCE *Multiple Choice* Which of the following most accurately represents the complete range of wavelengths to which the human eye is sensitive:

- W) 320 to 600 nanometers
- X) 380 to 740 nanometers
- Y) 450 to 850 nanometers
- Z) 480 to 950 nanometers

ANSWER: X) 380 TO 740 NANOMETERS

BONUS

20) GENERAL SCIENCE *Multiple Choice* Which of the following is NOT true:

- W) over 50% of all stars that appear to be single are double or multiple systems
- X) aurora borealis can occur in all 4 seasons
- Y) tetanus toxin causes muscle stiffness in affected humans
- Z) the Large Hadron Collider at CERN began colliding electrons in September of 2008

ANSWER: Z) THE LARGE HADRON COLLIDER AT CERN BEGAN COLLIDING ELECTRONS IN SEPTEMBER OF 2008

(Solution: the LHA collides hadrons...electrons are leptons)

TOSS-UP

21) ASTRONOMY *Short Answer* If the surface temperature of a star increased from 6,000 kelvin to 18,000 kelvin, how many times as much energy would it radiate?

ANSWER: 81

BONUS

21) ASTRONOMY *Short Answer* Using the most common temperature-based spectral classification system, a star with an apparent color of blue and a surface temperature of 55,000 kelvin would have what spectral letter classification?

ANSWER: O

TOSS-UP

22) BIOLOGY *Short Answer* What is the most common name for the terminus of a tRNA molecule to which amino acids are attached?

ANSWER: 3-PRIME TERMINUS (ACCEPT: CCA 3-PRIME END or 3-PRIME END or 3-PRIME)

BONUS

22) BIOLOGY *Short Answer* What protein, that takes its name from its apparent molecular weight, can arrest cells in the G1-S checkpoint, initiate apoptosis (read as: aye-pop-TOE-sis) and, when deactivated, is implicated in a wide variety of cancers?

ANSWER: P53

TOSS-UP

23) CHEMISTRY *Short Answer* According to general solubility rules, name all of the following 5 substances that are NOT soluble in water:

lithium iodide; sodium chloride; iron(II) hydroxide; sodium nitrate; barium sulfate

ANSWER: IRON(II) HYDROXIDE; BARIUM SULFATE

BONUS

23) CHEMISTRY *Short Answer* Consider a hypothetical reaction, $A + B \rightarrow C + D$. At zero time, the concentration of A = 1 molar, after 30 seconds A = 0.5 molar, and after 50 seconds A = 0.3 molar. Calculate the average rate of disappearance of A over the time interval 30 seconds to 50 seconds, in molarity per second:

ANSWER: 1×10^{-2} (ACCEPT: 0.01)

(Solution: ave rate = $-\Delta A/\Delta t = (0.3 - 0.5M)/(50 - 30s) = 0.010 \text{ M/s}$)

TOSS-UP

24) PHYSICS *Short Answer* What is the most common name for the field, which is believed to act somewhat like a fluid that fills space and endows quarks with mass?

ANSWER: HIGGS FIELD (ACCEPT: HIGGS)

BONUS

24) PHYSICS *Short Answer* Order the following 3 isotopes from the one with the LOWEST nuclear binding energy to the HIGHEST: iron-58; hydrogen-2; oxygen-16

ANSWER: HYDROGEN-2; OXYGEN-16; IRON-58

TOSS-UP

25) **BIOLOGY** *Short Answer* Into what specific mitochondrial compartment are hydrogen ions pumped out during chemiosmosis (read as: chem-ee-oz-MOE-sis)?

ANSWER: MATRIX

BONUS

25) **BIOLOGY** *Short Answer* Name all of the following 4 hormones that are formed primarily from the amino acid tyrosine: glucagon; thyroxine; epinephrine; erythropoietin (read as: EE-rith-roe-POE-ih-tin)

ANSWER: THYROXINE; EPINEPHRINE