ROUND 14

TOSS-UP

1) CHEMISTRY *Short Answer* Name the elements in the following reaction that have been oxidized and reduced, respectively: $Zn_{(solid)} + CuSO_{4(aqueous)} \rightarrow ZnSO_{4(aqueous)} + Cu_{(solid)}$

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 $K_a = 5.0 \times 10^{-4}$:

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

ANSWER: X) 3.3
(Solution: $pK_a = -\log_{10}K_a = 3.3$)

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

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 $1/6^{th}$ 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) $\left(\dfrac{1}{x-5}\right)^3$

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_{base} = 3+4+5 = 12m; A = ½bh = 6 m^2; TA = LA + 2B = (12)(2) + 2(6) = 36 m^2)

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)

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

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)

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

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

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

---

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

18) MATH *Short Answer* Add the following rational expressions and give your answer in fully factored form: $\dfrac{x}{(x+2)} + \dfrac{4x}{(x-6)}$

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

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)

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

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

---

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-PIME END or 3-PRIME END or 3-PRIME)

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

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 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

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