ROUND 15

TOSS-UP

1) PHYSICS *Multiple Choice* Which of the following BEST describes how the most accurate value for the gravitational constant has been determined:

W) through theoretical calculations from General Relativity  
X) through theoretical calculations using the masses and motions of certain celestial bodies  
Y) through theoretical calculations from quantum electrodynamics  
Z) through experimentation

ANSWER: Z) THROUGH EXPERIMENTATION

BONUS

1) PHYSICS *Multiple Choice* Which of the following BEST describes how Thomas Young produced sufficiently coherent separate light sources in order to produce interference patterns:

W) passing coherent light through 2 closely spaced holes in the same opaque screen  
X) passing incoherent light 1st through an opaque screen with a single hole, and then through a 2nd opaque screen with 2 holes  
Y) passing polarized light through 2 holes in a single opaque screen  
Z) passing laser light through 2 holes in a single opaque screen

ANSWER: X) PASSING INCOHERENT LIGHT 1ST THROUGH AN OPAQUE SCREEN WITH A SINGLE HOLE, AND THEN THROUGH A 2ND OPAQUE SCREEN WITH 2 HOLES

TOSS-UP

2) CHEMISTRY *Multiple Choice* Which of the following is NOT true:

W) a reaction that requires free energy is spontaneous  
X) gases, as a group, have higher entropies than liquids  
Y) standard molar entropies of pure substances are always positive values  
Z) spontaneous processes involve non-equilibrium conditions

ANSWER: W) A REACTION THAT REQUIRES FREE ENERGY IS SPONTANEOUS

BONUS

2) CHEMISTRY *Short Answer* Consider the reaction, \( \text{N}_2(\text{gas}) + 3\text{H}_2(\text{gas}) \rightarrow 2\text{NH}_3(\text{gas}) \). If the concentration of ammonia increases from 0.3 molar to 0.9 molar in a 10-minute period, find the average rate of reaction over this time interval. Give your answer to the 2nd decimal place in moles per liter minute:

ANSWER: 0.03
(Solution: rate = \( \Delta[\text{NH}_3]/2\Delta t = 0.6 \text{M}/2(10 \text{min}) = 0.03 \text{ mole/L-min} \))
TOSS-UP

3) BIOLOGY  Short Answer  What enzyme in *E. coli* functions as the primary proof-reading molecule during replication?

ANSWER: DNA POLYMERASE  (ACCEPT: DNA POLYMERASE 3)

BONUS

3) BIOLOGY  Multiple Choice  Which of the following is NOT true of DNA replication:

W) it is initiated by a short DNA primer
X) the growing strand is polymerized in a 5-prime to 3-prime direction
Y) DNA polymerase helps form the phosphodiesterase (read as: FOSS-foe-ESS-ter-ase) bonds
Z) synthesis of the lagging strand is discontinuous

ANSWER: W) IT IS INITIATED BY A SHORT DNA PRIMER

TOSS-UP

4) MATH  Multiple Choice  A data set has a mean of 10 and variance of 10. If every set element is multiplied by 2, which of the following is TRUE of the new mean and variance:

W) mean is 20, variance is 40
X) mean is 20, variance is 10
Y) mean is 20, variance is 20
Z) mean is 10, variance is 20

ANSWER: W) MEAN IS 20, VARIANCE IS 40

BONUS

4) MATH  Short Answer  Convert the angle, 18°18′36″ (read as: 18 degrees, 18 minutes, 36 seconds) to degrees, to the second decimal place:

ANSWER: 18.31

(Solution: $18 + \frac{18}{60} + \frac{36}{3600} = 18.31$)
TOSS-UP

5) EARTH SCIENCE  *Multiple Choice*  A meromictic lake has layers of water that typically:

W) intermix once a year  
X) intermix each spring and autumn  
Y) intermix only when the winds are favorable  
Z) do not intermix

ANSWER:  Z)  DO NOT INTERMIX

BONUS

5) EARTH SCIENCE  *Short Answer*  Name all of the following 4 factors that are reasons why biomes are not considered homogeneous biotic communities:  local topography;  soil characteristics;  temperature;  water

ANSWER:  ALL

TOSS-UP

6) GENERAL SCIENCE  *Multiple Choice*  In which of the following processes would isinglass (read as: eye-zen-glass) most likely be used:

W) clarification of beers and wines  
X) baking of yeast-free breads  
Y) glazing of ceramics  
Z) thickening of puddings

ANSWER:  W)  CLARIFICATION OF BEERS AND WINES

BONUS

6) GENERAL SCIENCE  *Multiple Choice*  In which of the following instances would using a student t-test be most appropriate:

W) comparing yes or no answers on a single question on a questionnaire  
X) determining statistical differences between 5 different age groups of males that received a drug that increases red blood cell production  
Y) finding the statistical differences between two groups in an experiment on a drug’s effect in raising or lowering blood pressure  
Z) comparing the strengths of 5 different types of fishing lines

ANSWER:  Y)  FINDING THE STATISTICAL DIFFERENCES BETWEEN TWO GROUPS IN AN EXPERIMENT ON A DRUG’S EFFECT IN RAISING OR LOWERING BLOOD PRESSURE
TOSS-UP

7) ASTRONOMY  Multiple Choice  Which of the following positions is an inferior planet most likely in if it is seen just after sunset:

W) opposition  
X) superior conjunction  
Y) greatest eastern elongation  
Z) greatest western elongation  

ANSWER: Y) GREATEST EASTERN ELONGATION

BONUS

7) ASTRONOMY  Short Answer  According to the Pogson scale for brightness, by what multiple does the brightness of 2 stars differ that have apparent magnitudes of +3 and +8?

ANSWER: 100

TOSS-UP

8) PHYSICS  Multiple Choice  To early astrophysical researchers, the Sun was originally found to emit about one-third of the expected amount of neutrinos. Which of the following BEST explains why:

W) about 66% of the neutrinos were deflected by the Earth’s magnetic field  
X) two-thirds of the neutrinos were too energetic to be detected  
Y) neutrinos were changing flavor on their way to Earth  
Z) original estimations of the numbers emitted by the Sun were incorrect  

ANSWER: Y) NEUTRINOS WERE CHANGING FLAVOR ON THEIR WAY TO EARTH

BONUS

8) PHYSICS  Multiple Choice  If you were using a 50-millimeter camera lens and changed the lens aperture from 8.0 to 5.6, about how much LESS light would the lens be allowing to pass through it:

W) 60% less  
X) 50% less  
Y) 35% less  
Z) 22% less  

ANSWER: X) 50% LESS

(Solution: 5.6/8.0 = 0.70; (0.70)^2 = 0.49 ~ 50%)
TOSS-UP

9) CHEMISTRY  Multiple Choice  Which of the following is NOT generally true of reaction equilibria:

W) if the temperature of an exothermic reaction is raised, the equilibrium shifts to the left
X) the equilibrium constants for forward and reverse reactions are the reciprocals of each other
Y) pure liquids appear in the equilibrium expression but pure solids do not
Z) an equilibrium constant greater than 1 means that the reaction favors products at equilibrium

ANSWER: Y) PURE LIQUIDS APPEAR IN THE EQUILIBRIUM EXPRESSION BUT PURE SOLIDS DO NOT

(Solution: pure solids and liquids do not appear in the equilibrium expression)

BONUS

9) CHEMISTRY  Short Answer  Calculate $\Delta G^\circ$ (read as: delta G naught), giving your answer in kilojoules, for a reaction in which $\Delta H^\circ = +180$ kilojoules and $\Delta S^\circ = +100$ joules per kelvin at 300 kelvin and 1 atmosphere pressure:

ANSWER: +150  (ACCEPT: 150)  (SO NOT ACCEPT: −150)

(Solution: $\Delta G^\circ = \Delta H^\circ – T\Delta S^\circ = 180\text{kJ} – [300K(0.10\text{kJ/K})] = 150\text{kJ}$)

TOSS-UP

10) BIOLOGY  Multiple Choice  Which of the following is MOST characteristic of human blast cells in on observation with light microscopy:

W) large nuclear to cytoplasmic ratio
X) small nucleolus and mostly heterochromatin in the nucleus
Y) lack of cytoplasmic granules and small overall size compared to mature cells
Z) absence of nucleolus (read as: NEW-clee-oh-luss) and endoplasmic reticulum

ANSWER: W) LARGE NUCLEAR TO CYTOPLASMIC RATIO

BONUS

10) BIOLOGY  Short Answer  What specific molecule binds immediately upstream of the structural genes in the lac (read as: LACK) operon and functions to transcribe these genes?

ANSWER: RNA POLYMERASE
TOSS-UP

11) MATH Multiple Choice  The graph of \( r = 3 \sec(\theta) \) (read as: \( r = 3 \sec \theta \)) is a:

W) parabola
X) circle
Y) hyperbola
Z) line

ANSWER: Z) LINE

BONUS

11) MATH Short Answer  Give the resulting vector for the cross product of vector \( \langle 1,0,0 \rangle \) with vector \( \langle 0,0,1 \rangle \):

ANSWER: \( \langle 0,-1,0 \rangle \)

TOSS-UP

12) EARTH SCIENCE Multiple Choice  When sampling for organic matter in seawater, any organic matter retained by a 0.2 micrometer pore filter is classified as:

W) dissolved organic carbon
X) particulate organic carbon
Y) detrital organic carbon
Z) live or dead marine algae

ANSWER: X) PARTICULATE ORGANIC CARBON

BONUS

12) EARTH SCIENCE Multiple Choice  Which of the following soil additives would be most efficient at increasing the acidity of a slightly alkaline soil:

W) ground chalk
X) aluminum sulfate
Y) calcium sulfate
Z) calcium carbonate

ANSWER: X) ALUMINUM SULFATE
TOSS-UP

13) GENERAL SCIENCE  Multiple Choice  Clean or unpolluted rain water has a pH of about:

W) 5.6  
X) 6.5  
Y) 7.0  
Z) 7.6

ANSWER: W) 5.6

BONUS

13) GENERAL SCIENCE  Multiple Choice  Which of the following plays the greatest role in the effect of acid rain on the environment:

W) the ability of soils and bedrock to neutralize the acid  
X) the initial pH of the rain in the upper troposphere  
Y) low-level ozone concentration  
Z) temperature of the troposphere

ANSWER: W) THE ABILITY OF SOILS AND BEDROCK TO NEUTRALIZE THE ACID

TOSS-UP

14) ASTRONOMY  Multiple Choice  Which of the following is closest to the age of most chondrites:

W) 150 million years  
X) 1.5 billion years  
Y) 4.6 billion years  
Z) 13.7 billion years

ANSWER: Y) 4.6 BILLION YEARS  
(Solution: most are about the same age as our solar system)

BONUS

14) ASTRONOMY  Multiple Choice  Which of the following best describes the hydrogen spectral line strength for an A-type star of about 3 solar masses:

W) missing  
X) weak  
Y) medium  
Z) strong

ANSWER: Z) STRONG
TOSS-UP

15) PHYSICS  *Multiple Choice*  Which of the following BEST describes spin quantum numbers:

W) orientation of intrinsic angular momenta of electrons  
X) centripetal accelerations of atoms  
Y) angular momenta of only hadrons  
Z) centripetal acceleration of electrons

**ANSWER:**  W) ORIENTATION OF INTRINSIC ANGULAR MOMENTA OF ELECTRONS

**BONUS**

15) PHYSICS  *Short Answer*  What is the spin of the muon, in quantum units?

**ANSWER:**  $\frac{1}{2}$

(Solution: muons are fermions which have a spin of $\frac{1}{2}$)

TOSS-UP

16) CHEMISTRY  *Multiple Choice*  Which of the following substances has the greatest density:

W) hexane  
X) methylene chloride  
Y) diethyl ether  
Z) ethyl acetate

**ANSWER:**  X) METHYLENE CHLORIDE

(Solution: halogenated solvents possess a higher density than non-halogenated ones)

**BONUS**

16) CHEMISTRY  *Multiple Choice*  Which of the following molecules is most likely to have a zero dipole moment based on its molecular shape:

W) PF$_3$  
X) H$_2$O  
Y) PCl$_3$  
Z) BeF$_2$

**ANSWER:**  Z) BeF$_2$
TOSS-UP

17) BIOLOGY  Short Answer  What is the most common name for the first membrane-associated molecule discovered to function in a wide variety of cells in what is commonly referred to as a second messenger?

ANSWER: CYCLIC AMP (ACCEPT: cAMP)

BONUS

17) BIOLOGY  Multiple Choice  With which of the following are cyclin-dependent kinases most directly involved:

W) repairing damaged DNA
X) regulating cell cycle
Y) digesting plasmids
Z) insulin’s action on fat cells

ANSWER: X) REGULATING CELL CYCLE

TOSS-UP

18) MATH  Short Answer  What is the angle formed, in degrees, between the hour and minute hand of an analog clock at 10:30 AM?

ANSWER: 135

BONUS

18) MATH  Short Answer  Arrange the following 4 radicals in order of increasing value:

\( \sqrt[4]{12} ; \sqrt[4]{63} ; \sqrt{2} ; \sqrt{8} \)

ANSWER: \( \sqrt{2} ; \sqrt[4]{12} ; \sqrt{8} ; \sqrt[4]{63} \)
TOSS-UP

19) EARTH SCIENCE  Multiple Choice  Which of the following is TRUE regarding the Hadley cell:

W) it creates an area of high pressure along the equator  
X) it is an open ocean circulation at 30º north and south latitudes 
Y) it originates at the equator with strong solar heating  
Z) it is the only air circulation that is not affected by the Coriolis effect

ANSWER:  Y) IT ORIGINATES AT THE EQUATOR WITH STRONG SOLAR HEATING

BONUS

19) EARTH SCIENCE  Short Answer  Name all of the following 3 lavas from which stratovolcanoes are typically composed: andesite; rhyolite; basalt

ANSWER:  ANDESITE;  RHYOLITE

TOSS-UP

20) GENERAL SCIENCE  Multiple Choice  Which of the following is the primary detrimental effect to humans and animals who ingest high levels of melamine:

W) impaired nerve transmission  
X) impaired kidney function  
Y) liver failure  
Z) severe gastrointestinal distress

ANSWER:  X) IMPAIRED KIDNEY FUNCTION

BONUS

20) GENERAL SCIENCE  Multiple Choice  Which of the following is one of the main unique capabilities of the GLAST observatory:

W) it operates completely on photovoltaic cells  
X) it contains the largest superconducting magnet in space  
Y) it can survey the entire celestial sphere several times each day  
Z) it orbits the Moon

ANSWER:  Y) IT CAN SURVEY THE ENTIRE CELESTIAL SPHERE SEVERAL TIMES EACH DAY
TOSS-UP

21) ASTRONOMY  *Short Answer*  In astronomical units to the first decimal place, what is the Chandrasekhar Limit?

ANSWER: 1.4

BONUS

21) ASTRONOMY  *Short Answer*  If a new Moon occurs on May 5\textsuperscript{th} at 8:20 AM eastern daylight time, on what day will the full Moon occur that month?

ANSWER: 19\textsuperscript{th}

TOSS-UP

22) PHYSICS  *Short Answer*  Uranium-238 and plutonium-239, primarily decay by what mode?

ANSWER: ALPHA (ACCEPT: ALPHA EMISSION or ALPHA DECAY)

BONUS

22) PHYSICS  *Short Answer*  What is the name of the instrument invented by Charles Wilson and used in the early 1900’s in many experiments to show the tracks of charged particles passing through a chamber?

ANSWER: CLOUD CHAMBER (ACCEPT: WILSON CLOUD CHAMBER)
TOSS-UP

23) CHEMISTRY  Short Answer  What chemical term is given to the formations that occur in water when a hydrophilic head and a hydrophobic tail organize into spheres that orient the tails within the sphere?

ANSWER: MICELLE

BONUS

23) CHEMISTRY  Short Answer  Using proper chemical nomenclature, finish balancing the following combustion reaction for the gaseous products of carbon dioxide and water:

\[ 2C_4H_{10(gas)} + 13O_{2(gas)} \rightarrow \text{what?} \]

ANSWER: \(8\text{CO}_2 + 10\text{H}_2\text{O}\) (products in any order)

TOSS-UP

24) BIOLOGY  Short Answer  From what basic plant cell type are the majority of cells in a corm (read as: KORM) composed?

ANSWER: PARENCHYMA

BONUS

24) BIOLOGY  Short Answer  If a germ cell of a genus of grass has 48 chromosomes at metaphase-two, how many chromosomes will a germ cell of this grass have in anaphase-two?

ANSWER: 96
TOSS-UP

25) CHEMISTRY  Short Answer  Name all of the following 3 molecules that are considered saturated hydrocarbons: ethylene; ethane; cyclohexane

ANSWER: ETHANE; CYCLOHEXANE

BONUS

25) CHEMISTRY  Short Answer  How many milliliters of a 0.250 molar H₂SO₄ solution will react with 10 milliliters of a 0.250 molar NaOH solution

ANSWER: 5

(Solution: $N_{H_2SO_4} = (2\text{eq/mol})(0.250 \text{ mol/L}) = 0.5 \text{ eq/L}$; $N_{NaOH} = 0.250 \text{ eq/L}$; $(N_{H_2SO_4})(V_{H_2SO_4}) = (N_{NaOH})(V_{NaOH})$; $(0.5 \text{ meq/ml})(x) = (0.25 \text{ meq/ml})(10 \text{ ml}) = 5 \text{ ml}$)