

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-die-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) intrtmix 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: $5.6/8.0 = 0.70$; $(0.70)^2 = 0.49 \sim 50\%$)

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

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-lee-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 $r = 3 \secant(\theta)$ (read as: $r = 3 \secant \theta$) 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) PF₃
- X) H₂O
- Y) PCl₃
- Z) BeF₂

ANSWER: Z) BeF₂

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:

$\sqrt{12}$; $\sqrt[4]{63}$; $\sqrt[3]{2}$; $\sqrt[4]{8}$

ANSWER: $\sqrt[3]{2}$; $\sqrt{12}$; $\sqrt[4]{8}$; $\sqrt[4]{63}$

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 30° 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 5th at 8:20 AM eastern daylight time, on what day will the full Moon occur that month?

ANSWER: 19th

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:
 $2C_4H_{10(gas)} + 13O_{2(gas)} \rightarrow$ what?

ANSWER: $8CO_2 + 10H_2O$ (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: $N_{\text{H}_2\text{SO}_4} = (2\text{eq/mol})(0.250\text{ mol/L}) = 0.5\text{ eq/L}$; $N_{\text{NaOH}} = 0.250\text{ eq/L}$;
 $(N_{\text{H}_2\text{SO}_4})(V_{\text{H}_2\text{SO}_4}) = (N_{\text{NaOH}})(V_{\text{NaOH}})$; $(0.5\text{ meq/ml})(x) = (0.25\text{ meq/ml})(10\text{ ml}) = 5\text{ ml}$)