ROUND 8

TOSS-UP

1) MATH *Multiple Choice* A positive three digit integer n is chosen at random, with each three digit number having an equal chance of being chosen. What is the probability that $\log_2 n$ ***[log base 2 of n]*** is an integer?

W) 3/899
X) 1/300
Y) 1/222
Z) 1/150

ANSWER: X) 1/300

BONUS

1) MATH *Short Answer* A point moves on the curve $6x^2 - 3y^2 = 18$ so that its *y*-coordinate increases at a constant rate of 12 meters per second. At what rate, in meters per second, is the *x*-coordinate changing when the point is at $(3, 2\sqrt{3})$?

ANSWER: $4\sqrt{3}$

TOSS-UP

2) CHEMISTRY *Multiple Choice* "Synthons" are key precursors associated with retrosynthetic analysis, a logical framework pioneered by what chemist?

W) Emil Fischer
X) Robert Robinson
Y) E. J. Corey
Z) Georg Wittig

ANSWER: Y) E. J. COREY

BONUS

2) CHEMISTRY *Short Answer* A buffer solution contains a 10 to 1 ratio of conjugate base to weak acid. The pKa of the weak acid is 5. What is the pH of the solution?

ANSWER: 4

TOSS-UP

3) PHYSICS *Multiple Choice* A 20 kilogram mass is suspended from the end of a spring with a spring constant of 5 newtons per meter. If the mass is displaced 10 centimeters from equilibrium ***[ee-kwuh-LIB-ree-uhm]***, what is the maximum speed of the mass in meters per second?

W) 0.05
X) 0.25
Y) 0.5
Z) 2

ANSWER: W) 0.05

BONUS

3) PHYSICS *Short Answer* A distant planet has a 3:2 spin-orbit resonance due to tidal influences from its nearby host star. If this planet's sidereal day is 50 Earth days, how long, respectively, in Earth days, are its year and its solar day?

ANSWER: YEAR=75, SOLAR DAY=150

TOSS-UP

4) EARTH AND SPACE *Short Answer* Which two spectral classes of main sequence stars have the smallest vertical velocity dispersion about the plane of the galaxy?

ANSWER: O AND B

BONUS

4) EARTH AND SPACE *Multiple Choice* Which of the following two organisms that still exist today first appeared in the recovery period directly after the Permian-Triassic extinction?

W) Marsupial wombats and wallabies
X) Sea urchins and sea stars
Y) Sharks and rays
Z) Magnolias and grasses

ANSWER: X) SEA URCHINS AND SEA STARS

TOSS-UP

5) BIOLOGY *Short Answer* What is the most common autosomal recessive lethal disease in the U.S. among Caucasians?

ANSWER: CYSTIC FIBROSIS

BONUS

5) BIOLOGY *Short Answer* Name all of the following five organisms that lack vessel elements as conducting cells: 1) Norway spruce, 2) Dandelion, 3) Eastern white pine, 4) White fir, 5) Kousa dogwood.

ANSWER: 1, 3, 4 (ACCEPT: NORWAY SPRUCE, EASTERN WHITE PINE, WHITE FIR)

TOSS-UP

6) ENERGY *Short Answer* Air source heat pumps rely on an evaporative and condensing intermediate fluid. What is the general term for this fluid?

ANSWER: REFRIGERANT

BONUS

6) ENERGY *Multiple Choice* Which of the following terms does NOT uniquely apply to the description of magnet properties?

W) Coercive force
X) Anisotropy ***[an-eye-suh-TROP-ik]***
Y) Curie temperature
Z) Remanance ***[REM-uh-nuhns]***

ANSWER: X) ANISOTROPY

TOSS-UP

7) MATH *Short Answer* If $f(x) = 2 - x$ ***[f of x equals 2 minus x]***, find $f(f'(x))$ ***[f of f prime of x]***.

ANSWER: 3

BONUS

7) MATH *Short Answer* Express the following in terms of a single trigonometric function, given that all fractions are defined: $(\sec x + \csc x)/(1 + \tan x)$ ***[the fraction with numerator secant of x plus cosecant of x and denominator 1 plus the tangent of x]***.

ANSWER: $\csc x$ (ACCEPT: $1/\sin x$)

TOSS-UP

8) CHEMISTRY *Short Answer* An enzyme begins oxidation of a fourteen-carbon fatty acid. This metabolic step produces a twelve-carbon fatty acid and what other product?

ANSWER: ACETIC ACID (ACCEPT: ETHANOIC ACID)

BONUS

8) CHEMISTRY *Short Answer* What ring size would be obtained at the end of the following three-step reaction sequence: 1) Diels-Alder cyclization of 1,3- cyclohexadiene ***[sy-kloh-HEK-suh-deen]*** with methyl vinyl ketone; 2) Ozone; 3) Dimethyl ***[dy-METH-uhl]*** sulfide?

ANSWER: SIX

TOSS-UP

9) PHYSICS *Multiple Choice* Which of the following light movement directions is NOT able to produce total reflection from a surface perpendicular to a light beam?

W) From water to air
X) From air to water
Y) From glass to air
Z) From oil to air

ANSWER: X) FROM AIR TO WATER

BONUS

9) PHYSICS *Multiple Choice* A 100 watt current of heat flows via conduction between two stable temperature reservoirs through a material of length 5 centimeters and cross-sectional area 0.5 square meters. If the length of material is extended to 1 meter and the cross-sectional area increased to 1 square meter, what is the new heat current in watts?

W) 5
X) 10
Y) 20
Z) 50

ANSWER: X) 10

TOSS-UP

10) EARTH AND SPACE *Multiple Choice* Hurricanes are rated on the Saffir-Simpson Scale. Tornadoes are rated on the Enhanced Fujita Scale. How are these ratings determined?

W) Saffir-Simpson is based on central pressure and Enhanced Fujita is based on damage
X) Saffir-Simpson is based on wind speed and Enhanced Fujita is based on damage
Y) Both are based on damage
Z) Both are based on vorticity

ANSWER: X) SAFFIR-SIMPSON IS BASED ON WIND SPEED AND ENHANCED FUJITA IS BASED ON DAMAGE

BONUS

10) EARTH AND SPACE *Short Answer* What are the two most abundant components of Venus's atmosphere?

ANSWER: CARBON DIOXIDE AND MOLECULAR NITROGEN (ACCEPT: NITROGEN GAS, NITROGEN)

TOSS-UP

11) BIOLOGY *Short Answer* What is the unit in which the lengths of gene-coding DNA sequences are measured?

ANSWER: BASE PAIR (ACCEPT: BP)

BONUS

11) BIOLOGY *Multiple Choice* While on holiday in Mexico, you note a local vendor selling arrow plant seed pods that jump due the presence of an immature insect that is violently throwing itself from side to side in the seed pod. The insect responsible for this would be a member of what insect order?

W) Lepidoptera ***[lep-i-DOP-ter-uh]***
X) Diptera
Y) Coleoptera ***[koh-lee-OP-ter-uh]***
Z) Hymenoptera ***[hy-muh-NOP-ter-uh]***

ANSWER: W) LEPIDOPTERA

TOSS-UP

12) ENERGY *Short Answer* What is the term for a rate structure where the cost of electricity is based on the time of day you use it?

ANSWER: TIME OF USE (ACCEPT: REAL-TIME PRICING, PEAK USE)

BONUS

12) ENERGY *Multiple Choice* Enhanced Geothermal Systems, developed by the DOE, increased the availability of geothermal generated electricity in the U.S. by what multiple?

W) 3
X) 5
Y) 10
Z) 40

ANSWER: Z) 40

TOSS-UP

13) MATH *Multiple Choice* Given $f(x) = \sqrt{7x^2 - 3}$ ***[f of x equals the square root of the quantity 7 x squared minus 3]***, which of the following are $u(x)$ and $g(u)$ such that $f(x) = g(u(x))$ ***[f of x equals g of u of x]?***

W) $u(x) = 7x^2 - 3$ and $g(u) = \sqrt{u}$
X) $u(x) = \sqrt{x}$ and $g(u) = 7u^2 - 3$
Y) $u(x) = \sqrt{7x^2 - 3}$ ***[u of x equals the square root of the quantity 7 x squared minus 3]*** and $g(u) = \sqrt{u}$
Z) $u(x) = \sqrt{7x - 3}$ and $g(u) = u^2$

ANSWER: W) $u(x) = 7x^2 - 3$ AND $g(u) = \sqrt{u}$

BONUS

13) MATH *Short Answer* Mother Goose divided her estate among her four favorite friends according to the following specifications:

- Humpty Dumpty shall receive half of the estate, less $9000;
- Simple Simon shall receive one third of the estate, less $3000;
- Little Jack Horner shall receive exactly one fourth of the estate;
- Little Miss Muffet shall receive one sixth of the estate, plus $3000.

What was the total dollar value of Mother Goose's estate?

ANSWER: $36,000

TOSS-UP

14) CHEMISTRY *Multiple Choice* The PH_3 molecule has what type of molecular geometry?

W) Trigonal pyramidal
X) Trigonal planar
Y) Angular
Z) Tetrahedral

ANSWER: W) TRIGONAL PYRAMIDAL

BONUS

14) CHEMISTRY *Short Answer* What term describes a reaction that forms two stereoisomers ***[ster-ee-oh-EYE-suh-mers]*** in unequal amounts?

ANSWER: STEREOSELECTIVE

TOSS-UP

15) PHYSICS *Multiple Choice* Three unequal forces act on an object. If the forces have magnitudes of 30 newtons, 50 newtons, and 70 newtons, what is the minimum net force in newtons that can act on this object?

W) 0
X) 10
Y) 50
Z) 90

ANSWER: W) 0

BONUS

15) PHYSICS *Short Answer* If we could capture one second of the total energy output of the Sun, store it, and use it with just 20% efficiency, how long, in years and to two significant digits, would this energy last based upon current global energy consumption? Assume the current global energy consumed per year is about 500,000,000 terajoules and the current luminosity of the Sun is 4×10^{26} watts.

ANSWER: 160,000

TOSS-UP

16) EARTH AND SPACE *Multiple Choice* If a climate report shows the difference in surface air pressure between the Azores and Iceland, what phenomenon is it measuring?

W) El Nino Southern Oscillation
X) Pacific Decadal Oscillation
Y) North Atlantic Oscillation
Z) Arctic Oscillation

ANSWER: Y) NORTH ATLANTIC OSCILLATION

BONUS

16) EARTH AND SPACE *Multiple Choice* Detrital rocks are classified based on which of the following?

W) Mineral composition
X) Grain size only
Y) The conditions in which they formed
Z) Grain shape, grain size, and sorting

ANSWER: Z) GRAIN SHAPE, GRAIN SIZE, AND SORTING

TOSS-UP

17) BIOLOGY *Short Answer* Barbara McClintock studied variation in maize kernel coloration. She found that different patterns of coloration were correlated with chromosome structural changes. She was awarded the 1983 Nobel Prize in physiology or medicine for her discovery. What were the genetic elements she discovered?

ANSWER: MOBILE GENETIC ELEMENTS (ACCEPT: TRANSPOSONS, JUMPING GENES OR MOBILE CONTROLLING ELEMENTS, TRANSPOSABLE ELEMENTS)

BONUS

17) BIOLOGY *Multiple Choice* Which of the following processes is NOT correctly matched with the role it plays in the global nitrogen cycle?

W) Nitrogen fixation with the Haber-Bosch process
X) Nitrogen-fixing bacteria with ammonia produced from nitrogen gas
Y) Legume root nodules with nitrate produced from ammonia
Z) Denitrification ***[dee-ny-truh-fi-KAY-shuhn]*** with nitrogen gas produced from nitrates

ANSWER: Y) LEGUME ROOT NODULES WITH NITRATE PRODUCED FROM AMMONIA

TOSS-UP

18) PHYSICS *Multiple Choice* A 2 kilogram piece of clay is moving with a velocity of 4 meters per second to the north when it collides perfectly inelastically with another 2 kilogram piece of clay that is moving with a speed of 3 meters per second to the east. Which of the following is nearest the angle in degrees that the combined clay's velocity will make with the east after the collision?

W) 30°
X) 37°
Y) 53°
Z) 60°

ANSWER: Y) 53°

BONUS

18) PHYSICS *Short Answer* Given $h = 6.6 \times 10^{-34}$ joule seconds and providing your answer in scientific notation to one significant figure, what is the energy of a photon in joules with a wavelength of 0.1 micrometers?

ANSWER: 2×10^{-18}

TOSS-UP

19) MATH *Multiple Choice* If X and Y are bounded sets, then which of the following is true?

W) Both the union and the intersection of sets X and Y are bounded
X) Both the union and the intersection of sets X and Y are unbounded
Y) The union of sets X and Y is bounded and the intersection of sets X and Y is unbounded
Z) The union of sets X and Y is unbounded and the intersection of sets X and Y is bounded

ANSWER: W) BOTH THE UNION AND THE INTERSECTION OF SETS X AND Y ARE BOUNDED

BONUS

19) MATH *Short Answer* If each interior angle of a polygon is 14 times the size of each exterior angle, what is the sum in degrees of the interior angles of this polygon?

ANSWER: 5040°

TOSS-UP

20) CHEMISTRY *Multiple Choice* The Michaelis-Menten assumptions are integral to understanding the kinetics of enzyme-based reactions. Which of the following is NOT one of these assumptions?

W) Substrate is present in slightly greater quantities than the enzyme
X) In a steady state, the concentration of the intermediate is always constant
Y) Rate is highest when enzyme catalytic sites are saturated with substrate
Z) The reaction between the substrate and the enzyme is reversible

ANSWER: W) SUBSTRATE IS PRESENT IN SLIGHTLY GREATER QUANTITIES THAN THE ENZYME

BONUS

20) CHEMISTRY *Short Answer* Hydrazine, N_2H_4, is manufactured at extremely high pressures and temperatures using ammonia gas and producing hydrogen gas. If 22.4 liters of ammonia gas are used to make hydrazine, how many liters of hydrazine gas are produced?

ANSWER: 11.2

TOSS-UP

21) PHYSICS *Multiple Choice* If the proper energy of 15 grams of matter is 1.35×10^{n} joules, what is the value of *n*?

W) 9
X) 12
Y) 15
Z) 18

ANSWER: Y) 15

BONUS

21) PHYSICS *Short Answer* Given that the elementary charge is 1.6×10^{-19} coulombs and providing your answer in scientific notation to one significant digit, how many excess electrons would be present in an object with a net negative charge of 2.5 coulombs?

ANSWER: 2×10^{19}

TOSS-UP

22) EARTH AND SPACE *Multiple Choice* What is the shape of the orbit of a long period comet that has exactly as much kinetic energy as the absolute value of its gravitational potential energy?

W) Circle
X) Parabola
Y) Hyperbola
Z) Ellipse

ANSWER: X) PARABOLA

BONUS

22) EARTH AND SPACE *Short Answer* Order the following four index minerals according to increasing grade of metamorphism of shale: 1) Sillimanite ***[SIL-uh-muh-nyt]***, 2) Biotite, 3) Chlorite, 4) Garnet.

ANSWER: 3, 2, 4, 1 (ACCEPT: CHLORITE, BIOTITE, GARNET, SILLIMANITE)

TOSS-UP

23) BIOLOGY *Short Answer* What is the name of the phenomenon whereby microorganisms detect and respond to the microbial population density in their immediate surroundings?

ANSWER: QUORUM SENSING

BONUS

23) BIOLOGY *Multiple Choice* Which of the following is NOT true regarding juvenile hormone (JH) in the silkworm moth as it pertains to the hormonal control of insect metamorphosis?

W) JH is produced by the prothoracic ***[proh-tha-RAS-ik]*** gland
X) Levels of JH are higher in first instar larvae ***[LAHR-vee]*** relative to levels in fifth instar larvae
Y) Pupae ***[PYOO-pee]*** have little to no JH
Z) The interplay of ecdysone ***[EK-duh-sohn]*** and JH is important to the molting process

ANSWER: W) JH IS PRODUCED BY THE PROTHORACIC GLAND

TOSS-UP

24) ENERGY *Short Answer* What is the name of the energy storage method where water is pumped from a lower elevation reservoir to a higher elevation during off-peak periods, then released through turbines to produce electric power during peak periods?

ANSWER: PUMPED-STORAGE HYDROELECTRICITY (ACCEPT: HYDRO-STORAGE, PUMPED HYDRO)

BONUS

24) ENERGY *Short Answer* Rank the following four sources of U.S. primary energy production in 2011 from greatest to least: 1) coal, 2) solar, 3) natural gas, 4) crude oil.

ANSWER: 3, 1, 4, 2 (ACCEPT: NATURAL GAS, COAL, CRUDE OIL, SOLAR)

TOSS-UP

25) BIOLOGY *Multiple Choice* Which of the following sea turtle species is phylogenetically distinct from the others and can maintain body temperature elevated above ambient levels?

Y) Kemp's Ridley
X) Leatherback
Y) Green
Z) Loggerhead

ANSWER: X) LEATHERBACK

BONUS

25) BIOLOGY *Multiple Choice* Which of the following scenarios most closely resembles Hardy-Weinberg equilibrium ***[ee-kwuh-LIB-ree-uhm]***?

W) Lizards on a large, isolated island with scarce, scattered food resources
X) Lizards on a large, isolated island with plentiful food resources
Y) Birds on a small island that have highly selective mating behavior
Z) Birds on a small island that fly frequently back and forth to the mainland

ANSWER: X) LIZARDS ON A LARGE, ISOLATED ISLAND WITH PLENTIFUL FOOD RESOURCES