ROUND 13

TOSS-UP

1) MATH *Short Answer* Let $y = e^{x^2}$ ***[e to the power of x squared]***. Find dy/dx.

ANSWER: $2xe^{x^2}$

BONUS

1) MATH *Short Answer* How many distinct permutations can be made from the letters in the word INFINITY?

ANSWER: 3360

TOSS-UP

2) CHEMISTRY *Multiple Choice* What is the local VSEPR geometry of a fully substituted carbonyl carbon?

W) Tetrahedral
X) Trigonal pyramidal
Y) Trigonal planar
Z) T-shaped

ANSWER: Y) TRIGONAL PLANAR

BONUS

2) CHEMISTRY *Multiple Choice* Which of the following analytical tools can provide information about the crystalline structure of unknown materials?

W) X-ray diffraction
X) X-ray photoelectron spectroscopy
Y) High pressure liquid chromatography
Z) Dynamic light scattering

ANSWER: W) X-RAY DIFFRACTION

TOSS-UP

3) PHYSICS *Short Answer* A ball is dropped from rest at a height of 60 meters above the ground. If the potential energy is zero at the ground, then at what height in meters is the potential energy 60% of its initial potential energy?

ANSWER: 36

BONUS

3) PHYSICS *Short Answer* What is the minimum current in amperes a circuit breaker fuse must be able to handle in order to run a 1450 watt refrigerator hooked up to a 110 volt kitchen circuit, assuming fuses are only available in whole number increments?

ANSWER: 14

TOSS-UP

4) EARTH AND SPACE *Multiple Choice* During an El Niño event, the thermocline ***[THUR-muh-klyn]*** in the eastern equatorial Pacific is which of the following, compared to normal?

W) Thicker
X) Thinner
Y) The same
Z) Either thicker or thinner depending on the salinity

ANSWER: W) THICKER

BONUS

4) EARTH AND SPACE *Multiple Choice* Which of the following scenarios made navigation difficult for early sailors and, according to legend, caused them to sacrifice their horses?

W) Sailing from east to west between a subtropical high and subpolar low
X) Sailing adjacent to the intertropical convergence zone
Y) Sailing through the middle of a subtropical high
Z) Sailing from west to east at 23.5° latitude

ANSWER: Y) SAILING THROUGH THE MIDDLE OF A SUBTROPICAL HIGH

TOSS-UP

5) BIOLOGY *Short Answer* What wasteful process occurs when rubisco acts as an oxygenase ***[OK-si-juh-nays]*** instead of a carboxylase ***[kahr-BOK-suh-layz]*** during the Calvin cycle, decreasing the efficiency of photosynthesis and producing carbon dioxide?

ANSWER: PHOTORESPIRATION

BONUS

5) BIOLOGY *Multiple Choice* In contrast to the lysogenic ***[ly-suh-JEN-ik]*** cycle of a bacteriophage ***[bak-TEER-ee-uh-fayj]***, the lytic cycle does which of the following?

W) Integrates phage DNA into the host chromosome
X) Involves the dissolution of host cells to release new phages
Y) Features prophages that can be excised from the host chromosome
Z) Copies phage DNA when the cell divides

ANSWER: X) INVOLVES THE DISSOLUTION OF HOST CELLS TO RELEASE NEW PHAGES

TOSS-UP

6) ENERGY *Multiple Choice* The Marcellus shale gas formation is located in which of the following states?

W) Pennsylvania
X) Texas
Y) Oklahoma
Z) Wyoming

ANSWER: W) PENNSYLVANIA

BONUS

6) ENERGY *Multiple Choice* Compounds of bismuth telluride are used in which of the following types of devices?

W) Photovoltaic devices
X) Computer chips
Y) Energy control devices
Z) Thermoelectric devices

ANSWER: Z) THERMOELECTRIC DEVICES

TOSS-UP

7) MATH *Short Answer* Solve for x: $\ln(x + 1) - 1 = 0$ ***[the natural log of open parenthesis x plus 1 close parenthesis minus 1 equals 0]***.

ANSWER: e - 1

BONUS

7) MATH *Short Answer* Assuming $y^2 + 3x^2y = 7x^2 - 5$ implicitly defines y as a function of x, find dy/dx at the point $(3, 2)$.

ANSWER: 6/31

TOSS-UP

8) CHEMISTRY *Multiple Choice* What are the products of the complete combustion of cyclohexane ***[sy-kluh-HEK-sayn]***?

W) Carbon monoxide, carbon trioxide and water
X) Carbon dioxide and water
Y) Carbon monoxide and water
Z) A variety of small hydrocarbons

ANSWER: X) CARBON DIOXIDE AND WATER

BONUS

8) CHEMISTRY *Multiple Choice* Which of the following ionization techniques will produce the maximum amount of fragmentation?

W) Chemical ionization
X) Fast atom bombardment
Y) Plasma desorption
Z) Electron impact

ANSWER: Z) ELECTRON IMPACT

TOSS-UP

9) PHYSICS *Short Answer* What is the efficiency of a Carnot heat engine in which 500 joules of heat enters from the hot reservoir and 300 joules exits into the cold reservoir?

ANSWER: 40%

BONUS

9) PHYSICS *Short Answer* A typical incandescent light bulb wastes 90% of its power as heat. Ignoring the contribution of the walls and any furniture, if you left a 100 watt incandescent bulb on in a 5 by 5 by 5 meter room for 100,000 seconds, how much would the temperature of the air in the room increase, in degrees Celsius? Assume, for simplicity, that the room is a closed thermodynamic system, the heat capacity of air is 1 joule per gram per degree, and the mass density of air in the room is 1.2 kilograms per cubic meter.

ANSWER: 60

TOSS-UP

10) EARTH AND SPACE *Short Answer* Which class of supernova exhibits strong silicon lines but no hydrogen or helium lines?

ANSWER: TYPE IA

BONUS

10) EARTH AND SPACE *Multiple Choice* How does the Sound Fixing and Ranging (SOFAR) channel support our study of climate change?

W) The deep SOFAR channel is populated with organisms extremely sensitive to ocean temperature change
X) World War II submarines gathered rich and extensive data sets about the SOFAR channel that can be compared with current data
Y) Video monitoring of marine mammal mating behavior is useful because mating behavior in this region is impacted by temperature
Z) Speed of sound is temperature-dependent in the SOFAR channel

ANSWER: Z) SPEED OF SOUND IS TEMPERATURE-DEPENDENT IN THE SOFAR CHANNEL

TOSS-UP

11) BIOLOGY *Multiple Choice* Which of the following organisms stores major food reserves as laminarin and oil instead of starch?

W) Green algae
X) Brown algae
Y) Red algae
Z) Flowering plants

ANSWER: X) BROWN ALGAE

BONUS

11) BIOLOGY *Multiple Choice* Which of the following reactions is incorrectly matched to its enzyme?

W) Kinase: catalyzes the removal of a phosphate group from a molecule
X) Isomerase ***[eye-SOM-uh-rays]***: catalyzes the rearrangement of bonds within a single molecule
Y) Synthase: condenses two smaller molecules together
Z) Protease ***[PROH-tee-ays]***: breaks down proteins by hydrolyzing bonds between amino acids

ANSWER: W) KINASE: CATALYZES THE REMOVAL OF A PHOSPHATE GROUP FROM A MOLECULE

TOSS-UP

12) ENERGY *Multiple Choice* Which of the following explanations is used by scientists to justify the observed accelerating expansion of the universe?

W) Dark matter
X) Fast moving neutrinos
Y) Dark energy
Z) Supernovae ***[soo-per-NOH-vee]***

ANSWER: Y) DARK ENERGY

BONUS

12) ENERGY *Multiple Choice* Power is being transmitted at 100,000 volts and the current flow is 20 amperes. What is the power loss in watts over 120 miles if the resistance of the power line is 0.5 ohms per mile?

W) 6,000
X) 6,667
Y) 12,000
Z) 24,000

ANSWER: Z) 24,000

TOSS-UP

13) MATH *Short Answer* Given $g(x) = \frac{1-\cos(x)}{x^2}$ ***[g of x equals the fraction with numerator 1 minus cosine of x and denominator x squared]***, find $\lim_{x\to 0} g(x)$ ***[the limit as x approaches 0 of g of x]***.

ANSWER: 1/2

BONUS

13) MATH *Short Answer* A store has been buying a certain type of calculator at $25 and selling them at $40. At this price, they have been selling 50 calculators per month. The owner of the store wishes to increase the price of the calculator and estimates that for each $1 increase in price, 3 fewer calculators will be sold each month. Determine the price, to the nearest dollar, that maximizes profit.

ANSWER: $41

TOSS-UP

14) CHEMISTRY *Multiple Choice* Which of the following is considered a diatomic element?

W) Sodium
X) Sulfur
Y) Iodine
Z) Tungsten

ANSWER: Y) IODINE

BONUS

14) CHEMISTRY *Multiple Choice* Which of the following molecules does NOT have D_{3h} symmetry?

W) Phosphorus pentachloride
X) Cyclopropane
Y) Boric acid
Z) Bicyclo[2.2.2]octane

ANSWER: Y) BORIC ACID

TOSS-UP

15) PHYSICS *Multiple Choice* A small rubber duck is held underwater at a depth of 10 meters, then released. When the duck reaches a depth of 5 meters, how much has the buoyant force on the duck changed?

W) It has decreased by half
X) It is unchanged
Y) It has doubled
Z) It has quadrupled

ANSWER: X) IT IS UNCHANGED

BONUS

15) PHYSICS *Short Answer* Charged particles in a uniform magnetic field will undergo circular motion with a period of $T = 2\pi m/(qB)$. The magnetic field of the Earth is roughly 10^{-4} tesla, assuming it is uniform. Given the mass of a proton to be 1.6×10^{-27} kilograms and its electric charge to be 1.6×10^{-19} coulombs, providing your answer in scientific notation to one significant figure, what period in seconds would you measure for a proton?

ANSWER: 6×10^{-4}

TOSS-UP

16) EARTH AND SPACE *Multiple Choice* For the mass-radius relation of white dwarfs, M is proportional to R to what power?

W) -1/3
X) 1/3
Y) 1
Z) 3

ANSWER: W) -1/3

BONUS

16) EARTH AND SPACE *Multiple Choice* What is the primary mode of heat transport in a white dwarf?

W) Convection
X) Conduction
Y) Radiation
Z) Advection

ANSWER: X) CONDUCTION

TOSS-UP

17) BIOLOGY *Multiple Choice* Which of the following marine fish groups reproduces ovoviviparously ***[oh-voh-vy-vip-ER-uhs-lee]***?

W) Coelocanth ***[SEE-luh-kanth]***
X) Ratfish
Y) Ray
Z) Lamprey

ANSWER: W) COELOCANTH

BONUS

17) BIOLOGY *Short Answer* What is the process in which a protein inhibits the function of a second protein by binding to the regulatory site of that second protein, thus altering its functionality?

ANSWER: ALLOSTERIC REGULATION (ACCEPT: ALLOSTERIC INHIBITION)

TOSS-UP

18) CHEMISTRY *Multiple Choice* Dr. Ecniecs, the evil genius, has released multiple dangerous weather balloons into the atmosphere, filled with his new concoction - Boomgas! If the density of Boomgas drops below one third of its density at room temperature, it will explode with the force of $1/10^{th}$ of an atomic bomb. Which of the following disposal methods would force the balloons to explode?

W) Throwing weighted balloons into the sea
X) Releasing the balloons into space
Y) Cryogenically storing the balloons in liquid nitrogen
Z) Venting Boomgas from the balloons

ANSWER: X) RELEASING THE BALLOONS INTO SPACE

BONUS

18) CHEMISTRY *Multiple Choice* Consider the following reaction: $5H_2O_{(l)} + S_2O_3^{2-} + 4Cl_{2\ (aq)} \rightarrow$ ***[yields]*** $8Cl^-_{(aq)} + 2SO_4^{2-}{}_{(aq)} + 10H^+$. What is the oxidizing agent in this reaction?

W) Cl^-
X) $S_2O_3^{2-}$
Y) Cl_2
Z) H_2O

ANSWER: Y) Cl_2

[(L) = LIQUID; (AQ) = AQUEOUS]

TOSS-UP

19) MATH *Short Answer* Given $f(x) = ln\sqrt{e^x}$ ***[f of x equals the natural log of the square root of the quantity e to the x]***, find its first derivative with respect to x.

ANSWER: 1/2

BONUS

19) MATH *Short Answer* Providing your answer in slope intercept form, what is the equation of the line tangent to the graph of $y = \frac{e^{2x}}{x^2}$ ***[y equals the fraction with numerator e to the power of 2x and denominator x squared]*** where $x = 1$?

ANSWER: $y = e^2$ (ACCEPT: $y = 0x + e^2$)

TOSS-UP

20) ENERGY *Multiple Choice* How much energy is required to run a device with compressed air compared to running the same device with electricity?

W) An equal amount
X) Twice as much
Y) Four times as much
Z) Six times as much

ANSWER: Y) FOUR TIMES AS MUCH

BONUS

20) ENERGY *Multiple Choice* Traditional solar cells have a maximum conversion efficiency of about 34% because many of the captured wavelengths result in the creation of heat, not electrons. Newly published research has shown that cell efficiencies can reach up to 44% by doing which of the following?

W) Making them thinner
X) Capturing the blue wavelength
Y) Using gallium arsenide instead of silicon
Z) Using selenium in one of the layers

ANSWER: X) CAPTURING THE BLUE WAVELENGTH

TOSS-UP

21) PHYSICS *Short Answer* What law describes the relationship between the direction of incident and refracted light rays?

ANSWER: SNELL'S LAW

BONUS

21) PHYSICS *Short Answer* A container contains 3 moles of helium. The volume remains constant after 2 moles of gas are added and the temperature is halved. Providing your answer as a fraction, what is the ratio of the initial gas pressure to the final gas pressure?

ANSWER: 6/5

TOSS-UP

22) EARTH AND SPACE *Multiple Choice* According to the United Nations, what is the global warming potential of methane on a 100 year time scale?

W) 1
X) 21
Y) 150
Z) 310

ANSWER: X) 21

BONUS

22) EARTH AND SPACE *Multiple Choice* Which of the following pairs correctly matches the U.S. geographic location and its typical tidal pattern?

W) West Coast – semidiurnal
X) West Coast – diurnal
Y) Gulf of Mexico – diurnal
Z) East Coast – mixed semidiurnal

ANSWER: Y) GULF OF MEXICO – DIURNAL

TOSS-UP

23) BIOLOGY *Multiple Choice* In one form of the disease called macular degeneration, eyesight decreases due to overproduction of new blood vessels (angiogenesis ***[an-jee-oh-JEN-uh-sis]***) in the eye. Inhibition of a gene involved in angiogenesis can be achieved by introducing which of the following forms of complementary RNA molecule into the eye?

W) siRNA
X) Messenger RNA
Y) lncRNA
Z) Transfer RNA

ANSWER: W) siRNA

BONUS

23) BIOLOGY *Multiple Choice* Enzyme A has a high K_m value and low V_{max} value relative to Enzyme B. This means Enzyme A, relative to Enzyme B has which of the following?

W) Higher substrate affinity and a lower reaction rate
X) Lower substrate affinity and a higher reaction rate
Y) Higher substrate affinity and higher reaction rate
Z) Lower substrate affinity and lower reaction rate

ANSWER: Z) LOWER SUBSTRATE AFFINITY AND LOWER REACTION RATE

TOSS-UP

24) CHEMISTRY *Short Answer* What is the oxidation number of tin in SnS_2?

ANSWER: +4

BONUS

24) CHEMISTRY *Short Answer* What term describes the general process by which a racemate ***[ray-SEE-mayt]*** is separated into its component enantiomers ***[i-NAN-tee-uh-mers]***?

ANSWER: RESOLUTION (ACCEPT: CHEMICAL RESOLUTION)

TOSS-UP

25) BIOLOGY *Multiple Choice* You suspect that Cylon, an alien, may be the parent of a human-alien hybrid baby. The alien's blood type happens to be homozygous ***[hoh-muh-ZY-guhs]*** for blood type P for purple, the allele of which is symbolized by I^P ***[eye superscript P]***. As with other blood types, the P protein is co-dominant. If the human parent's blood type is A with a homozygous genotype, what blood phenotype would the baby have to be in order to be a confirmed human-alien hybrid baby?

W) O
X) AP
Y) P
Z) A

ANSWER: X) AP

BONUS

25) BIOLOGY *Multiple Choice* How do bacteria protect their own genomic DNA from being cut by their restriction endonucleases ***[en-duh-NOO-klee-ays-is]***?

W) Genomic DNA of a bacterial species does not contain the recognition sequences for its own restriction endonucleases
X) Bacteria apply protective methyl groups to DNA at sites recognized by their restriction endonucleases
Y) Bacteria have proteins associated with their genomic DNA, preventing the endonucleases from getting close enough to cut
Z) Sequestration of chromosomal DNA in the nucleoid region of a bacterial cell protects it from being cut by restriction endonucleases

ANSWER: X) BACTERIA APPLY PROTECTIVE METHYL GROUPS TO DNA AT SITES RECOGNIZED BY THEIR RESTRICTION ENDONUCLEASES