**TOSS UP**

1. BIOLOGY *Short Answer* Many cartilaginous fishes are able to sense electric fields in the water due to special sensing organs located in their heads. What are these sensory organs called, which consist of a network of jelly-filled pores that can detect voltage differences between the skin and electroreceptors?  
     
   ANSWER: ampullae of lorenzini

**BONUS**

1. BIOLOGY *Short Answer* In the human eye, the visual pigment rhodopsin is compound which is responsible for the first events in the perception of light. Name both the light absorbing molecule and membrane protein which combine to make rhodopsinANSWER: opsin and retinal

**TOSS UP**

1. PHYSICS *Multiple Choice* Which of the following small-angle approximations about the displacement angle, theta, is made when considering a pendulum as a simple harmonic oscillatorW) tangent theta equals theta

X) sine theta equals theta

Y) cosine theta equals 1 minus theta squared over 2

Z) cotangent theta equals thetaANSWER: X) sine theta equals theta

**BONUS**

1. PHYSICS *Short Answer* An object in simple harmonic motion on the end of a spring. How many degrees out of phase is its velocity and acceleration, respectively, from its displacement as a function of time?ANSWER: 90 and 180

**TOSS UP**

1. CHEMISTRY *Short Answer* By name or number, identify all of the following three factors which affect the coupling constant in proton NMR  
   1. distance between protons

2. angle between C-H bonds

3. electronegative substituents  
ANSWER: all of them

**BONUS**

1. CHEMISTRY *Multiple Choice* Which of the following atomic nuclei does NOT exhibit nuclear magnetic resonance?W) hydrogen 1

X) hydrogen 2

Y) silicon 28

Z) xenon 129ANSWER: Y) silicon 28

**TOSS UP**

1. EARTH AND SPACE SCIENCE *Multiple Choice* Most ore-indicating pegmatites areW) granitic

X) rhyolitic

Y) andesitic

Z) basalticANSWER: W) granitic

**BONUS**

1. EARTH AND SPACE SCIENCE *Short Answer* Order the following four volcanic eruption types in order of increasing plume height and eruptive volume1. hawaiian

2. plinian

3. strombolian

4. vulcanianANSWER: 1 3 4 2

**TOSS UP**

1. MATH *Short Answer* A three-digit number abc has the property that the product of a and b is equal to c. What is the greatest possible value of this number?  
     
   ANSWER: 919

**BONUS**

1. MATH *Short Answer* The first three terms of an arithmetic sequence are as follows: 1/2, x-1, 3x. what is the value of the second term if x is plugged in? Express your answer as a simplified improper fraction. ANSWER: -7/2

**TOSS UP**

1. ENERGY *Short Answer* By name or number, identify all of the following three changes to a circuit with a single resistor and battery which would increase the power dissipated by the resistor1. changing the battery to one with a higher voltage

2. adding another resistor in parallel

3. adding another resistor in seriesANSWER: 1 only

**BONUS**

1. ENERGY *Short Answer* How much more power is dissapated by a 3 ohm resistor if it is connected in parallel with a 1 ohm resistor to a 12 V battery than if it is connected in series to the same 1 ohm resistor and battery? Give your answer in wattsANSWER: 21 Watts

**TOSS UP**

1. BIOLOGY *Short Answer* Which of the following groups of animals are NOT tetrapods?   
   W) amphibians

X) mammals

Y) lizards

Z) lungfishes  
ANSWER: Z) lungfishes

**BONUS**

1. BIOLOGY *Multiple Choice* Which of the following is an example of behavioral isolationism?W) blue-footed boobies mate only after a courtship display unique to their species

X) two species of garter snakes occur in the same geographic are but one is terrestrial while the other is aquatic

Y) the geographic ranges of the eastern and western spotted skunk overlap, but one mates in the winter and the other in the summer

Z) the hybrid offspring of a donkey and horse, the mule, is sterileANSWER: W) blue-footed boobies mate only after a courtship display unique to their species

**TOSS UP**

1. PHYSICS *Short Answer* How many degrees of freedom does the nitrogen molecule have, when only considering translational and rotational motion?ANSWER: five

**BONUS**

1. PHYSICS *Short Answer* Calculate the molar constant volume heat capacity of an ideal gas to two significant figures, given that gamma, the ratio of heat capacities for the gas is 1.67 and the ideal gas constant can be approximated as 8.3 J/molK. Give your answer in J/molKANSWER: 13

**TOSS UP**

1. CHEMISTRY *Multiple Choice* Which of the following statements best explains why sodium borohydride is used preferentially over hydrides such as lithium aluminum hydride?  
   W) sodium borohydride is a stronger hydride donor

X) sodium borohydride is more soluble in solutions than other hydrides

Y) sodium borohydride is a stronger reducing agent

Z) sodium borohydride is more stable in water  
ANSWER: Z) sodium borohydride is more stable in water

**BONUS**

1. CHEMISTRY *Multiple Choice* Hemiacetals are formed from the reaction of ketones or aldehydes withW) alcohols

X) water

Y) amides

Z) iminesANSWER: W) alcohols

**TOSS UP**

1. EARTH AND SPACE SCIENCE *Multiple Choice* Which of the following astronomical objects is a ring galaxy?W) Ring Nebula

X) Sombrero Galaxy

Y) Hoag's Object

Z) Pinwheel galaxyANSWER: Y) Hoag's Object

**BONUS**

1. EARTH AND SPACE SCIENCE *Multiple Choice* When a star passes by a black hole but does not collide with it directly, roughly what percent of mass falls into the black hole during the formation of an accretion disk?W)1%

X) 10%

Y) 50%

Z) 90%

ANSWER: W)1%

**TOSS UP**

1. MATH *Short Answer* What is the smallest positive three-digit multiple of 24?  
     
   ANSWER: 120

**BONUS**

1. MATH *Multiple Choice* In a right triangle with legs x, y, and hypotenuse z, y is three times the value of x. What percent of z is y, expressing your answer to the nearest whole number?W) 20%

X) 45%

Y) 75%

Z) 95%ANSWER: Z) 95%

**TOSS UP**

1. ENERGY *Short Answer* What country contains the world's largest proven gas reserves?ANSWER: Russia

**BONUS**

1. ENERGY *Short Answer* Order the following four counties in order of smallest to largest proven oil reserves1. Canada

2. Iran

3. Saudi Arabia

4. VenezuelaANSWER: 2 1 3 4

**TOSS UP**

1. BIOLOGY *Short Answer* Some protists combine both photosynthesis and heterotropic nutrition, both producing their own food from sunlight and eating other organisms. What term is given to these nutritionally diverse protists, which have arisen independently across many protist lineages?   
     
   ANSWER: mixotrophs

**BONUS**

1. BIOLOGY *Short Answer* Identify the following four plastid-bearing eukaryotes as having either plastids derived from red algae or green algae1. dinoflagellates

2. stramenopiles

3. euglenids

4. chlorarachniophytesANSWER: 1 red 2 red 3 green 4 green

**TOSS UP**

1. PHYSICS *Multiple Choice* You are trying to cool a cylinder of gas containing 10 moles of an ideal gas from 30 to 20 degrees celsius. The amount of heat you need to extract from the cylinder would be the least if it was filled with aW) monatomic gas

X) diatomic gas

Y) non-linear polyatomic gas

Z) it does not matter what kind of gas the cylinder is filled withANSWER: W) monatomic gas

**BONUS**

1. PHYSICS *Short Answer* You have three samples of an ideal gas. Each sample contains the same number of moles of gas and are all at STP. You compress each sample to half its original volume. For each of the following samples and compression conditions, order the final pressure from lowest to highest1. a monatomic gas compressed isothermally

2. a monatomic gas compressed adiabatically

3. a diatomic gas compressed adibaticallyANSWER: 1 3 2

**TOSS UP**

1. CHEMISTRY *Short Answer* Certain species of cyclic molecules with alternating CH2CH2O units bind strongly to metal cations, encasing them in a nonpolar shell. Often, this is useful when one wishes to carry out oxidation reactions with a metal in a nonpolar solvent. Name these "trojan horse" ethers.   
     
   ANSWER: crown ethers

**BONUS**

1. CHEMISTRY *Short Answer* Give the structureal formula of the compound formed from the reaction between propanoic acid, CH3CH2COOH, and methanol, CH3OHANSWER: CH3CH2COOCH3

**TOSS UP**

1. EARTH AND SPACE SCIENCE *Short Answer* Mercury has a large impact crater about 1500 km in diameter, making it one of the largest impact sites in the solar system. What is the name of this basin, flanked by mountains 2 km tall and named because the sun shines directly overhead every time Mercury passes perihelion.ANSWER: caloris basin

**BONUS**

1. EARTH AND SPACE SCIENCE *Short Answer* Objects caught in a 2:3 orbital resonance with Neptune, at a distance of 39.4 AU take about 250 years to orbit the sun. What is the name of this population of objects, named after the first of such bodies to be discovered?ANSWER: plutinos

**TOSS UP**

1. MATH *Short Answer* If m is a non-zero real number, then what is the arithmetic mean of the (m+3)/m and (m-3)/m?  
     
   ANSWER: 1

**BONUS**

1. MATH *Short Answer* The formula t equals n(n+1)/2 will determine a triangular number, where n is a natural number. For what value of n will the triangular number 325 be found?ANSWER: 25

**TOSS UP**

1. ENERGY *Multiple Choice* Which of the following statements best explains why engine exhaust contains carbon monoxide and unburned hydrocarbons?W) it is difficult to regulate the fuel-air mixture in order to ensure complete combustion

X) it is advantageous for reliable ignition to have a mixture which is richer in gasoline than oxygen, resulting in incomplete combustion

Y) catalytic converters convert combustion products of CO2 and water back into hydrocarbons for reuse

Z) carbon monoxide and unburned hydrocarbons are a result of gasoline vapors escaping from the fuel tank into the exhaustANSWER: X) it is advantageous for reliable ignition to have a mixture which is richer in gasoline than oxygen, resulting in incomplete combustion

**BONUS**

1. ENERGY *Short Answer* During the 1960s, a series of satellites known as Vela were launched to monitor gamma ray bursts. When the detectors were switched on, they detected hundred of gamma ray bursts. Which of the following was the main source of the gamma rays?W) nuclear weapons tests

X) cosmic sources such as hypernova and neutron stars

Y) nuclear fusion in the sun

Z) natural decay of radioactive elements in spaceANSWER: X) cosmic sources such as hypernova and neutron stars

**TOSS UP**

1. BIOLOGY *Short Answer* What small, water-dwelling segmented animals are noted for being one of the most complex extremophiles, being able to withstand extreme temperatures, pressures, and radiation and are under investigation for their ability to survive in outer space?  
     
   ANSWER: tardigrades (accept water bears)

**BONUS**

1. BIOLOGY *Multiple Choice* In the average human, roughly what percent of water loss is through urination?W) 10%

X) 40%

Y) 60%

Z) 90%ANSWER: Y) 60%

**TOSS UP**

1. PHYSICS *Multiple Choice* A student has a circuit with a 12V battery and 4 ohm resistor. He connects an ammeter and voltmeter to the circuit, and finds that while he is able to get a reading on the voltmeter, the ammeter displays no current going through it. Which of the following is the best explanation for this situation?W) he failed to properly connect the circuit to the battery

X) he failed to properly connect the circuit to the resistor

Y) he connected the voltmeter in series

Z) he connected the ammeter in parallelANSWER: Y) he connected the voltmeter in series

**BONUS**

1. PHYSICS *Short Answer* What is the terminal potential difference for a 12 volt battery with an internal resistance of 0.4 ohms connected to a 2 ohm resistor?ANSWER: 10 volts

**TOSS UP**

1. CHEMISTRY *Multiple Choice* Which of the following statements explains why natural latex is softer than the harder gutta percha, although both are naturally-occurring products derived from tree sap?  
   W) latex has neoprene monomers, while gutta percha has isoprene monomers

X) latex has higher water content than gutta percha

Y) latex is cis polymerized, while gutta percha is trans polymerized

Z) latex polymers are shorter than gutta percha polymers  
ANSWER: Y) latex is cis polymerized, while gutta percha is trans polymerized

**BONUS**

1. CHEMISTRY *Short Answer* During synthetic rubber production, what catalysts are used in order to ensure the isoprene polymers are all cis-polyisoprene instead of a random mix of cis-and trans- which would yield a sticky, unusable product.ANSWER: ziegler natta catalysts

**TOSS UP**

1. EARTH AND SPACE SCIENCE *Multiple Choice* The majority of damage caused by hurricanes along the coast is due toW) storm surge

X) rain-related flooding

Y) low pressure

Z) wind ANSWER: W) storm surge

**BONUS**

1. EARTH AND SPACE SCIENCE *Short Answer* By name or number, identify all of the following three regions which are currently experiencing isostatic rebound1. Northern Britain

2. the Great Lakes

3. FloridaANSWER: 1 and 2

**TOSS UP**

1. MATH *Multiple Choice* If a function f is defines by f(x) equals 2 +ln(x+3), then an inverse of f is  
   W) (2 + ln(x+3))^-1

X) ln(x-2)

Y) e^(x-2) - 3

Z) e^(x+2) - 3  
ANSWER: Y) e^(x-2) - 3

**BONUS**

1. MATH *Short Answer* Find the limit as x goes to zero of the fraction with numerator sinx - sin2x and denominator xANSWER: -1

**TOSS UP**

1. ENERGY *Short Answer* Also known as calomel, what compound is employed in electrochemistry as a reference electrode and used to commonly be found in electronic pH meters until it was phased out due to its toxicity?ANSWER: mercury i chloride

**BONUS**

1. ENERGY *Short Answer* The Sicilian, Frasch, and Claus process are all methods of producing what element?ANSWER: sulfur

**TOSS UP**

1. BIOLOGY *Short Answer* In the hydrozoan Oberlia, found in the phylum Cnideria, one stage of its life is as a medusa. What is the other major stage of its life, during which the organism grows a cylindrical sac, with a holdfast at one end and the mouth and tentacles at the other?  
     
   ANSWER: polyp

**BONUS**

1. BIOLOGY *Multiple Choice* Which of the following organisms is NOT classified as a true jellyfish?W) Portuguese-man-of-war

X) black sea nettle

Y) moon jellyfish

Z) box jellyfishANSWER: W) Portuguese-man-of-war