**TOSS UP**

1. BIOLOGY *Multiple Choice* Which of the following methods is a process by which molecules in solution, commonly proteins, are fractionated by size by exploiting the differences in the rates at which they diffuse through a bed of porous, semisolid substance packed in a vertical column?  
   W) gel chromatography

X) gel electrophoresis

Y) Southern Blotting

Z) Northern Blotting  
ANSWER: W) gel chromatography

**BONUS**

1. BIOLOGY *Multiple Choice* A raspberry is an example of W) accessory fruit

X) simple fruit

Y) aggregate fruit

Z) multiple fruitANSWER: Y) aggregate fruit

**TOSS UP**

1. PHYSICS *Short Answer* What theorem in theoretical physics, first proved by its namesake German mathematician in 1915, states that any differentiable symmetry of the action of a physical system has a corresponding conservation law. More informally, it says that if a system has a continuous symmetry property, then there are corresponding quantities that are conserved in time. Name this theorem, which is exemplified by conservation of energy, conservation of momentum, and conservation of angular momentum. ANSWER: noether's theorem

**BONUS**

1. PHYSICS *Short Answer* Give the conserved quantities proven by Noether's Theorem for the following three symmetries: time symmetry, spatial symmetry, rotational symmetryANSWER: energy, linear momentum, angular momentum

**TOSS UP**

1. CHEMISTRY *Multiple Choice* Which of the following is capable of oxidizing oxygen?  
   W) cesium

X) gold

Y) hydrogen

Z) fluorine

ANSWER: Z) fluorine

**BONUS**

1. CHEMISTRY *Short Answer* In the following unbalanced redox reaction MnO4- + I- yields I 2 + Mn2+, how many water molecules are produced as a result?ANSWER: 8

**TOSS UP**

1. EARTH AND SPACE SCIENCE *Multiple Choice* Which of the following is the largest reservoir of drinkable water on Earth, supporting one third of the world's population?W) fresh groundwater

X) ice caps, glaciers, and permanent snow

Y) fresh lakes and rivers

Z) oceans, seas, and bays

ANSWER: X) ice caps, glaciers, and permanent snow

**BONUS**

1. EARTH AND SPACE SCIENCE *Short Answer* What Norwegian term refers to a long, narrow inlet with steep sides or cliffs, created by a glacier that has since melted and flooded by the sea? These bodies of water are characteristic of much of the coast of Norway, as well as the island of GreenlandANSWER: fjord

**TOSS UP**

1. MATH *Short Answer* A set includes all the three digit numbers that contain only one and two as their digits. How many members of this set have an integer average of the sum of the hundreds, tens, and units place?  
     
   ANSWER: 2

**BONUS**

1. MATH *Multiple Choice* Set A contains the integers 1 to 30, inclusive. Set B consists of all the integers with only one prime factor. How many numbers are contained in the union of A and B? W) 10

X) 13

Y) 21

Z) 30

ANSWER: X) 13

**TOSS UP**

1. ENERGY *Multiple Choice* In 2010, approximately what percentage of the US's energy came from renewable sources such as biomass, geothermal, wind, and hydropower?W) 60%

X) 40%

Y) 23%

Z) 8%ANSWER: Z) 8%

**BONUS**

1. ENERGY *Multiple Choice* Which of the following is being investigated as a possible method of reducing phonon drag while simultaneously preserving electrical conductivity in thermoelectric devices?W) high-temperature superconductors

X) clathrates and skutterudites

Y) symmetrical piezoelectric quartz crystals

Z) gallium nitride semiconductorsANSWER: X) clathrates and skutterudites

**TOSS UP**

1. BIOLOGY *Multiple Choice* Oxygenated blood flowing to the heart from the lungs first enters the  
   W) right ventricle

X) right atrium

Y) left ventricle

Z) left atrium  
ANSWER: Z) left atrium

**BONUS**

1. BIOLOGY *Multiple Choice* The phylum cnidaria contains all of the following except for W) sea anemone

X) box jellyfish

Y) corals

Z) starfish

ANSWER: Z) starfish

**TOSS UP**

1. PHYSICS *Multiple Choice* A toy top is spun on the earth with an initial angular velocity omega , and T, the period of precession is measured. The top is then taken to the moon, which has a gravitational field 1/6th that of earths, and started with the same initial angular velocity omega. Compared to its period on the earth, the gyroscope now has a period ofW) 1/6th T

X) T

Y) 6 T

Z) 36 TANSWER: W) 1/6 T

**BONUS**

1. PHYSICS *Short Answer* An object is connected to an ideal spring with spring constant 20 N/m that is set in simple harmonic motion. If the displacement in meters of the object is given by the equation 3cos(2x)

A. what is the period of the object's oscillation?

B. on the interval negative pi over two to pi over two, inclusive, what is the magnitude of the maximum force exerted on the object, and at what displacement value does this occur?ANSWER: a. pi, b. 60 n, 0 meters

**TOSS UP**

1. CHEMISTRY *Short Answer* One mole of a monatomic gas is heated isochorically from 1 Kelvin to 2.71828 Kelvin. What is the change in entropy, to two significant digits?  
     
   ANSWER: 12 J/K

**BONUS**

1. CHEMISTRY *Short Answer* By name or number, identify all of the following four statements that are true for a reaction in which both delta q and delta S system are negative1. the reaction is spontaneous only at high temperatures

2. delta S surroundings is positive

3. the magnitude of delta S system must be less than the magnitude of delta S surroundings

4. some of the heat released by the reaction increases the entropy of the surroundingsANSWER: 2, 4

**TOSS UP**

1. EARTH AND SPACE SCIENCE *Short Answer* What type of biogeneous pelagic sediment, covering 48% of the ocean's floor is made up of tests, the microscopic calcium-based shells of foraminifera, coccolithophores, and pteropods, and accumulates more rapidly than any other pelagic sediment type? ANSWER: Calcareous ooze

**BONUS**

1. EARTH AND SPACE SCIENCE *Short Answer* Classify the following five features of the continental margin from lowest elevation to highest elevation: abyssal plain, coastal plain, continental rise, continental slope, continental shelfANSWER: abyssal plain, continental rise, continental slope, continental shelf, coastal plain (1, 3, 4, 5, 2)

**TOSS UP**

1. MATH *Multiple Choice* If x-1 is a factor of two, three, four, and twelve, which of the following gives the next largest value that is also divisible by these factors?  
   W) x

X) x+1

Y) x+5

Z) x+11  
ANSWER: Z) x+11

**BONUS**

1. MATH *Short Answer* Click here to enter text.ANSWER: Click here to enter text.

**TOSS UP**

1. ENERGY *Short Answer* What renewable energy source, accounting for 4.4% of the energy consumption of the US in 2010, consists of any organic matter that is used for energy? ANSWER: biomass

**BONUS**

1. ENERGY *Short Answer* List the following three sources of biomass in DECREASING percent contribution to US biomass energy production: biofuels, garbage and landfill waste, wood and wood wasteANSWER: wood and wood waste, biofuels, garbage and landfill waste

**TOSS UP**

1. BIOLOGY *Short Answer* In vascular plants, what tissue carries organic nutrients, in particular sucrose, in a process called translocation and comprises the innermost layer orf the bark.   
     
   ANSWER: phloem

**BONUS**

1. BIOLOGY *Short Answer* List the following four layers of a tree trunk from innermost to outermost: secondary phloem, vascular cambium, heartwood, sapwoodANSWER: heartwood, sapwood, vascular cambium, secondary phloem (3, 4, 2, 1)

**TOSS UP**

1. PHYSICS *Short Answer* An open tube manometer consists of an U shaped tube containing mercury that is open to the atmosphere at its right end, with the left end connected to a container with gas at a pressure p. If the difference in heights between the right and left sides is 30 mm, what is the ABSOLUTE pressure of the gas in the container, in mm of mercury?

ANSWER: 790 mm

**BONUS**

1. PHYSICS *Short Answer* A ball is released from the left side a bowl from a height h naught whose cross section can be approximated as a semicircle opening upwards, and rolls without slipping down the bowl and up the opposite side, reaching a maximum height of h on the right side. Which of the following statements gives the relationship between h and h naught?W) h is less than h naught

X) h is greater than h naught

Y) h is equal to h naught

Z) the relationship cannot be determined using the given informationANSWER: Y) h is equal to h naught

**TOSS UP**

1. CHEMISTRY *Multiple Choice* Assuming equal amounts added to a fixed volume, which of the following acids will have the highest percent disassociation in water?

W) HF

X) HCl

Y) HBr

Z) HI  
ANSWER: Z) HI

**BONUS**

1. CHEMISTRY *Multiple Choice* In the reaction 2KMnO4 + 3H3SO4 + 5H2S yields 5S + 2MnSO4 + K2SO4 + 8H2O, the oxidation number of sulfur changes fromW) 8 to 0

X) -2 to 0

Y) -2 to 8

Z) 8 to -2ANSWER: X) -2 to 0

**TOSS UP**

1. EARTH AND SPACE SCIENCE *Multiple Choice* Lunar eclipses can only happen when the moon's phase is W) a new moon

X) a full moon

Y) a waxing gibbous moon

Z) a third quarter moonANSWER: X) a full moon

**BONUS**

1. EARTH AND SPACE SCIENCE *Short Answer* What cycle of 223 syndotic months, approximately equating to 18 years and 11 days, can be used to predict both lunar and solar eclipses? After one of these cycles, the sun, earth and moon return to approximately the same relative geometry, resulting in a cycle of eclipses that are nearly identical to their corresponding predecessors.ANSWER: saros cycle

**TOSS UP**

1. MATH *Short Answer* Integrate the following function: (lnx)/x  
     
   ANSWER: 1/2 (lnx) squared plus c

**BONUS**

1. MATH *Short Answer* What is the indefinite integral oh log base 2 of the quantity sin 3x close quantity in simplest form?ANSWER: 3cot3x over ln 2

**TOSS UP**

1. ENERGY *Short Answer* The Weldon, Hooker, and Chloralkali processes are used to produce what gaseous element?ANSWER: chlorine

**BONUS**

1. ENERGY *Short Answer* A Carnot engine expels 100 J of heat into its cold reservoir after doing 400 J of useful work. If the temperature of the cold reservoir is 200 K, what is the minimum temperature of the hot reservoir in KelvinANSWER: 1000 K

**TOSS UP**

1. BIOLOGY *Short Answer* In what type of mycorrhizae does the mycelium form a dense mantle over the surface of the root, with fungal hyphae forming a network in the extracellular space without penetration of the root cells?   
     
   ANSWER: ectomycorrhizae

**BONUS**

1. BIOLOGY *Short Answer* Classify the following 4 steps of the nitrogen cycle as either reducing or oxidizing: 1. ammonification 2. nitrogen fixation 3. nitrification 4. denitrification ANSWER: 1. reducing 2. reducing 3. oxidizing 4. oxidizing

**TOSS UP**

1. PHYSICS *Multiple Choice* A horizontal steel beam is supported on the undersides of its two ends. A downward force is then applied on the middle of the length of the beam, causing the beam to flex downwards, forming an upwards U shape. Which of the following statements describes the stresses in the beam?W) compression stress on the upper surface, tensile stress on the lower surface

X) tensile stress on the upper surface, compression stress on the lower surface

Y) compression stress throughout the entire beam

Z) tensile stress throughout the entire beamANSWER: W) compression stress on the upper surface, tensile stress on the lower surface

**BONUS**

1. PHYSICS *Short Answer* A force of 600 N is applied to a wire with a Young's Modulus of 6 Pascals. If the wire has an original length of 50 cm and cross sectional area of 2 cm squared, what will be the final length of the wire to the nearest centimeter?ANSWER: 51 cm

**TOSS UP**

1. CHEMISTRY *Short Answer* Saaket has a solution of saturated barium chloride solution. For some reason, he wishes to increase the concentration of chloride ions in the solution. Which of the following actions could he take in order to achieve this?  
   W) bubbling chlorine gas through the solution

X) cooling the solution, then adding more barium chloride

Y) adding sodium chloride to the solution

Z) adding potassium sulfate to the solution, then adding barium chloride

ANSWER: Z) adding potassium sulfate to the solution, then adding barium chloride

**BONUS**

1. CHEMISTRY *Multiple Choice* In a mixture of HCl gas and Argon gas, which of the following dominates intermolecular forces between HCl and Argon molecules?W) dipole-dipole forces

X) dipole-induced dipole forces

Y) ion-dipole forces

Z) London dispersion forces

ANSWER: X) dipole-induced dipole forces

**TOSS UP**

1. EARTH AND SPACE SCIENCE *Short Answer* A cannonball is fired horizontally from the top of a very tall mountain with an initial velocity of 12 km/s. Assuming the projectile is solely under the influence of earth's gravity, by name or number, identify all of the following 5 statements that are true about the orbit of the cannonball.1. the orbit of the cannonball is closed

2. the orbit of the cannonball is open

3. the cannonball follows a hyperbola

4. the cannonball follows a parabola

5. the cannonball follows an ellipse

ANSWER: 2, 3

**BONUS**

1. EARTH AND SPACE SCIENCE *Multiple Choice* Which of the following statements best explains why Mercury's perihelion advances 43 arc seconds per century faster than was originally predicted by Newton's laws? W) by general relativity, the sun's gravity curves space-time, allowing Mercury's orbit to precess faster than if space-time were flat

X) there is a large quantity of dust between Mercury and the sun whose gravitational field was not accounted for in the Newtonian calculations

Y) tidal forces between Mercury and the sun increase its rate of precession; these forces are minimal on planets farther away from the sun and so were not originally taken into consideration

Z) Astronomers originally calculating Mercury's precession were mistaken in their observations, and improved technology has since accounted for the discrepancy

ANSWER: W) by general relativity, the sun's gravity curves space-time, allowing Mercury's orbit to precess faster than if space-time were flat

**TOSS UP**

1. MATH *Short Answer* What is the definite integral from - pi over three to pi over three of cos(5x) + 3?  
     
   ANSWER: zero

**BONUS**

1. MATH *Short Answer* A function f(x) that passes the horizontal line test is concave up increasing monotonically on the interval [1, 5]. What are the signs of the first derivative and second derivative, respectively, of x inverse of x at x = 3?ANSWER: positive, negative

**TOSS UP**

1. ENERGY *Short Answer* What thermodynamic temperature scale, named after the Scottish physicist who first proposed it in 1959, is the Imperial equivalent of the Kelvin scale, with -459.67 degrees Fahrenheit equivalent to absolute zero. ANSWER: rankine scale

**BONUS**

1. ENERGY *Short Answer* What country was estimated by the UN to have the highest total carbon dioxide emissions, producing 29.9 billion tons of CO2 and accouting for 23.53% of global emissions in 2008?ANSWER: china

**TOSS UP**

1. PHYSICS *Multiple Choice* A rocket is in orbit with a distance R from the earth's center with a velocity v. If the commander wishes to enter change the orbit of the rocket from a closed orbit to an open one, what is the minimum factor by which the velocity of the rocket must increase?  
   W) 2Rv

X) sqrt(2)

Y) 2

Z) 2v

ANSWER: X) sqrt(2)

**BONUS**

1. PHYSICS *Short Answer* 480 Coulomb passes through a 4 ohm resistor in 10 minutes. Give A. the potential difference across the resistor, and B. the power dissipated by the resistorANSWER: A. 3.2 V B. 2.56 W