**TOSS UP**

1. BIOLOGY *Short Answer* What are the names of the large granular bodies found in neurons, which are rough endoplasmic reticulum used in protein synthesis?  
     
   ANSWER: nissl bodies

**BONUS**

1. BIOLOGY *Short Answer* Which layer of the meninges is positioned between the other 2?ANSWER: arachnoid mater

**TOSS UP**

1. PHYSICS *Short Answer* What is the magnitude of force on an object with a charge of q = 2 in an electric field of 5 V/m?ANSWER: 10 N

**BONUS**

1. PHYSICS *Multiple Choice* If a nonzero net torque is applied from an external source onto a frictionless rotating device, which of the following statements is false?  
   W) The rotational velocity at some time t can be equal to zero after the torque begins.  
   X) The final total rotational energy of the system can be greater than the total work done by the net torque.  
   Y) The total momentum of the device is constant before and after the torque is applied.  
   Z) Any gravitational potential energy gained by the device during rotation is lost upon completion of a full revolution.ANSWER: Y

**TOSS UP**

1. CHEMISTRY *Multiple Choice* Which of the following compounds has the highest lattice energy?  
   W) KCl  
   X) MgO  
   Y) NaF  
   Z) CaS  
     
   ANSWER: X

**BONUS**

1. CHEMISTRY *Multiple Choice* Which of the following will decrease the vapor pressure of a liquid?  
   W) Increasing the kinetic energy of the molecules in the liquid  
   X) Increase intramolecular hydrogen bonding  
   Y) Decrease intermolecular hydrogen bonding  
   Z) Decreasing temperature of the liquidANSWER: Z

**TOSS UP**

1. EARTH AND SPACE SCIENCE *Short Answer* What is the name of the rocking, swaying, or nodding motion in the axis of rotation of a largely axially symmetric object, caused by tidal forces that cause the precession of the equinoxes to vary over time so that the speed of precession is not constant?ANSWER: nutation

**BONUS**

1. EARTH AND SPACE SCIENCE *Short Answer* What 3 externally observable parameters of a black hole are postulated to completely characterize it, by the no hair theorem? ANSWER: mass, electric charge, angular momentum

**TOSS UP**

1. MATH *Multiple Choice* Give the area that lies below the x-axis and is contained within the region bounded by the polar curve, r=1+2sin(theta).  
   W) pi – 4 + root3 over 2  
   X) pi – 2 + 3root3 over 2  
   Y) pi over 2 minus 2 + 3root3 over 2  
   Z) pi over 2 – 4 + 3root3 over 2  
     
   ANSWER: Z

**BONUS**

1. MATH *Short Answer* Denote by name or number all of the following 3 statements which is or are true of the function, f(x) = (sinx)/x^2  
   1. The graph is always concave up.  
   2. The graph of the function is symmetric about the x axis.  
   3. The function has a vertical asymptote at x=0ANSWER: 3 only

**TOSS UP**

1. ENERGY *Short Answer* If you are given 3 mixtures of quantum dots, the first one glowing red, the second one glowing green, and the third one glowing blue, order these mixtures in order from least to greatest in size of the crystals found inside the semiconductor quantum dots.ANSWER: 321

**BONUS**

1. ENERGY *Short Answer* What process, important in semiconductor physics involving light, is caused when a material absorbs photons and electron-hole pairs are created?ANSWER: photovoltaic effect

**TOSS UP**

1. BIOLOGY *Short Answer* Denote by name or number all of the following 5 animals which are vertebrates.  
   1. Lampreys  
   2. Carp  
   3. Coelacanths  
   4. Falcons  
   5. Abalone  
     
   ANSWER: 1234

**BONUS**

1. BIOLOGY *Short Answer* What organelles are the centers of carbon dioxide fixation within the chloroplasts of algae and hornworts?ANSWER: pyrenoid

**TOSS UP**

1. PHYSICS *Short Answer* If the escape velocity of a rocket from the surface of the Earth is v, then the escape velocity of the same rocket from the surface of a planet whose acceleration due to gravity is 4 times that of Earth, and whose radius is 4 times that of the Earth is what, in terms of v?ANSWER: 4v

**BONUS**

1. PHYSICS *Short Answer* A force of 10 N was applied to opposite faces of a 0.5 m x 0.5 m x 0.5 m box. The height of the box then became 0.25 m. What is the Youngs Modulus for this box?ANSWER: 80

**TOSS UP**

1. CHEMISTRY *Short Answer* What heterogeneous catalyst that consists of palladium deposited on calcium carbonate and treated with various forms of lead is used for the hydrogenation of alkynes to alkenes?  
     
   ANSWER: lindlar catalyst

**BONUS**

1. CHEMISTRY *Multiple Choice* The pKa of the amino acid tyrosine is between 10.0 and 10.3. Tyrosine molecule R groups are phenolics, with the hydroxyl hydrogen titrating in the pH range given. If a given solution of tyrosine molecules is brought from pH 9 to pH 11, what do you expect to occur to the hydroxyl group?  
   W) The hydroxyl will go from being protonated at pH 9 to being deprotonated at pH 11  
   X) The hydroxyl will go from being deprotonated at pH 9 to being protonated at pH 11  
   Y) The hydroxyl will remain deprotonated during the pH shift  
   Z) The hydroxyl will remain protonated during the pH shiftANSWER: W

**TOSS UP**

1. EARTH AND SPACE SCIENCE *Short Answer* What event, once known informally as the KT, or Cretaceous-Tertiary extinction, is now known by a new name, since the title tertiary is not considered a formal time or rock unit?ANSWER: Creataceous Paleogene Extinction event/ k-pg

**BONUS**

1. EARTH AND SPACE SCIENCE *Short Answer* The KT boundary was discovered in strata due to clay which contained high amounts of which element, embedded between more normal strata? ANSWER: iridium

**TOSS UP**

1. MATH *Multiple Choice* The graph of y=5x^4 – x^5 has a point of inflection at which point or points?   
   W) (0,0) only  
   X) (3, 162) only  
   Y) (0,0) and (3, 162)  
   Z) (0,0) and (4, 256)  
     
   ANSWER: X

**BONUS**

1. MATH *Short Answer* If dy/dx = tanx, then what does y equal?ANSWER: ln (absval(secx)) + c

**TOSS UP**

1. ENERGY *Short Answer* Denote by name or number all of the following 3 which is or are disadvantages of fluidized bed converters.  
   1. Particles can become entrained in the fluid  
   2. They require the addition and removal of heat.  
   3. More cost due to higher pressure requirements.ANSWER: 1 and 3

**BONUS**

1. ENERGY *Short Answer* What quasiparticle represents an excited state in the quantum mechanical quantization of the modes of vibrations of elastic structures of interacting particles?ANSWER: phonon

**TOSS UP**

1. BIOLOGY *Short Answer* During what phase of meiosis is oocyte development arrested at when a human female is born?  
     
   ANSWER: Prophase I

**BONUS**

1. BIOLOGY *Short Answer* What is the phenomenon where the effects of one gene are modified by one or several other genes, which are sometimes called modifier genes?ANSWER: epistasis

**TOSS UP**

1. PHYSICS *Multiple Choice* There is a stationary rectangular loop circuit. A magnetic field passes through the loop and into the page. The magnetic field is increasing. What is the direction of the induced current?  
   W) Clockwise  
   X) Counter Clockwise  
   Y) Potato  
   Z) There is no induced currentANSWER: X

**BONUS**

1. PHYSICS *Short Answer* What device, useful for measuring tiny magnetic fields and establishing precise voltage standards, consists of two superconductors separated by an oxide layer a few atoms thick?ANSWER: josephson junction

**TOSS UP**

1. CHEMISTRY *Multiple Choice* The Beer-Lambert law suggests which of the following?  
   W) The greater the path length, the higher the molar absorptivity  
   X) The greater the molar absorptivity, the higher the concentration  
   Y) The greater the concentration, the higher the absorbance value  
   Z) The greater the absorbance value, the higher the molecular weight  
     
   ANSWER: Y

**BONUS**

1. CHEMISTRY *Multiple Choice* A chemical compound is insoluble in water. Upon reaction with NaOH, however, the compound becomes soluble. What has most likely happened to the chemical compound?  
   W) An -O- group or a -COO- group has been protonated  
   X) An -OH or a -COOH group has been ionized  
   Y) A hydrogen from an alkyl group has been lost to OH- to make H2O and a water soluble carbanion  
   Z) A hydrogen from an alkyl group has been lost to OH- to make H2O and a water soluble carbocationANSWER: X

**TOSS UP**

1. EARTH AND SPACE SCIENCE *Short Answer* What is the lifetime of a star, in solar lifetimes, which weighs 9 solar masses? Give your answer as a fraction.ANSWER: 1/243

**BONUS**

1. EARTH AND SPACE SCIENCE *Short Answer* Proponents of what hypothesis argue that it best explains sedimentary deposits generally regarded as of glacial origin at tropical paleolatitudes, and other otherwise enigmatic features in the geological record?ANSWER: snowball earth

**TOSS UP**

1. MATH *Multiple Choice* If 3x^2 + 2xy + y^2 = 2, then the value of dx/dy at x=1 is:  
   W) 0  
   X) 2  
   Y) 4  
   Z) Undefined  
     
   ANSWER: Z

**BONUS**

1. MATH *Short Answer* What is the integral of x^2 over e to the quantity x^3 close quantity?ANSWER: - 1/ (3E^(X^3))

**TOSS UP**

1. ENERGY *Short Answer* What facility in the Mojave Desert is currently the US’s largest photovoltaic plant?ANSWER: copper mountain solar facility

**BONUS**

1. ENERGY *Short Answer* The US DOE has created safety measures for the disposal of compact fluorescent lightbulbs because they contain what hazardous element?ANSWER: mercury

**TOSS UP**

1. BIOLOGY *Short Answer* Order the following 4 ecosystems in order from least to greatest in net primary productivity per unit area: Desert, Coral Reefs, Savannah, Open Ocean   
     
   ANSWER: 1432

**BONUS**

1. BIOLOGY *Short Answer* What division of the kingdom Fungi is responsible for an infectious disease which has been linked to dramatic population declines or even extinctions of amphibian species?ANSWER: chytrids

**TOSS UP**

1. PHYSICS *Short Answer* What is the name of the particle detector experiment run at the LHC which is designed to observe phenomena that involve highly massive particles which were not observable using earlier lower-energy accelerators?ANSWER: atlas

**BONUS**

1. PHYSICS *Short Answer* What are the 2 proposed forms that dark energy could take in the universe, one which is an unvarying amount, and one which is a dynamic quantity?ANSWER: cosmological constant and quintessence

**TOSS UP**

1. CHEMISTRY *Short Answer* U-238 (Uranium of atomic number 92) undergoes alpha decay, followed by a series of 3 beta decays, followed by a final alpha decay and a gamma emission. How many neutrons will there theoretically be in this atom after the series of decays?  
     
   ANSWER: 139

**BONUS**

1. CHEMISTRY *Short Answer* Denote by name or number all of the following 3 actions which would cause a non-spontaneous reaction with a positive change in enthalpy and entropy to be made spontaneous.  
   1. Increasing Pressure  
   2. Adding More Reactant  
   3. Increasing the TemperatureANSWER: 3 only

**TOSS UP**

1. EARTH AND SPACE SCIENCE *Short Answer* Denote the following descriptions as either a disconformity, nonconformity, or angular unconformity.  
   1. An unconformity where horizontally parallel strata of sedimentary rock is deposited on tilted and eroded layers  
   2. An unconformity between parallel layers of sedimentary rocks  
   3. An unconformity existing between sedimentary rocks and metamorphic or igneous rocks when the sedimentary rock lies aboveANSWER: Angular, dis, non

**BONUS**

1. EARTH AND SPACE SCIENCE *Short Answer* What is a planned space telescope optimized for observations in the infrared, a formal successor to the Hubble Space Telescope and the Spitzer Space Telescope?ANSWER: james c webb space telescope

**TOSS UP**

1. MATH *Short Answer* What is the x coordinate of the point of inflection on the graph of y=1/3 x ^3 + 5x^2 + 24?  
     
   ANSWER: -5

**BONUS**

1. MATH *Short Answer* The first derivative of the function f is given by f’(x) = (cos^2(x)/x)-(1/5). How many critical values does f have on the open interval 0, 10?ANSWER: 3

**TOSS UP**

1. ENERGY *Short Answer* Denote by name or number all of the following 3 choices which is or are true of propane.  
   1. Propane has a very low octane rating compared to regular gasoline.  
   2. It is produced as a by-product of natural gas processing and crude oil refining.  
   3. About 10% of US propane consumption is used for transportation fuelANSWER: 2 only

**BONUS**

1. ENERGY *Multiple Choice* Which of the following statements is true of octane ratings?  
   W) Lower octane ratings correlate to higher activation energy.  
   X) Higher octane ratings correlate to higher activation energy.  
   Y) Octane rating does not affect activation energy of ignition.  
   Z) Octane rating’s effect on activation energy is based solely on the molar mass of the compound.ANSWER: X

**TOSS UP**

1. PHYSICS *Short Answer* Denote by name or number all of the following 3 statements which is or are true of CP Violation.  
   1. The violation occurs between charge conjugation and parity symmetries  
   2. It predicts why there is more matter than antimatter in the universe.  
   3. It shows that if a particle were interchanged with its antiparticle, and left and right were swapped, the particle would always be the same.  
     
   ANSWER: 1 and 2

**BONUS**

1. PHYSICS *Short Answer* Name the class of Feynman diagrams which are important for understanding CP violating processes in the standard model.ANSWER: penguin diagrams