**TOSS UP**

1. BIOLOGY *Short Answer* What is the term for a structure that evolves in one context but is co-opted for another function?  
     
   ANSWER: Exaptation

**BONUS**

1. BIOLOGY *Short Answer* In an exaptation, as cynodonts gave rise to early mammals, bones that formerly comprised the jaw hinge were incorporated into what region of mammals?ANSWER: Ear region

**TOSS UP**

1. PHYSICS *Short Answer* Suppose that an object that is at rest when t=1s undergoes an acceleration of c/t from t=1s to t=2s. What is its velocity at t=2s?ANSWER: 0.6c

**BONUS**

1. PHYSICS *Short Answer* Suppose a photon has an energy E in the lab frame. Find: i) the energy of the photon in frame A travelling at 0.5c relative to the lab frame in the direction of the photon ii) the energy of the of the photon in frame B travelling at 0.5c relative to the lab frame in the direction opposite that of the photon iii) the momentum of the photon in all three frames.ANSWER: i) E/sqrt{3} II) E\*SQRT{3} III) Lab Frame: E/C, Frame A: E/ (SQRT{3}c), Frame B: SQRT{3}E/C

**TOSS UP**

1. CHEMISTRY *Short Answer* Name this type of material that is insoluble in water, very hard, stable to high temperatures and stable to corrosion, an inorganic material that has been hardened by heating to a high temperature.  
     
   ANSWER: CERAMIC

**BONUS**

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

**TOSS UP**

1. EARTH AND SPACE SCIENCE *Short Answer* Give by name or number all of the following that are true about tidal forces:I. Tidal forces are caused by variations in the gravitational force

II. Tidal forces are inversely proportional to the square of the distance between two objects

III. Tidal forces affect only water.

IV. Tidal forces from the Sun are negligible compared to tidal forces from the moon.

ANSWER: I only

**BONUS**

1. EARTH AND SPACE SCIENCE *Short Answer* Give by name or number all of the following that are true about the effects of tidal forces on the moon:

I. Tidal forces are making the moon’s orbit grow larger by about 3.8 cm/year

II. Tidal forces have slowed the rotation of the moon so that it now keeps the same face towards Earth.

III. Tidal forces act on the flexing rock in the moon.

ANSWER: I, II, III (All of Them)

**TOSS UP**

1. MATH *Short Answer* Name all of the following four graphs that are planar:  
     
   ANSWER: 2

**BONUS**

1. MATH *Short Answer* Find the improper integral from 0 to infinity of t^8 e^{-t} dtANSWER: 40320

**TOSS UP**

1. ENERGY *Multiple Choice* Name the four steps of the Carnot cycle.ANSWER: Adiabatic expansion, Isothermal Expansion, Adiabatic compression, IsoThermal Compression; (Accept any Cyclic Permutation thereof)

**BONUS**

1. ENERGY *Short Answer* If a Carnot engine runs between a hot reservoir at 400 K and a cold reservoir at 250 K, by what percent must the absolute temperature of the cold reservoir be lowered to increase efficiency by 33.3%?ANSWER: 20%; Accept: “It needs to be About 20% Cooler”

**TOSS UP**

1. BIOLOGY *Short Answer* Name all of the following four factors that contribute most to membrane fluidity:

I. Presence of cholesterol

II. Presence of saturated phospholipids

III. Presence of unsaturated phospholipids

IV. Presence of intercellular proteins  
  
ANSWER: I & III

**BONUS**

1. BIOLOGY *Multiple Choice* Which is not true about cholesterol in the membrane?

W. Cholesterol acts as a temperature buffer for the cell membrane.

X. Cholesterol reduces membrane fluidity at high temperatures

Y. Cholesterol increases the temperature needed for a membrane to solidify

Z. Cholesterol is a steroid.

ANSWER: Y (It reduces said temperature)

**TOSS UP**

1. PHYSICS *Short Answer* Find the potential energy of a 10 nF parallel plate capacitor with charge 20 nC on each plate. You may use the permittivity of the vacuum in your answerANSWER: 20 nanojoules

**BONUS**

1. PHYSICS *Multiple Choice* Consider two identical capacitors with capacitance C, one initially uncharged and one charged with charge Q. This system has initial energy (Q^2)/(2C). The two capacitors are connected with a superconducting wire with a switch that is initially in the off position. The switch is flipped to the on position and the two capacitors receive an equal charge of Q/2 on each plate. The final system has energy (Q^2)/(4C). Where does the missing energy go?

W. Energy is radiated away in electromagnetic radiation.

X. Energy is not conserved in the system due to a nonconservative magnetic field.

Y. Energy is dissipated in heat to the superconducting wires.

Z. Energy is stored in the capacitors electric field.

ANSWER: W. Do not Accept Y: Superconducting Wires have no Resistance

**TOSS UP**

1. CHEMISTRY *Short Answer* Calculate the change in internal energy if 200 mol of an ideal gas at 200 K expands isothermally from 100 L to 800 L. Take R=8.31 J/mol\*K  
   ANSWER: 0

**BONUS**

1. CHEMISTRY *Short Answer* Calculate the change in internal energy if 200 mol of an ideal gas at 200 K expands adiabatically from 100 L to 800 L. Take R=8.31 J/mol\*K  
   ANSWER: 249300 J

**TOSS UP**

1. EARTH AND SPACE SCIENCE *Short Answer* Given that the life expectancy of a star with mass M is 8 solar lifetimes, estimate the life expectancy of a star with mass 4M.ANSWER: 0.25 solar Lifetimes

**BONUS**

1. EARTH AND SPACE SCIENCE *Short Answer* What is the lower edge of the main sequence band, where a star settles when it beings its stable life fusing hydrogen?ANSWER: Zero-Age Main Sequence

**TOSS UP**

1. MATH *Short Answer* Find the derivative of f(x)=x^2e^{-x} with respect to x  
     
   ANSWER: 2x\*EXP(-X)-X^2\*Exp(-x)

**BONUS**

1. MATH *Short Answer* Find the 2013th derivative of the function f(x)=xe^{-x}ANSWER: 2013x\*EXP(-X)-EXP(-X)

**TOSS UP**

1. ENERGY *Short Answer*

ANSWER: I, II, III

**BONUS**

1. ENERGY *Short Answer* For each of the following particles, identify whether it is a baryon, lepton or boson:
2. Electron
3. Proton
4. Photon
5. Muon

ANSWER: Lepton, Baryon, Boson, Lepton