

TOSS-UP

1) Energy – *Short Answer* Scientists at SLAC are studying an enzyme that uses blue light to decarboxylate lipids. What coenzyme in the protein absorbs the blue light?

ANSWER: FAD (ACCEPT: FLAVIN ADENINE DINUCLEOTIDE)

BONUS

1) Energy – *Multiple Choice* Scientists at Argonne National Lab are using lanthanum-containing perovskites to catalyze the oxygen evolution reaction. They found that by doping the lanthanum with another metal, they introduced holes in the valence band and thereby increased the catalytic activity. Which of the following metals did they use for this purpose?

- W) Strontium
- X) Scandium
- Y) Titanium
- Z) Gallium

ANSWER: W) STRONTIUM

TOSS-UP

2) Math – *Short Answer* What are the coordinates of the center of the circle with equation $x^2 + y^2 + 6x + 10y + 27 = 0$?

ANSWER: $(-3, -5)$ (ACCEPT: $X = -3$ AND $Y = -5$)

BONUS

2) Math – *Short Answer* What is the average value of the square root of open parenthesis $2x - 3$ close parenthesis on the closed interval from 6 to 14?

ANSWER: $49/12$ (ACCEPT: $4 \frac{1}{12}$)

TOSS-UP

3) Physics – *Multiple Choice* A gust of wind causes the blades of a wind turbine to begin rotating. Which of the following is an accurate description of the blades?

W) They are out of static equilibrium because the wind provides a net horizontal force

X) They are out of static equilibrium because the wind provides a net torque

Y) They are in static equilibrium because the forces are balanced

Z) They are in static equilibrium because their center of mass remains in place

ANSWER: X) THEY ARE OUT OF STATIC EQUILIBRIUM
BECAUSE THE WIND PROVIDES A NET TORQUE

BONUS

3) Physics – *Short Answer* A 1500-kilogram vehicle is moving at 20 meters per second. The driver sees a red light and applies the brakes, which apply a force of 6000 newtons directly opposite the vehicle's velocity. In meters, how far will the vehicle travel before coming to a stop?

ANSWER: 50

TOSS-UP

4) Biology – *Multiple Choice* Which of the following cell types is NOT part of the innate immune system?

W) T cells

X) Neutrophils

Y) Natural killer cells

Z) Macrophages

ANSWER: W) T CELLS

BONUS

4) Biology – *Short Answer* Order the following three plant taxa in order of increasing number of known extant species: 1) Angiosperms; 2) Ginkgophytes; 3) Bryophytes.

ANSWER: 2, 3, 1

TOSS-UP

5) Chemistry – *Short Answer* What type of reaction occurs when, instead of attacking a carbon atom, a nucleophile attacks a hydrogen atom?

ANSWER: ELIMINATION

BONUS

5) Chemistry – *Short Answer* Identify all of the following three species that are considered oxidizing agents: 1) H_2O_2 ; 2) MnO_4^- ; 3) O_3 .

ANSWER: ALL

TOSS-UP

6) Earth and Space – *Multiple Choice* The Gulf Stream is which of the following?

- W) Deepwater current
- X) Eastern boundary current
- Y) Transverse current
- Z) Western boundary current

ANSWER: Z) WESTERN BOUNDARY CURRENT

BONUS

6) Earth and Space – *Short Answer* Identify all of the following three mineral properties that can be used to distinguish gold from pyrite: 1) Streak; 2) Density; 3) Mohs hardness.

ANSWER: ALL

TOSS-UP

7) Energy – *Multiple Choice* Scientists at Thomas Jefferson National Accelerator Facility are colliding electrons with protons to try to understand the distribution of charge in the proton. What two kinds of particles were collided in the similar Geiger-Marsden scattering experiment?

- W) Electrons and protons
- X) Electrons and alpha particles
- Y) Electrons and gold nuclei
- Z) Alpha particles and gold nuclei

ANSWER: Z) ALPHA PARTICLES AND GOLD NUCLEI

BONUS

7) Energy – *Short Answer* Scientists at Thomas Jefferson National Accelerator Facility are studying the decays of long-lived particles. Identify all of the following three particles that will eventually decay if they are isolated in a vacuum: 1) Neutron; 2) Electron; 3) Muon.

ANSWER: 1, 3

TOSS-UP

8) Math – *Multiple Choice* If x is a positive integer that is divisible by 30 and by 42, it must also be divisible by which of the following?

W) 12

X) 18

Y) 60

Z) 70

ANSWER: Z) 70

BONUS

8) Math – *Short Answer* What is the slope-intercept equation of the slant asymptote of the graph of y equals the fraction with numerator $6x^2 + 3x - 7$ and denominator $2x - 5$?

ANSWER: $y = 3x + 9$

TOSS-UP

9) Physics – *Short Answer* What is the adjective for a harmonic oscillator that is acted upon by a frictional force proportional to its velocity?

ANSWER: DAMPED (DO NOT ACCEPT: DAMPENED)

BONUS

9) Physics – *Multiple Choice* Which of the following best describes the circumstances in which mechanical energy is conserved?

- W) When only conservative forces are acting
- X) When at least one conservative force is acting
- Y) When collisions are completely inelastic
- Z) When collisions are at least partially inelastic

ANSWER: W) WHEN ONLY CONSERVATIVE FORCES ARE ACTING

TOSS-UP

10) Biology – *Short Answer* What is the term for speciation that occurs when gene flow is interrupted by a geographic barrier?

ANSWER: ALLOPATRIC

BONUS

10) Biology – *Multiple Choice* Some bacteria have the ability to form endospores to survive in extreme environments. Which of the following is true of endospores?

- W) They are sensitive to ultraviolet radiation
- X) They have metabolic activity
- Y) They can absorb Gram stain
- Z) They are dehydrated

ANSWER: Z) THEY ARE DEHYDRATED

TOSS-UP

11) Chemistry – *Multiple Choice* What type of interaction dominates between polar molecules?

- W) Covalent
- X) London dispersion
- Y) Induced dipole-induced dipole
- Z) Dipole-dipole

ANSWER: Z) DIPOLE-DIPOLE

BONUS

11) Chemistry – *Multiple Choice* Chlorine has a molar mass of 35.5 grams per mole. This is because chlorine has two isotopes with what ratio of abundances?

- W) 1 to 1 chlorine-35 to chlorine-36
- X) 3 to 1 chlorine-35 to chlorine-36
- Y) 1 to 1 chlorine-35 to chlorine-37
- Z) 3 to 1 chlorine-35 to chlorine-37

ANSWER: Z) 3 TO 1 CHLORINE-35 TO CHLORINE-37

TOSS-UP

12) Earth and Space – *Multiple Choice* Which of the following greenhouse gases has the greatest 100-year global-warming potential?

W) Carbon dioxide

X) Methane

Y) Nitrous oxide

Z) Hydrofluorocarbons

ANSWER: Z) HYDROFLUOROCARBONS

BONUS

12) Earth and Space – *Short Answer* Identify all of the following three metamorphic rocks that are foliated: 1) Marble; 2) Quartzite; 3) Anthracite.

ANSWER: NONE

TOSS-UP

13) Energy – *Short Answer* Scientists at Ames Lab are studying the nanoscale aluminum oxide layer that forms when aluminum metal is exposed to oxygen molecules in the air. What is the chemical formula for aluminum oxide?

ANSWER: Al_2O_3

BONUS

13) Energy – *Multiple Choice* Scientists at Pacific Northwest National Lab are studying lipids. In humans, which of the following is a lipid-derived hormone?

- W) Cortisol
- X) Oxytocin
- Y) Thyroxine
- Z) Insulin

ANSWER: W) CORTISOL

TOSS-UP

14) Math – *Short Answer* For what value of a is the vector $3\mathbf{i} + 4\mathbf{j}$ orthogonal to the vector $a\mathbf{i} - 12\mathbf{j}$?

ANSWER: 16

BONUS

14) Math – *Short Answer* Giving your answer to one decimal place, what is the square root of 472?

ANSWER: 21.7

TOSS-UP

15) Physics – *Short Answer* Consider an ideal gas at 300 kelvins with particles of mass 8 times 10^{-27} kilograms. According to the Maxwell-Boltzmann distribution, what is the magnitude, in meters per second, of the average velocity of particles?

ANSWER: 0

BONUS

15) Physics – *Short Answer* A rock of mass 3 kilograms and volume 450 cubic centimeters is dropped in water. To two significant figures and in newtons, what is the magnitude of the upward force required to lift the rock while it is submerged?

ANSWER: 25

TOSS-UP

16) Biology – *Short Answer* Microfilaments are composed of what protein?

ANSWER: ACTIN

BONUS

16) Biology – *Short Answer* Assuming that the reactions catalyzed by aldolase are irreversible, a glucose molecule radioactively labeled at the first and second carbons would produce a fructose 1,6-bisphosphate molecule with how many radioactive carbon atoms?

ANSWER: 2

TOSS-UP

17) Chemistry – *Multiple Choice* What law states that equal volumes of gases at the same temperature and pressure contain the same number of particles?

W) Avogadro's law

X) Dalton's law

Y) Charles's law

Z) Boyle's law

ANSWER: W) AVOGADRO'S LAW

BONUS

17) Chemistry – *Short Answer* Rank the following three elements in order of increasing first ionization energy: 1) Rubidium; 2) Sodium; 3) Potassium.

ANSWER: 1, 3, 2

TOSS-UP

18) Earth and Space – *Short Answer* What gas is primarily responsible for the blue coloration of Uranus and Neptune?

ANSWER: METHANE (ACCEPT: CH₄)

BONUS

18) Earth and Space – *Multiple Choice* Which of the following best explains why many radio telescopes are ground based?

W) The atmosphere is relatively transparent to radio waves

X) The telescopes have to be very large, making them expensive to put into orbit

Y) Ground-based telescopes always have better seeing than space-based telescopes

Z) There is too much radio interference in space

ANSWER: W) THE ATMOSPHERE IS RELATIVELY TRANSPARENT TO RADIO WAVES