TOSS-UP

1) Math − *Short Answer*   What is the square of the complex number $1 - 3i$?

ANSWER: $-8 - 6i$

BONUS

1) Math − *Multiple Choice*   A differentiable function f of x has domain the closed interval from -5 to 4 and range the closed interval from 3 to 12. If f prime of x is less than 0 for all x in the domain, what is f of -5?

W) -5
X) 3
Y) 4
Z) 12

ANSWER: Z) 12

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TOSS-UP

2) Biology − *Short Answer*   What stain, performed with crystal violet dye, provides the most common way of classifying bacteria?

ANSWER: GRAM

BONUS

2) Biology − *Short Answer*   What is the term for mobile genetic elements that can move from one location to another in a cell's genome?

ANSWER: TRANSPOSONS (ACCEPT: JUMPING GENE)

TOSS-UP

3) Earth and Space − *Multiple Choice*   Which of the following surface reservoirs on Earth contains the most carbon?

W) Soil
X) Atmosphere
Y) Vegetation
Z) Ocean

 ANSWER: Z) OCEAN

BONUS

3) Earth and Space − *Multiple Choice*   Which of the following pairs of metamorphic rocks can both form from shale?

W) Slate and phyllite *[FILL-lite]*
X) Schist and marble
Y) Quartzite and migmatite
Z) Gneiss *[nice]* and anthracite

ANSWER: W) SLATE AND PHYLLITE

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TOSS-UP

4) Physics − *Short Answer*   An astronaut weighs 500 newtons on planet X, which has a gravitational acceleration of 4 meters per second squared. If he travels to planet Y, which has a gravitational acceleration of 12 meters per second squared, then in newtons, what is his new weight?

ANSWER: 1500

BONUS

4) Physics − *Short Answer*   Jan heats a kilogram of an unknown solid at a rate of 25 kilojoules per minute. The solid rises in temperature for 2 minutes, melts for a minute and a half, then rises in temperature for 6 minutes until Jan ends the experiment. In kilojoules per kilogram, what is the heat of fusion for this substance?

ANSWER: 37.5 (ACCEPT: 37½, 75/2)

TOSS-UP

5) Chemistry − *Short Answer*   What intermolecular force is responsible for the secondary structure of proteins?

ANSWER: HYDROGEN BONDING

BONUS

5) Chemistry − *Short Answer*   Rank the following three straight-chained alkanes in increasing order of their carbon-chain lengths: 1) Propane; 2) Butane; 3) Methane.

ANSWER: 3, 1, 2

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TOSS-UP

6) Energy − *Short Answer*   Scientists at Oak Ridge National Lab are using the Titan supercomputer to model diesel engines. Unlike the Otto cycle, the Diesel cycle relies on what to ignite the fuel?

ANSWER: COMPRESSION

BONUS

6) Energy − *Short Answer*   Chemists at SLAC National Lab have developed a copper catalyst with a large surface area that converts carbon dioxide to ethanol in an acidic environment. Identify all of the following three statements that are TRUE of this process: 1) Carbon dioxide is oxidized in this reaction; 2) This is an example of homogenous catalysis; 3) The reaction has many side products.

ANSWER: 3

TOSS-UP

7) Physics − *Multiple Choice*   A torque *[tork]* integrated over an angle describes which of the following quantities?

W) Force
X) Work
Y) Angular momentum
Z) Linear momentum

ANSWER: X) WORK

BONUS

7) Physics − *Short Answer*   Consider a box containing an unknown number of charges with unknown magnitude. Identify all of the following three quantities that can be determined by performing a test with a known charge at a single point in space outside the box: 1) Number of charges inside the box; 2) Net charge inside the box; 3) Sign of each charge in the box.

ANSWER: 2

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TOSS-UP

8) Math − *Short Answer*   If exactly 14 diagonals of a particular convex polygon contain the same vertex, how many total sides does the polygon have?

ANSWER: 17

BONUS

8) Math − *Short Answer*   Evaluate the summation, from $n = 1$ to infinity, of the fraction with numerator 40 and denominator 5^n.

Answer: 10

TOSS-UP

9) Earth and Space – *Multiple Choice*   A waning gibbous *[JIH-bus]* moon describes which of the following parts of the lunar cycle?

W) Third quarter moon to new moon
X) Full moon to third quarter moon
Y) First quarter moon to full moon
Z) New moon to first quarter moon

ANSWER: X) FULL MOON TO THIRD QUARTER MOON

BONUS

9) Earth and Space – *Short Answer*   Telescope A has 2 times the light gathering power of telescope B. If telescopes A and B are of the same type of telescope, what is the ratio of the diameter of telescope A to that of telescope B?

ANSWER: √2 (ACCEPT: √2 TO ONE)

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TOSS-UP

10) Energy – *Short Answer*   Researchers at Ames Lab are developing a sub-diffraction Raman platform. In this case, sub-diffraction refers to the diffraction of what?

ANSWER: LIGHT (ACCEPT: ELECTROMAGNETIC WAVES, PHOTONS)

BONUS

10) Energy – *Short Answer*   The DES at Fermi National Accelerator Lab is studying the properties of what energy in the universe that is thought to counteract the effects of gravity?

ANSWER: DARK ENERGY

TOSS-UP

11) Chemistry – *Short Answer*   Rank the following three species in terms of increasing basicity: 1) Chloride; 2) Cyanide; 3) Water.

ANSWER: 1, 3, 2

BONUS

11) Chemistry – *Short Answer*   2-methylpropene can react with hydrogen bromide to form 2-bromo-2-methyl-propane. Identify all of the following three species that act as nucleophiles in this reaction: 1) Bromide; 2) Pi *[pie]* bond; 3) Sigma bond.

ANSWER: 1, 2

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TOSS-UP

12) Biology − *Multiple Choice*   Which of the following plant hormones play a role in fruit ripening?

W) Gibberellins *[jib-er-ELL-ins]*
X) Abscisic *[ab-SIH-zik]* acid
Y) Cytokinins *[sigh-toh-KYE-nins]*
Z) Brassinosteroids

ANSWER: W) GIBBERELLINS

BONUS

12) Biology − *Short Answer*   Identify all of the following three substances that are able to pass through the glomerulus *[glo-MAIR-yoo-lus]* of a healthy nephron *[NEF-ron]* into the filtrate: 1) Albumin; 2) Glucose; 3) Red blood cell.

ANSWER: 2

TOSS-UP

13) Physics − *Short Answer*   The mass of an oscillator *[AWS-ih-later]* is doubled. Identify all of the following three systems in which the resulting period of oscillation will NOT significantly change as a result of the change in mass: 1) Pendulum; 2) Spring; 3) Orbiting satellite.

ANSWER: 1, 3

BONUS

13) Physics − *Short Answer*   The permeability of free space is 1.26×10^{-6} when expressed in SI base units. If a current of 10 amperes flows through a wire, then to the nearest whole microtesla, what is the strength of the induced magnetic field 1 meter from the wire?

ANSWER: 2

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TOSS-UP

14) Chemistry − *Short Answer*   What gas law implies that the volume of an ideal gas is directly proportional to its temperature?

ANSWER: CHARLES'S LAW

BONUS

14) Chemistry − *Short Answer*   Identify all of the following three nuclides that are likely to undergo beta-minus decay over other forms of nuclear decay: 1) Carbon-14; 2) Nitrogen-13; 3) Polonium *[pawl-OH-nee-um]*-210.

ANSWER: 1

TOSS-UP

15) Earth and Space − *Short Answer*   What is the name of the climate phenomenon in which high atmospheric pressure builds in the Western Pacific, causing the trade winds to weaken or reverse direction?

ANSWER: EL NIÑO (DO NOT ACCEPT: LA NIÑA)

BONUS

15) Earth and Space − *Short Answer*   A slab of oceanic lithosphere is subducting at a rate of 8 centimeters per year. How far, in meters, will the slab subduct in 5 centuries if current rates are maintained?

ANSWER: 40

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TOSS-UP

16) Biology − *Multiple Choice*   Which of the following types of signaling best describes cellular communication via hormones?

W) Exocrine *[EX-oh-krin]*
X) Endocrine *[EN-doh-krin]*
Y) Paracrine *[para-krin]*
Z) Autocrine *[auto-krin]*

ANSWER: X) ENDOCRINE

BONUS

16) Biology – *Short Answer*   Identify all of the following three conditions that apply to a population in Hardy-Weinberg equilibrium: 1) Selection pressure; 2) Gene flow to other populations; 3) Random mating.

ANSWER: 3

TOSS-UP

17) Math – *Short Answer*   Solve the following equation for *x*: log base 2 of
<u>open parenthesis *x* + 5 close parenthesis</u> = 5?

ANSWER: 27

BONUS

17) Math – *Short Answer*   An isosceles trapezoid with integer side lengths has bases of length 24 and 40. What is the minimum possible length of its shortest side?

ANSWER: 9

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TOSS-UP

18) Energy – *Multiple Choice*   Research from the Pacific Northwest National Lab indicates that plant mortality in the moist tropics can be largely attributed to what two factors?

W) Carbon glut and hydraulic failure
X) Carbon starvation and hydraulic failure
Y) Carbon glut and overhydration
Z) Carbon starvation and overhydration

ANSWER: X) CARBON STARVATION AND HYDRAULIC FAILURE

BONUS

18) Energy – *Multiple Choice*   Fermi National Lab scientists demonstrated the accuracy of lattice quantum chromodynamics, which is a theory that, among other predictions, predicts which of the following experimental observations?

W) Color confinement
X) Electron capture
Y) Beta plus decay
Z) Nuclear fission

ANSWER: W) COLOR CONFINEMENT

TOSS-UP

19) Earth and Space − *Short Answer*   What is the boundary between an isolated volume of space-time and the rest of the universe?

ANSWER: EVENT HORIZON

BONUS

19) Earth and Space − *Short Answer*   What name is given to the regions of the asteroid belt that contain few asteroids and correspond to orbital resonances with Jupiter?

ANSWER: KIRKWOOD GAPS

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TOSS-UP

20) Chemistry − *Short Answer*   Sodium metal is produced by the electrolysis of sodium chloride in what special type of cell?

ANSWER: DOWNS CELL

BONUS

20) Chemistry − *Short Answer*   What is the oxidation state of oxygen in hydrogen peroxide?

ANSWER: NEGATIVE ONE

21) Math − *Short Answer*   If f of x equals $4x^2 - x + 3$, what is f of -2?

ANSWER: 21

BONUS

21) Math − *Short Answer*   An airplane is traveling at 380 miles per hour with respect to the Earth. The Sun's reflection off the plane illuminates a small area on the surface of the Earth. A passenger on the plane observes this illuminated spot move between two houses in 15 seconds. Expressing your answer as a decimal to the nearest tenth of a mile, how far apart are the two houses?

ANSWER: 1.6

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TOSS-UP

22) Biology − *Short Answer*   Stones made of precipitated bile products can sometimes cause problems in the digestive system. What organ can be surgically removed to remedy this?

ANSWER: GALLBLADDER

BONUS

22) Biology − *Short Answer*   Based on modern taxonomy, how many domains of life are there?

ANSWER: 3

TOSS-UP

23) Physics − *Short Answer*   A Leyden *[LAY-den]* jar, which has a layer of metal coating the inside and outside of a glass jar, is an early form of what circuit component?

ANSWER: CAPACITOR

BONUS

23) Physics − *Short Answer*   Given that the electric constant is 8.9 times 10^{-12} farads *[FAIR-adz]* per meter and a charge of 8 times 10^{-11} coulombs is at the center of a spherical surface, then, to the nearest volt-meter, what is the electric flux that passes through the surface?

ANSWER: 9