TOSS-UP

1) Chemistry – *Short Answer* [4] When performing hydroboration oxidation on a terminal alkyne, a vinyl alcohol is formed, which forms what other functional group after isomerization?

ANSWER: ALDEHYDE (ACCEPT: CARBONYL; DO NOT ACCEPT: KETONE) [CT]

BONUS

1) Chemistry – *Short Answer* [4] A 1 liter solution contains 1 mole of acetic acid and 1 mole of sodium acetate. To the nearest milliliter, how much of a 1 molar solution of sodium hydroxide must be added in order to raise the pH of the solution by 1 unit?

ANSWER: 818 [CT]

TOSS-UP

2) Earth and Space – *Multiple Choice* [2] Which of the following regions of the Sun's atmosphere has the highest average temperature?

W) Inner corona
X) Outer corona
Y) Photosphere
Z) Chromosphere

ANSWER: X) OUTER CORONA [SF]

BONUS

2) Earth and Space – *Short Answer* [2] Identify all of the following three statements regarding the El Niño Southern Oscillation that are true: 1) In an El Niño year, there is a positive SST anomaly in the eastern Pacific; 2) In an El Niño year, there is suppressed upwelling in the eastern Pacific; 3) In a La Niña year, the thermocline in the eastern Pacific is anomalously deep.

ANSWER: 1 AND 2 [YL]

TOSS-UP

3) Math – *Short Answer* [4] 7 identical seats are evenly spaced around a circular table. If rotations are indistinct, how many ways are there to arrange 7 people in these seats?

ANSWER: 720 [CT]

BONUS

3) Math – *Short Answer* [4] A square and a regular hexagon each have a circumradius of 1. What is the ratio of the area of the hexagon to the area of the square?

ANSWER: 3 ROOT 3 OVER 4 [CT]

TOSS-UP

4) Biology – *Multiple Choice* [2] Which of the following amino acids can form disulfide bonds with itself?

W) Tyrosine
X) Phenylalanine
Y) Methionine
Z) Cysteine

ANSWER: Z) CYSTEINE [SF]

BONUS

4) Biology – *Short Answer* [5] Identify all of the following three clades of plants that are considered non-vascular: 1) Lycopodiophyta; 2) Marchantiophyta; 3) Pinophyta.

ANSWER: 2 ONLY [SF]

TOSS-UP

5) Physics – *Multiple Choice* [2] Which of the following types of magnetism is characterized by a lack of unpaired electrons?

W) Ferromagnetism
X) Ferrimagnetism
Y) Paramagnetism
Z) Diamagnetism

ANSWER: Z) DIAMAGNETISM [CT]

BONUS

5) Physics – *Short Answer* [3] A ball is dropped from a height of 30 meters and repeatedly bounces on the ground, rebounding to half of its previous height every time. What is the limit of the total distance that the ball travels?

ANSWER: 90 [CT]

TOSS-UP

6) Energy – *Short Answer* [2] Researchers at Oak Ridge National Lab are investigating the kinetics of various methods of uranium isotope separation. What corrosive acid is produced when uranium hexafluoride is hydrolyzed?

ANSWER: HYDROFLUORIC ACID (ACCEPT: HF) [YL]

BONUS

6) Energy – *Multiple Choice* [2] Scientists at Fermilab are constructing liquid argon chambers in order to better detect hypothetical sterile neutrinos. Sterile neutrinos are only able to interact with which of the following fundamental forces?

W) Electromagnetic
X) Gravitational
Y) Strong
Z) Weak

ANSWER: X) GRAVITATIONAL [CT]

TOSS-UP

7) Biology – *Short Answer* [4] The inheritance of the *Igf-2* gene in mice is known for only expressing the phenotype of the father. This is an example of what phenomena which is mediated by DNA methylation?

ANSWER: GENOMIC IMPRINTING (ACCEPT: IMPRINTING; DO NOT ACCEPT: EPIGENETICS) [SF]

BONUS

7) Biology – *Short Answer* [6] Identify all of the following three statements that are true concerning viruses: 1) The lytic cycle is found in temperate phages; 2) The lysogenic cycle is always deadly; 3) Prophages never leave the host's genome while proviruses do.

ANSWER: 1 ONLY [SF]

TOSS-UP

8) Physics – *Short Answer* [2] What is the efficiency of a Carnot refrigerator with a hot reservoir of 500 Kelvin and a cold reservoir of 100 Kelvin?

ANSWER: 80% [CT]

BONUS

8) Physics – *Short Answer* [3] In units of kilogram meters squared, what is the moment of inertia of a uniform cylinder of radius 3 meters and mass 4 kilograms about its central axis?

ANSWER: 18 [DK]

TOSS-UP

9) Earth and Space – *Short Answer* What is the name of the depth in the ocean at which carbon dioxide, water, and bicarbonate are in chemical equilibrium?

ANSWER: CARBONATE COMPENSATION DEPTH (ACCEPT: CCD)

BONUS

9) Earth and Space – *Short Answer* [5] What is the altitude angle, in degrees, of the sun at noon on the summer solstice for an observer at 30 degrees north?

ANSWER: 83.5 [YL]

TOSS-UP

10) Chemistry – *Short Answer* [2] Mass spectrometry can be used to analyze a chemical species by measuring the ratio of its mass to what other property?

ANSWER: CHARGE [CT]

BONUS

10) Chemistry – *Short Answer* [3] Identify all of the following 3 statements regarding the one-dimensional particle in a box model that are true: 1) The particle can have exactly 0 energy; 2) The particle can never escape the box; 3) The particle's energy is directly proportional to its mass.

ANSWER: 2 ONLY [AS]

TOSS-UP

11) Math – *Short Answer* [3] Phillip makes a set of the 9 smallest positive multiples of 1000. Jay takes Phillip's set and increases the smallest number by 11 and decreases the largest number by 4. Identify all of the following 3 quantities that are bigger for Jay's set than Phillip's set: 1) Mean; 2) Median; 3) Range.

ANSWER: 1 ONLY [CT]

BONUS

11) Math – *Short Answer* [2] What is the smallest positive argument, in degrees, of a complex number z such that $z^4 = -1$?

ANSWER: 45 [CT]

TOSS-UP

12) Energy – *Short Answer* [7] Scientists at Pacific Northwest National Lab have been using electrospray ionization mass spectrometry to study the lipid surface proteins of lung tissues in order to understand various diseases, such as the lack of surfactant production in infants that are born early. What is the term for this disease where the lack of surfactant production causes emphysema in infants born prematurely?

ANSWER: RESPIRATORY DISTRESS SYNDROME [SF]

BONUS

12) Energy – *Short Answer* [1] Researchers at Fermilab are investigating the induced wave broadening by the generalized uncertainty principle. Classically, this wave broadening may be caused by the addition of multiple waves that are in phase with each other, resulting in a final wave that is more intense than its substituents. What is the term for this phenomenon?

ANSWER: CONSTRUCTIVE INTERFERENCE (DO NOT ACCEPT: INTERFERENCE) [CT]

TOSS-UP

13) Biology – *Multiple Choice* [3] If Jack has hemophilia, an X linked disease, and he marries a woman that is not a carrier and does not have hemophilia, which of the following must be true?

W) All of his daughters are neither affected nor carriers
X) Exactly half of his children are affected
Y) All of his sons are unaffected
Z) Exactly half of his daughters are affected

ANSWER: Y) ALL OF HIS SONS ARE UNAFFECTED [SF]

BONUS

13) Biology – *Short Answer* [4] Identify all of the following three hormones that are steroids: 1) Aldosterone; 2) Cortisol; 3) Thyroxine.

ANSWER: 1 AND 2 [SF]

TOSS-UP

14) Physics – *Multiple Choice* [4] Which of the following statements best describes the proportionality between the drag force and the velocity of a relatively small object traveling through a viscous fluid?

W) Drag force is proportional to velocity
X) Drag force is proportional to velocity squared
Y) Drag force is proportional to velocity cubed
Z) Drag force is proportional to velocity to the fourth

ANSWER: W) DRAG FORCE IS PROPORTIONAL TO VELOCITY [CT]

BONUS

14) Physics – *Short Answer* [3] If the radius of curvature for a concave spherical mirror is 3 meters, what is the focal length of the mirror?

ANSWER: 1.5 [CT]

TOSS-UP

15) Math – *Multiple Choice* [3] Two complex numbers x and y have the property that, for a certain positive integer n, x to the power of n equals y to the power of n. Which of the following statements regarding x and y must be true?

W) They have the same argument
X) They have the same complex conjugate
Y) They have the same magnitude
Z) They have the same real part

ANSWER: Y) THEY HAVE THE SAME MAGNITUDE [CT]

BONUS

15) Math – *Short Answer* [3] A computer starts printing the positive integers in ascending order. How many digits are necessary to print the first 1000 integers?

ANSWER: 2893 [CT]

TOSS-UP

16) Earth and Space – *Multiple Choice* [3] Which of the following elements comprises the majority of the core of a 1 solar mass subgiant star?

W) Hydrogen
X) Helium
Y) Carbon
Z) Iron

ANSWER: X) HELIUM [YL]

BONUS

16) Earth and Space – *Short Answer* [3] Identify all of the following three variables that affect open ocean wave height: 1) Ocean depth; 2) Wind fetch; 3) Wind velocity.

ANSWER: 2 AND 3 [YL]

TOSS-UP

17) Chemistry – *Multiple Choice* [2] Which of the following elements has a first ionization energy closest to that of boron?

W) Beryllium
X) Carbon
Y) Magnesium
Z) Silicon

ANSWER: Z) SILICON [CK]

BONUS

17) Chemistry – *Multiple Choice* [4] Hydrobromic acid is added to 1,3-butadiene. Which of the following statements is true regarding the 1,2 adduct formed in this reaction?

W) It is the kinetic product and dominates at low temperatures
X) It is the kinetic product and dominates at high temperatures
Y) It is the thermodynamic product and dominates at low temperatures
Z) It is the thermodynamic product and dominates at high temperatures

ANSWER: W) IT IS THE KINETIC PRODUCT AND DOMINATES AT LOW TEMPERATURES [CT]

TOSS-UP

18) Math – *Short Answer* [2] The line segment connecting the origin and the point (40, 40) is drawn. Including its endpoints, how many lattice points does the segment contain?

ANSWER: 41 [CT]

BONUS

18) Math – *Short Answer* [6] Identify all of the following 3 statements that are true about a positive integer n with k positive factors: 1) if k is divisible by 4, n is a perfect cube, 2) if k is even, n is never a square, 3) if k is an odd prime, n is a perfect power.

ANSWER: 2 AND 3 [CT]

TOSS-UP

19) Physics – *Multiple Choice* [4] A silicon wafer doped with which of the following elements will have holes as the majority carrier?

W) Boron
X) Phosphorus
Y) Germanium
Z) Arsenic

ANSWER: W) BORON [DK]

BONUS

19) Physics – *Short Answer* [3] A hollow sphere with radius 2 meters and mass 3 kg uniformly distributed around its surface starts rolling without slipping down a 75 meter long slope from rest with an angle of declination of 30 degrees. What percentage of the sphere's kinetic energy is rotational kinetic energy?

ANSWER: 40 [CT]

TOSS-UP

20) Earth and Space – *Short Answer* [4] What type of highly variable protostar possesses a stellar cocoon and has not yet reached the Hayashi track?

ANSWER: T-TAURI STAR [SF]

BONUS

20) Earth and Space – *Multiple Choice* [6] Which of the following statements regarding glacial flow is not true?

W) Glacial flow is mechanistically driven by basal slip and plastic deformation
X) Polar glaciers flow primarily through basal slip
Y) The bottom of a polar glacier flows slower than the top
Z) The sides of a warm glacier flow slower than the center

ANSWER: X) POLAR GLACIERS FLOW PRIMARILY THROUGH BASAL SLIP [YL]

TOSS-UP

21) Biology – *Short Answer* [5] What is the term for the major relay center within the brain that lies in the diencephalon?

ANSWER: THALAMUS [SF]

BONUS

21) Biology – *Short Answer* [6] Kaposi's sarcoma is a rare cancer usually only found in people with what immune disorder?

ANSWER: AIDS (DO NOT ACCEPT: HIV) [SF]

TOSS-UP

22) Energy – *Short Answer* [2] Researchers at Lawrence Livermore National Lab have investigated alpha radiation damage in metals used for radiation storage. They observed surficial nanometer-scale bubbles generated from the release of what gas?

ANSWER: HELIUM (ACCEPT: HELIUM-4) [YL]

BONUS

22) Energy – *Short Answer* [3] Scientists at Lawrence Livermore National Lab have been studying photosynthesis and the effects of wildfires on the atmosphere. Identify all of the following three statements that are true about a wildfire in a previously inhabited ecosystem: 1) It demonstrates primary succession; 2) It results in a short term increase in biodiversity; 3) Following the wildfire, the surviving inhabitants are classified as the climax community.

ANSWER: NONE [SF]

TOSS-UP

23) Chemistry – *Multiple Choice* [1] Which of the following molecules have different molecular and electron geometries around the central atom?

W) Ammonia
X) Dichloromethane
Y) Phosphorus pentachloride
Z) Sulfur hexafluoride

ANSWER: W) AMMONIA [CT]

BONUS

23) Chemistry – *Short Answer* [5] At a pH of 8, some L-proline molecules have a negative charge on the carboxylic group and a positive charge on the amine group. What is the term for these molecules which have separate oppositely charged groups?

ANSWER: ZWITTERIONS [AS]