TOSS-UP

1) Physics [3] – *Short Answer* Identify all of the following three quantities that are conserved in an inelastic collision: 1) Linear momentum; 2) Angular momentum; 3) Velocity of center of mass.

ANSWER: ALL [GW, Conservation]

BONUS

1) Physics [] – *Short Answer* A block is moving in a horizontal circle on a frictionless banked curve of radius 30 meters. The block is traveling at a speed of 20 meters per second. What is the angle of the incline, to the nearest 10 degrees?

ANSWER: 50 DEGREES (Note: $\arctan(20^2/30 * 9.8) \approx \arctan(4/3) \approx 53°$) [GW, Circles]

TOSS-UP

2) Biology [] – *Multiple Choice* Which of the following is NOT a contributing factor of RNA's catalytic abilities?

W) RNA molecules can hydrogen bond with other nucleic acids allowing for specificity.
X) The bases in RNA molecules act as functional groups in catalysis.
Y) The phosphate ions of an RNA molecule allow for catalytic stability in different environments.
Z) A region of the RNA molecule can base pair with itself.

ANSWER: Y) THE PHOSPHATE IONS OF AN RNA MOLECULE ALLOW FOR CATALYTIC STABILITY IN DIFFERENT ENVIRONMENTS [DJ, BIOCHEM]

BONUS

2) Biology [] – *Short Answer* Identify all of the following three organisms which are pseudocoelomates: 1) Earthworms; 2) Roundworms; 3) Planarians.

ANSWER: 2 ONLY [RS, DIVERSITY]

TOSS-UP

3) Math [] – *Short Answer* A particular dice has 8 sides, each with a ⅛ probability of landing face-up. What is the probability that when three dice are rolled, exactly two dice roll a prime?

ANSWER: 3/8 [SS, Dice/Coins]

BONUS

3) Math [5] – *Short Answer* What is the area of a triangle in the coordinate plane with vertices at (0, 0), (4, 6), and (13, 1)?

ANSWER: 37 [LY, COORDS]

TOSS-UP

4) Earth and Space [5] – *Multiple Choice* Which of the following best describes the keplerian and observed orbital velocity in a galaxy, respectively, as distance from the center of the galaxy increases?

W) Decreases, Decreases
X) Decreases, Increases
Y) Increases, Decreases
Z) Increases, Increases

ANSWER: X) DECREASES, INCREASES [SS, Cosmology]

BONUS

4) Earth and Space [] – *Short Answer* A blue metamorphic mineral is extracted from a sample of pegmatite, and is heated to 800 degrees Celsius. What aluminosilicate polymorph is most likely to be formed?

ANSWER: SILLIMANITE [SS, Mineralogy]

TOSS-UP

5) Chemistry [] – *Multiple Choice* Which of the following elements has the lowest residual entropy at absolute zero?

W) Silicon
X) Phosphorus
Y) Sulfur
Z) Bromine

ANSWER: X) PHOSPHORUS [SS, Usnco]

BONUS

5) Chemistry [] – *Short Answer* Identify all of the following groups that can be used to protect an alcohol. 1) OTMS; 2) Fmoc; 3) t-BOC.

ANSWER: 1 ONLY [SS, lazy]

TOSS-UP

6) Energy [RR] – *Multiple Choice* Researchers at Lawrence Berkeley National Lab are detecting and mapping seed plant mitochondrial DNA in order to reconstruct plant phylogeny. Which of the following laboratory techniques is most likely being used?

W) Northern Blot
X) Eastern Blot
Y) Southern Blot
Z) Western Blot

ANSWER: Y) SOUTHERN BLOT [DJ, BIOLOGY]

BONUS

6) Energy [] – *Multiple Choice* Researchers at Ames National Lab are revisiting the mechanism for EAS reactions after new computational methods have shown that the sigma complex in certain conditions might not be formed. Which of the following compounds would be the least reactive in EAS?

W) Methyl benzene
X) Methoxy benzene
Y) Acetophenone
Z) Bromobenzene

ANSWER: Y) ACETOPHENONE [DJ, CHEM]

TOSS-UP

7) Physics [5] – *Short Answer* Identify all of the following 3 options that could be the shape of the orbit of an object with a negative mechanical energy: 1) Circle; 2) Parabola; 3) Hyperbola.

ANSWER: 1 ONLY [GW, Orbits]

BONUS

7) Physics [6] – *Short Answer* An RC circuit consists of a 10 farad capacitor and two resistors in parallel, one of which has twice the resistance of the other. The circuit is completed, and it takes 35 seconds for the capacitor to reach half its maximum charge. To two significant figures, what is the resistance, in ohms, of the higher resistance resistor?

ANSWER: 15 [LY, Circuits]

TOSS-UP

8) Biology [RR] – *Short Answer* Identify all of the following 3 deoxynucleotide triphosphates that can be used in Next-Generation Sequencing: 1) dATP; 2) dCTP; 3) dGTP.

ANSWER: ALL [DJ, BIOTECH]

BONUS

8) Biology [] – *Multiple Choice* Which of the following glutamate receptors are blocked by a magnesium ion?

W) AMPA
X) Kainate
Y) NMDA
Z) mGluR

ANSWER: Y) NMDA [SL, NEURO]

TOSS-UP

9) Math [3] – *Multiple Choice* Which of the following statements is NOT true about the function $f(x) = x + \sin(x)$?

W) It has infinitely many local minima
X) It has infinitely many critical points
Y) It has infinitely many inflection points
Z) It is monotonically non-decreasing

ANSWER: W) IT HAS INFINITELY MANY LOCAL MINIMA [LY, DERIVATIVES]

BONUS

9) Math [3] – *Short Answer* How many quadratics with leading coefficient 1 have two distinct integer roots between -10 and 10 inclusive?

ANSWER: 210 [LY, POLY]

TOSS-UP

10) Earth and Space [] – *Short Answer* What type of unconformity represents a gap in the rock record in which erosion occurred rather than deposition?

ANSWER: DISCONFORMITY [SS, Deserts]

BONUS

10) Earth and Space [] – *Multiple Choice* Which of the following types of objects, as observed from Earth, would be the LEAST likely to be observed at low redshifts?

W) Quasar
X) Blazar
Y) Supermassive black hole
Z) Seyfert galaxy

ANSWER: W) QUASAR [GW, AGN]

TOSS-UP

11) Chemistry [] – *Short Answer* When chlorine reacts with water under high temperature basic conditions, what is the molar ratio of the two chlorine species formed?

ANSWER: 5 (ACCEPT: 1-TO-5) [SS, 1/10 chlorine questions]

BONUS

11) Chemistry [] – *Short Answer* Identify all of the following three statements that are true about tetrahedral and octahedral coordination complexes. 1) Tetrahedral complexes are almost invariably high spin; 2) Tetrahedral complexes have a higher splitting than octahedral complexes; 3) Strong field ligands generally produce high-spin complexes.

ANSWER: 1 ONLY [SS, smolbrain]

TOSS-UP

12) Energy [] – *Short Answer* Researchers at SLAC are working with Caltech to study the deflection patterns of baryons and heavy mesons. Identify all of the following 3 integer charges that a meson could have: 1) -1; 2) 0; 3) +1.

ANSWER: ALL [DJ, PHYSICS]

BONUS

12) Energy [RR] – *Short Answer* Researchers at Lawrence Berkeley National Lab are computing High Performance Multigrid using parallel list traversals. Order the following 3 lists in increasing order of average random-access time of an element: 1) Array List; 2) Singly Linked List; 3) Double Linked List.

ANSWER: 1, 3, 2 [DJ, CS]

TOSS-UP

13) Physics [6] – *Short Answer* General relativity predicts that orbits around massive objects follow what paths, which are generalizations of straight lines to Riemann manifolds?

ANSWER: GEODESIC (DO NOT ACCEPT: WORLD LINE) [GW, Relativity]

BONUS

13) Physics [] – *Short Answer* Identify all of the following four properties that are necessarily conserved as a light ray refracts: 1) Frequency; 2) Wavelength; 3) Phase; 4) Polarization.

ANSWER: 1 AND 3 [GW, Optics]

TOSS-UP

14) Biology [] – *Multiple Choice* Which of the following situations would cause a photosynthetic plant cell to act as a sucrose sink?

W) When it is growing
X) When it is humid
Y) When it is bright
Z) When it is dying

ANSWER: W) WHEN IT IS GROWING [DJ, PLANT]

BONUS

14) Biology [RR] – *Short Answer* What 2 sections of the heart prevent the backflow of the blood during systole in the semilunar valve?

ANSWER: AORTA AND PULMONARY ARTERY [DJ, CIRCULATION]

TOSS-UP

15) Math [5] – *Short Answer* What is the surface area of a cube whose space diagonal is 1?

ANSWER: 2 [LY, 3D]

BONUS

15) Math [5] – *Short Answer* In a 5 by 5 grid of squares, if each square can be black or white, how many ways are there to color the grid such that it has 4 fold rotational symmetry?

ANSWER: 128 [LY, COMBO]

TOSS-UP

16) Earth and Space [] – *Short Answer* Order the following 3 components of the interstellar medium by increasing temperature: 1) Reflection nebula; 2) Molecular cloud; 3) H II region.

ANSWER: 2, 1, 3 [GW, Interstellar Medium]

BONUS

16) Earth and Space [] – *Short Answer* Identify all of the following 3 statements that are true of Charon's orbit around Pluto: 1) It is highly eccentric; 2) It has a retrograde rotation; 3) Its orbit is retrograde.

ANSWER: 2 AND 3 [SS, Compact Objects]

TOSS-UP

17) Chemistry [] – *Short Answer* Rank the following 3 chemical bonds in order of increasing ionic character: 1) Rb-Cl; 2) Ca-Cl; 3) Ca-Br

ANSWER: 3, 2, 1 [BZ, Bonding]

BONUS

17) Chemistry [] – *Short Answer* How many distinct H1-NMR signals exist for 2,4-diethylbenzoic acid?

ANSWER: 8 [BZ, orgo]

TOSS-UP

18) Energy [] – *Multiple Choice* Researchers at Lawrence Berkeley National Lab are working with the Joint Genome Institute to produce a more cost effective genome assembly process. Which of the following is the main advantage of shotgun sequencing over Sanger sequencing?

W) The temperature required to denature in Sanger sequencing is too high and volatile, while shotgun sequencing allows for more control over the temperature.
X) Sanger sequencing uses Taq polymerase which is difficult to extract, while shotgun sequencing uses coli DNA polymerase 1 which is easily extracted from e. coli.
Y) Sanger sequencing produces a significant amount of unusable products which must be dealt with, while shotgun sequencing degrades the products in vitro.
Z) Sanger sequencing can only sequence 100-1000 base pairs, while shotgun sequencing could do significantly more.

ANSWER: Z) SANGER SEQUENCING COULD ONLY SEQUENCE 100-1000 BASE PAIRS, WHILE SHOTGUN SEQUENCING COULD DO MUCH MORE. [DJ, BIO]

BONUS

18) Energy [] – *Short Answer* Researchers at Pacific Northwest National Lab are investigating ways to store adsorbed xenon in space. They are trying to use what class of materials, which are porous coordination polymers that typically use boron and nitrogen linked together with their namesake bonds?

ANSWER: COVALENT ORGANIC FRAMEWORKS [LY, CHEM]

TOSS-UP

19) Physics [] – *Short Answer* To the nearest 10 volts, what is the peak voltage of a AC wave with a root mean square voltage of 120 volts?

ANSWER: 170 [GW, Circuits]

BONUS

19) Physics [6] – *Multiple Choice* A block is attached to a frictionless ideal spring centered at $x = 0$. The spring oscillates between $x = -1$ and $x = 1$. At which of the following x values does the block experience the most power?

W) 0.2
X) 0.5
Y) 0.7
Z) 1

ANSWER: Y) 0.7 [GW, SHO]

TOSS-UP

20) Biology [] – *Short Answer* During DNA replication, what section is formed on the lagging strand by DNA polymerase III, that will later be removed by DNA ligase?

ANSWER: OKAZAKI FRAGMENTS [DJ, DNA/RNA]

BONUS

20) Biology [] – *Multiple Choice* Which of the following bacteria has the LEAST amount of inhibition of peptidoglycan cross-linking from penicillin?

W) Helicobacter pylori
X) Streptococcus pneumoniae
Y) Mycobacterium tuberculosis
Z) Staphylococcus aureus

ANSWER: W) HELICOBACTER PYLORI [DJ, BACTERIA]

TOSS-UP

21) Math [2] – *Multiple Choice* Which of the following is closest to the argument in degrees of the complex number $5 + 12i$?

W) 30
X) 50
Y) 70
Z) 90

ANSWER: Y) 70 [LY, COMPLEX]

BONUS

21) Math [6] – *Short Answer* A spiral staircase has a radius of 6 meters and makes 3 total revolutions. If the staircase rises 3pi meters in total, then what is the length of the staircase?

ANSWER: 3 PI ROOT 145 [LY, 3D]

TOSS-UP

22) Earth and Space [] – *Multiple Choice* Mylonite is a fine-grained foliated rock that is a product of which of the following types of metamorphism?

W) Shock
X) Cataclastic
Y) Contact
Z) Regional

ANSWER: X) CATACLASTIC [BZ, rock]

BONUS

22) Earth and Space [] – *Short Answer* In Oxisol soils, identify all of the following three components that are likely to be left as a residue after rainfall: 1) Gibbsite; 2) Hematite; 3) Calcite.

ANSWER: 1 AND 2 [SS]

TOSS-UP

23) Chemistry [] – *Short Answer* Given that the equilibrium constant for the decomposition of N_2O_4 yields $2NO_2$ is 16, then what is the equilibrium constant for the reaction NO_2 yields one half N_2O_4?

ANSWER: 0.25 (ACCEPT: 1/4) [BZ, Equilibrium]

BONUS

23) Chemistry [] – *Multiple Choice* A certain compound is determined to have a fluorine weight percent of 82%. Which of the following compounds is this most likely to be?

W) CH_3F
X) CH_2F_2
Y) CHF_3
Z) CF_4

ANSWER: Y) CHF_3 [BZ, idklazy]