TOSS-UP

1) Physics – *Multiple Choice* Which of the following statements is true about a capacitor?

W) Voltage leads current by 90°
X) Voltage lags current by 90°
Y) Voltage leads power by 90°
Z) Voltage lags power by 90°

ANSWER: W) VOLTAGE LEADS CURRENT BY 90° [GW, Harder Circuits]

BONUS

1) Physics – *Short Answer* What is the term for the Fourier transform of a Bravais lattice?

ANSWER: RECIPROCAL LATTICE [GW, Stock]

TOSS-UP

2) Biology – *Short Answer* Identify all of the following 3 bacteria that would cause the release of interferons when infecting a human cell: 1) E coli; 2) M tuberculosis; 3) H Pylori.

ANSWER: NONE [DJ, CRINGE]

BONUS

2) Biology – *Multiple Choice* Which of the following compounds is NOT involved in the phospholipase C signal transduction pathway?

W) IP3
X) PIP2
Y) DAG
Z) cAMP

ANSWER: Z) cAMP [DJ, SIGNALING]

TOSS-UP

3) Math – *Short Answer* How many intersections do the functions floor of *x* and ceiling of *x* have over the closed interval from 0 to 2pi?

ANSWER: 7 [LY, FUNCTION]

BONUS

3) Math – *Short Answer* What is the area of the region enclosed by the x-axis, the curve y = square root of quantity 32 minus x^2, and $y = 4$?

ANSWER: 8PI PLUS 16 [LY, funky]

TOSS-UP

4) Earth and Space – *Multiple Choice* Which of the following plates does not directly border the South American plate?

W) Cocos plate
X) Nazca plate
Y) Caribbean plate
Z) Scotia plate

ANSWER: W) COCOS PLATE [BZ, plates]

BONUS

4) Earth and Space – *Short Answer* Identify all of the following 3 regions of a galaxy that have a high abundance of stars with high metallicity: 1) Disk; 2) Halo; 3) Spiral arms.

ANSWER: 1 AND 3 [GW, Galaxies]

TOSS-UP

5) Chemistry – *Short Answer* The fact that the transition state of an exothermic reaction resembles the products more than the reactants is best explained by what statement?

ANSWER: HAMMOND'S POSTULATE [GW, Stock]

BONUS

5) Chemistry – *Short Answer* How many sp^2 hybridized nitrogen atoms are present in quinoline?

ANSWER: 1 [BZ, L]

TOSSUP

6) Energy [] – *Multiple Choice* Researchers at SLAC are using the large underground xenon experiment to study dark matter to find experimental evidence for various dark matter candidates. Which of the following is NOT a candidate for dark matter?

W) WIMP
X) Axion

Y) Intergalactic dust
Z) Primordial Black Hole

ANSWER: Y) INTERGALACTIC DUST [DJ, PHYSICS]

BONUS

6) Energy – *Short Answer* Researchers at Brookhaven National Lab are investigating how to increase the efficiency of industrial polymerization. What titanium-based catalysts are classically used to synthesize olefin polymers?

ANSWER: ZIEGLER-NATTA CATALYSTS [LY, stock]

TOSS-UP

7) Physics – *Short Answer* What phenomenon can be visualized by plotting the magnetization vs applied magnetic field intensity, forming a loop that shows the ferromagnet's dependence on its history?

ANSWER: HYSTERISIS [GW, Magnetism]

BONUS

7) Physics [] – *Short Answer* Identify all of the following 3 interactions that are mediated by the W^+ boson: 1) Alpha decay; 2) Beta decay of proton; 3) Beta decay of neutron.

ANSWER: 2 ONLY [GW, Particle]

TOSS-UP

8) Biology – *Multiple Choice* Which of the following species and environments is NOT an example of keystone species?

W) Kangaroos in savannas
X) Sea Stars in intertidal environments
Y) Wolves in forests
Z) Otters in kelp forests

ANSWER: W) KANGAROOS IN SAVANNAS [DJ, SPECIES]

BONUS

8) Biology – *Multiple Choice* Which of the following cranial nerves is considered both a motor and a sensory nerve?

W) Oculomotor

X) Trochlear
Y) Trigeminal
Z) Abducens

ANSWER: Y) TRIGEMINAL [dj, more cringe shit]

TOSS-UP

9) Math – *Short Answer* What is the limit as x approaches 3 of the fraction with numerator $x^2 + 5x - 24$ and denominator $x^2 - 5x + 6$?

ANSWER: 11 [LY, DERIVATIVE]

BONUS

9) Math – *Short Answer* Find the cosine of the largest angle in a triangle with side lengths of 4, 13, and 15.

ANSWER: -5/13 [GW, Trig]

TOSS-UP

10) Earth and Space – *Short Answer* Identify all of the following 3 planets that have a ring system: 1) Mars; 2) Jupiter; 3) Neptune.

ANSWER: 2 AND 3 [GW, Gas Giants]

BONUS

10) Earth and Space – *Short Answer* What structures, the largest known structures in the universe, consist of walls of superclusters between cosmic voids?

ANSWER: FILAMENTS (ACCEPT: GALAXY FILAMENTS) [GW, Miscellanous]

TOSS-UP

11) Chemistry – *Multiple Choice* Which of the following bonds has the most p character?

W) Carbon-hydrogen single
X) Carbon-carbon single
Y) Carbon-carbon double
Z) Carbon-carbon triple

ANSWER: Z) CARBON-CARBON TRIPLE [GW, is this good prob m]

BONUS

11) Chemistry – *Multiple Choice* For which of the following reactions does the equilibrium constant increase with temperature?

W) Dimerization of NO_2
X) Decomposition of NH_3
Y) Combustion of CH_4
Z) Hydrogenation of benzene

ANSWER: X) DECOMPOSITION OF NH_3 [BZ, equilibrium]

TOSS-UP

12) Energy [] – *Multiple Choice* Scientists at Fermilab are using bash to interact with computers. Which of the following bash commands is used to navigate between different folders on a computer?

W) cd
X) du
Y) nano
Z) touch

ANSWER: W) cd [GW, Computer Science/Bash Commands]

BONUS

12) Energy – *Short Answer* Researchers at Ames National Lab are using Monte Carlo simulations with Nvidia CUDA to confirm the veracity of Lennard-Jones models for molecules in a microporous framework. According to the Lennard-Jones potential, the strength of London Dispersion forces is proportional to what power of distance?

ANSWER: –7 [DJ, CHEM] wait what? It is -67 m bruh..

TOSS-UP

13) Physics – *Short Answer* Identify all of the following 3 individual transformations that preserve the laws of physics: 1) Charge conjugation; 2) Parity transformation; 3) Time reversal.

ANSWER: NONE [GW, Conservation]

BONUS

13) Physics – *Multiple Choice* The pressure drop of an incompressible Newtonian fluid in laminar flow through a cylindrical pipe is proportional to what power of the pipe's radius?

W) -4
X) -2
Y) 2
Z) 4

ANSWER: W) -4 (Note: Hagen–Poiseuille equation) [GW, Fluids]

TOSS-UP

14) Biology – *Short Answer* What defining process in adaptive immunity uses genetic fragments randomly rearranged and joined through non-homologous end joining to produce T cell receptors?

ANSWER: VDJ RECOMBINATION (ACCEPT: VJ RECOMBINATION) [DJ, VDJ RECOMBINATION]

BONUS

14) Biology – *Short Answer* Identify all of the following 3 cell types that you would expect to find suberin: 1) Periderm; 2) Bundle sheath cells; 3) Root endodermis.

ANSWER: 1 AND 3 [DJ, IDK IF THIS IS RIGHT NGLLLLLL]

TOSS-UP

15) Math – *Multiple Choice* Geoffrey can mow a lawn in 15 hours, and Sanjay can mow the same lawn in 10 hours. How many hours would it take for the two of them to mow the lawn together?

W) 5
X) 5.4
Y) 6
Z) 7.2

ANSWER: Y) 6 [GW, Rate]

BONUS

15) Math – *Short Answer* An ant starts at one vertex of a tetrahedron. Every second, it chooses another vertex to go to at random. What is the probability that the ant is back at the starting vertex after 4 seconds?

ANSWER: 7/27 [LY, casework]

TOSS-UP

16) Earth and Space – *Multiple Choice* What type of stream only flows for a short duration directly after precipitation?

W) Ephemeral
X) Intermittent
Y) Perennial
Z) Straight channel

ANSWER: W) EPHEMERAL [GW, Rivers and Streams]

BONUS

16) Earth and Space – *Short Answer* Identify all of the following 3 organisms whose shells compose siliceous ooze: 1) Radiolarians; 2) Diatoms; 3) Coccolithophores.

ANSWER: 1 and 2 [BZ, biogeo]

TOSS-UP

17) Chemistry – *Short Answer* Identify all of the following 3 molecular orbitals that have 2 nodal planes: 1) LUMO of ethylene; 2) LUMO of O_2; 3) HOMO of 1,3 butadiene.

ANSWER: 1 and 3 [BZ, mo]

BONUS

17) Chemistry – *Short Answer* Identify all of the following 3 types of pericyclic reactions that result in a net increase in the number of sigma bonds: 1) Cycloaddition; 2) Electrocyclic; 3) Sigmatropic.

ANSWER: 1 AND 2 [GW, Pericyclic]

TOSS-UP

18) Energy [] – *Multiple Choice* Scientists at Brookhaven National Lab are using gel electrophoresis to obtain high-quality separation and purification of proteins. Which of the following buffers is most commonly used in gel electrophoresis?

W) Phosphate
X) MOPS
Y) HEPES
Z) Tris

ANSWER: Z) TRIS [GW, Biology]

BONUS

18) Energy [] – Short Answer Scientists at Oakridge National Lab are investigating Moore's Law by trying to redesign certain circuit components. What device allows for the conversion of 2^n input lines into a single output line?

ANSWER: MULTIPLEXER (ACCEPT: MUX) [DJ, CS252]

TOSS-UP

19) Physics – *Multiple Choice* An object that is constrained to the x axis experiences a constant acceleration of +10 meters per second squared over a period of time where it has a displacement of 20 meters. In meters per second squared, what is the maximum change in speed of the object?

W) 10
X) 20
Y) 30
Z) 40

ANSWER: X) 20 [GW, Kinematics]

BONUS

19) Physics – *Short Answer* Identify all of the following 3 modes of polarization that have 2 perpendicular polarization planes: 1) Linear; 2) Circular; 3) Elliptical.

ANSWER: 2 AND 3 [GW, Optics]

TOSS-UP

20) Biology – *Multiple Choice* Which of the following best describes the blood of the pulmonary circuit in the mammalian circulatory system before it goes into gas exchange tissues?

W) CO2 rich and O2 rich
X) CO2 rich and O2 poor
Y) CO2 poor and O2 rich
Z) CO2 poor and O2 poor

ANSWER: X) CO2 RICH AND O2 POOR [DJ, MONETARY INEQUALITY]

BONUS

20) Biology – *Short Answer* After 4 cycles of PCR, how many strands have the exact same length as the target sequence?

ANSWER: 4 [DJ/GW, PCR]

TOSS-UP

21) Math – *Short Answer* What is the maximum value from x = 0 to x = 2pi of sin(x) + 2cos(x)?

ANSWER: ROOT 5 [LY, pythagorean]

BONUS

21) Math – *Short Answer* Geoffrey the code monkey prints the integers from 1 to 2022. How many times did he print the digit 0?

ANSWER: 525 [LY, python]

TOSS-UP

22) Earth and Space – *Multiple Choice* Which of the following individual modifications to a telescope will quadruple its light gathering power?

W) Halving the eyepiece diameter
X) Doubling the eyepiece diameter
Y) Halving the objective diameter
Z) Doubling the objective diameter

ANSWER: Z) DOUBLING THE OBJECTIVE DIAMETER [GW, Telescopes]

BONUS

22) Earth and Space – *Short Answer* Though molybdenum is commercially produced from the sulfide ore molybdenite, it can also be produced through what lead containing oxide ore?

ANSWER: WULFENITE [BZ/DJ, lmaorip]

TOSS-UP

23) Chemistry – *Short Answer* Identify all of the following 3 d orbitals that have a higher energy than the d_{z^2} orbital in a square planar complex: 1) $d_{x^2-y^2}$; 2) d_{xy}; 3) d_{xz}.

ANSWER: 1 [BZ, cft]

BONUS

23) Chemistry – *Short Answer* In the reaction C yields D, C converts to D via a first order reaction mechanism. If the initial concentration of C is 2 molar, and the mean lifetime of C is 20 seconds, then to 1 significant figure, what is the rate constant for the reaction?

ANSWER: 0.05 [BZ, lol]