

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 2π ?

ANSWER: 7 [LY, FUNCTION]

BONUS

3) Math – *Short Answer* What is the area of the region enclosed by the x-axis, the curve $y = \sqrt{32 - x^2}$, 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: HYSTERESIS [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, Miscellaneous]

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 NO₂
- X) Decomposition of NH₃
- Y) Combustion of CH₄
- Z) Hydrogenation of benzene

ANSWER: X) DECOMPOSITION OF NH₃ [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 O₂; 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 $x = 2\pi$ of $\sin(x) + 2\cos(x)$?

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]