TOSS-UP

1) BIOLOGY – *Short Answer*   Adenosine can be converted to Inosine by the enzyme Adenosine deaminase in the presence of what compound?

ANSWER: Water

BONUS

1) BIOLOGY – *Short Answer*   In the pentose phosphate pathway, sugar phosphates of Erythrose and Xylulose can be acted on by transketolase to create Glyceraldehyde 3 Phosphate and another molecule of a phosphate attached to what sugar?

ANSWER: Fructose

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TOSS-UP

2) CHEMISTRY – *Multiple Choice* If I treat 4,4-dimethylpent-2-ene with NBS and light, which of the following is the major product?

W) 1-bromo-4,4-dimethylpent-2-ene
X) 5-bromo-4,4-dimethylpent-2-ene
Y) 2-bromo-4,4-dimethylpentane
Z) 3-bromo-4,4-dimethylpentane

ANSWER: W) 1-bromo-4,4-dimethylpent-2-ene

BONUS

2) CHEMISTRY – *Multiple Choice* Which of the following values is closest to the pH of a 0.01M solution of ammonia if its pKb is 4.74?

W) 8.8
X) 9.2
Y) 10.6
Z) 12

ANSWER: Y) 10.6

TOSS-UP

3) EARTH AND SPACE – *Multiple Choice* The pronounced dark area between the A and B rings of Saturn is known by which of the following names?

W) Herschel Division
X) Cassini Division
Y) Colombo Gap
Z) Huygens Gap

ANSWER: X) Cassini Division

BONUS

3) EARTH AND SPACE – *Multiple Choice* Which of the following is the correct ordering, from least to greatest radius, of Saturn's rings?

W) C, B, D, A, G, F, E
X) A, B, C, D, E, F, G
Y) F, E, C, A, B, D, G
Z) D, C, B, A, F, G, E

ANSWER: Z) D, C, B, A, F, G, E

TOSS-UP

4) PHYSICS – *Multiple Choice*   Which of the following is closest to the time elapsed since the Big Bang?

W) 4×10^{14} seconds
X) 14 billion seconds
Y) 4×10^{17} seconds
Z) 4×10^{20} seconds

ANSWER: Y) 4×10^{17} SECONDS

BONUS

4) PHYSICS – *Short Answer*   A copper wire generates a magnetic field of 2.0×10^{-5} T at a point 10 cm away from the wire. Calculate the current of the wire, in Amperes, giving your answer in terms of pi and mu naught.

ANSWER: 4pi $* 10^{-6}$ / (μ_0)

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TOSS-UP

5) MATH – *Short Answer*   If a multivariate function is defined as $f(x, y) = 4\sin^2(x)\cos(y)$, evaluate $\nabla f(x, y)$ (READ AS: the gradient of $f(x, y)$)

ANSWER: $8\sin(x)\cos(x)\cos(y)\mathbf{i} - 4\sin^2(x)\sin(y)\mathbf{j}$

BONUS

5) MATH – *Multiple Choice* If A is a n x n matrix, then which of the following statements is NOT true?

W) $Ax = 0$ has only the trivial solution
X) The row vectors of A are linearly independent
Y) A has nullity n
Z) The orthogonal complement of the null space of A is R^n

ANSWER: Y) A has nullity n (A has nullity 0 while the rank is n)

TOSS-UP

6) ENERGY – *Short Answer* Metformin, a widely used medication for type 2 diabetes, primarily works by affecting cellular metabolism. One of its key mechanisms involves the activation of an enzyme that plays a crucial role in regulating energy balance. What is the name of this enzyme, which helps lower blood glucose levels?

ANSWER: AMP-activated protein kinase (AMPK)

BONUS

6) ENERGY – *Short Answer* What optimization algorithm, based on the Metropolis Hastings method, uses a Markov chain to choose when to change states in a method?

ANSWER: SIMULATED ANNEALING

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TOSS-UP

7) BIOLOGY – *Short Answer*   What is the term for the technique where an applied electric current can increase cell membrane permeability?

ANSWER: Electropermeabilization (Accept: Electroporation)

BONUS

7) BIOLOGY – *Multiple Choice*   Which of the following functional group changes would be necessary to convert Chlorophyll A to Chlorophyll B?

W Ketone to Methyl
X Methyl to Ketone
Y Aldehyde to Methyl
Z Methyl to Aldehyde

ANSWER: Z

TOSS-UP

8) CHEMISTRY – *Short Answer* Assuming Michaelis-Menten enzyme substrate interaction, what is the reaction speed at the time when the substrate concentration is equivalent to the Michaelis constant given a maximum reaction velocity of 8 millimolar per second.

Answer: 4 millimolar per second

BONUS

8) CHEMISTRY – *Multiple Choice* Which of the following best gives the ionic strength for a mixed solution of 0.05M $MgSO_4$ and 0.03M $CaCl_2$?

W) 0.08 M
X) 0.15 M
Y) 0.19 M
Z) 0.29 M

ANSWER: Z) 0.29 M

TOSS-UP

9) EARTH AND SPACE – *Multiple Choice* Which of the following greenhouse gases has the highest global warming potential?

W) sulfuryl fluoride
X) trifluoromethane
Y) perfluorotributylamine
Z) sulfur hexafluoride

ANSWER: X) trifluoromethane

BONUS

9) EARTH AND SPACE – *Multiple Choice* Asteroids which orbit between Earth and Mars but do not cross the path of either fall into which grouping?

W) 'Ayló'chaxnim (eye-lo-chack-nim)
X) Apollo
Y) Aten (ah-tin)
Z) Amor

ANSWER: Z) Amor

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TOSS-UP

10) PHYSICS – *Short Answer* Identify all of the following reasons as to why hyperopia may occur in humans: 1) The lens is too strong, 2) The eye is too short, 3) The lens is too weak, 4) The eye is too long.

ANSWER: 2 and 3

BONUS

10) PHYSICS – *Short Answer* A capacitor with plate area 0.01 meters squared and plate separation 0.1 meters has a dielectric inserted with constant 1 over twice the permittivity constant. In coulombs, how much charge can be stored in this capacitor at 9 Volts.

ANSWER: 0.45

TOSS-UP

11) MATH – *Short Answer* Solve the following equation for all values between 0 and 2π inclusive: $4\cos(2x) + 14 \sin(x) - 9 = 0$.

ANSWER: $\pi/6$ AND $5\pi/6$

BONUS

11) MATH – *Multiple Choice* If $70x^2$ has 70 factors, how many factors does $99x^3$ have?

W) 195
X) 365
Y) 420
Z) 693

ANSWER: Y) 420

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TOSS-UP

12) ENERGY – *Short Answer* Researchers at observatories such as the Kamioka Gravitational Wave Detector and the European Gravitational Observatory rely on what method of repeatedly reflecting lasers to achieve measurement accuracy precise enough to detect gravitational waves?

ANSWER: laser interferometry (accept: interferometry)

BONUS

12) ENERGY – *Multiple Choice* Researchers at the Very Large Telescope use four telescopes named Antu, Kueyen, Melipal, and Yepun to observe the universe. Given that each of these telescopes has a primary mirror diameter of 8.2 m and disregarding atmospheric distortion, how far apart would two objects 4.6×10^5 km away, emitting an average wavelength of 550 nm, have to be from each other in order to be resolved by a single telescope, to the nearest whole meter?

ANSWER: 38 km

TOSS-UP

13) BIOLOGY – *Multiple Choice* What is the cellular mechanism of cyanide?

W) It inhibits ATP production by decomposing aconitase, stalling the conversion of citrate into isocitrate
X) It inhibits ATP production by binding to cytochromes in the mitochondrial electron transport chain
Y) It inhibits nervous system activity by activating scavenger receptors to bind to neurotransmitters
Z) It inhibits nervous system activity by initiating intrinsic apoptosis in the central nervous system

Answer: X) It inhibits ATP production by binding to cytochromes in the mitochondrial electron transport chain

BONUS

13) BIOLOGY – *Short Answer* What is the most common gel dye used in gel electrophoresis of DNA and RNA?

ANSWER: Ethidium Bromide

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TOSS-UP

14) CHEMISTRY – *Multiple Choice* Which of the following complexes absorbs visible light of the longest wavelength?

W) $CoCl_6^{3-}$
X) $Co(H_2O)_6^{3-}$
Y) $Co(CN)_6^{4-}$
Z) $Co(NH_3)_6^{3+}$

ANSWER: W) $CoCl_6^{3-}$:

BONUS

14) CHEMISTRY – *Multiple Choice* You convert 4-chlorobenzaldehyde to (4-chlorophenyl)methanol and 4-chlorobenzoic acid using excess potassium hydroxide, methanol, and workup with acid. To begin extracting your 4-chlorobenzoic acid, you add sodium bicarbonate to your product, forming two layers. Which compound will be found in the top layer?

W) 4-chlorobenzaldehyde
X) (4-chlorophenyl)methanol
Y) 4-chlorobenzoic acid
Z) sodium bicarbonate

ANSWER: X) (4-chlorophenyl)methanol

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TOSS-UP

15) EARTH AND SPACE – *Short Answer* What is the peak wavelength, to the nearest nanometer, of a star of temperature 16,000K?

ANSWER: 181 nm

BONUS

15) EARTH AND SPACE – *Short Answer* An air parcel has an initial temperature of 23°C and a dry air lapse rate of 9.8°C/km as well as a sea level dew point of 16°C and a dew point lapse rate of 1.9°C/km. What is the cloud base altitude of this air mass, to the nearest tenth of a kilometer?

ANSWER: 0.9 km

TOSS-UP

16) PHYSICS – *Short Answer* A rocket is launched vertically upward from the ground with an initial velocity of 230 m/s. Assuming g equals 10 m/s^2, calculate the maximum height (in meters) it will reach before falling back to the ground.

ANSWER: 2645 meters

BONUS

16) PHYSICS – *Short Answer* If a supernova of apparent magnitude 2.6 was observed in 2024 at a distance of 5 kiloparsecs from Earth, how many years before observation, to the nearest hundred years, did the supernova occur?

ANSWER: 16300 years

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TOSS-UP

17) MATH – *Short Answer* What quantity can be calculated by evaluating the surface integral over a vector field, F, assuming that the vector field represents a fluid?

Answer: Flux

BONUS

17) MATH – *Short Answer* Find the volume of the solid generated when the region enclosed by xy=4 and x+y=5 is revolved about the x-axis.

ANSWER: 9π

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TOSS-UP

18) ENERGY – *Multiple Choice* Niskayuna Newtons Research Center is studying COVID-19, and wants to purify a sample of the virus' "spike protein" along with its associated proteins. Which of the following assays should the Niskayuna Newtons use?

W) Immunoprecipitation
X) Co-Immunoprecipitation
Y) Enzyme linked immunoassay
Z) Western Blot

ANSWER: X) CO-IMMUNOPRECIPITATION

BONUS

18) ENERGY – *Short Answer* Researchers at Korea University claim to have discovered a room-temperature, ambient-pressure superconductor called LK-99 which supposedly exhibits partial diamagnetism. To verify these results, multiple independent researchers have tried simulating LK-99 computationally using density functional theory, or DFT. These simulations employ what common approximation used in molecular dynamics, which assumes that the nuclei of atoms remain fixed in space over time?

ANSWER: BORN-OPPENHEIMER APPROXIMATION