NWI2 DE3

TOSS-UP

1) Energy – *Multiple Choice* A national achievement test is administered annually to 3rd graders. The test has a mean score of 100 points and a standard deviation of 15. If Jane's z-score is 1.20, what was her score, in points, on the test?

W) 82
X) 100
Y) 118
Z) 136

ANSWER: Y) 118

BONUS

1) Energy – *Multiple Choice* The DUNE experiment at Fermilab generates a powerful neutrino beam that travels 1,300 kilometers to a detector in South Dakota. Almost all of the neutrinos generated at Fermilab are muon neutrinos. If N muon neutrinos are generated initially, which of the following is closest to the number of muon neutrinos that will arrive at the detector?

W) N
X) $N/2$
Y) $N/3$
Z) $N/4$

ANSWER: Y) $N/3$

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TOSS-UP

2) BIOLOGY - *Short Answer* By name or number, identify all of the following three statements that are true of catecholamines: 1) they are only secreted by the adrenal glands, 2) catecholamines can be degraded by MAO through deamination, 3) catecholamines solely excite the sympathetic nervous system
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ANSWER: 2 ONLY

BONUS

2) BIOLOGY - *Short Answer* Oscar is so stressed about his upcoming APUSH test that he develops a thyroid storm. The thyroid panel determines he has elevated levels of TRH, TSH, T3 and T4. Assuming in each case that only one component in the thyroid hormone synthesis pathway may be dysfunctional, identify all of the following three components in the thyroid hormone synthesis pathway that can be dysfunctional: 1) hypothalamus, 2) anterior pituitary gland, 3) thyroid gland

ANSWER: 1 ONLY

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TOSS-UP

3) Chemistry - *Multiple Choice* To which of the following are the best conditions for an SN2 reaction?
W) Primary electrophile, strong base
X) Primary electrophile, strong nucleophile
Y) Tertiary electrophile, strong base
Z) Tertiary electrophile, strong nucleophile

ANSWER: X) primary electrophile, strong nucleophile

BONUS

3) CHEMISTRY - *Short Answer* Given the gaseous reaction A + B -> C (Read as: A plus B yields C) has equilibrium constant k=4, what is the equilibrium constant from the reaction 5C -> 5A +5B (Read as: 5C yields 5A plus 5B)?

ANSWER: 1/1024

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TOSS-UP

4) PHYSICS - *Multiple Choice* A pendulum consists of a block of mass 7 kg and a string of negligible mass. If the period of the pendulum is T, what is its new period on the moon if the acceleration due to gravity is ⅙ that of earth and the string's length is cut in half?

W) T/3
X) T
Y) $\sqrt{3}$T
Z) 3T

ANSWER: Y) $\sqrt{3}$T

BONUS

4) PHYSICS - *Short Answer* In volts per meter, what is the electric field at the center of a hollow metallic sphere with a radius of 60 centimeters when the center of the sphere is 8 meters from a particle with a charge of 40 coulombs?

ANSWER: 0

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TOSS-UP

5) MATH - *Short Answer* A triangle has two side lengths measuring 14 meters and 17 meters. Which of the following, in meters, could *not* be a possible length of the third side?

W) 3
X) 4
Y) 5
Z) 6

ANSWER: W) 3

BONUS

5) MATH - *Short Answer* Find the determinant of the 3x3 matrix (Read as Matrix with row one: 5,2,1 second row: -2,6,-2 and third row: 3,-2,4)
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$$\begin{vmatrix} 5 & 2 & 1 \\ -2 & 6 & -2 \\ 3 & -2 & 4 \end{vmatrix}$$

ANSWER: 90

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TOSS-UP

6) EARTH AND SPACE - *Multiple Choice* Which of the following changes could result in the formation of an exfoliation dome?

W) Increase in pressure
X) Decrease in pressure
Y) Increase in temperature
Z) Decrease in temperature

ANSWER: X) Decrease in pressure

BONUS

6) EARTH AND SPACE - *Short Answer* Deposits from turbidity currents typically form what clastic sedimentary rock?

ANSWER: Greywacke

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TOSS-UP

7) ENERGY - *Multiple Choice* What was the approximate percentage of total energy consumption from renewable energy sources in the US in 2023?

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

ANSWER: W) 10%

BONUS

7) ENERGY - *Short Answer* The 2024 Nobel Prize in chemistry was awarded for the creation of what artificial intelligence system, developed by Google DeepMind, that predicts the 3D structure of proteins based on their amino acid sequences?

ANSWER: ALPHAFOLD

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TOSS-UP

8) BIOLOGY - *Multiple Choice* Which of the following is an agranular leukocyte?

W) Neutrophils
X) Basophils
Y) T cells
Z) Eosinophils

ANSWER: Y) T cells

BONUS

8) BIOLOGY - *Short Answer* Identify the protein complex that forms the points of contact between homologous chromosomes during meiosis.

ANSWER: Synaptonemal complex

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TOSS-UP

9) CHEMISTRY - *Short Answer* If the value of the freezing point depression constant for water is 1.86 degrees celsius per molal, what would be the freezing point, in degrees Celsius, of a solution where 0.1 moles of Lithium Chloride are dissolved in 100mL of water?

ANSWER: -3.72^{O}C (DO NOT ACCEPT: 3.72)

BONUS

9) CHEMISTRY - *Multiple Choice* NaOH is added to a 400mL of 2M acetic acid. If the pKa value of acetic acid is approximately 4.8, what volume of 1M NaOH must be added so that the pH of the solution is 4.8?

W) 100mL
X) 200mL
Y) 400mL
Z) 800mL

ANSWER: Y) 400 mL

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TOSS-UP

10) PHYSICS - *Short Answer* The deviation of the precession of mercury was explained by what model?

ANSWER: General Theory of Relativity (Do not accept: Theory of Relativity)

BONUS

10) PHYSICS - *Short Answer* Let there be an object of mass 5 kg moving at 2 m/s in the positive x direction and another object of mass 3 kg moving at 3 m/s in the negative x direction. After they collide elastically, which of the following is the final velocity of the 5 kg object in the negative x direction?

w) 2 m/s
x) 1.75 m/s
y) 1.5 m/s
z) 1.25 m/s

ANSWER: x) 1.75 m/s

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TOSS-UP

11) MATH - *Short Answer* What is the equation of the slant asymptote of the Function$(3x^2 - 5x + 11)/(x - 4)$? (Read as: The fraction with numerator 3 x squared minus 5x plus 11 and denominator x minus 4)

ANSWER: y=3x+7 (DO NOT ACCEPT: 3x+7)

BONUS

11) MATH - *Short Answer* What is the value of $(-1 + i\sqrt{3})^{10}$(Read as: Open parentheses negative 1 plus i times the square root of 3 closed parentheses raised to the tenth power)?

ANSWER: $-512 + 512i\sqrt{3}$(Read as: Negative 512 plus 512 i times the square root of 3)

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TOSS-UP

12) EARTH AND SPACE - *Short Answer* What term is used to describe the center of mass of a binary star or planetary system that both bodies orbit around?

ANSWER: Barycenter

BONUS

12) EARTH AND SPACE - *Short Answer* Identify all of the following four values for orbital eccentricity that describe closed orbits: 1) 0; 2) 0.5; 3) 1; 4) 1.5.

ANSWER: 1 and 2

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TOSS UP

13) ENERGY - Multiple Choice Researchers at the De Nooij Lab are studying proprioception. Which of the following best describes proprioception?
W) Ability to sense pressure
X) Ability to sense light touch
Y) Ability to sense body position
Z) Ability to sense temperature

ANSWER: Y) ABILITY TO SENSE BODY POSITION

BONUS

13) ENERGY - Short Answer Researchers at the Gaynor Group at Northwestern University are studying coordination complexes. In the $[Ag(NH_3)_2]^+$, what molecule is the Lewis base?

ANSWER: NH_3 (Accept: Ammonia)

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TOSS-UP

14) BIOLOGY - *Multiple Choice* The endomembrane system is crucial for protein synthesis and transport. Which of the following organelles is not part of the endomembrane system

W) Mitochondria
X) Golgi Apparatus
Y) Lysosome
Z) Endoplasmic reticulum

ANSWER: W) Mitochondria

BONUS

14) BIOLOGY - *Multiple Choice* Bacterial transformation involves the uptake of foreign DNA by a bacterial cell. Which scientist is credited with discovering the phenomenon of bacterial transformation in the early 20th century?

W) Louis Pasteur
X) Robert Koch
Y) Frederick Griffith
Z) Alexander Fleming

ANSWER: Y) FREDERICK GRIFFITH

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TOSS-UP

15) CHEMISTRY - *Short Answer* If Mihir and Arjun were allowed to make Tollens' reagent, they could use it to distinguish between aldehydes and what other functional group, which are formed by the oxidation of secondary alcohols?

ANSWER: KETONES

BONUS

15) CHEMISTRY - *Short Answer* Oscar slowly adds 50mL of 1M nitric acid into a mixture containing 0.01 mol of $Ca(OH)_2$, 100mL water, and phenolphthalein. Identify all of the following three statements that are true: 1) The solution turns pink, 2) The solution becomes opaque, 3) The pH of the final solution is slightly basic

ANSWER: NONE

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16) PHYSICS - *Multiple Choice* A car travels along a straight road with an initial velocity of 30 meters per second and comes to rest after covering a distance of 50 meters due to a constant deceleration. What is the magnitude of the deceleration in meters per second squared?

W) 3
X) 6
Y) 9
Z) 12

ANSWER: Y) 9

BONUS

16) PHYSICS – *Short Answer*—A ball is launched from a 20 meter tall building with a velocity of 40 meters per second at an angle of 30 degrees with respect to the horizontal. Given that the acceleration due to gravity is 10 meters per second squared and ignoring air resistance, how much time, in seconds, does it take for the ball to reach the ground?

ANSWER: 2

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TOSS-UP

17) MATH- *Short Answer* Given a 6 by 6 grid of unit squares, how many total squares of any size are there in this grid?

ANSWER: 105

BONUS

17) MATH - *Multiple Choice* If $y = \frac{2x+3}{3x+2}$(Read as: y equals the fraction with numerator 2 x plus 3 and denominator 3 x plus 2), then what is f ‘ (x) (Read as: f prime of x)?

W) $\frac{12x+13}{(3x+2)^2}$ (Read as: The fraction with numerator 12 x plus 13 and denominator open parentheses 3 x plus 2 closed parentheses squared)
X) $\frac{12x-13}{(3x+2)^2}$ (Read as: The fraction with numerator 12 x minus 13 and denominator open parentheses 3 x plus 2 closed parentheses squared)
Y) $\frac{5}{(3x+2)^2}$(Read as: The fraction with numerator 5 and denominator open parentheses 3 x plus 2 closed parentheses squared)
Z) $\frac{-5}{(3x+2)^2}$(Read as: The fraction with numerator negative 5 and denominator open parentheses 3 x plus 2 closed parentheses squared)
ANSWER: Z) $\frac{-5}{(3x+2)^2}$

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TOSS-UP

18) EARTH AND SPACE - *Multiple Choice* In which of the following locations can the highest open ocean salinities generally be found?

W) At the equator
X) At the center of gyres
Y) Along the western edge of gyres
Z) Along the eastern edge of gyres

ANSWER: X) At the center of gyres

BONUS

18) EARTH AND SPACE - *Multiple Choice* On the moment magnitude scale, a difference in magnitude of 1 is associated with a difference in energy released of 10 raised to what power?

ANSWER: 3/2

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TOSS UP

19) ENERGY - *Short Answer* Researchers at the Center for Peripheral Neuropathy at the University of Chicago are studying peripheral neuropathy, where nerves in the peripheral nervous system are damaged. These nerves are myelinated by what type of glial cell?

ANSWER: SCHWANN CELL

BONUS

19) ENERGY - *Multiple Choice* Researchers at the Blood Research Center at UNC Chapel Hill are studying the formation of thrombi. Which of the following is not one of the three factors thought to contribute to thrombus formation according to Virchow's triad?

W) Stasis of blood flow
X) Turbulent blood flow
Y) Endothelial injury
Z) Hypercoagulability

ANSWER: X) TURBULENT BLOOD FLOW

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TOSS-UP

20) BIOLOGY - *Multiple Choice* In the process of cellular respiration, the citric acid cycle (Krebs cycle) plays a crucial role in transforming reactants into high energy intermediates. Which of the following molecules is NOT produced during the citric acid cycle?

W) $FADH_2$
X) NADH
Y) ATP
Z) Glucose

ANSWER: Z) GLUCOSE

BONUS

20) BIOLOGY - *Short Answer* Young children often pick up new languages and skills with astonishing ease compared to adults. This is an example of what ability of the brain to form and reorganize synaptic connections.

ANSWER: NEUROPLASTICITY (ACCEPT: PLASTICITY)
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