NWI2 DE5

TOSS-UP

1) MATH - *Multiple Choice* Which of the following is equivalent to !(x>y & y<=0) (Read as: Not open parenthesis x is greater than y and y is less than or equal to zero close parenthesis)?

W) !(x<=y) or (y>0) (Read as: Not open parenthesis x is less than or equal to y close parenthesis or y is larger than 0)
X) x>y & y<=0 (Read as: x is larger than y and y is less than or equal to 0)
Y) x<=y or y>0 (Read as: x is less than or equal y or y is larger than 0)
Z) x>y or y<0 (Read as: x is greater than y or y is less than 0)

ANSWER: Y) x<=y or y>0 (Read as: x is less than or equal y or y is larger than 0)

BONUS

1) MATH - *Short Answer*What is the area, in square units, of the pentagon marked by these 4 coordinates: (2,3), (5,7), (7,-2), (-5,6) and (-6,0)?

ANSWER: 55/2 (ACCEPT: 27.5)

REPLACE: 5) Math – *Multiple Choice* Which of the following values of x will give you a perfect square from the function f(x) = x^2+19x+38 (READ AS: f of x equals x squared plus 19x plus 38)

W) 11
X) 24
Y) 43
Z) 52

ANSWER: Y) 43

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TOSS-UP

2) EARTH AND SPACE - *Short Answer* An asteroid traveling around the Sun has a perihelion of 2 AU and an aphelion of 4 AU. What is the ratio of the asteroid's speed at perihelion to its speed at aphelion?

W) 1/4
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X) 1/2
Y) 2
Z) 4

ANSWER: Y) 2

BONUS

2) EARTH AND SPACE - *Short Answer* Which of the following temperatures is closest to the maximum temperature, in Kelvin, at which a star's peak wavelength of emission will still be in the visible spectrum?

W) 8,000
X) 16,000
Y) 32,000
Z) 64,000

ANSWER: W) 8,000

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TOSS-UP

3) Energy – *Multiple Choice* Researchers at Ames Lab have discovered a new type of electron band splitting occurring in materials with temperatures below the Néel temperature. Below this temperature, metallic compounds transition to which of the following types of magnetism?

W) Ferromagnetism
X) Antiferromagnetism
Y) Ferrimagnetism
Z) Paramagnetism

ANSWER: X) Antiferromagnetism

BONUS

3) Energy – *Multiple Choice* Researchers at Pacific Northwest National Lab are working on the BELLE II experiment, designed to produce large numbers of B mesons that may decay into dark
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matter particles. Identify all of the following three particles that could pair with a bottom antiquark to produce a B meson: 1) Up antiquark; 2) Down quark; 3) Strange quark.

ANSWER: 2 and 3

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TOSS-UP

4) BIOLOGY - *Short Answer* Which of the following interactions is typically not involved in stabilizing a protein's tertiary structure?

W) Hydrogen Bonds
X) Ionic Interactions
Y) Hydrophobic Interactions
Z) Phosphodiester Bonds

ANSWER: Z) PHOSPHODIESTER BONDS

BONUS

4) BIOLOGY - *Short Answer* A dihybrid cross between two heterozygous pea plants for two traits is conducted: R (READ AS "Big R") represents the dominant trait for round peas as opposed to r (READ AS "Little R") which represents wrinkled peas and Y (READ AS "Big Y") which represents yellow peas as opposed to y (READ AS "Little y") which represents green peas. What is the expected phenotypic ratio of the offspring?

ANSWER: 9 TO 3 TO 3 TO 1 (ACCEPT 9 DOMINANT DOMINANT, 3 DOMINANT RECESSIVE, 3 RECESSIVE DOMINANT, 1 RECESSIVE RECESSIVE or any order. Do NOT accept any order if the answer is given without stating dominancy)

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TOSS-UP

5) CHEMISTRY - *Multiple Choice* Which of the following ratios is closest to that of the M+1 peak to the M peak in the mass spectrum for pentane?

W) 1:20
X) 1:15
Y) 1:10
Z) 1:5

ANSWER: W) 1:20

BONUS

5) CHEMISTRY - *Short Answer* Order the following three ions by increasing K_b value: 1) Carbonate, 2) Nitrate, 3) Fluoride

ANSWER: 2, 1, 3

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TOSS-UP

6) PHYSICS- *Multiple Choice* Two pieces of space junk of equal masses are in circular orbit around earth. Object A has a speed of V. The orbital radius of object B is 16 times that of object A. In terms of V, what is the speed of object B.

W) V
X) V/16
Y) 16V
Z) V/4

ANSWER: Z) V/4

6) PHYSICS-*Short Answer* Two bags of sand contain an equal amount of mass and are separated by a distance of 4 meters. One third of the mass from one bag is moved into the other bag. If the magnitude of the original gravitational force before moving the mass was F, in terms of F what is the magnitude of the gravitational force after the masses are transferred?

ANSWER: 8F/9

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TOSS-UP

7) MATH - *Short Answer* What is the eccentricity of the hyperbola with equation $\frac{(x-7)^2}{36} - \frac{(y-3)^2}{81} = 1$

ANSWER: $\frac{\sqrt{13}}{2}$

BONUS

7) MATH - *Short Answer* Evaluate the limit as x approaches 1 of the quantity with numerator x squared minus 1 and denominator sine of pi x.

$$\lim_{x \to 1} \frac{x^2 - 1}{\sin(\pi x)}$$

ANSWER: -2/pi

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TOSS-UP

8) EARTH AND SPACE - *Short Answer* What name is given to the type of stationary circular clouds often mistaken for UFOs that typically form above mountains and other surface disturbances?

ANSWER: Lenticular

BONUS

8) EARTH AND SPACE - *Short Answer* Which of the following best characterizes the direction of groundwater flow beneath an ephemeral stream?

W) Along the stream's flow
X) Opposite the stream's flow
Y) Towards the stream
Z) Away from the stream

Z) Away from the stream

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TOSS-UP

9) Energy – *Multiple Choice* The FLARE facility at Pacific Northwest National Lab is studying solar flares to better understand what process, which occurs when magnetic field lines join together and break apart in high-energy plasmas?

ANSWER: Magnetic reconnection (ACCEPT: Reconnection)

BONUS

9) Energy – *Multiple Choice* Researchers at Argonne National Lab are attempting to reduce the computational difficulty of QR matrix decomposition, which finds an orthogonal and upper triangular matrix that multiply to give an original matrix. Which of the following matrices would be considered both an orthogonal and upper triangular matrix?

W) [The matrix with first row 1, 0 and second row 0, 1]
X) [The matrix with first row 1, 1/2 and second row 0, square root 3 over 2]
Y) [The matrix with first row 2, -1 and second row -1, 2]
Z) [The matrix with first row 2, 1/2 and second row 1/2, 2]

ANSWER: X) [The matrix with first row 1, 1/2 and second row 0, square root 3 over 2]

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TOSS-UP

10) BIOLOGY - *Short Answer* What pigment found in the retina is responsible for scotopic vision?

ANSWER: RHODOPSIN

BONUS

10) BIOLOGY - Short Answer Identify all of the following three statements that are true of mitochondrial dynamics:

I) Mitochondrial fission is primarily mediated by the dynamin-related protein DRP1
II) Mitochondrial fusion involves outer membrane mitofusins (MFN1/2) and inner membrane protein OPA1
III) The mitochondrial outer membrane is capable of exchanging proteins directly with the inner membrane through large transmembrane pores

ANSWER: I and II

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TOSS-UP

11) CHEMISTRY - TU Multiple Choice - Which of the following is the major product when aniline is treated with concentrated nitric acid and sulfuric acid?
W) Nitrobenzene
X) 3-nitro-aniline
Y) 4-nitro-aniline
Z) There is no reaction

ANSWER: Z) There is no reaction

BONUS

11) CHEMISTRY - *Short Answer* Identify all of the following 4 compounds that are aromatic: 1) 1,3-cyclobutadiene, 2) Pyridine, 3) 1,3-cyclopentadiene anion, 4) 1,3,5-cycloheptatriene cation
ANSWER: 2,3,4

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TOSS UP

12) PHYSICS - The function of the force on an object with mass 3 kilograms with time is defined as $F(t) = 1/2t^2 + 4t + 2$. In meters per second, what is the change in velocity from t = 0 to t = 6.

ANSWER: 40 m/s

BONUS

12) PHYSICS - *Short Answer* A current loop rotates in a uniform magnetic field of magnitude 7.5x10^-3 teslas. The loop has an area of 4 x 10^-3 square meters. The angle between the area vector and the magnetic field changes from 0 degrees to 180 degrees in 2.0 seconds. In volts and to 1 significant figure, what is the magnitude of the average induced EMF in the loop?

Answer: 3x10^-5

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TOSS UP

13) MATH - *Short Answer* What is the value of 11^5 mod 7?

ANSWER: 4

BONUS

13) MATH - *Multiple Choice* The graph of the polar curve $r=1+2\cos(\theta)$ takes which of the following shapes?

W) Cardioid
X) Convex Limacon [lee-ma-sohn]
Y) Dimpled Limacon
Z) Inner-Loop Limacon

ANSWER: Z) INNER-LOOP LIMACON

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TOSS-UP
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14) EARTH AND SPACE - *Short Answer* The cosmological principle suggests that the universe fits which of the following descriptions?

W) Isotropic and homogeneous
X) Isotropic and heterogeneous
Y) Anisotropic and homogeneous
Z) Anisotropic and heterogeneous

ANSWER: W) Isotropic and homogeneous

BONUS

14) EARTH AND SPACE - *Multiple Choice* Which of the following statements is NOT correct regarding Population I stars relative to Population II stars?

W) They are younger
X) They are bluer
Y) They have higher temperatures
Z) They have lower metallicities

ANSWER: Z) They have lower metallicities

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TOSS UP

15) ENERGY - Short Answer In an object oriented programming language, a subclass may inherit from a superclass. What is the term used to describe an object created using the subclass but defined with the superclass?

ANSWER: POLYMORPHISM

BONUS

15) ENERGY - Short Answer The subclass overwrites a function from the superclass. When we call this function on an object created using polymorphism, the program will use the subclass's definition of the function to resolve the call at run time. What is this process called?

ANSWER: DYNAMIC BINDING

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TOSS-UP

16) BIOLOGY - Multiple Choice Which of the following correctly describes the role of the cytochrome b6/f complex in photosynthesis within the thylakoid membranes of chloroplasts?

W) It transfers electrons directly to plastocyanin to fill the electron hole left by Photosystem I.
X) It pumps protons from the stroma to the thylakoid lumen to contribute to the proton gradient used in ATP synthesis.
Y) It accepts electrons from water molecules during photolysis to initiate the electron transport chain.
Z) It synthesizes ATP directly from the gradient created by photolysis of water.

ANSWER: X) It pumps protons from the stroma to the thylakoid lumen to contribute to the proton gradient used in ATP synthesis.

BONUS

16) BIOLOGY - *Multiple Choice* Identify all of the following three statements that are true of specialized photosynthetic mechanisms in plants:
I) The biosynthesis of ethylene in plants requires only ACC synthase without the need for oxygen.
II) Secondary metabolite production in plants is exclusively a response to environmental stress, not occurring during normal growth.
III) The C_4 photosynthetic pathway is characterized by spatial compartmentalization of CO_2 fixation and the Calvin cycle in mesophyll and bundle sheath cells, as seen in many grasses.

ANSWER: III only

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TOSS-UP

17) CHEMISTRY - *Multiple Choice* Which of the following best explains why imine formation is a pH dependent reaction, with a maximum rate at a pH between 4 and 5?
W) At low pH no nucleophile is present, while at high pH the reactants are unable to be protonated
X) At low pH the reactants are unable to be protonated, while at high pH no nucleophile is present
Y) At both high and low pH no nucleophile is present
Z) At both high and low pH no electrophile is present

ANSWER: W) AT LOW PH NO NUCLEOPHILE IS PRESENT, WHILE AT HIGH PH THE REACTANTS ARE UNABLE TO BE PROTONATED

BONUS
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17) CHEMISTRY - *Short Answer* Identify all of the following 3 compounds that when reacted with Triphenylphosphine can be used to produce a Z isomer in a Wittig reaction: 1) 1-bromo-methanol, 2) dibromomethane, 3) 1-bromopropa-2-one

ANSWER: 1

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TOSS UP

18) PHYSICS - *Short Answer* A 1-kilogram object is moving in a vertical circle of radius 2 meters at a constant speed of 6 meters per second. What is the tension in the string at the bottom of the circle? Assume the acceleration due to gravity is 10 meters per second squared.

ANSWER: 28 N

BONUS

18) PHYSICS - *Short Answer* A hollow sphere rolls without slipping with a translational speed of 6 m/s. Assuming the sphere has a radius of 30 cm and a mass of 30 kg, in Joules, which of the following is closest to the total energy in its motion?

W) 540
X) 630
Y) 810
Z) 900

Answer: Z) 900

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TOSS-UP

19) MATH - *Short Answer* How many digits are in 16^16?

ANSWER: 20

BONUS

19) MATH - *Short Answer* Given that $\log_x y$ (log base x of y)=0.63 and $\log_z y$ (log base z of y)=0.54, what is $\log_x yz$ (log base x of yz) rounded to the nearest thousandth?

ANSWER: 1.797

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TOSS-UP
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20) EARTH AND SPACE - *Short Answer* A perched aquifer does not drain down towards the water table because groundwater flow is blocked by what low-permeability layer?

ANSWER: Aquiclude (ACCEPT: Aquitard)

BONUS

20) EARTH AND SPACE - *Short Answer* An anticline forms with a bed of Triassic sandstone at its center. Identify all of the following three periods that the rock at the limb of the fold could have formed: 1) Jurassic; 2) Paleogene; 3) Permian.

ANSWER: 1 and 2

3) Energy – *Short Answer* Although now used for rapid weight loss, in 1921 Dr. Russell Wilder used what type of diet characterized by its high fat yet low carbohydrate content to combat epilepsy? (AI)

ANSWER: KETOGENIC (ACCEPT: KETO)