ROUND 6

TOSS-UP

1) Biology – *Multiple Choice* Which of the following is not a function of piwi-interacting RNAs?

W) Inducing formation of heterochromatin
X) Blocking of gene expression via RNA interference
Y) Blocking expression of transposons
Z) Establishing appropriate methylation patterns in germ cells

ANSWER: X) BLOCKING OF GENE EXPRESSION VIA RNA INTERFERENCE

BONUS

1) Biology – *Short Answer* Which class of toll-like receptors recognizes bacterial flagellin from invading bacteria?

ANSWER: TOLL-LIKE RECEPTOR 5 (ACCEPT: TLR5)

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TOSS-UP

2) Chemistry – *Multiple Choice* How does a catalyst increase the rate of a chemical reaction?

W) By changing the magnitude of the enthalpy change
X) By decreasing potential energy of the products
Y) By decreasing potential energy for reactants
Z) By providing a pathway for the reaction that has lower activation energy

Answer: Z) By providing a pathway for the reaction that has lower activation energy

BONUS

2) Chemistry – *Short Answer* In a first order reaction, the concentration of reactant A at t = 0 seconds is 1 molar. At t = 2 seconds, the concentration of A is 2.7 molar. What is the value of rate constant with appropriate units to the nearest 10th?

ANSWER: -0.5 Hz (1/s)
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TOSS-UP

3) Physics – *Multiple Choice* A meter stick whose length is parallel to the x-axis. The meterstick is moving in the x direction at a speed comparable to the speed of the light. According to an observer on the origin, what is the measured length of the meter stick compared to one meter?

W) Same
X) Shorter
Y) Longer
Z) Thicker

ANSWER: X) Shorter

BONUS

3) Physics – *Short Answer* In the Lorentz transformations of the electromagnetic fields, the electric field is symmetric to the magnetic field times what constant?

ANSWER: c or Speed of Light

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TOSS-UP

4) Math – *Short Answer* What mathematical technique involves expressing a periodic function as the sum of sine and cosine functions of different frequencies?

ANSWER: Fourier Transformation (ACCEPT: Fourier Series, Fourier Transform)

BONUS

4) Math – *Short Answer* Suppose the heights of men and women are normally distributed, with the mean height of men being 69 inches with standard deviation 4 inches and the mean height of women being 64 inches with standard deviation 3 inches. If a large number of couples are randomly sampled, what percent of them, according to the Empirical Rule, are expected to have the man taller than the woman by at least 15 inches, to the nearest tenth?

ANSWER: 2.5

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TOSS-UP

5) Earth and Space – *Multiple Choice* Which of the following drainage patterns is often formed where water drains from all directions into a central basin

W) Centripetal
X) Radial
Y) Trellis
Z) Dendritic

ANSWER: W) CENTRIPETAL [SP]

BONUS

5) Earth and Space – *Multiple Choice* Which of the following types of stars lacks hydrogen in its spectra?

W) Heavy-Metal-Oxide
X) Peculiar A
Y) Mira variable
Z) Wolf-Rayet

ANSWER: Z) WOLF-RAYET [SP]

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TOSS-UP

6) Physics – *Multiple Choice* Inductors are usually constructed out of a coiled wire. What do inductors resist a change in?

W) Current
X) Voltage
Y) Charge
Z) Resistance
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ANSWER: W) Current

BONUS

6) Physics – *Short Answer* The rapid acceleration and deceleration of charged particles creates what physical phenomenon that can be detected over large distances in space?

ANSWER: Electromagnetic Waves or EM Waves or Light or Radiation (ACCEPT: BREMSSTRAHLUNG RADIATION OR BRAKING RADIATION)

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TOSS-UP

7) Math – *Short Answer* What is the sum of the coefficients of the binomial expansion of open parentheses, x plus two times y, close parentheses raised to the fourth power?

ANSWER: 81

BONUS

7) Math – *Short Answer* An equiangular hexagon has diagonally opposite pairs of equal side lengths measuring 4, 6, and 8. What is the area of this hexagon?

ANSWER: 52sqrt3

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TOSS-UP

8) Chemistry – *Multiple Choice* Determine the type of cell needed for the reaction Sn(*s*) + $Co^{2+}(aq) \rightarrow Sn^{2+}(aq)$ + Co(*s*) to occur spontaneously given that the standard reduction potentials of Sn & Co are -0.14 & -0.28 respectively

W) Voltaic Cell
X) Electrolytic Cell
Y) Concentration Cell
Z) There is no cell that can make this reaction occur spontaneously

Answer: X) Electrolytic Cell

BONUS

8) Chemistry -- *Short Answer* How many protons are needed in the half-reaction reduction of a nitrate ion to a nitrogen monoxide molecule?

Answer: 4

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TOSS-UP

9) Earth and Space – *Short Answer* What effect results from the gravitational redshift of photons from the cosmic microwave background radiation?

ANSWER: SACHS-WOLFE EFFECT [SW]

BONUS

9) Earth and Space – *Multiple Choice* The Tolman–Oppenheimer–Volkoff limit, or TOV limit, denotes the maximum mass a cold, non-rotating neutron star can have. One of the steps in calculating the TOV limit is finding the pressure needed to resist gravity. What theorem relates the average total kinetic energy of a system of particles bound by gravity to its potential energy, which finds the pressure needed to resist gravity?

ANSWER: VIRIAL THEOREM [SP]

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TOSS-UP

10) Biology – *Short Answer* Shlok had his last period on March 14th and took a pregnancy test 1 week later on March 21st and tested positive. Using today's date, and estimating a month to 4 weeks, what is the embryonic age of Shlok's fetus?

ANSWER: 4 WEEKS

BONUS

10) Biology – *Short Answer* What is the first line of inducible defense in plants which depends on plants ability to recognize molecular sequences specific to certain pathogens such as bacterial flagellin, leading to local production of antimicrobial chemicals?

ANSWER: PATTERN-TRIGGERED IMMUNITY, PAMP/MAMP-TRIGGERED IMMUNITY

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TOSS-UP

11) Chemistry – *Multiple Choice* When Phosphorus or Arsenic is used to dope a pure semiconductor with their pentavalent impurities, what type of semiconductor results?

W) P-Type
X) N-Type
Y) Intrinsic
Z) The resulting product would not be a semiconductor

Answer: X) N-Type

BONUS

11) Chemistry – *Short Answer* Which of the following are characteristics of extrinsic semiconductors 1) higher electrical conductivity than intrinsic semiconductors 2) they are doped to get higher electrical conductivity 3) the conductivity is based solely on temperature

Answer: 1 & 2 Only

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TOSS-UP

12) Math – *Short Answer* Alice and Bob are about to run on a very long straight-line track. Alice can run at 5 meters per second whereas Bob can run at 10 meters per second. If Alice and Bob take off in opposite directions and continue at their listed speeds, how far apart will they be after 1 minute, in meters?

ANSWER: 900

BONUS

12) Math – *Short Answer* The volume of a sphere is increasing at a rate of <u>12 pi meters cubed per second</u> when the radius of the sphere is 4 meters. At this instant, what is the rate of increase of the radius of the sphere, in meters per second?

ANSWER: 3/16 or 0.1875

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TOSS-UP
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13) Earth and Space – *Short Answer* Omuamua was the first interstellar object that visited our solar system that we were able to observe. It is now headed towards the constellation Pegasus and will leave our solar system in a few thousand years. What is Omuamuas trajectory?

ANSWER: HYPERBOLIC [SP]

BONUS

13) Earth and Space – *Short Answer* The insertion of aerosols of what element into the atmosphere has been proposed as a way to combat global warming?

ANSWER: SULFUR [SP]

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TOSS-UP

14) Physics – *Multiple Choice* In Dulles's Physics 2 class, students are learning about Young's double slit experiment. The distances between bright fringes on a screen are inversely proportional to what value?

W) Wavelength
X) Separation of Slits
Y) Intensity of Light
Z) Distance from Screen

ANSWER: X) Separation of Slits

BONUS

14) Physics – *Short Answer* Planet 1 orbits around a star with an orbital period of 32 years and Planet 2 orbits the same star with an orbital period of 4 years. On average, how many times farther is Planet 1 from the star when orbiting than Planet 2?

ANSWER: 4, 4 times

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TOSS-UP

15) Biology – *Multiple Choice* What would be the most immediate effect on the urine if we were to 'despawn' every loop of Henle in the kidney?

W) Higher H_2O content
X) Lower H_2O content
Y) Lower Na^+ content
Z) Lower Cl^- content

ANSWER: W) HIGHER H_2O CONTENT

BONUS

15) Biology – *Multiple Choice* Which of the following remnants of embryological cardiac structures from fetal life is mismatched?

W) Fossa Ovalis - remnant of the Foramen Ovale
X) Ligamentum Arteriosum - remnant of the Ductus Arteriosus
Y) Ligamentum Teres - remnant of the Umbilical vein
Z) Falciform Ligament - remnant of the Umbilical artery

ANSWER: Z) FALCIFORM LIGAMENT - REMNANT OF THE UMBILICAL ARTERY

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TOSS-UP

16) Earth and Space – *Short Answer* The luminosity of a main sequence is generally proportional to what power of its mass?

ANSWER: 3.5 [SP]

BONUS

16) Earth and Space – *Multiple Choice* Which of the following is not true about western boundary currents in Northern Hemisphere Subtropical Gyres?

W) They are generally cooler and shallower than eastern boundary currents
X) The Gulf Stream is an example of a western boundary current
Y) They have greater volume transport than eastern boundary currents
Z) They travel north

ANSWER: W) THEY ARE GENERALLY COOLER AND SHALLOWER THAN EASTERN BOUNDARY CURRENTS [SP]

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TOSS-UP

17) Math – *Short Answer* Let f of x equal x raised to the power of 6. Evaluate the sixth derivative of *f* with respect to *x* at x equals 3.

ANSWER: 720

BONUS

17) Math – *Short Answer* Find the volume of the solid formed by revolving the region bounded by y equals x squared and y equals 4 times x around the y-axis.

ANSWER: 2048/15 pi

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TOSS-UP

18) Physics – *Multiple Choice* The Carnot Efficiency is the maximum possible efficiency an engine can run at between two thermal reservoirs. What is the Carnot efficiency of an engine with a hot reservoir of temperature 500K and a cold reservoir of temperature 160K?

W) 96%
X) 84%
Y) 68%
Z) 32%

ANSWER: Y) 68%

BONUS

18) Physics – *Multiple Choice* Fluid flow is one of most currently researched fields in physics. The viscous force on a fluid is not proportional to what property of the fluid?

W) Temperature
X) Fluid Flow Rate
Y) Area
Z) Rate of Shear

ANSWER: W) Temperature

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TOSS-UP→

19) Biology – *Short Answer* The human genome is identical in all individuals in the vast majority of base pairings, but what variations in base pairings in both coding and noncoding portions of DNA occur in the human genome and can be utilized as genetic markers for disease-associated alleles?

ANSWER: SINGLE NUCLEOTIDE POLYMORPHISM (ACCEPT: SNP, "SNIP")

BONUS

19) Biology – *Short Answer* Which of the following are characteristic of human embryological development?

1) Spiral, determinate cleavage
2) Folds of archenteron forming the coelom
3) Mouth forms from a secondary opening, rather than the anus

ANSWER: 2 AND 3

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TOSS-UP

20) Chemistry – *Short Answer* In a reaction with a negative delta H, how will decreasing the temperature shift the equilibrium?

Answer: Towards the products (to the right)

BONUS

20) Chemistry – *Multiple Choice* Which of the following plots results in a linear graph with a slope equivalent to the negative of the rate constant where A is a reactant in a first-order reaction?

W) 1/[A] vs time (1 over the molarity of A vs time)
X) 1/[A]^2 vs time (1 over the molarity of A squared vs time)
Y) ln[A] vs time (natural log of A vs time)
Z) ln[A]^2 vs time (natural log of A squared vs time)

Answer: Y) ln[A] vs time (natural log of A vs time)
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