ROUND 12

TOSS-UP

1) Biology – *Short Answer* What large chromosomes have thousands of DNA strands and provide a high level of function in certain tissues such as in salivary glands of insects ?

ANSWER: POLYTENE CHROMOSOMES

BONUS

1) Biology – *Short Answer* Which of the following cardiovascular morphology changes do not occur at birth?

1) Closing of ductus arteriosus
2) Closing of placental circulation
3) Blood forced into pulmonary circuit
4) Closing of the foramen secundum

ANSWER: NONE

TOSS-UP

2) Physics – *Multiple Choice* In which of the following situations is the disintegration constant used in calculations?

W) Heat transfer
X) Dispersion of air
Y) Internal Forces
Z) Radiation Decay

ANSWER: Z) Radiation Decay

BONUS

2) Physics – Short Answer A conductive ring of radius 50 centimeters carrying a charge of 1 Coulomb is spun around its central axis at an angular speed of 2 pi radians per second. If placed in a uniform magnetic field of strength 4 Teslas aligned along a diameter of the ring, what would be the magnitude of the torque that the ring experiences at this instant, in Newton meters and in terms of pi?

ANSWER: PI

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TOSS-UP

3) Math – *Short Answer* An undirected graph is considered bipartite if its vertices can be colored using two colors such that no vertices connected by an edge are the same color. If a graph consists of four components that are each bipartite graphs, how many ways can the graph be colored using only the colors red and blue?

ANSWER: 16

BONUS

3) Math – *Short Answer* Let the random variable X denote the sum of outcomes of twelve fair six-sided dice. What is the variance of X?

ANSWER: 35

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TOSS-UP

4) Earth and Space - *Multiple Choice* What yellow-green, Uranium-bearing phosphate mineral is formed as an oxidation product of uranium minerals in granite pegmatites and hydrothermal deposits?

W) Autunite
X) Saleeite
Y) Tobernite
Z) Uranophane

ANSWER: W) AUTUNITE [SW]

BONUS

4) Earth and Space - *Short Answer* What is the name for the concentrated powder formed during the milling process of uranium that most often has the formula U_3O_8?

ANSWER: YELLOWCAKE [SW]

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TOSS-UP

5) Chemistry – *Multiple Choice* The peak current observed in cyclic voltammetry experiments is proportional to what power of the scan rate?

W) –1
X) –0.5
Y) 0.5
Z) 1

ANSWER: Y) 0.5 (ACCEPT: ½) -randles sevcik eqn

BONUS

5) Chemistry – *Multiple Choice* In an aldehyde's IR spectrum, what is the source of the weak peak around 3400 inverse centimeters?

W) C=O stretch fundamental frequency
X) H--C=O stretch fundamental frequency
Y) C=O stretch first overtone
Z) H--C=O stretch first overtone

ANSWER: Y) C=O stretch first overtone

TOSS-UP

6) Chemistry – *Short Answer* While researchers were attempting to make a useful polymer out of propylene, they ran into the issue that the resulting product was not stereoregular. The introduction of what general catalyst, commonly consisting of titanium tetrachloride and triethylaluminum, solved this problem and paved the way for stereoregular polymerization?

Answer: ZIEGLER–NATTA CATALYST

BONUS

6) Chemistry – *Short Answer* While conducting the aldol reaction between acetone and benzaldehyde, Akul worries that a side reaction could lead to the disproportionation of benzaldehyde into benzoic acid and benzyl alcohol, thereby destroying his reactant and lowering his yield of pure product. What is the name of this reaction?
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ANSWER: CANNIZZARO REACTION

TOSS-UP

7) Biology – *Short Answer* Which vitamin is responsible for synthesis of nucleic acids and differentiation of embryonic nervous tissue?

ANSWER: FOLIC ACID, VITAMIN B_9

BONUS

7) Biology – *Short Answer* Shlok, a human, closely resembles an ogre and is therefore provided with food, shelter and protection as he cannot be distinguished from other fellow ogres? What type of mimicry is displayed?

ANSWER: WASMANNIAN MIMICRY

TOSS-UP

8) Earth and Space – *Short Answer* What is the term used to describe the crystals distinctly larger than the grains of the groundmass of an igneous rock?

ANSWER: PHENOCRYSTS [SP]

BONUS

8) Earth and Space – *Multiple Choice* In determining the distance of an earthquake from its epicenter, which of the following is the most useful tool?

W) time interval between Surface and S waves

X) time interval between P and L waves

Y) time interval between S and L waves

Z) time interval between P and S waves

ANSWER: Z [SP]

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TOSS-UP

9) Physics – *Multiple Choice* A semi infinite solenoid with radius 5 meters that goes to infinity on one end has a current of 10 Amperes running through it. At what angle does the field line that intersects the last loop on the finite end make with the axis of the solenoid?

W) 0 degrees
X) 45 degrees
Y) 90 degrees
Z) 180 degrees

ANSWER: Y) 90 degrees

BONUS

9) Physics – *Short Answer* An incompressible hollow sphere of negligible mass and radius 140 centimeters is held at the bottom of a container filled with oil. If the density of the oil is 0.798 grams per centimeter cubed, what is the acceleration of the sphere, in meters per second squared, after it is released to two significant digits?

ANSWER: 4.9, 4.9 meters per second squared.

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TOSS-UP

10) Math – *Multiple Choice* Which mathematical technique is used to solve partial differential equations by representing them as simpler algebraic equations?
W) Poisson bracket
X) Laplace transformation
Y) Fourier transform
Z) Partial differential decomposition

ANSWER: X) Laplace transformation

BONUS

10) Math – *Multiple Choice* Which of the following is the Laplace transform of the function f of t equals e raised to the power of open parentheses, 4 times t, close parentheses.
W) One over open parenthesis s minus 4 close parenthesis
X) One over open parenthesis s minus 16 close parenthesis
Y) One over open parenthesis 4 times s close parenthesis
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Z) <u>One over open parenthesis 16 times s close parenthesis</u>

ANSWER: W) <u>One over open parenthesis s minus 4 close parenthesis</u>

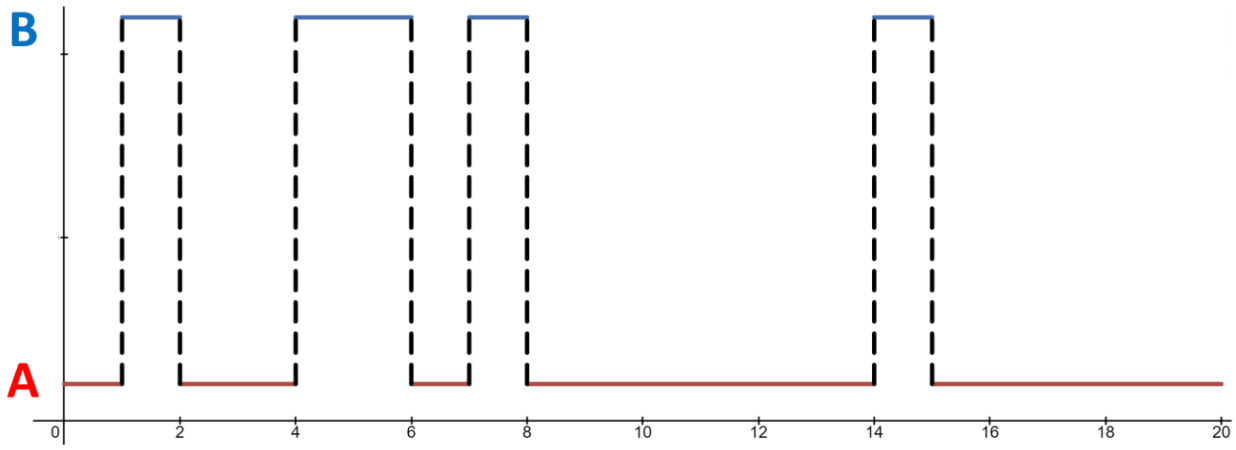
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TOSS-UP

11) Chemistry – *Short Answer* What principle is commonly applied in physical organic chemistry in order to obtain the activation energy of a reaction and explains that, for closely-related reactions, there is a linear relationship between activation energy and enthalpy of reaction?

ANSWER: BELL–EVANS–POLANYI PRINCIPLE (ACCEPT: EVANS–POLANYI PRINCIPLE)

VISUAL BONUS (Give 30 seconds)



11) Chemistry -- *Short Answer* The diagram shown depicts a concerted single-molecule isomerization reaction, switching between two isomers, A and B. A macroscale experiment demonstrated that the equilibrium constant of the conversion from A to B is 0.7. Given that the *x*-axis is indicative of time, answer the following two questions: 1) What is the time-calculated equilibrium constant for the conversion from A to B, to the nearest decimal place?; 2) Does this system satisfy the ergodic hypothesis?

ANSWER: 1) 0.3; 2) NO

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TOSS-UP

12) Biology – *Short Answer* Which extrinsic salivary gland in humans possesses primarily mucous acini and produces a relatively viscous secretion?

ANSWER: SUBLINGUAL (DO NOT ACCEPT: SUBLINGUAL AND INTRINSIC)

BONUS

12) Biology – *Short Answer* What structure is located at the base of the brain inferior to the hypothalamus, superior to the pituitary gland, and is the portion of the brain where cranial nerves II cross?

ANSWER: OPTIC CHIASMA (ACCEPT: OPTIC CHIASM)

TOSS-UP

13) Earth and Space - *Short Answer* To the nearest minute, how far apart are the low tides on a coastline with a semidiurnal tide cycle?

ANSWER: 12 HOURS AND 25 MINUTES (ACCEPT: 745) [SW]

BONUS

13) Earth and Space - *Multiple Choice* - Which of the following types of estuaries is characterized by a strong outflow of freshwater and little mixing at larger depths?

W) Drowned River
X) Salt Wedge
Y) Tectonic
Z) Fjord-Type

ANSWER: X) SALT WEDGE [SW]

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TOSS-UP

14) Math – *Short Answer* Identify all of the following triangle centers which lie along the Euler [“oiler”] line of a triangle:
1) Orthocenter
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2) Incenter
3) Nine-point center
4) Centroid

ANSWER: 1, 3, 4 or ALL BUT 2

BONUS

14) Math – *Multiple Choice* The sigmoid function is defined as S of x equals one over open parenthesis, one plus *e* raised to the power of negative x, close parenthesis. What is the limit of its first order derivative with respect to x of this function as *x* approaches zero?
W) 1/8
X) 1/4
Y) 1/2
Z) 1

ANSWER: X) 1/4

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TOSS-UP

15) Physics – *Short Answer* A Fermion that is its own antiparticle is called what?

ANSWER: MAJORANA FERMION (ACCEPT: MAJORANA PARTICLE, MAJORANA)

BONUS

15) Physics – *Short Answer* A Parallel plate capacitor is held at a voltage difference of 30 Volts. A flat dielectric with a thickness one third that of the distance of between the parallel plates is inserted into the capacitor. Given that the dielectric constant of the dielectric is 4, what is the new voltage difference, in volts, assuming that no charge leaves the plates?

ANSWER: 60

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TOSS-UP

16) Physics – *Multiple Choice* A rope of length 3 meters has its ends tied to two 5 meter poles which are separated by 2 meters. In what direction does the center of mass of the rope move as a person pulls the rope down?

W) Right
X) Left
Y) Down
Z) Up

ANSWER: Z) Up

BONUS

16) Physics – *Multiple Choice* A particle experiencing linear drag is thrown upward. How does the time the ball spent going up compare to the time spent going down?

W) Equal
X) Less than
Y) Greater than
Z) Depends on initial speed

ANSWER: X) Less than

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TOSS-UP

17) Earth and Space – *Short Answer* What down-slope drainage winds are caused by cold air mass movement over an elevated plateau in winter?

ANSWER: KATABATIC WINDS [SP]

BONUS

17) Earth and Space - *Multiple Choice* Which of the following statements about glaciers and glacial deposits is NOT true?

W) drumlins are asymmetrical, canoe shaped hills made mainly of till
X) a water-filled depressions in a glacial valley connected by a single or braided stream is called a paternoster lake
Y) the presence of kames is often commonly associated with the presence of kettles
Z) an esker is a thin ridge of rock typically formed when two glaciers erode parallel U-shaped valleys
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ANSWER: Z) AN ESKER IS A THIN RIDGE OF ROCK TYPICALLY FORMED WHEN TWO GLACIERS ERODE PARALLEL U-SHAPED VALLEYS [SP]

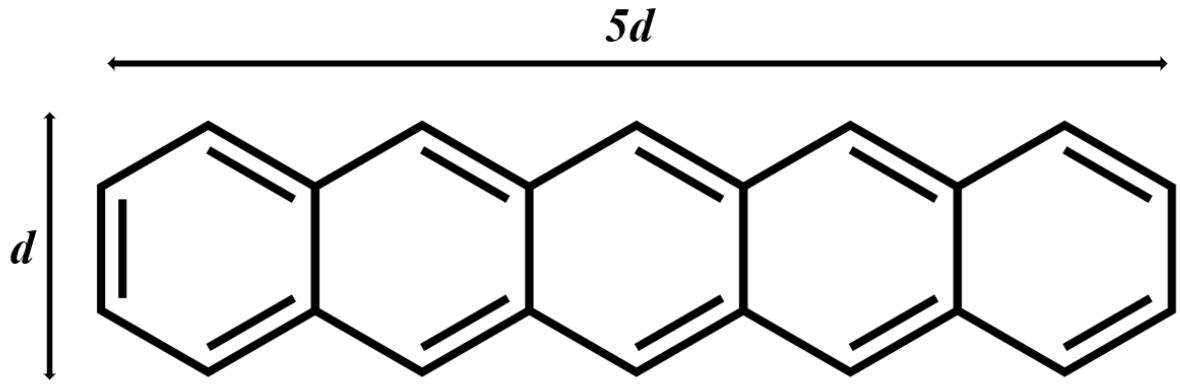
TOSS-UP

18) Chemistry – *Multiple Choice* In the Mitsunobu reaction, how does the reagent diethylazodicarboxylate (or DEAD) help facilitate the substitution of a hydroxyl group with a nucleophile?

W) The N=N double bond attacks the electrophilic carbon of the alcohol, kicking off a hydroxide and stabilizing an intermediate to substitution.
X) The resonance stabilized anion formed after the binding of triphenylphosphine can deprotonate and thus intensify the nucleophile, in addition to deprotonating an unstable intermediate formed by the attack of the alcohol on the triphenylphosphine.
Y) DEAD acts as a heterogeneous catalyst, providing a solid surface for the reagents to bind to and facilitating atom transfer.
Z) DEAD is an excellent solvent for S_N2 reactions involving triphenylphosphine as a co-reagent.

ANSWER: X) THE RESONANCE STABILIZED ANION FORMED AFTER THE BINDING OF TRIPHENYLPHOSPHINE CAN DEPROTONATE AND THUS INTENSIFY THE NUCLEOPHILE, IN ADDITION TO DEPROTONATION OF AN UNSTABLE INTERMEDIATE FORMED BY THE ATTACK OF THE ALCOHOL ON THE TRIPHENYLPHOSPHINE.

VISUAL BONUS (Give 40 seconds)



18) Chemistry – *Short Answer* [7] The polycyclic aromatic hydrocarbon pentacene, containing 5 fused benzene rings, can be modeled as a 2-dimensional particle in a box with width 5*d* and

height *d*. Give the quantum numbers *n_x* and *n_y* for both the HOMO and LUMO of pentacene according to this model.

ANSWER: HOMO: n_x = 9, n_y = 1; LUMO: n_x = 3, n_y = 2 []

TOSS-UP

19) Math – *Short Answer* Characterize each of the following pairs of vectors as linearly independent or linearly dependent:

1) open bracket, 3 comma 4, close bracket and open bracket, 5 comma 6, close bracket
2) open bracket, 5 comma 10, close bracket and open bracket, 2 comma 1, close bracket
3) open bracket, 6 comma 2, close bracket and open bracket, 3 comma 1, close bracket

ANSWER: 1) Independent 2) Independent 3) Dependent

BONUS

19) Math – *Short Answer* Suppose the natural log of 20 equals 3.00. At what value of *x*, rounded to the nearest hundredth, is the function x times zero point zero 5 raised to the power of x maximized if *x* is a real number?

ANSWER: 0.33

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TOSS-UP

20) Biology – *Short Answer* What type of selection curve is present in Portugese man o' war?

ANSWER: TYPE III

BONUS

20) Biology – *Short Answer* This protein is found in striated muscle tissue and its functions include stabilizing and centering the thick filament, preventing overstretching of the sarcomere, and recoiling of the sarcomere. For 10 points, name this largest protein in the human body.

ANSWER: TITIN
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