SBL FALL SEMIFINALS

TOSS-UP

1) Math – *Multiple Choice* [6] Which of the following numbers has a multiplicative inverse modulo 39?

W) 12
X) 13
Y) 14
Z) 15

ANSWER: Y) 14 [Alg - Abs, CT]

BONUS

1) Math – *Short Answer* [6] Alice rolls a die repeatedly until she rolls a 1. What is the expected value of the sum of her rolls?

ANSWER: 21 [Com - Dice, CT]

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TOSS-UP

3) Physics – Short Answer What physical constant is referred to as the fundamental quantum of magnetic moment?

ANSWER: BOHR MAGNETON [CK]

BONUS

3) Physics – *Short Answer* Two polarizing sheets are placed in series, and an unpolarized light source passes through a polarizing sheet, and then another polarizing sheet with its polarizing direction at 30 degrees relative to the first sheet. If the initial intensity of light is given by a, what is the transmitted intensity in terms of a?

ANSWER: $3a/8$ [CK]

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TOSS-UP

4) Biology – *Short Answer* [1] The cornea is continuous with which outer white layer of the eye?

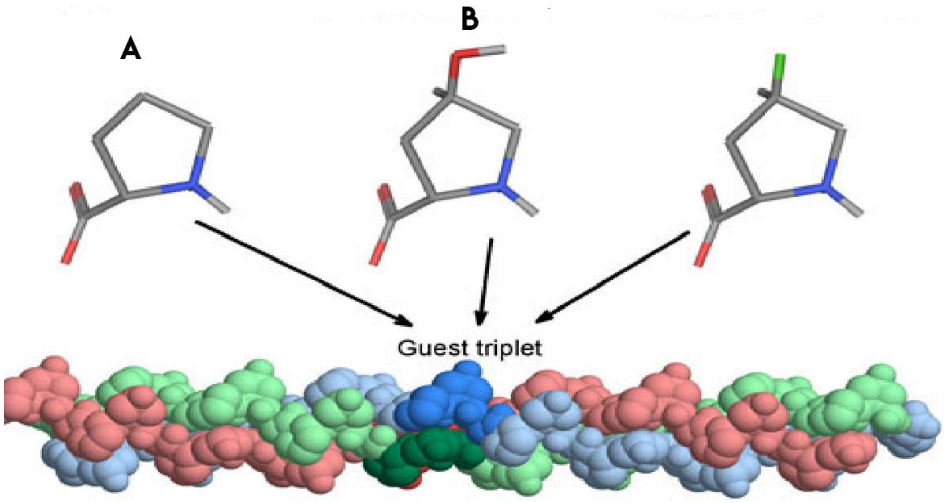
ANSWER: SCLERA [Animal Physiology - Nervous Systems, SF]

VISUAL BONUS

4) Biology – *Short Answer* [8] Shown in the image is a specific protein that adopts a triple helix as a super secondary structure and requires certain cofactors for the crucial hydroxylation of amino acid residues within the protein. Answer the following two questions concerning this protein: 1) What protein is depicted?; 2) A and B are modified forms of what amino acid?

Commented [1]: What the actual fuck

Commented [2]: This is a lot easier than I thought it was going to be nvm
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ANSWER: 1) COLLAGEN; 2) PROLINE [Biochemistry - Proteins, SF]

TOSS-UP

5) Chemistry – *Short Answer* The lowest unoccupied molecular orbital of acetylene in its ground state is what specific type of orbital?

ANSWER: SIGMA STAR (ACCEPT: SIGMA ANTIBONDING)

BONUS

5) Chemistry – *Short Answer* Rank the following three ions in terms of increasing pKa:
1) Amide anion; 2) Carboxylate anion; 3) Ketone enolate anion.

ANSWER: 2, 1, 3 [DJ]

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TOSS-UP

6) Energy – *Short Answer* Researchers at Argonne National Lab are working to develop catalysts for the production of liquid fuels from methane. Which of the following is likely the greatest challenge they have encountered?

W) Methane is expensive
X) Methane transportation is inefficient
Y) Methane is relatively unreactive
Z) Methane is difficult to isolate

ANSWER: Y) METHANE IS RELATIVELY UNREACTIVE [CK]

BONUS

6) Energy – *Short Answer* Scientists at Lawrence Berkeley National Lab have been studying two-dimensional materials. When these one-atom thick layers are stacked on top of each other at an angle, what characteristic pattern is formed?

ANSWER: MOIRÉ PATTERN [CK]
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TOSS-UP

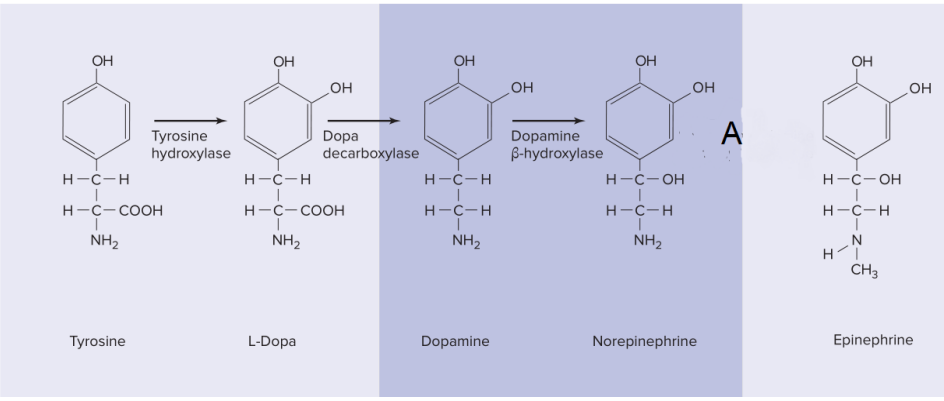
7) Biology – *Short Answer* [6] What term is given to a sustained muscle contraction that occurs when skeletal muscles are innervated by their motor neurons at a very high rate?

ANSWER: TETANY [Animal Physiology - Circulatory Systems, SF]

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VISUAL BONUS

7) Biology – *Short Answer* [8] Shown in the image is a pathway regarding the synthesis of neurotransmitters within the brain. 1) Give the general name for these compounds derived from tyrosine, containing a benzene ring and 2 hydroxyl groups; 2) Which of the following compounds is found at the post synaptic clefts of sympathetic nerves?



Source: Vander's Human Physiology [Chapter 6]

ANSWER: 1) CATECHOLAMINES; 2) NOREPINEPHRINE [SF]

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TOSS-UP

8) Earth and Space – *Short Answer* [7] What is the name for the specific solution to the Einstein vacuum field equations that describes a charged, nonrotating black hole?

ANSWER: REISSNER-NORDSTROM [Astronomy - Cosmology, SF]

BONUS

8) Earth and Space – *Short Answer* [9] Identify all of the following three mechanisms or phenomena that contribute to ocean mixing: 1) Cyclones; 2) Internal tidal waves; 3) Vertical eddy diffusion.

ANSWER: ALL [Oceanography, YL]

TOSS-UP

9) Chemistry – *Short Answer* Reacting alkenes with peroxy acids forms an epoxide. Identify all of the following three reagents that may be used to open this ring: 1) Sodium methoxide; 2) Aqueous hydrochloric acid; 3) Sodium cyanide.

ANSWER: ALL [CK]

BONUS

9) Chemistry – *Short Answer* What equation in chemistry calculates the lattice energy of a crystalline ionic solid that includes a repulsion term which includes the compressibility constant of the crystal?

ANSWER: BORN-MAYER EQUATION [DJ]

TOSS-UP

10) Math – *Short Answer* [5] How many ways are there to divide 8 students into 2 equal teams?

ANSWER: 35 [Com - Com, CT]

BONUS

10) Math – *Short Answer* [6] A function $f(x)$ is continuous and triply differentiable such that f triple prime of x is always positive. If $f(0) = 1$, $f(1) = 2$, and $f(2) = 4$, what is the minimum integer value of $f(4)$?

ANSWER: 12 [Calc - Der, CT]

TOSS-UP

11) Energy – *Multiple Choice* Researchers at NIH are studying secretion. Which of the following cell types is not correctly paired with its secretion?

W) Parietal cells and hydrochloric acid
X) Gastric chief cells and pepsinogen
Y) Alpha cells and somatostatin
Z) Pancreatic cells and trypsinogen

ANSWER: Y) ALPHA CELLS AND SOMATOSTATIN [TZ]

BONUS

11) Energy – *Short Answer* Scientists at Lawrence Livermore National Lab in collaboration with MIT are using affinity selection followed by tandem mass spectrometry sequencing to identify peptides with high specificities for cardiac tissues. Identify all of the following three amino acids that they excluded from the original synthetic library: 1) Isoleucine; 2) Cysteine; 3) Methionine.

ANSWER: 1 AND 2

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TOSS-UP

12) Physics – *Short Answer* The Biot-Savart law displays what relationship with respect to distance?

ANSWER: INVERSE SQUARE

BONUS

12) Physics – *Short Answer* What method of controlled nuclear fusion uses a very strong magnetic field to keep fusion fuels in the plasma state?

ANSWER: MAGNETIC CONFINEMENT (DO NOT ACCEPT: TOKAMAK)
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TOSS-UP

13) Chemistry – *Multiple Choice* Which of the following is the reason ketones are often treated with acid during nucleophilic substitution?

W) To make the carbonyl group less sterically hindered
X) To make the carbonyl group more sterically hindered
Y) To make the carbonyl group less electrophilic
Z) To make the carbonyl group more electrophilic

ANSWER: Z) TO MAKE THE CARBONYL GROUP MORE ELECTROPHILIC

BONUS

13) Chemistry – *Short Answer* Rank the following three compounds in terms of increasing rate of bromination in methanol: 1) *trans*-2-butene; 2) *cis*-2-butene; 3) 2-methylpropene.

ANSWER: 1, 2, 3 [DJ]

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TOSS-UP

14) Biology – *Multiple Choice* [6] In most plant cell walls, cellulose microfibrils are generally oriented parallel to each other and cross linked by polysaccharides. Relative to these microfibrils, in which direction does the cell wall expand during growth?

W) Parallel to the cellulose microfibrils
X) Parallel to the expansion enzymes
Y) Perpendicular to the cellulose microfibrils
Z) Perpendicular to expansion enzymes

ANSWER: Y) PERPENDICULAR TO THE CELLULOSE MICROFIBRILS [Plants - Physiology, SF]

BONUS

14) Biology – *Short Answer* [8] Identify all of the following three plants that if examined in their roots, would contain scattered vascular bundles: 1) Garden bean; 2) Orchid; 3) Rose.

ANSWER: NONE [Plants - Anatomy Diseases, SF]
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TOSS-UP

15) Math – *Short Answer* [5] If a positive integer has 1000 digits in base 2, how many digits does it have in base 16?

ANSWER: 250 [NT - Base, CT]

BONUS

15) Math – *Short Answer* [6] A triangular region on the coordinate plane has vertices at the points (0, 0), (0, 3), and (4, 0). If a random point is chosen on the perimeter of the region, what is the expected value of its *x*-coordinate?

ANSWER: 3/2 [Geo - Coord, CT]

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TOSS-UP

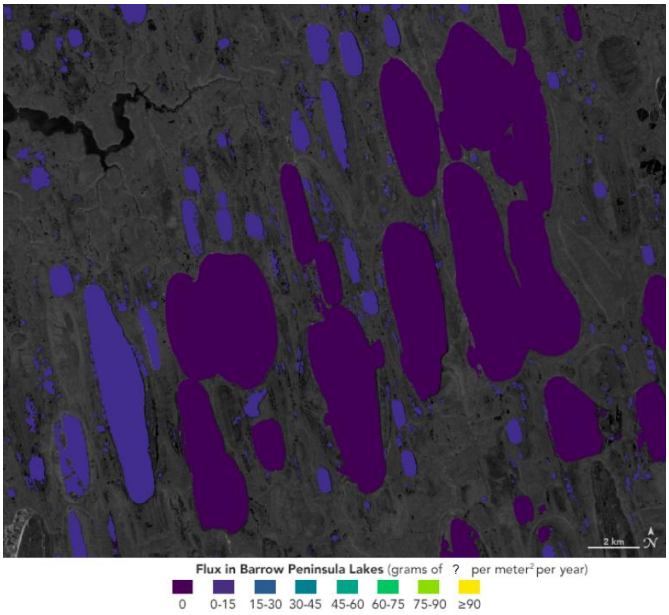
16) Earth and Space – *Multiple Choice* [7] Which of the following statements best explains the presence of more than three convection circulation cells in Jupiter's atmosphere?

W) Jupiter's strong magnetic field causes distortions within meridional heat transport
X) Jupiter's rapid rotation causes strong Coriolis deflection
Y) Jupiter's large size limits the size of atmospheric convection cells due to very strong gravity
Z) Helium rain within Jupiter's atmosphere causes significant vertical wind shear

ANSWER: X) JUPITER'S RAPID ROTATION CAUSES STRONG CORIOLIS DEFLECTION [Astronomy - Solar System, YL]

VISUAL BONUS

16) Earth and Space – *Short Answer* [8] Shown in the image is the measured flux of a gas within the frozen lakes of the Arctic tundra. Answer the following two questions regarding this image: 1) The flux of what gas is shown in this image? 2) Giving your answer as a letter, what is the likely Koppen climate of the pictured region?
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ANSWER: 1) METHANE; 2) E (ACCEPT: D) [Other - Climate?, YL]

TOSS-UP

17) Energy – *Multiple Choice* Scientists at Brookhaven national labs are studying the activity of fatty acid desaturase enzymes in plant tissues in order to gain insight into how biological systems achieve metabolic channeling. The activity of which of the following enzymes provides a typical example of metabolic channeling?

W) Phosphofructokinase
X) Pyruvate Dehydrogenase
Y) ATP Synthase
Z) Phosphoprotein phosphatase 1

ANSWER: X) PYRUVATE DEHYDROGENASE [DJ]

BONUS

17) Energy – *Multiple Choice* Researchers at NIH laboratories are studying comas. Which of the following brain structures, when damaged, is most likely to result in a coma?

W) Corpus callosum
X) Limbic system
Y) Medulla Oblongata
Z) Reticular formation

ANSWER: Z) RETICULAR FORMATION [TZ]

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TOSS-UP

18) Physics – *Short Answer* [6] Two metal plates are arranged to form a parallel-plate capacitor. A third identical plate is inserted halfway in between the other two. By what factor is the capacitance of the device multiplied?

ANSWER: 1 [Electrostatics, DK]

BONUS

18) Physics – *Short Answer* A pipe contains water flowing at 20 m/s. It goes from an elevation of 10 m to 20 m. Given that the density of water is 1000 kg/m^3 and g = 10, what is the new speed of the water?

ANSWER: 10 ROOT 2
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TOSS-UP

19) Math – *Short Answer* [5] If $f(x) = 6x^3 + 17x^2$, what is the multiplicity of the root $x = 0$?

ANSWER: 2 [Alg - Poly, CT]

BONUS

19) Math – *Short Answer* [4] What is the x squared coefficient of the quadratic in x that passes through the points (***read slowly***) (5, 11), (6, 13), and (7, 18)?

ANSWER: 3/2 [Alg - Poly, CT]

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TOSS-UP

20) Earth and Space – *Short Answer* [7] The transition from the lepton epoch to the photon epoch followed the disappearance of most leptons and antileptons via what mechanism?

ANSWER: ANNIHILATION [Astronomy - Cosmology, YL]

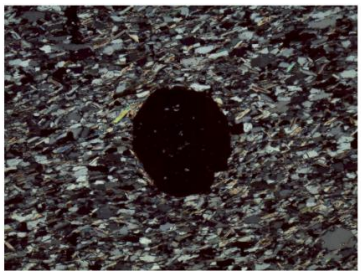
VISUAL BONUS

20) Earth and Space – *Multiple Choice* [9] Jay the geochemist is trying to identify zircon crystals in his thin sections. However, he accidentally fell asleep during the class session in which zircon identification was taught, so he is in desperate need of help. Shown in the figure are four thin sections in plane polarized light. Identify the thin section that contains zircon.

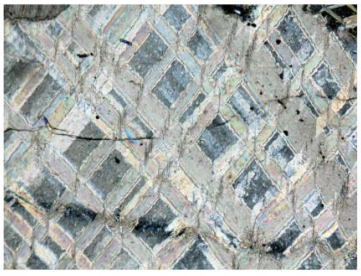
W)



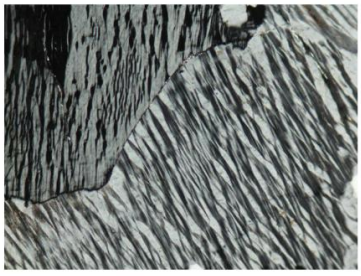
X)



Y)



Z)


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ANSWER: W [Geology - Mineralogy, YL]

TOSS-UP

21) Chemistry – *Multiple Choice* In transition state theory, the Eyring equation can be used to model reaction rates. When compared to the Arrhenius equation, which of the following quantities has replaced the activation energy?

W) Enthalpy of activation
X) Gibbs free energy of activation
Y) Entropy of activation
Z) Transmission coefficient

ANSWER: X) GIBBS FREE ENERGY OF ACTIVATION [Notabely not right :yaw:]

BONUS

21) Chemistry – *Short Answer* In the conformational analysis of n-butane, it is observed that the majority of the molecules exist in a state where the methyl groups are further apart. What type of strain causes these methyl groups to be further apart?

ANSWER: STERIC STRAIN [DJ]

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TOSS-UP

22) Biology – *Short Answer* [7] According to the ABC hypothesis, which floral whorl is produced when both A and B genes are inactivated?

ANSWER: CARPELS [Plants - Physiology, SF]

BONUS

22) Biology – *Short Answer* [8] Identify all of the following three statements that are true of an Western blot: 1) It is mainly used to identify post translational modifications; 2) It mainly detects proteins rather than nucleic acids; 3) An SDS-page must be run before the blot is performed.

ANSWER: 2 AND 3 [Cell Biology - Biotech, SF]
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TOSS-UP

23) Physics – *Multiple Choice* [5] In celestial mechanics, the effective potential is used to convert a two-body problem to a one-body one. It is defined as the sum of the potential energy and what other quantity?

W) Moment of inertia
X) Reduced mass
Y) Radial kinetic energy
Z) Angular kinetic energy

ANSWER: Z) ANGULAR KINETIC ENERGY [Mech, DK]

BONUS

23) Physics – *Short Answer* Identify all of the following three constituent quarks that may be found in a delta baryon: 1) Up quark; 2) Strange quark; 3) Top quark.

ANSWER: 1 ONLY