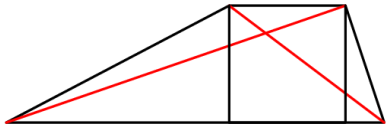
SBL FALL FINALS 3
Literally only ess and math are done
TOSS-UP

1) Math – *Short Answer* [9] Compute hyperbolic sine of 1 minus hyperbolic cosine of 1.

ANSWER: -1/e [Alg - Trig, CT]

VISUAL BONUS

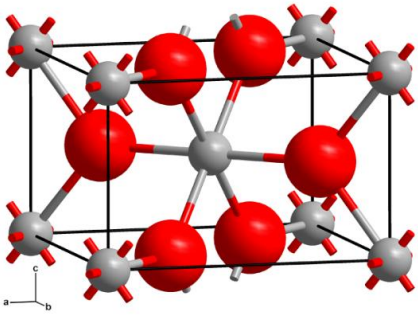
1) Math – *Short Answer* [8] Shown in the image is a trapezoid formed from a rectangle and two right triangles. The red diagonals have lengths of 20 and 37. If the height of the rectangle is 12, what is the area of the trapezoid?



ANSWER: 306 [Geo - Quad, CT]

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ANSWER: 1) RUTILE; 2) TETRAGONAL [Geology - Mineralogy, YL]

TOSS-UP

3) Physics – *Short Answer* If the Lagrangian of a 3-dimensional system is independent of x, identify all of the following 3 quantities that must be conserved: 1) Energy; 2) Total momentum; 3) Angular momentum.

ANSWER: NONE [SS]

BONUS

3) Physics – *Short Answer* What term is given to the type of fluid flow that can be modeled by a vector field with zero curl?

ANSWER: IRROTATIONAL [CK]

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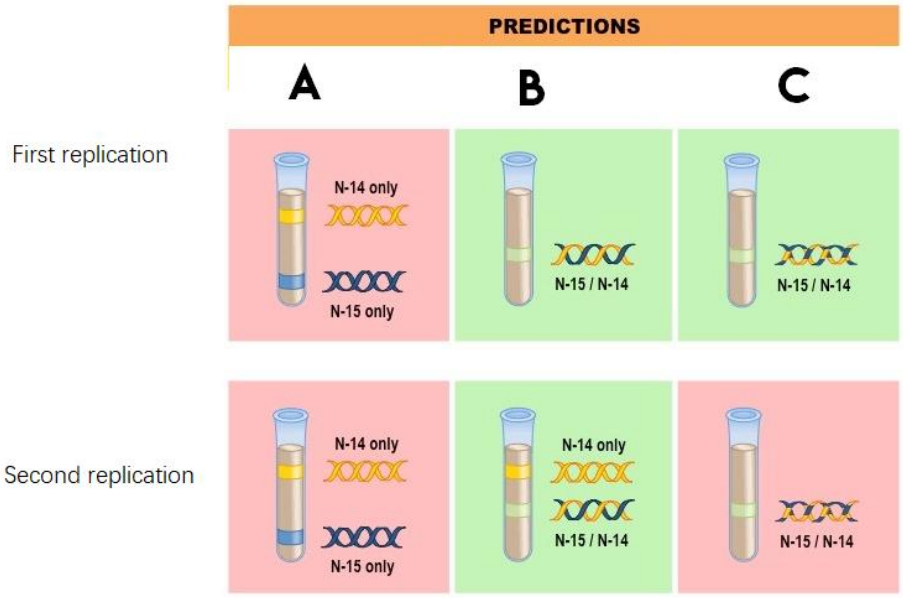
TOSS-UP

4) Biology – *Short Answer* What nitrogenous base is formed from the deamination of 5-methylcytosine?

ANSWER: THYMINE [SF]

VISUAL BONUS

4) Biology – *Short Answer* [7] Depicted in the image are predictions from the Meselson and Stahl experiment, which was fundamental in proving that DNA replication is semiconservative. Before the results of the experiment, there existed three main models for DNA replication, the conservative model, the dispersive model and the semiconservative model. Answer the following two questions concerning the image: 1) Match the three models with their respective letters on the diagram; 2) During DNA replication in eukaryotes, at what points in the chromosome does helicase unwind to initiate replication?
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ANSWER: 1) A is CONSERVATIVE MODEL; B IS SEMICONSERVATIVE; C IS DISPERSIVE; 2) ORIGINS OF REPLICATION

TOSS-UP

5) Chemistry – *Multiple Choice* Jay heats 1 mole of iodine vapor in a flask from 0 degrees C to 1,500 deg C and plots the constant volume heat capacity against temperature. Assuming the gas is ideal, which of the following statements regarding this experiment is false?

W) At the start of the experiment, the heat capacity of the vapor is 2.5R
X) The heat capacity at 100 degrees Celsius is greater than that at the beginning of the experiment due to vibrational motion
Y) The final measured heat capacity is between 2R and 2.5R
Z) The pressure of the flask increases monotonically

ANSWER: Y) THE FINAL MEASURED HEAT CAPACITY IS BETWEEN 2R and 2.5R [YL]

BONUS

5) Chemistry – *Short Answer* Answer the following 2 questions about free radicals: 1) What radical based oxidant is inert towards secondary alcohols and is 2,2,6,6 tetramethyl on a piperidine ring? 2) What type of spectroscopy would you expect to use to detect a radical species?

ANSWER: 1) TEMPO; 2) EPR (ACCEPT: ESR) [DJ]

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TOSS-UP

6) Energy – *Short Answer Short Answer* Scientists at Los Alamos National Lab have been studying the frequency of vibrations of individual atoms in a crystal in order to better improve monitor refresh rates. By assuming that every atom in a crystal vibrates at the same frequency, the average thermal vibrational energy can be approximated by the equipartition theorem known as what criterion?

ANSWER: LINDEMANN'S CRITERION [DJ]

BONUS

6) Energy – *Short Answer* Researchers at Brookhaven national lab have been conducting experiments on the relation of diabete mellitus over dementia related illnesses. Type 3 diabetes mellitus is a theorized connection with what other disease?

ANSWER: ALZHEIMER'S [DJ]
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TOSS-UP

7) Biology – *Short Answer* The action of the plant hormone gibberellin breaks seed dormancy by inducing the synthesis of what enzyme in the endosperm?

ANSWER: ALPHA AMYLASE (ACCEPT: AMYLASE) [SF]

BONUS

7) Biology – *Multiple Choice* The addition of sumo as a noncovalent modification is observed in which of the following functions?

W) Kinesis
X) Rho dependent termination
Y) ATP Regulation
Z) DNA Repair

ANSWER : Z) DNA REPAIR [SF]

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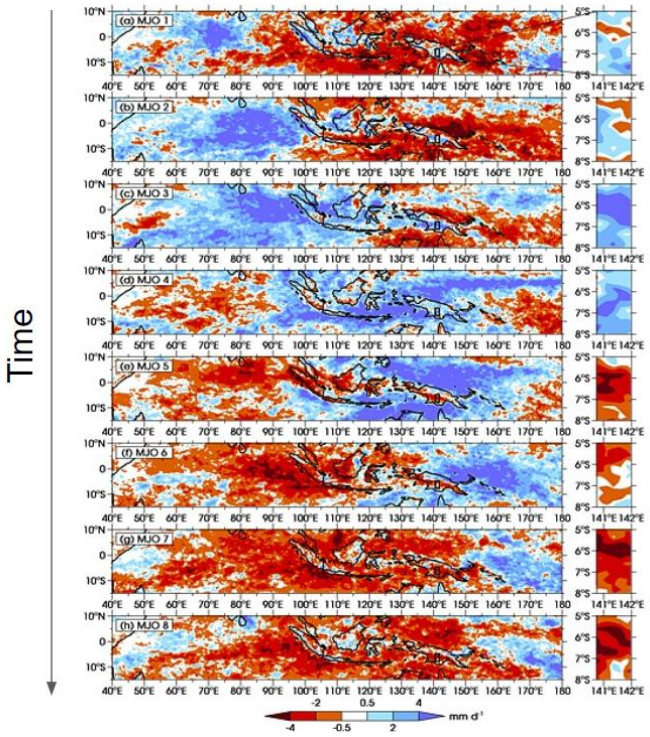
TOSS-UP

8) Earth and Space – *Short Answer* [8] GW Virginis variables are a special class of pulsating white dwarfs. These variables operate via the Kappa mechanism between which two ionized elements?

ANSWER: CARBON AND OXYGEN [Astronomy - YL]

VISUAL BONUS

8) Earth and Space – *Short Answer* [9] Shown in the image are the precipitation anomalies of eight different phases of a tropical oscillation centered around the Indonesia region, which is located between the Indian and Pacific Oceans. Answer the following two questions regarding the image: 1) What oscillation is pictured? 2) This atmospheric phenomenon has been shown to be linked with pressure and temperature anomalies around the world via what meteorological mechanism?
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ANSWER: 1) MADDEN-JULIAN OSCILLATION (ACCEPT: MJO, MADDEN OSCILLATION); 2) TELECONNECTION [Meteorology, YL]

TOSS-UP

9) Chemistry – *Short Answer* When some group 2 dihalides are studied in the gas phase, their structures deviate from the geometry as predicted by VSEPR theory. Rank the following gas-phase three compounds in terms of increasing bond angle: 1) BeF_2; 2) SrF_2; 3) BaF_2

Commented [1]: huh

ANSWER: 3, 2, 1 [YL]

BONUS

9) Chemistry – *Short Answer* Which of the following could be the units for linear density in a crystal structure?

W) Inverse meters squared
X) Inverse meters
Y) Inverse liters
Z) Inverse liters squared

ANSWER: X) INVERSE METERS [DJ]

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TOSS-UP

10) Math – *Short Answer* [9] A triangular region on the coordinate plane has vertices at the points (0, 0), (0, 1), and (1, 0). If a random point is chosen on the interior of the region, what is the expected value of its x-coordinate?

ANSWER: 1/3 [Alg - ExpVal]

BONUS

10) Math – *Short Answer* [8] Compute the last three digits of 2^{2020}.

ANSWER: 576 [NT - Pow]
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TOSS-UP

11) Energy – *Multiple Choice* Scientists at Lawrence Berkeley National Lab are studying the connections between serine proteases in humans and HIV peptides in order to better the treatment methods for patients with HIV. Which of the following statements is NOT true when comparing the two?

W) Both use nucleophilic attack to hydrolyze the peptide bond.
X) Both form acyl-enzyme intermediates.
Y) Both require water to complete the catalytic cycle.
Z) Both show specificity for certain amino acid sequences.

ANSWER: X) BOTH FORM ACYL-ENZYME INTERMEDIATES [DJ]

BONUS

11) Energy – *Multiple Choice* [6] Researchers at Lawrence Berkeley National Lab discovered that the phosphorylation of CheY sets off a pathway that rotates flagella. Which of the following is the most likely identity and location of the specific amino acid that is phosphorylated?

W) Aspartate and interior
X) Aspartate and exterior
Y) Tryptophan and interior
Z) Tryptophan and exterior

ANSWER: W) ASPARTATE AND INTERIOR [DJ]

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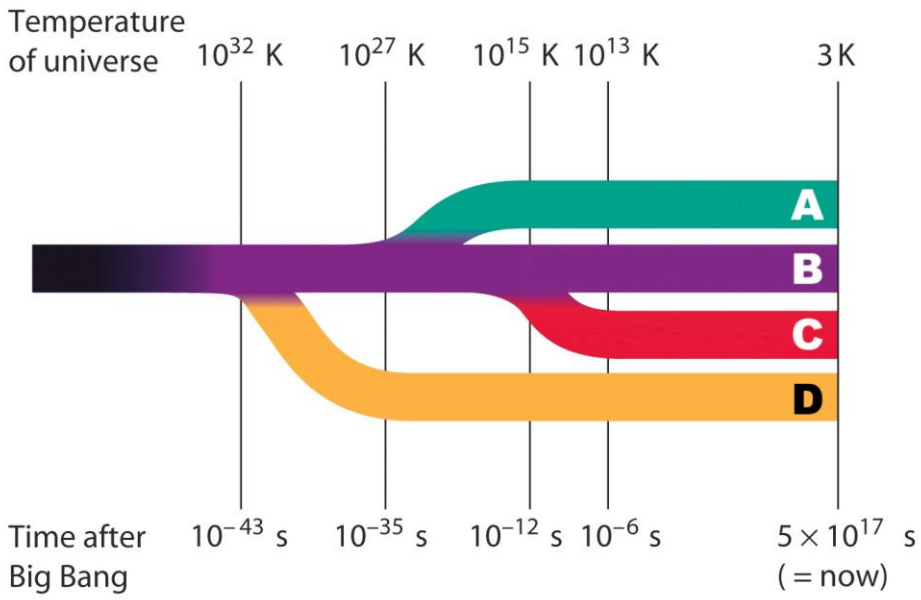
TOSS-UP

12) Physics – *Multiple Choice* [8] Which of the following statements is false regarding the Schwarzchild metric?
W) It is spherically symmetric
X) It describes a neutral particle
Y) It describes a rotating particle
Z) It has a singularity at nonzero radius

ANSWER: Y) IT DESCRIBES A ROTATING PARTICLE [GR, DK]

VISUAL BONUS

12) Physics – *Short Answer* [8] Shown is a diagram of the four fundamental interactions as they split from a theorized unified force shortly after the Big Bang. Answer the following two questions: 1) What forces are labeled A and D, respectively?; 2) What theory provides a unified description of the forces labeled B and C?
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ANSWER: 1) A. STRONG NUCLEAR, D. GRAVITY, 2) ELECTROWEAK [Particle, DK]

TOSS-UP

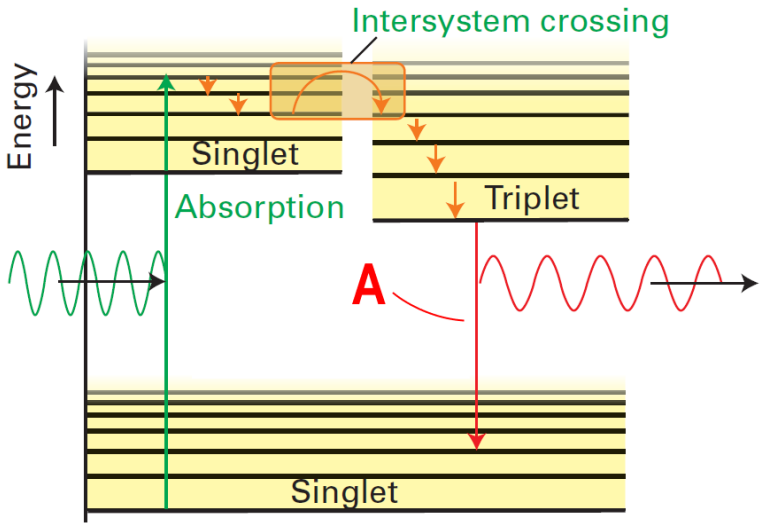
13) Chemistry – *Short Answer* Identify all of the following 3 substituents on a phosphorus ylide that would cause the formation of a Z alkene in a wittig reaction. 1) NO_2; 2) CN; 3) CH_2CH_3.

ANSWER: 3 ONLY (Clayden/Klein idk) [DJ]
The question was wrong

VISHWAL BONUS

13) Chemistry – *Short Answer* Answer the following two questions regarding the figure: 1) What type of electronic transition occurs is denoted by A? 2) What relativistic interaction aids in the intersystem crossing from the excited singlet state to the triplet state?

ANSWER: 1) PHOSPHORESCENCE; 2) SPIN-ORBIT COUPLING [YL]



TOSS-UP

14) Biology – *Short Answer* Oseltamivir and Zanamivir are antiviral drugs used to treat influenza by competitively inhibiting what viral enzyme that cleaves the sialic acid residue for viral release?

ANSWER: NEURAMINIDASE [SF]

BONUS

14) Biology – *Short Answer* Identify, by name or number, all of the following three statements concerning alpha helices that are true: 1) The R groups of the amino acids face out; 2) The hydrogen bonds stabilizing the structure appear between the R groups of adjacent amino acids; 3)

Extended left handed alpha helices are less stable and therefore have not been observed in proteins.

ANSWER: 1 AND 3 [SF]

TOSS-UP

15) Math – *Short Answer* [7] *n* is a positive integer such that *n* squared has 9 positive factors. What is the maximum number of positive factors that *n* could have?

ANSWER: 5 [NT - Fac]

BONUS

15) Math – *Short Answer* [9] The point (6, 8) is rotated 60 degrees counterclockwise around the origin. What is the y-coordinate of the resulting point?

ANSWER: 4 + 3 ROOT 3 [Alg - Coord]

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TOSS-UP

16) 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]

BONUS

16) Earth and Space – *Short Answer* [9] Order the following four regions of an ideal ophiolite sequence from the lowest to the highest, assuming no overturning: 1) Sheeted dike complex; 2) Depleted harzburgite; 3) Pillow basalts; 4) Layered gabbro.

ANSWER: 2, 4, 1, 3 [Geology - Petrology, YL]
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TOSS-UP

17) Energy – *Multiple Choice* Researchers at SLAC National Accelerator Lab are investigating massive quiescent galaxies using weak gravitational lensing. Which of the following characteristics best explains why high redshift massive quiescent galaxies are of particular interest in galaxy evolution studies?

W) All quiescent galaxies are dwarf galaxies, which are much rarer in the cosmological past
X) Quiescent galaxies do not have active star formation and thus indicate a previous period of rapid star formation
Y) Quiescent galaxies, like quasars, are much more common in the cosmological past and thus represent a broad population of galaxies that may be sampled
Z) Quiescent galaxies are usually the result of galactic mergers, which are exceedingly rare in the cosmological past

ANSWER: X) QUIESCENT GALAXIES DO NOT HAVE ACTIVE STAR FORMATION AND THUS INDICATE A PREVIOUS PERIOD OF RAPID STAR FORMATION [YL]

BONUS

17) Energy – *Short Answer* Researchers at Los Alamos National Lab are investigating the ocean-atmosphere interactions associated with Southern Ocean polynyas, stretches of open water near the ice shelf. Identify all of the following three characteristics that would be associated with polynyas: 1) Enhanced heat transfer from ocean to atmosphere relative to the ice sheet; 2) Enhanced deep water formation due to brine rejection; 3) Raising of local ocean pH.

ANSWER: 1 AND 2 [ocean - YL]

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TOSS-UP

18) Physics – *Short Answer* [7] Identify all of the following three statements that are always true of a charge at equilibrium: 1) It is in a region of zero electric potential; 2) It is in a region of zero magnetic field; 3) The equilibrium is not stable

ANSWER: 3 ONLY [E&M - Electrostatics, DK]

BONUS

18) Physics – *Short Answer* [9] In order to make calculations in quantum electrodynamics more accurate, higher-order terms are summed up. However, these terms, represented graphically as Feynman diagrams, contribute exponentially less to the final result. This approximation series is expanded in terms of powers of what physical constant?

ANSWER: FINE STRUCTURE CONSTANT [Quantum, DK]
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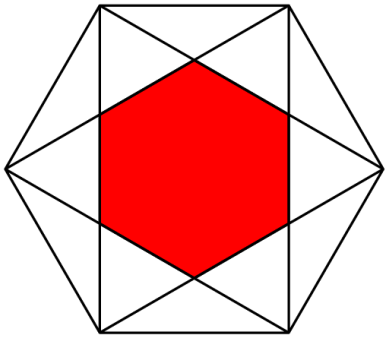
TOSS-UP

19) Math – *Short Answer* [8] How many integers between 1 and 8 inclusive are quadratic residues mod 8?

ANSWER: 3 [NT - Mod, CT]

VISUAL BONUS

19) Math – *Short Answer* [8] Shown in the image is a regular hexagon with a side length of 6. All of the short diagonals are drawn, and those diagonals enclose a smaller hexagon that is shown in red in the image. What is the area of the red hexagon?



ANSWER: 18 ROOT 3 [Geo - OthPoly, CT]

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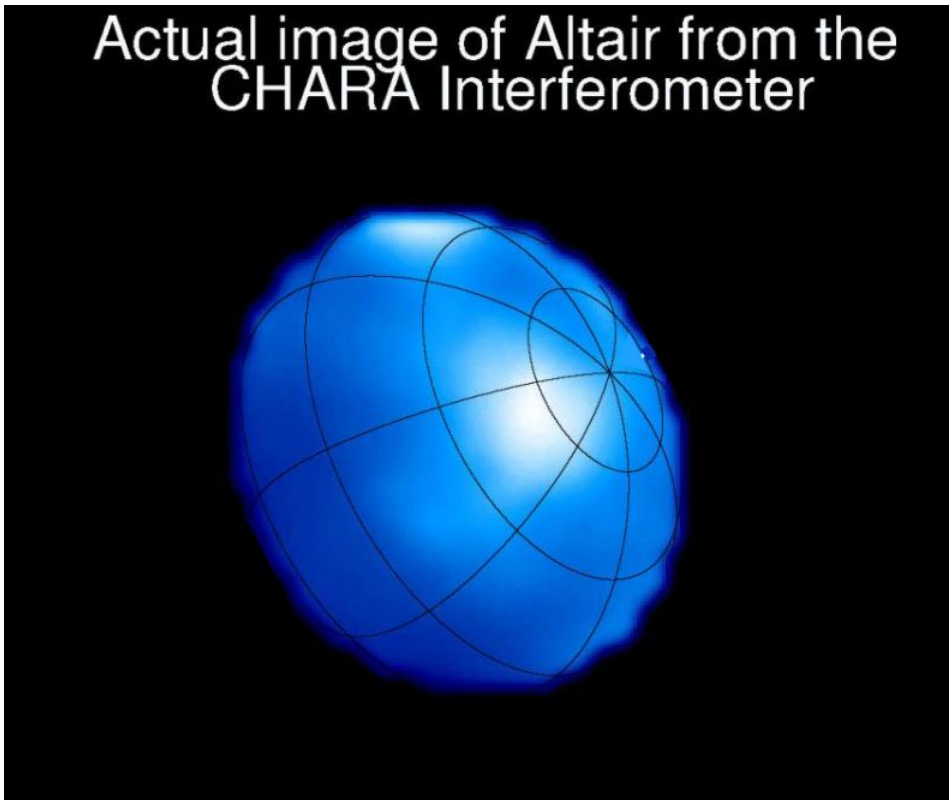
TOSS-UP

20) Earth and Space – *Short Answer* [9] What term is used to refer to the basal thrust fault that separates a large allochthon that has moved on top of an autochthon?

ANSWER: DÉCOLLEMENT (ACCEPT: DETACHMENT FAULT or BASAL DETACHMENT FAULT) [Geology - Structural, YL]

VISUAL BONUS

20) Earth and Space – *Short Answer* [9] Shown in the image is a false color image of the star Altair as imaged by the CHARA Interferometer. Answer the following two questions regarding the image: 1) Why is Altair flattened compared to seemingly spherical stars like our sun? 2) What phenomenon causes the significant negative brightness anomaly at the equator of Altair?
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ANSWER: 1) RAPID ROTATION; 2) GRAVITY DARKENING [Astronomy - Astrophysics, YL]

TOSS-UP

21) Chemistry – *Short Answer* Identify all of the following 3 functional groups that can be produced in the Corey-Chaykovsky reaction: 1)

ANSWER: SP2 [DJ]

BONUS

21) Chemistry – *Multiple Choice* In a BCC crystal structure, which of the following must be true for the value of $h+k+l$ in the Miller Indice given that diffraction occurs?

W) It is a prime number
X) It is a multiple of 3
Y) It is even
Z) It is odd

ANSWER: Y) IT IS EVEN [DJ]

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TOSS-UP

22) Biology – *Short Answer* An N-linked glycosyl bond is linked to what amino acid in glycoproteins?

ANSWER: ASPARAGINE [SF]

BONUS

22) Biology – *Short Answer* Identify all of the following statements that are true of both vessel elements and tracheids: 1) They are found in angiosperms but not gnetophytes; 2) They die at functional maturity; 3) They contain pits.

ANSWER: 2 AND 3 [SF]
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TOSS-UP

23) Physics – *Short Answer* What approximation in quantum mechanics solves for the one-dimensional time-independent Schrodinger equation by assuming that the amplitude is slowly-varying?

ANSWER: WKB-APPROXIMATION (ACCEPT: WENTZEL-KRAMERS-BRILLOUIN APPROXIMATION) [SS]

BONUS

23) Physics – *Short Answer* [8] Identify all of the following three statements that are true of a quantum particle trapped in a one-dimensional ring:

1) Its energy levels are evenly spaced
2) It has no zero-point energy
3) Its angular momentum operator commutes with the Hamiltonian

ANSWER: 2 AND 3 [Quantum, DK]