SBL FALL FINALS 1

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TOSS-UP

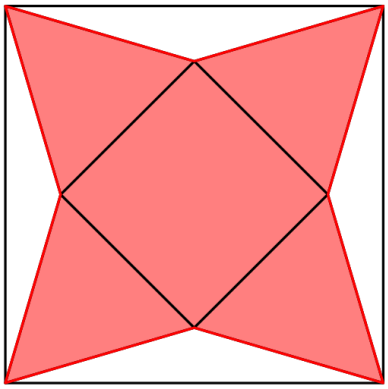
1) Math – *Multiple Choice* [8] Which of the following numbers has a multiplicative inverse modulo 1001?

W) 11
X) 12
Y) 13
Z) 14

ANSWER: X) 12 [NT - Mod, CT]

VISUAL BONUS

1) Math – *Short Answer* [9] Shown in the image are two squares centered at the same point. The bigger one has side length 2 and the smaller one has side length 1 and is tilted at a 45 degree angle relative to the big square. The red path alternately connects vertices of the two squares. What is the area of the region enclosed by the red path?



ANSWER: 2 ROOT 2 [Geo - OthPoly, CT]

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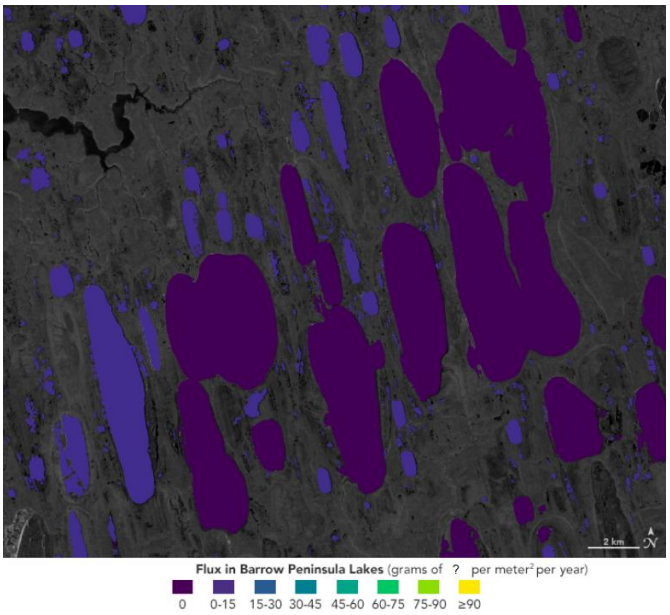
TOSS-UP

2) Earth and Space – *Short Answer* [8] What mechanism, characterized by the anomalous relation between temperature and opacity in some stars, drives brightness variation in pulsating variables?

ANSWER: KAPPA MECHANISM (ACCEPT: EDDINGTON VALVE) [Astronomy - Stellar, YL]

VISHWAL BONUS

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?



ANSWER: 1) METHANE; 2) E (ACCEPT: D) [Other - Climate?, YL]

TOSS-UP

3) Physics – *Short Answer* [7] In a quasistatic process, 480 joules of heat are exhausted, and friction does -120 joules of work. If the process takes place at 300 kelvin, what is the change in entropy of the universe, in joules per kelvin?

ANSWER: 0.4 [Thermo, DK]

BONUS

3) Physics – *Multiple Choice* [9] A particle travels between two points in spacetime following a null world line, with an invariant interval of 0. Which of the following could be its identity?

W) Neutrino
X) Gluon
Y) W+ boson
Z) Muon

ANSWER: X) GLUON [Relativity/Particle, DK]

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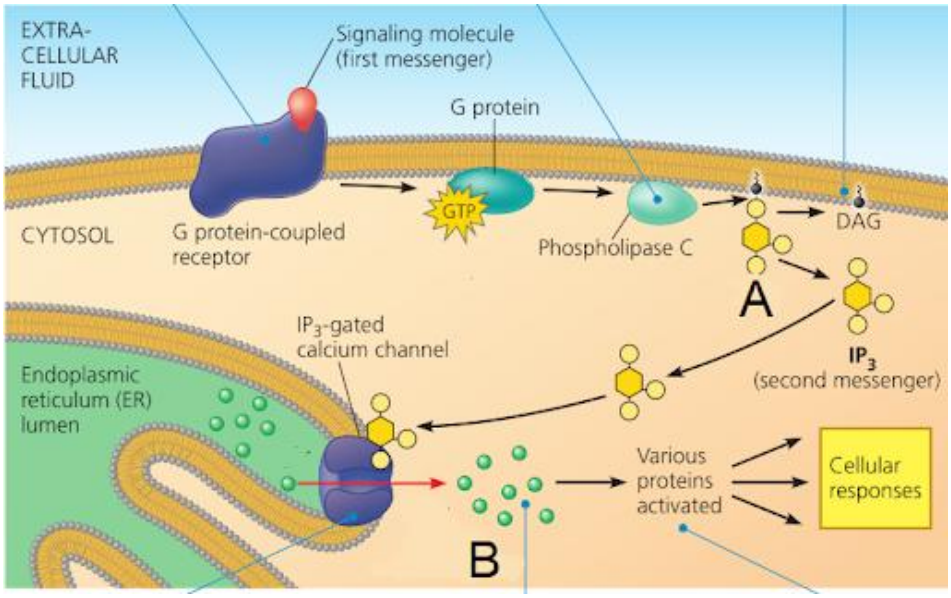
TOSS-UP

4) Biology – *Short Answer* [5] From what layer of the vascular cylinder do lateral roots emerge?

ANSWER: PERICYCLE [Plants - Anatomy , SF]

VISUAL BONUS

4) Biology – *Short Answer* [9] Shown in the image is a specific signaling pathway commonly found in animal cells. Answer the following two questions regarding this cell signaling mechanism: 1) Indicate the names of the molecules labeled labeled A and B respectively; 2) Indicate, by name or number all of the following three hormone signaling circumstances that would activate this pathway: 1) Acetylcholine in smooth muscle; 2) Epinephrine on blood vessel; 3) Insulin in the liver.
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Source: Campbell Biology 11e [Chapter 11]

ANSWER: 1) A IS PHOSPHATIDYLINOSITOL 4,5 BISPHOSPHATE (ACCEPT: PIP2), B IS CA^{2+}; 2) 1 ONLY

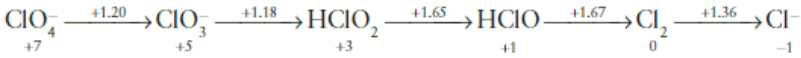
TOSS-UP

5) Chemistry – *Short Answer* Paints exhibit what property, where a fluid's viscosity decreases when a stress is applied, then returns to a more viscous state after some time?

ANSWER: THIXOTROPY [TZ]

VISHWAL BONUS

5) Chemistry – *Short Answer* Shown in the image is a Latimer diagram for chlorine in an acidic solution depicting standard potentials, answer the following 2 questions using the information provided: 1) What is the pH of the solution? 2) Which chlorine species is the most reducing?



Atkins Inorganic Chapter 5
ANSWER: 1) 0; 2) Cl- [DJ]

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TOSS-UP

6) Energy – *Short Answer* Researchers at Lawrence Berkeley National lab have been studying the Toray process, an industrial scale process in the production of caprolactam through an oxime intermediate. What reaction involves the rearrangement of oxime in acid to form amides?

ANSWER: BECKMANN REARRANGEMENT [DJ]

BONUS

6) Energy – *Short Answer* Researchers at Ames national lab have been studying the control of ATP binding from the Q motif. Which of the following classes of motifs would these researchers most likely also be interested in?

W) EF Hand
X) P Loop
Y) Zinc Finger
Z) Glizzy motif

ANSWER: X) P LOOP [DJ]

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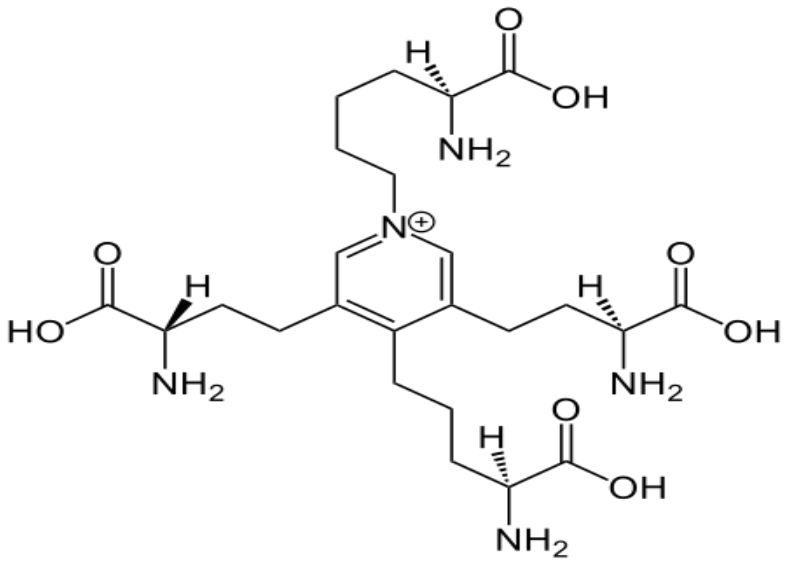
TOSS-UP

7) Biology – *Short Answer* [7] Indicate, by name or number, all of the following 3 residues when found on the outside of a protein would indicate improper folding: 1) Alanine; 2) Histidine; 3) Serine.

ANSWER: 1 ONLY [Biochemistry - Proteins, SF]

BONUS

7) Biology – *Short Answer* [8] Shown in the image is a unique amino acid commonly found in the protein elastin, a key component of most connective tissues, and is derived from four instances of an amino acid: Answer the following two questions: 1) What amino acid is desmosine derived from; 2) Would this amino acid be found in higher concentrations in the dermis or the epidermis?



ANSWER: 1) LYSINE; 2) DERMIS [Biochemistry - Proteins, SF]

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TOSS-UP

8) Earth and Space – *Multiple Choice* [7] Which of the following marine sediments is most uniform throughout the oceans, regardless of depth or latitude?

W) Calcareous ooze
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X) Siliceous ***[si-LIH-shus]*** ooze
Y) Tektites
Z) Metal sulfides

ANSWER: Y) TEKTITES [Oceanography, YL]

BONUS

8) Earth and Space – *Short Answer* [8] Identify all of the following three statements regarding the plagioclase feldspar solid solution that are true: 1) The transition from albite to anorthite involves a coupled substitution; 2) There exists multiple miscibility gaps within the solid solution characterized by concave-down solvuses; 3) The solid solution becomes completely continuous at high temperatures.

ANSWER: ALL [Geology - Mineralogy, YL]

TOSS-UP

9) Chemistry – *Short Answer* Identify all of the following 3 ligands that are considered a bridging ligand: 1) Chloride; 2) Acetate; 3) Triphenylphosphine.

ANSWER: 1 AND 2 [DJ]

BONUS

9) Chemistry – *Short Answer* The Sakurai Allylation reaction uses a trimethyl silane reagent to add to carbonyl groups. The intermediate in this reaction is stabilized through what effect analogous to hyperconjugation?

ANSWER: BETA SILICON EFFECT [DJ]

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TOSS-UP

10) Math – *Short Answer* [8] 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]

BONUS

10) Math – *Short Answer* [9] When 65 to the 6th is converted from base 10 to base 8, what is the sum of its digits? Give your answer in base 10.

ANSWER: 36 [NT - Base, CT]
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TOSS-UP

11) Energy – *Multiple Choice* Researchers at Pacific Northwest National Lab have been studying the impacts of chymotrypsin in rumination digestion in order to better aid economical agriculture. Which of the following is NOT correct regarding chymotrypsin's mechanism of catalysis?

W) An oxyanion hole is comprised of amino groups that bind to a hydroxide ion.
X) A histidine in the active site acts as both a general base and a general acid.
Y) A serine in the active site participates in covalent catalysis.
Z) A hydrophobic pocket on the enzyme is used to bind the substrate.

ANSWER: W) AN OXYANION HOLE IS COMPRISED OF AMINO GROUPS THAT BIND TO A HYDROXIDE ION. [DJ]

BONUS

11) Energy – *Short Answer* Researchers at Brookhaven National Lab are studying the crystal structure of the CFTR inhibitory factor. Identify all of the following three statements that are true about the CFTR protein and gene: 1) In patients with cystic fibrosis, the CFTR protein does not allow the movement of chloride ions; 2) In patients with cholera, the CFTR protein transports excessive amount of chloride ions; 3) The CFTR gene is encoded in mitochondrial DNA.

ANSWER: 1 AND 2 [TZ]

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TOSS-UP

12) Physics – *Multiple Choice* [7] An electromagnetic wave has an electric field E = cos(kx - ωt) times y hat. What is the direction of the corresponding magnetic field at time t=0?
W) positive x hat
X) negative y hat
Y) positive z hat
Z) negative z hat

ANSWER: Y) POSITIVE Z HAT [E&M, DK]

BONUS

12) Physics – *Short Answer* [8] A cylinder containing a mole of oxygen gas starts at STP. Order the following four processes it could undergo by increasing change in entropy: 1) Reversible adiabatic doubling in volume; 2) Isobaric doubling in volume; 3) Isothermal doubling in volume; 4) Isochoric doubling in temperature

ANSWER: 1, 3, 4, 2 [Thermo, DK]
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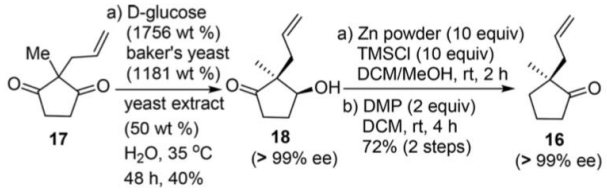
TOSS-UP

13) Chemistry – *Short Answer* What model approximates the potential energies of diatomic molecules by modifying the quantum harmonic oscillator model?

ANSWER: MORSE POTENTIAL [CK]

VISHWAL BONUS

13) Chemistry – *Short Answer* Shown in the image is a reaction scheme for the cyclization precursor in the total synthesis of hamigeran. Answer the following 2 questions regarding this scheme: 1) What is the name of the reaction using Zinc to remove the ketone functional group? 2) What is the full name of the reagent DMP used to convert compound 18 to compound 16?



http://pubs.acs.org/action/showCitFormats?doi=10.1021/acs.orglett.8b01490

ANSWER: 1) CLEMMENSEN REDUCTION; 2) DESS-MARTIN PERIODINANE. [DJ]

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TOSS-UP

14) Biology – *Short Answer* What term is given to the serine proteases secreted by cytotoxic T cells and natural killer cells that induce apoptosis in infected somatic cells?

ANSWER: GRANZYMES [SF]

BONUS

14) Biology – *Short Answer* [8] Identify all of the following three types of cells that are found in the retina: 1) Müller cells; 2) Langerhans cells; 3) Opponent color cells.

ANSWER: 1 AND 3 [Animal Physiology - Nervous Systems, SF]
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TOSS-UP

15) Math – *Short Answer* [9] A circular table has 6 seats around it. Ben sits in a seat and flips a coin. If the coin lands on heads, he moves 1 seat to his left; otherwise, he moves 1 seat to his right. If he flips the coin 6 times, what is the probability that he ends up in the same seat that he started in?

ANSWER: 11/32 [Com - Com, CT]

BONUS

15) Math – *Short Answer* [8] Let S be the locus of points that are exactly twice as far away from the point (6, 0) than the origin in the *xy* plane. What are the coordinates of the center of S?

ANSWER: (–2, 0) [Alg - Coord, CT]

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TOSS-UP

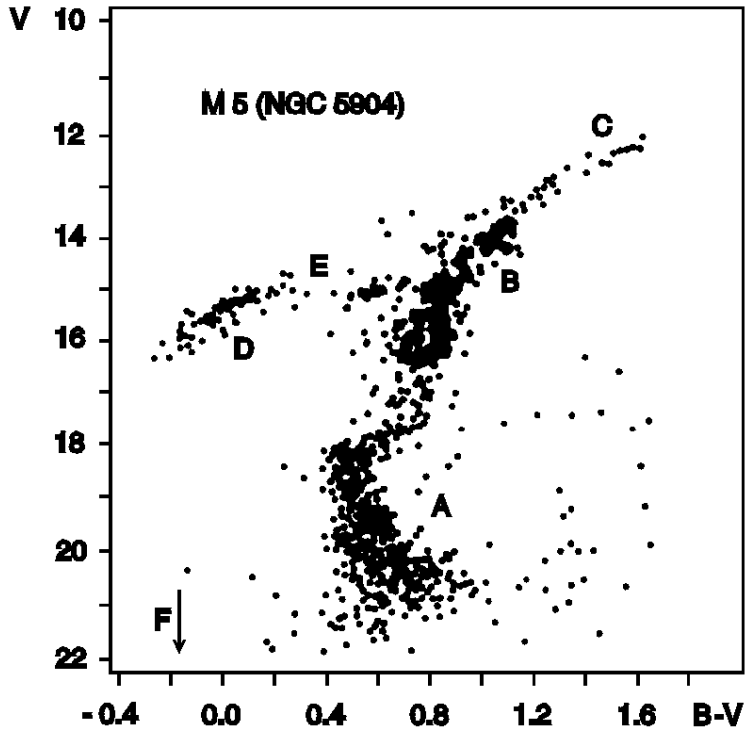
16) Earth and Space – *Multiple Choice* [9] Jay is studying thermoremanent magnetization preserved through iron oxide minerals. When very small crystals of magnetite are cooled below their Curie temperature, they do not immediately become ferrimagnetic. Instead, they enter which form of magnetism, which is characterized by random magnetization flipping and a large overall magnetic susceptibility?

W) Ferromagnetism
X) Superparamagnetism
Y) Antiferromagnetism
Z) Diamagnetism

ANSWER: X) SUPERPARAMAGNETISM [Geology - Mineralogy, Yl]

VISUAL BONUS

16) Earth and Space – *Short Answer* [9] Shown in the image is a color-magnitude diagram of Messier object 5, with individual stars plotted as dots. Answer the following three questions regarding this image: 1) What type of variable star is represented by the population at letter E? 2) What stellar evolutionary stage is represented by stars near letter D? 3) Is M5 an open cluster, a globular cluster, or a galaxy?
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ANSWER: 1) RR LYRAE; 2) HORIZONTAL BRANCH; 3) GLOBULAR CLUSTER
[Astronomy - Stellar, YL]

TOSS-UP

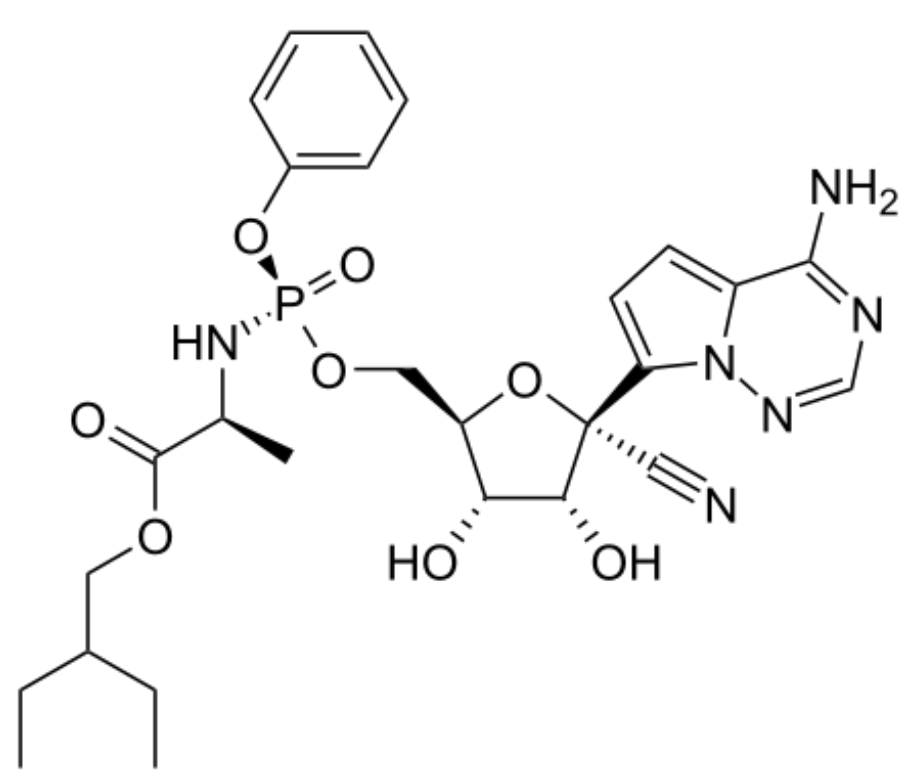
17) Energy – *Multiple Choice* Researchers at Brookhaven National Lab have been studying the asymmetric alkylations of enolates using chiral auxiliaries. Which of the following is NOT an auxiliary these researchers might be looking at?

W) (R,R)-Pseudoephedrine
X) SAMP/RAMP
Y) Oxazolidinone ***[ox-uh-zo-LID-uh-known]***
Z) Meta chloroperoxybenzoic acid

ANSWER: Z) META CHLOROPEROXYBENZOIC ACID [DJ]

VISHWAL BONUS

17) Energy – *Short Answer* Researchers at Argonne National Lab have been studying the drug Remdesivir, shown in the picture, which has been heavily researched in its effects to combat Covid-19. Answer the following 2 questions regarding remdesivir: 1) What amino acid is Remdesivir built on? 2) In the synthesis of this drug, the formation of the phosphodiester bond requires the protection of what other functional group in the drug, by forming an acetal with acetone?



ANSWER: 1) ALANINE; 2) VICINAL DIOL (ACCEPT: DIOL) [DJ]

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TOSS-UP

18) Physics – *Multiple Choice* [9] A pendulum is swinging and its length is slowly increased to double of its original length. If the energy of the pendulum was originally E, in terms of E, what is the energy of the pendulum finally?
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W) E rt 2
X) E
Y) E rt2/2
Z) E/2
ANSWER: Y) Ert2/2 [sanjay, sanjay] [SS]

BONUS

18) Physics – *Short Answer* [8] Elliptically polarized light is formed from the superposition of two perpendicular waves that are 30 degrees out of phase with each other. If the magnitude of each component wave is 1, what is the maximal magnitude of the resultant polarized light?

Commented [1]: this some pretty shit wording but i think it works in a pinch

ANSWER: 1 + ROOT 3 ALL OVER 2 [CT]

TOSS-UP

19) Math – *Short Answer* [8] How many ways are there to choose 3 vertices of a regular octagon so that they form a right triangle?

ANSWER: 24 [Geo - OthPoly, CT]

VISUAL BONUS

19) Math – *Short Answer* [9] Shown in the image is a certain integral substitution technique. Answer the following 2 questions regarding the image: 1) What substitution is being made, which converts trig functions of x into rational functions of t? 2) In terms of t, what is the sine of x over 2 if t is a small positive number?

$$\sin x = \frac{2t}{1+t^2} \qquad \cos x = \frac{1-t^2}{1+t^2} \qquad \mathrm{d}x = \frac{2}{1+t^2}\mathrm{d}t$$

ANSWER: 1) WEIERSTRASS (ACCEPT: TANGENT HALF-ANGLE); 2) t OVER SQUARE ROOT $t^2 + 1$ [Calc - Int, CT]

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TOSS-UP

20) Earth and Space – *Short Answer* [9] While most of the Earth's internal heat is generated from radioactive decay, the internal heat of Jupiter and Saturn is generated mostly through what mechanism?

ANSWER: KELVIN-HELMHOLTZ MECHANISM (ACCEPT: KH MECHANISM) [Astronomy - Solar System, YL]

VISHWAL BONUS

20) Earth and Space – *Short Answer* [9] Shown in the image is a rock outcrop, with a field of view of about 1 meter. Answer the following two questions regarding the image: 1) What rock is shown? 2) What specific type of folding is exemplified by this outcrop?
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ANSWER: 1) MIGMATITE; 2) PTYGMATIC ***[tig-matic]*** FOLDING [Geology - Petrology, YL]

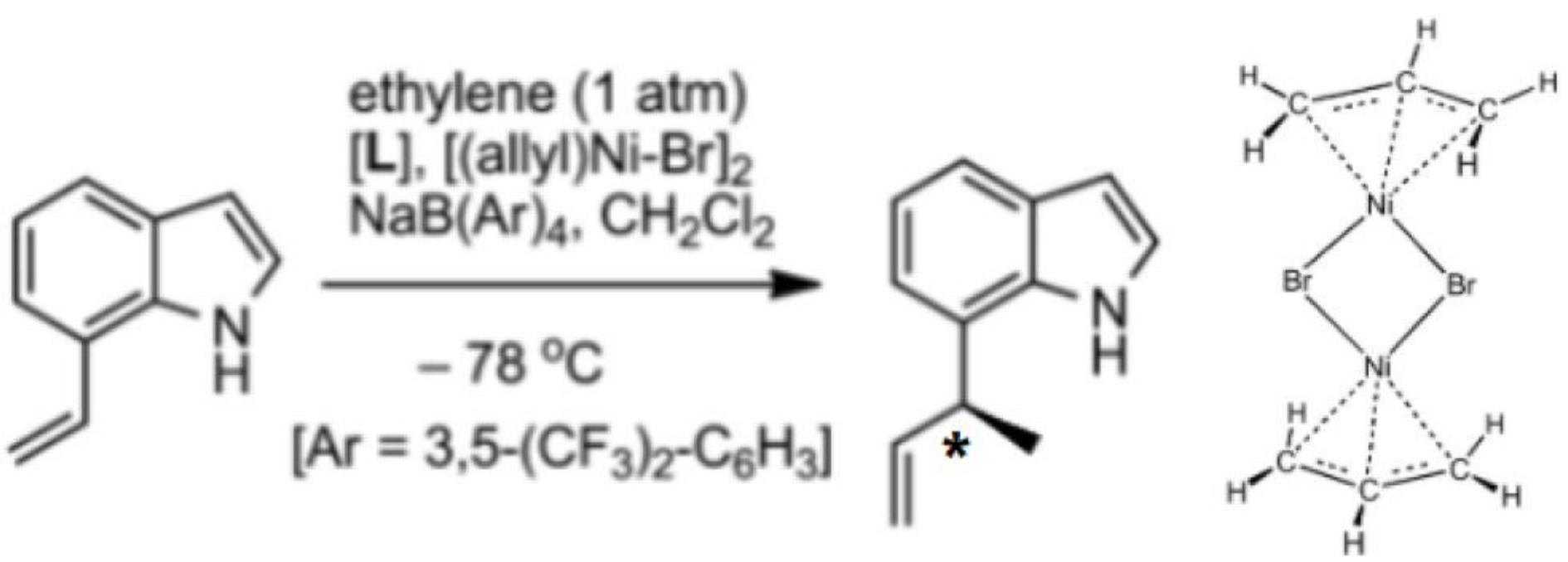
TOSS-UP

21) Chemistry – *Short Answer* Rank the following 3 salts from smallest to largest K_{sp} in water: 1) AgI; 2) HgI_2; 3) CrI_3

ANSWER: 2,1,3 [APC]

VISHWAL BONUS

21) Chemistry – *Short Answer* Here is shown a very well known (and noted) reaction, Ni(II) catalyzed asymmetric hydrovinylation. The structure of the nickel species used to mediate the reaction is also shown. Answer the following two questions about this reaction: 1) What is the R/S configuration of the stereocenter marked with an asterisk? 2) What is the electron count of the metal center in the nickel complex shown?



ANSWER: 1) S; 2) 16 [APC]

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TOSS-UP

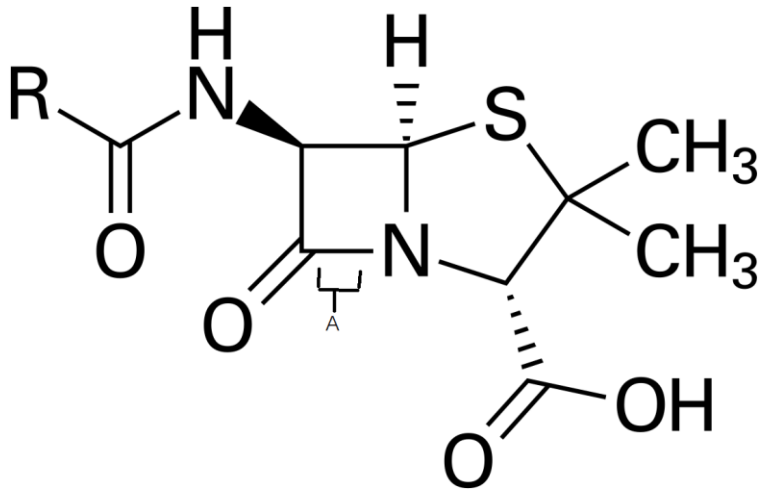
22) Biology – *Short Answer* [4] Occuring in salmon, what form of reproductive life history involves a massive number of offspring being produced in a single event?

ANSWER: SEMELPARITY [Ethology - , SF]

BONUS

22) Biology – *Short Answer* Answer the following three questions concerning the molecule depicted above: 1) What group of antibiotics does this molecule represent; 2) This group of antibiotics is characterized by the thiazolidine ring bound to what structural motif indicated by
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A?; 3) This group of antibiotics interferes with peptidoglycan synthesis by acting as a suicide inactivator of what enzyme?



ANSWER: 1) PENICILLINS; 2) β-LACTAM RING; 3) TRANSPEPTIDASE [DJ]

TOSS-UP

23) Physics – *Multiple Choice* [5] Which of the following particles is currently believed to be elementary?

W) Muon
X) Pion
Y) Neutron
Z) Kaon

ANSWER: W) MUON [Particle, DK]

BONUS

23) Physics – *Short Answer* [8] Polarized light with polarization vector n = 3i - 4j is incident on a polarizing filter oriented parallel to 2i + j. What is the ratio of the intensity of the transmitted light to the initial intensity?

ANSWER: 4/125 [Optics, DK]