SBL FALL FINALS 2

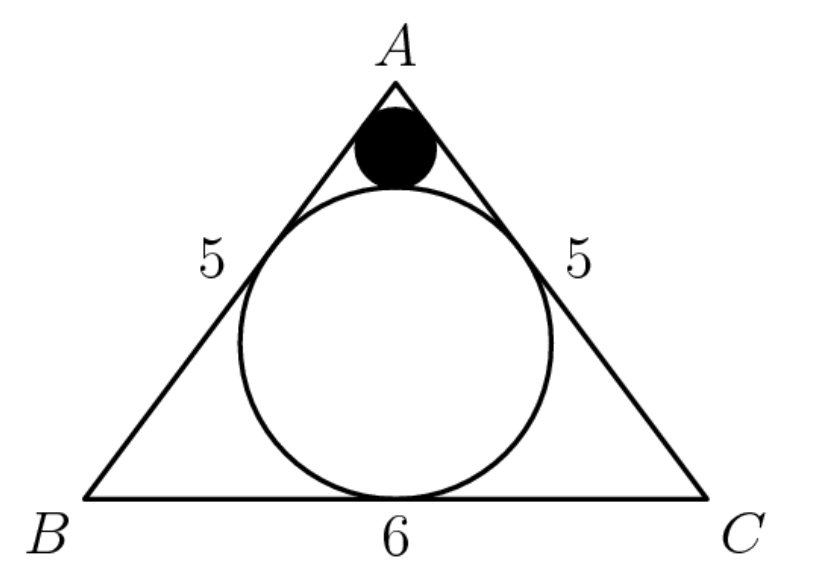
TOSS-UP

1) Math – *Short Answer* [7] 10 people are standing in a line. How many ways are there to choose 5 people such that no 2 of them are standing next to each other?

ANSWER: 6 [Com - Com, CT]

VISHWAL BONUS

1) Math – *Short Answer* [9] Shown in the image is triangle ABC with AB = AC = 5 and BC = 6. The incircle of triangle ABC is drawn, and the black circle is tangent to sides AB, AC, and the incircle. What is the radius of this black circle?



ANSWER: 3/8 [Geo - Tri, CT]

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TOSS-UP

2) Earth and Space – *Multiple Choice* [7] Which of the following statements regarding dynamic tide theory is false?

W) Amphidromic points represent points in the ocean that experience zero tidal range
X) Cotidal lines rotate around amphidromic points
Y) The number of amphidromic points present in the oceans may vary drastically throughout the year
Z) Waves associated with tidal movement have extremely long wavelengths and shallow amplitudes

ANSWER: Y) THE NUMBER OF AMPHIDROMIC POINTS PRESENT IN THE OCEANS MAY VARY DRASTICALLY THROUGHOUT THE YEAR [Oceanography, YL]

BONUS
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2) Earth and Space – *Short Answer* [7] Seyfert galaxies differ from quasars in that the host galaxy of the active nucleus is still significantly detectable. Which of the following characteristics would usually not be expected of Seyfert galaxies?

W) Presence of a supermassive black hole
X) Presence of an H alpha line
Y) Bright ultraviolet emission
Z) Lack of spiral arms

ANSWER: Z) LACK OF SPIRAL ARMS [Astronomy - Other, YL]

TOSS-UP

3) Physics – *Short Answer* [8] Identify all of the following 3 Lagrange points that are considered unstable equilibria: 1) L1; 2) L3; 3) L5.

ANSWER: 1 AND 2 [Astrophys, DK]

BONUS

3) Physics – *Short Answer* [8] Infrared thermometers can infer the temperature of objects at a distance by the amount of thermal radiation focused onto a detector. To the nearest tenth of a percent, if a patient's body temperature is elevated by 1 °C above normal, how much more radiation will the detector measure?

ANSWER: 1.3% [Thermo, DK]

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TOSS-UP

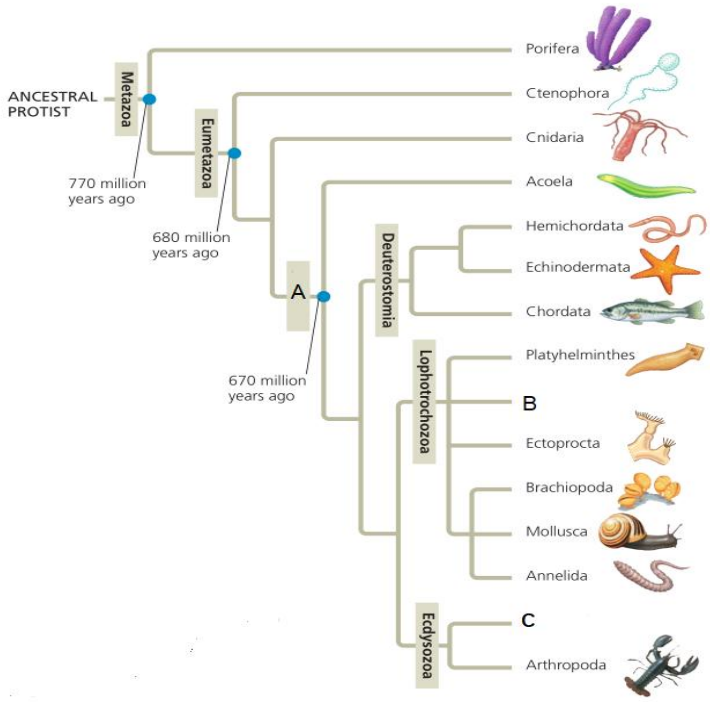
4) Biology – *Multiple Choice* Which of the following best characterizes a sensory system with high acuity?

W) Less convergence in descending pathways
X) More convergence in descending pathways
Y) Less convergence in ascending pathways
Z) More convergence in ascending pathways

ANSWER: Y) LESS CONVERGENCE IN ASCENDING PATHWAYS

VISHWAL BONUS

4) Biology – *Short Answer* [7] Shown in the image is a phylogenetic tree depicting Animalia and one interpretation of their evolutionary relationships. Answer the following three questions concerning this tree: 1) Indicate the name of the clade labeled A; 2) Knowing that phylum B is composed of pseudocoelomates who possess a cuticle, what is the identity of phylum B; 3) Indicate whether the phylum labeled C would possess a coelom, pseudocoelom or no coelom and how many germ layers it possesses.
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Source: Campbell Biology 11e [Chapter 11]

ANSWER: 1) Bilateria; 2) Nematoda; 3) COELOM AND 3 GERM LAYERS [Systematics - Animals, SF]

TOSS-UP

5) Chemistry – *Short Answer* What olefination can be used to generate an olefin from a molecule with vicinal diols?

ANSWER: COREY-WINTER OLEFINATION [DJ]

BONUS

5) Chemistry – *Multiple Choice* Which of the following statements regarding the typical Diels-Alder reaction is false?

W) Electrons flow from the HOMO of the diene to the LUMO of the dienophile
X) The ΔS of a typical Diels-Alder reaction is negative
Y) 1,3-cyclopentadiene dimerizes through a Diels-Alder reaction at room temperature
Z) The Diels-Alder reaction is favored at high temperatures

ANSWER: Z) THE DIELS-ALDER REACTION IS FAVORED AT HIGH TEMPERATURES [YL]

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TOSS-UP

6) Energy – *Multiple Choice* Researchers at Ames National Laboratory are studying the effects of the molecule 6-aminonicotinamide, a common inhibitor for the pentose phosphate pathway. For a patient without a functioning oxidative phase of the pentose phosphate pathway, which of the following best describes how they can get ribose-5-phosphate?

W) They can only get it by eating specific essential meat proteins
X) The reactions of the non-oxidative phase are reversible, so intermediates from glycolysis can be used to generate ribose-5-phosphate
Y) Ribose-5-phosphate is released after the damage of DNA, which can be picked up by the cell to be reused
Z) Ribose-5-phosphate can be recycled in the cell, but at a slower rate than the human body requires it to

ANSWER: X) THE REACTIONS OF THE NON-OXIDATIVE PHASE ARE REVERSIBLE, INTERMEDIATE FROM GLYCOLYSIS CAN BE USED TO GENERATE RIBOSE-5-PHOSPHATE [DJ]

BONUS

6) Energy – *Short Answer* Researchers at SLAC are using gravitational lensing to better quantify the expansion of the universe. The Friedmann equations are useful when dealing with models of the universe. Identify all of the following three statements regarding the Friedmann

Commented [1]: someone who is awake just look at the grammar for this

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equations that are true: 1) A density parameter omega greater than one means the universe will expand forever; 2) The critical density of the universe is expressed in terms of the Hubble parameter; 3) The majority of the mass of the universe is baryonic matter.

ANSWER: 2 ONLY [YL]

TOSS-UP

7) Biology – *Multiple Choice* Which of the following is a reason why a pain receptor can cause interneurons to perceive pain in locations other than where the nociceptor is, a phenomenon known as referred pain?

W) The nociceptive pathway excites nociceptors that they converge with
X) The nociceptors induce action potentials which diverge in the brain, and activate other nociceptors through descending pathways
Y) The nociceptor release neuromodulators into the blood which activate nociceptors in other regions of the body
Z) Visceral pathways and somatic pathways converge in the same location in the spinal cord

ANSWER: Z) VISCERAL PATHWAYS AND SOMATIC PATHWAYS CONVERGE IN THE SAME LOCATION IN THE SPINAL CORD [SF]

BONUS

7) Biology – *Short Answer* Identify, by name or number all of the following four actions that occur during NREM sleep: 1) Gonadotropin release of growth hormone; 2) Increased blood pressure; 3) Increase in respiratory rate; 4) Decrease in heart rate.

ANSWER: 1 AND 4 [SF]

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TOSS-UP

8) Earth and Space – *Multiple Choice* Which of the following combinations of the Pacific Decadal Oscillation, or PDO ***[spell out]***, and the El Niño Southern Oscillation, or ENSO ***[say as a word]***, creates the highest mean equatorial sea surface temperature anomaly?

W) Negative PDO, negative ENSO
X) Negative PDO, positive ENSO
Y) Positive PDO, negative ENSO
Z) Positive PDO, positive ENSO

ANSWER: Z) POSITIVE PDO, POSITIVE ENSO [Meteorology, YL]

BONUS

8) Earth and Space – *Short Answer* Degeneracy pressure, unlike regular gas pressure, does not have a temperature-dependent term. Instead, degeneracy pressure is proportional to the five-thirds power of what physical parameter of the gas?

ANSWER: DENSITY [Astronomy - Astrophysics, YL]
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TOSS-UP

9) Chemistry – *Short Answer* While conducting a retrosynthesis of 2,5-hexanedione you notice that you have a positive polarity on one of the alpha carbon synthons, however the polarity needs to be inverted. What term is given for the inversion of polarity on a carbon atom while doing a retrosynthesis.

ANSWER: UMPOLUNG [DJ]

BONUS

9) Chemistry – *Short Answer* Identify all of the following three statements regarding the color of diatomic halogens that are true: 1) Their color results from a transition between the sigma star LUMO and the pi star HOMO; 2) The color of bromine solvated in cyclohexane is different than bromine solvated in pyridine because cyclohexane forms a charge transfer complex; 3) An orange beam is suitable for a spectrophotometry experiment involving a solution of bromine.

ANSWER: 1 ONLY [YL]

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TOSS-UP

10) Math – *Short Answer* [7] $f(x)$ is a 7th degree polynomial with real coefficients, and z is a complex root of f with a nonzero imaginary component. What is the maximum multiplicity of this root?

ANSWER: 3 [Alg - Comp]

BONUS

10) Math – *Short Answer* [8] Alice estimates the value of the natural log of a large integer n by plotting the graph of $y = \ln(x)$ and performing the Euler method with a step size of 1 starting from the point (1, 0). She notices that, as n grows to infinity, the difference between her estimate and the true value of $\ln(n)$ approaches what constant?

ANSWER: EULER–MASCHERONI CONSTANT [Calc - Der]
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TOSS-UP

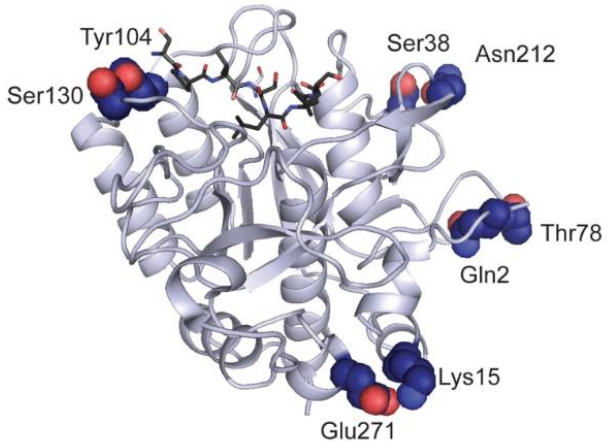
11) Energy – *Short Answer* Researchers at Sandia National Lab are using databases of galactic spectra to better classify high redshift galaxies. Identify all of the following three statements regarding galactic spectra that are true: 1) Elliptical galaxy spectra are characterized by a strong 4000-Angstrom break from the lack of blue stars; 2) Spiral galaxies are almost always characterized by a stark lack of an H alpha line; 3) Elliptical galaxies are usually characterized by strong absorption lines.

ANSWER: 1 AND 3 [YL]

VISHWAL BONUS

11) Energy – *Multiple Choice* Researchers at Brookhaven National Lab are trying to stabilize the proteolytic enzyme subtilisin for inclusion into a laundry detergent. The target enzyme is shown in the image with a protein inhibitor (black) bound in the active site. It has been proposed to stabilize the protein by introducing disulfide bonds. Which of the following substitutions would most likely lead to the most stable and active protein?

W) Introduce a disulfide bond between residues 2 and 271.
X) Introduce a disulfide bond between residues 15 and 271.
Y) Introduce a disulfide bond between residues 38 and 212.
Z) Introduce a disulfide bond between residues 104 and 130.



ANSWER: X) INTRODUCE A DISULFIDE BOND BETWEEN RESIDUES 15 AND 271. [DJ]

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TOSS-UP

12) Physics – *Short Answer* [8] Identify all of the following three statements that are true of the Dirac equation: 1) It predicts the existence of antiparticles; 2) It is Lorentz invariant; 3) It describes photons and other massless bosons.

ANSWER: 1 AND 2 [QM, DK]

BONUS

12) Physics – *Multiple Choice* [9] The seesaw mechanism is intended to explain the imbalance between which of the following?
W) Gravity and strong interaction strengths
X) Matter and antimatter
Y) Electroweak and GUT energy scales
Z) Neutrino and quark masses

ANSWER: Z) NEUTRINO AND QUARK MASSES [Particle, DK]

TOSS-UP

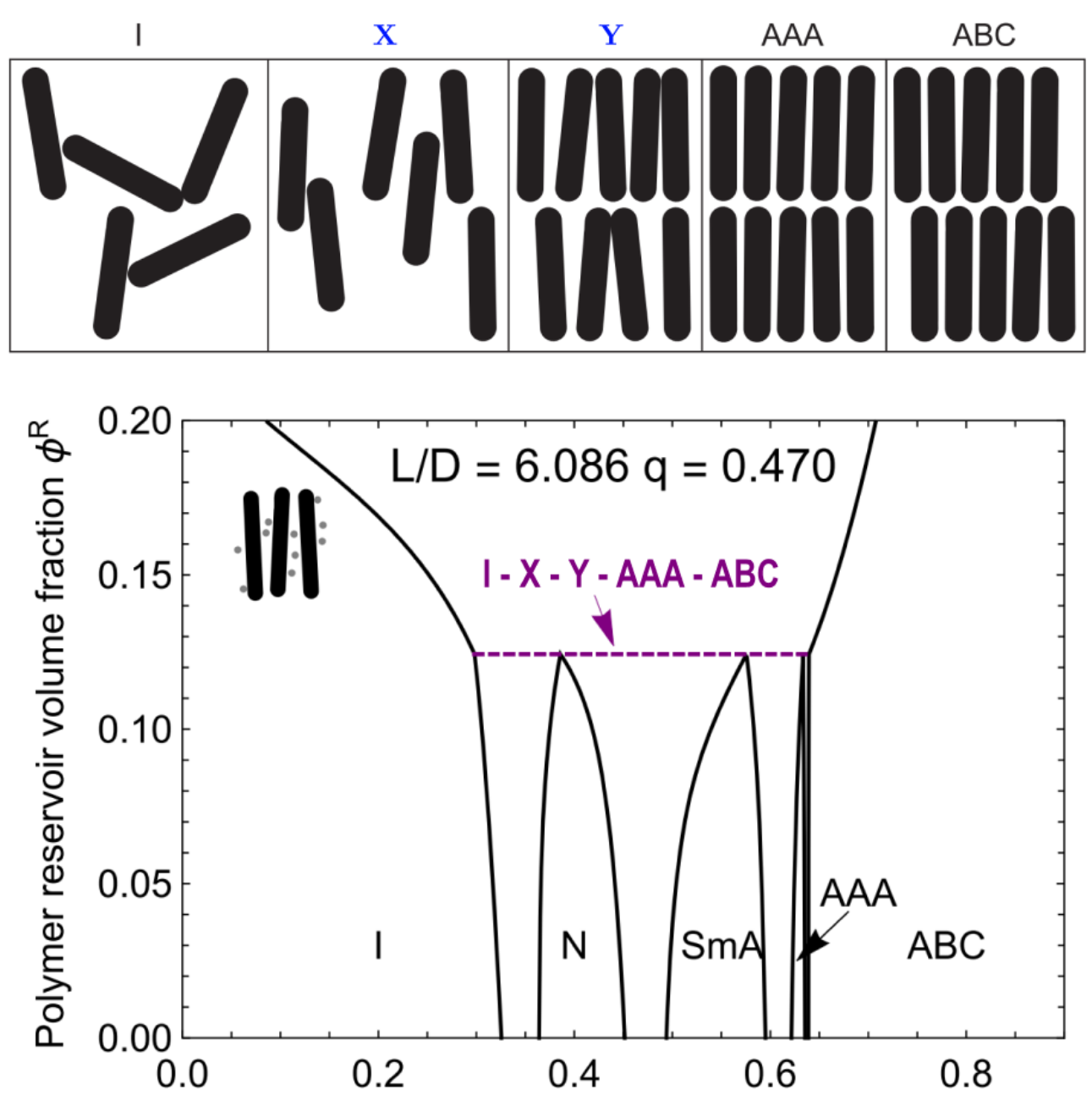
13) Chemistry – *Short Answer* Identify all of the following three statements that are true about the bifluoride anion HF_2^-: 1) It is formed from the dissociation of acids in liquid HF; 2) It is bent; 3) It exhibits 3-center-2-electron bonding.

ANSWER: 3 ONLY [YL]

VISHWAL BONUS

13) Chemistry – *Short Answer* Shown is a figure from a recently published paper where scientists have modeled a five-phase equilibrium within a binary rod-polymer mixture. Answer the following two questions about this image: 1) Which thermodynamic rule does this finding seemingly violate? 2) What types of liquid crystals are exemplified by X and Y, respectively?

ANSWER: 1) GIBBS PHASE RULE; 2) X - NEMATIC, Y - SMECTIC [YL]



(Peters *et al.,* 2020)

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TOSS-UP

14) Biology – *Short Answer* What disease is caused by the buildup of pressure in the inner ear, disrupting the vestibular apparatus and causing vertigo?

ANSWER: MENIERE'S DISEASE [SF]

BONUS

14) Biology – *Short Answer* What specific hormones are released to provide feedforward information of insulin secretion during eating?

ANSWER: INCRETINS [SF]

TOSS-UP

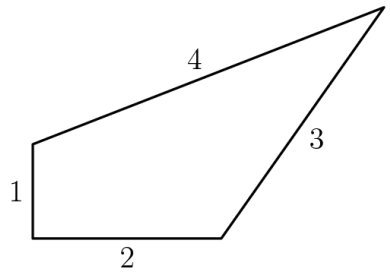
15) Math – *Multiple Choice* [9] A linear map f from R squared to R squared maps the point (x, y) to the point $(x, x + y)$. Which of the following best describes the Jacobian determinant of this transformation?

W) Less than 1
X) 1
Y) Between 1 and 2
Z) 2

ANSWER: X) 1 [Calc - Der, CT]

VISHWAL BONUS

15) Math – *Short Answer* [8] Shown in the image is a convex quadrilateral which has side lengths of 1, 2, 3, and 4, in that order. In addition, it has a right angle between the sides of lengths 1 and 2. What is the area of this quadrilateral?



ANSWER: 1 PLUS ROOT 11 [Geo - Quad, CT]

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TOSS-UP

16) Earth and Space – *Multiple Choice* [9] Which of the following would be expected for flat slab subduction, but not for steep angle subduction?

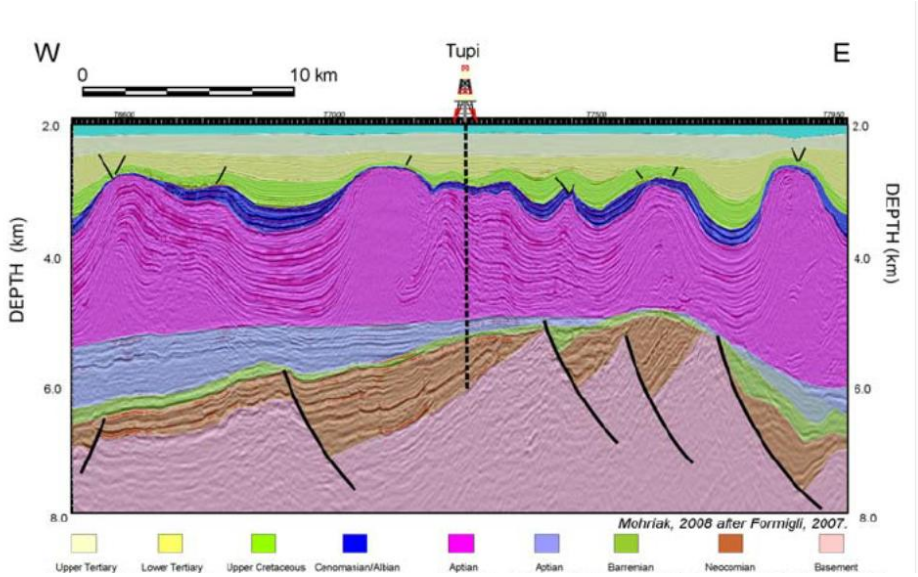
W) Adakitic ***[ada-KIH-tic]*** magmatism
X) Accretionary wedge formation
Y) Wadati-Benioff seismicity
Z) Back-arc basin formation

ANSWER: W) ADAKITIC MAGMATISM [Geology - Other, YL]

VISHWAL BONUS

16) Earth and Space – *Short Answer* [8] Shown in the image is a seismic cross section of the rock under the Santos Basin, located in the South Atlantic. Answer the following two questions
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regarding the image: 1) Identify the primary mineral of the purple unit; 2) What type of normal fault can be seen near the bottom of the profile?



ANSWER: 1) HALITE (ACCEPT: SALT); 2) LISTRIC FAULT [Geology - Structural, YL]

TOSS-UP

17) Energy – *Short Answer* Researchers at Ames National Lab are investigating the superfluid density of electrons near absolute zero. To better understand the superconducting gap symmetry, they also measured what parameter, which governs the decay of a magnetic field within a superconductor?

ANSWER: LONDON PENETRATION DEPTH [YL]

BONUS

17) Energy – *Short Answer* Chemists at Pacific Northwest National Lab are studying the migration of ions in solution. Rank the following four ions in terms of increasing ionic mobility in water at STP: 1) Li^+; 2) Na^+; 3) K^+; 4) H^+

ANSWER: 1, 2, 3, 4 [YL]

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TOSS-UP

18) Physics – *Short Answer* A particle of mass 2kg has a potential modeled by the function $U(x) = x^2 + 4x + 3$. What is the angular frequency of small oscillations around the point $x = -2$?

ANSWER: 1 [SS]

BONUS

18) Physics – *Short Answer* [8] Two trajectories with a small initial separation vector will diverge at a rate proportional to the exponentials of time and what other quantity whose maximal variety is used to bound separation distances?

ANSWER: LYAPUNOV EXPONENTS [idk, CT]
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TOSS-UP

19) Math – *Multiple Choice* [8] Which of the following numbers has the highest 2-adic valuation?

W) 62
X) 64
Y) 66
Z) 68

ANSWER: X) 64 [NT - Prim, CT]

BONUS

19) Math – *Short Answer* [8] A polynomial $f(x)$ that has integer coefficients satisfies $f(1) = 1$ and $f(2) = 11$. What is the smallest positive value of $f(10)$?

ANSWER: 19 [Alg - Poly, CT]

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TOSS-UP

20) Earth and Space – *Short Answer* [8] Identify all of the following three changes to an interstellar dust cloud that would lead to an increase in its Jeans mass: 1) Increasing temperature; 2) Increasing density; 3) Adiabatic expansion.

ANSWER: 1 ONLY [Astronomy - Astrophysics, YL]

BONUS

Earth and Space – *Short Answer* [8] Classify the following three oxide minerals in their standard states as either ferromagnetic, ferrimagnetic, or neither: 1) Hematite; 2) Magnetite; 3) Cuprite.

ANSWER: 1) NEITHER; 2) FERRIMAGNETIC; 3) NEITHER [Geology - Mineralogy, YL]
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TOSS-UP

21) Chemistry – *Short Answer* Identify all of the following three metals that can be used for the cathodic protection of aluminum: 1) Magnesium; 2) Iron; 3) Cobalt.

ANSWER: 1 ONLY [YL]

BONUS

21) Chemistry – *Multiple Choice* Which of the following statements is NOT true regarding the Sharpless asymmetric epoxidation?

W) The use of D-(-)-diethyl tartrate or D-(+)-diethyl tartrate is used to determine the stereochemistry of the reaction
X) There must be an allylic alcohol
Y) The reactive complex made from titanium isopropoxide and tartrate dimerizes
Z) A competing Baeyer-Villiger side reaction occurs from a reactive intermediate

ANSWER: Z) A COMPETING BAEYER-VILLIGER SIDE REACTION OCCURS FROM A REACTIVE INTERMEDIATE [DJ]

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TOSS-UP

22) Biology – *Multiple Choice* Which of the following endocrine hormones is initiated by the high concentration of fatty acids and amino acids in the small intestine, and thus signals for the gallbladder to contract?

W) CCK
X) Gastrin
Y) Secretin
Z) GIP

ANSWER: W) CCK

BONUS

22) Biology – *Short Answer* Na+ absorption in the ascending loop of henle from the lumen into the cell is accomplished by what Na+ transporter?

ANSWER: NKCC TRANSPORTER (ACCEPT: NA-K-2CL COTRANSPORTERS)
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TOSS-UP

23) Physics – *Multiple Choice* [8] A hysteresis loop is formed when magnetization is plotted against applied magnetic field for a ferromagnet, as the material retains a magnetic moment even after the field is removed. Which of the following quantities is equal to the area enclosed by the hysteresis loop?

W) Magnetic moment
X) Energy dissipated in a cycle
Y) Residual magnetism
Z) Magnetic coercivity

ANSWER: X) ENERGY DISSIPATED IN A CYCLE [Magnetism, DK]

BONUS

23) Physics – *Short Answer* [7] Identify all of the following three statements that are true of the weak interaction: 1) It acts only on charged particles, 2) It conserves lepton number, 3) It mediates the decay of the top quark
THIS IS A REPEAT YUCHEN HELP ill read rfrom 3
ANSWER: 2 AND 3 [Particle, DK]