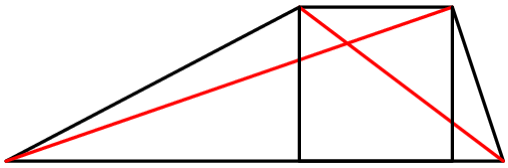
SBL FALL FINALS 3
TOSS-UP

1) Math – *Short Answer* [6] Using the Maclaurin series expansion to 2 terms, compute cosine of 1.

ANSWER: 1/2 [Calc - Der]

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]

~~~~~~

TOSS-UP

2) Earth and Space – *Short Answer* The supercontinent Pangaea broke up due to the action of what specific type of tectonic plate boundary?

ANSWER: DIVERGENT BOUNDARY

BONUS

2) Earth and Space – *Short Answer* Seasonal lag is the phenomenon whereby the warmest day of summer occurs after what date of maximum solar insolation?

ANSWER: SUMMER SOLSTICE (ACCEPT: ESTIVAL SOLSTICE, MIDSUMMER)
~~~~~~

TOSS-UP

3) Physics – *Short Answer* Real objects do not radiate as much thermal energy as predicted by the Stefan–Boltzmann law. What quantity is equal to the ratio of an object's measured thermal radiation to its ideal thermal radiation?

ANSWER: EMISSIVITY

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

~~~~~~

TOSS-UP

4) Biology – *Short Answer* Rank the following three ions in terms of decreasing concentration in the intracellular fluid of a resting neuron: 1) Na^+; 2) Cl^-; 3) K^+.

ANSWER: 3, 1, 2

BONUS

4) Biology – *Short Answer* Identify all of the following three types of plant ground tissue that possess secondary cell walls: 1) Parenchyma; 2) Collenchyma; 3) Sclerenchyma.

ANSWER: 2 AND 3
~~~~~~

TOSS-UP

5) Chemistry – *Short Answer* How many normal vibrational modes does one molecule of acetylene have?

ANSWER: 7

BONUS

5) Chemistry – *Short Answer* Identify all of the following three carbon dioxide vibrational modes that are considered to be Raman active: 1) Asymmetric C–O stretch; 2) Symmetric C–O stretch; 3) Symmetrical bend in plane.

ANSWER: 2 ONLY

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

6) Energy – *Short Answer* Scientists at Argonne National Lab are working on new solvent extraction methods that employ magnetic fields to act on paramagnetic metal ions. Identify all of the following three metal ions that are paramagnetic: 1) Na^{+}; 2) Cr^{3+}; 3) Zn^{2+}.

ANSWER: 2 ONLY

BONUS

6) Energy – *Short Answer* Researchers at Fermilab are conducting particle physics experiments in order to ascertain information about the early universe. One of their experiments focuses on the conversion of what particles to electrons without the emission of neutrinos?

ANSWER: MUONS
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

7) Biology – *Short Answer* Insects secrete what form of nitrogenous waste? ANSWER: URIC ACID

BONUS

7) Biology – *Short Answer* During inflammation, which class of leukocytes may migrate into the blood to become mast cells and release histamine?

ANSWER: BASOPHILS

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

8) Earth and Space – *Short Answer* Solid contours on a high level isobaric chart represent what quantity?

ANSWER: ELEVATION (ACCEPT: HEIGHT; ALTITUDE)

BONUS

8) Earth and Space – *Multiple Choice* Which of the following most closely approximates the time since the last geomagnetic reversal, in years?

W) 1,000
X) 10,000
Y) 100,000
Z) 1,000,000

ANSWER: Z) 1,000,000
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

9) Chemistry – *Multiple Choice* Which of the following compounds is the least suitable nucleophile for an SN2 reaction?

W) Ethanol
X) Methylamine
Y) Sodium iodide
Z) Sodium methoxide

ANSWER: W) ETHANOL

BONUS

9) Chemistry – *Short Answer* Rank the following three liquids in terms of increasing viscosity: 1) Mercury; 2) Water; 3) Diethyl ether.

ANSWER: 3, 2, 1

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

10) Math – *Short Answer* [7] A coin is weighted so that it comes up heads 60% of the time. Alice is standing on the x-axis at $x = 0$. She flips the coin 20 times, and, if it comes up heads, she moves to the right by 1 unit; otherwise, she moves to the left by 1 unit. What is the expected value of her final x-coordinate?

ANSWER: 4 [Alg - ExpVal]

BONUS

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

ANSWER: 576 [NT - Pow]
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

11) Energy – *Short Answer* Scientists at Lawrence Berkeley National Lab have been developing methods for performing artificial photosynthesis. In these methods, titanium dioxide is used for the water-splitting reaction that is traditionally catalyzed by what enzyme within photosystem 2 in plants?

ANSWER: OXYGEN-EVOLVING COMPLEX (ACCEPT: WATER-SPLITTING COMPLEX)

BONUS

11) Energy – *Short Answer* Researchers at Lawrence Livermore National Lab are using short laser pulses to remove atoms from the surface of metals. Lasers are generated by shooting photons at excited electrons, causing them to relax to their ground state. What is the term for this process?

ANSWER: STIMULATED EMISSION

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

12) Physics – *Multiple Choice* Most jet engines employ which of the following thermodynamic cycles?

W) Carnot cycle
X) Stirling cycle
Y) Otto cycle
Z) Brayton cycle

ANSWER: Z) BRAYTON CYCLE

BONUS

12) Physics – *Short Answer* Identify all of the following three statements that are true regarding electric field lines: 1) Induced electric field lines form closed loops; 2) Equipotential lines are always parallel to electric field lines; 3) More closely-spaced electric field lines correspond to stronger electric fields.

ANSWER: 1 AND 3
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

13) Chemistry – *Multiple Choice* How many net pi bonds are formed during a sigmatropic rearrangement?

W) –1
X) 0
Y) 1
Z) 2

ANSWER: X) 0

BONUS

13) Chemistry – *Multiple Choice* When H_2 forms a side-on complex with a tungsten center, which of the following is most likely to occur?

W) The H–H bond strength decreases because tungsten donates electrons into the H–H sigma star orbital
X) The H–H bond strength increases because tungsten donates electrons into the H–H sigma orbital
Y) The H–H bond strength decreases because tungsten donates electrons into the H–H pi star orbital
Z) The H–H bond strength increases because tungsten donates electrons into the H–H pi orbital

ANSWER: W) THE H–H BOND STRENGTH DECREASES BECAUSE TUNGSTEN DONATES ELECTRONS INTO THE H–H SIGMA STAR ORBITAL

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

14) Biology – *Short Answer* Identify all of the following three organelles that are enclosed by a double membrane: 1) Nucleus; 2) Glyoxysome; 3) Chloroplast.

ANSWER: 1 AND 3

BONUS

14) Biology – *Short Answer* What enzyme in red blood cells is responsible for the rapid conversion of water and carbon dioxide into carbonic acid?

ANSWER: CARBONIC ANHYDRASE
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

15) Math – *Short Answer* [7] Identify all of the following 3 functions that are considered bijective over all real numbers: 1) 1 over x; 2) 1 over x^2; 3) 1 over x^3.

ANSWER: NONE [Alg - Func]

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]

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

16) Earth and Space – *Multiple Choice* What is the largest tectonic plate on Earth?

W) Eurasian plate
X) North American plate
Y) Pacific plate
Z) Indo-Australian plate

ANSWER: Y) PACIFIC PLATE

BONUS

16) Earth and Space – *Multiple Choice* Which of the following stellar spectral classes is most likely associated with an emission nebula?

W) K
X) M
Y) G
Z) O

ANSWER: Z) O
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

17) Energy – *Multiple Choice* Scientists at Brookhaven National Lab are using cryoelectron microscopy to characterize the activated CAS9 guide RNA complex in E. coli. E. coli guide RNA is likely to exhibit sequence specificity for nucleic acids in which of the following organisms?

W) Treponema pallidum
X) T4
Y) Plasmodium falciparum
Z) HIV

ANSWER: X) T4

BONUS

17) Energy – *Short Answer* Researchers at Argonne National Lab have been looking for cost effective ways to enrich molybdenum isotopes. They have developed a method that used parts such as acrylic contractors, which were produced by what technique?

ANSWER: 3D PRINTING

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

18) Physics – *Short Answer* Curie's law states that the magnetization of a paramagnetic sample is equal to magnetic susceptibility times what quantity?

ANSWER: EXTERNAL MAGNETIC FIELD (ACCEPT: APPLIED MAGNETIC FIELD; MAGNETIC FIELD; H FIELD)

BONUS

18) Physics – *Short Answer* What is the name for devices containing one p–n junction that convert light into electrical current?

ANSWER: PHOTODIODE
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

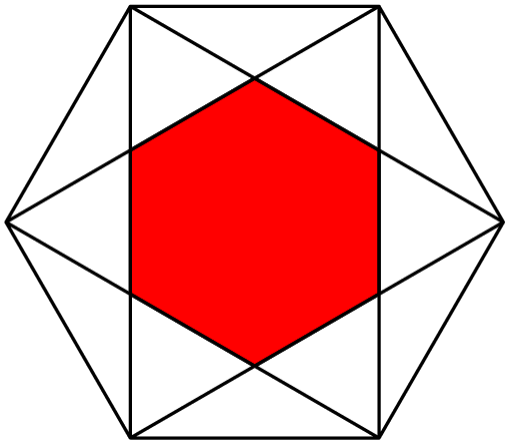
TOSS-UP

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

ANSWER: 3 [NT - Mod]

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]

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

20) Earth and Space – *Short Answer* Identify all of the following three solar system bodies that are known to have permanent polar ice caps: 1) Mars; 2) The Earth's moon; 3) Venus.

ANSWER: 1 ONLY

BONUS

20) Earth and Space – *Short Answer* Identify all of the following three features that would usually be associated with an extensional tectonic regime: 1) Graben and horst topography; 2) Normal faulting; 3) Low angle thrust faulting.

ANSWER: 1 AND 2
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

21) Chemistry – *Short Answer* Esters can be hydrolyzed under acidic conditions to form carboxylic acids and what other functional group?

ANSWER: ALCOHOL

BONUS

21) Chemistry – *Multiple Choice* For which of the following gas-phase reactions is the change in enthalpy the same as the change in internal energy?

W) Dissociation of water vapor to form hydrogen and oxygen gas
X) Formation of ammonia from hydrogen and nitrogen gas
Y) Hydrogenation of ethene to form ethane
Z) Formation of carbon dioxide and hydrogen gas from water vapor and carbon monoxide

ANSWER: Z) FORMATION OF CARBON DIOXIDE AND HYDROGEN GAS FROM WATER VAPOR AND CARBON MONOXIDE

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

22) Biology – *Short Answer* PYY is a hormone that suppresses the action of what hormone released by the walls of the stomach to increase hunger?

ANSWER: GHRELIN

BONUS

22) Biology – *Short Answer* What two monomers collectively compose the polysaccharide peptidoglycan?

ANSWER: N-ACETYLMURAMIC ACID AND N-ACETYLGLUCOSAMINE (ACCEPT: NAM AND NAG)
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

23) Physics – *Short Answer* Suppose a charged particle moves with an initial velocity neither parallel nor perpendicular to a uniform magnetic field. What type of curve will be traced out by its resultant motion?

ANSWER: HELICAL

BONUS

23) Physics – *Short Answer* Identify all of the following three statements that are true regarding statistical mechanics: 1) All microstates have equal probability of being occupied: 2) Entropy is proportional to the natural log of the number of microstates; 3) Canonical ensembles have a fixed number of particles.

ANSWER: ALL