SBL FALL QUARTERFINALS

TOSS-UP

1) Chemistry – *Multiple Choice* Which of the following compounds is not correctly matched with its structure?

W) Steel, amorphous
X) Glass, amorphous
Y) Table salt, crystalline
Z) Pyrite, crystalline

ANSWER: W) STEEL, AMORPHOUS [TZ]

BONUS

1) Chemistry – *Short Answer* Order the following 3 amino acids from closest to farthest from the starting point of a paper chromatography experiment with a mobile front of 70-30 methanol-water: 1) Phenylalanine, 2) Glutamate, 3) Glycine

ANSWER: 2, 3, 1 [TZ]

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

TOSS-UP

2) Biology – *Multiple Choice* [4] In a bottom-up model of an ecosystem, sharks eat humans, humans eat dogs, and dogs eat mustard plants. If you wished to increase the dog population, which of the following actions would have the LARGEST impact?

W) Adding sharks
X) Removing humans
Y) Adding mustard plants
Z) Removing both humans and mustard plants

ANSWER: Y) ADDING MUSTARD PLANTS [Ecology - Ecosystem, SF]

BONUS

2) Biology – *Short Answer* [8] Which specific cells in the retina are responsible for minimizing the free diffraction of light striking the retina and are the most common glial cells in the eye?

ANSWER: MULLER CELLS [Animal Physiology - Nervous Systems, SF]
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

3) Earth and Space – *Short Answer* [5] Order the following three gases from least to most abundant in the Martian atmosphere: 1) Methane; 2) Nitrogen; 3) Carbon dioxide.

ANSWER: 1, 2, 3 [SF]

BONUS

3) Earth and Space – *Short Answer* [3] Order the following three events chronologically in Earth's history: 1) First flowering plants; 2) First land mammals; 3) Largest mass extinction in history.

ANSWER: 2, 3, 1 [Other - Geo time scale, SF]

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

TOSS-UP

4) Math – *Short Answer* [4] What is the maximum number of acute angles in a convex octagon?

ANSWER: 3 [CT]

BONUS

4) Math – *Short Answer* [4] In right triangle ABC, leg AB is 3 and leg BC is 4. Let X be the incenter of triangle ABC. What is the measure of angle BAX?

ANSWER: 45 [CT]
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

5) Energy – *Multiple Choice* [?] Researchers at Pacific Northwest National Lab have been studying the physiological effects of ketone bodies in the bloodstream. When ketogenesis occurs in the liver, which of the following processes would you also expect to be occurring in the liver?

W) Glycogenesis
X) Gluconeogenesis
Y) Urea Cycle
Z) Fatty acid synthesis

ANSWER: X) GLUCONEOGENESIS [DJ]

BONUS

5) Energy – *Short Answer* [5] Scientists at Pacific National Lab have studied the propagation of uranium compounds in the environment. A common oxycation of uranium, the uranyl ion, has a chemical formula of UO_2^{2+}. What is the bond order of the uranium-oxygen bond in the uranyl cation?

ANSWER: 3 [Chem, YL]

~~~~~~

TOSS-UP

6) Physics – *Short Answer* What is the beat frequency when a sound wave of frequency 200 Hz and a sound wave of frequency 250 Hz are played simultaneously?

ANSWER: 50 Hz [TZ]

BONUS

6) Physics – *Short Answer* [6] A 2 microcoulomb charge is placed 3 centimeters away from an infinite conducting sheet. To the nearest whole number, how many newtons of force does it experience?

Commented [1]: doesn't this need like charge density

ANSWER: 10 [Electrostatics, DK]
~~~~~~

TOSS-UP

7) Earth and Space – *Short Answer* [8] The Penrose process proposes the extraction of energy from a rotating black hole in what region where any object is dragged by a rotating spacetime?

ANSWER: ERGOSPHERE [Astronomy - Other, SF]

BONUS

7) Earth and Space – *Short Answer* [8] Identify all of the following 3 climate feedbacks that are positive feedback loops: 1) Carbonate-silicate-weathering feedback; 2) Snow-ice-albedo feedback; 3) Water-vapor-temperature feedback.

ANSWER: 2 AND 3 [Meteorology, YL]

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

TOSS-UP

8) Biology – *Short Answer* [9] Identify all of the following three neurotransmitters that are generally inhibitory: 1) GABA; 2) Glycine; 3) Glutamate.

ANSWER: 1 AND 2 [Animal Physiology - Nervous Systems, SF]

BONUS

8) Biology – *Short Answer* [7] Identify all of the following three techniques that primarily serve to model protein secondary structure: 1) Edman degradation; 2) De-Novo synthesis using primer; 3) Circular dichroism spectroscopy.

ANSWER: 3 ONLY [Biochemistry - Protein Structure, SF]
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

9) Energy – *Short Answer* Researchers at Brookhaven National Lab have been studying the asymmetric alkylations of enolates. These reactions are considered asymmetric because they generate a stereocenter. IUPAC uses what convention of naming for these stereocenters that denotes them as R or S?

ANSWER: CAHN INGOLD PRELOG (ACCEPT: CIP) [DJ]

BONUS

9) Energy – *Short Answer* Researchers at Brookhaven National Lab have been measuring the rates of diffusion through cell membranes to aid in the development of drug delivery. Which of the following scenarios best increases the fluidity of a cellular membrane?

W) An increase in temperature
X) A decrease in the length of the alkyl chains in the lipid bilayer
Y) An increase in the percentage of saturated fatty acids in the lipid bilayer
Z) An increase in the rate of transverse diffusion of lipids

ANSWER: Y) AN INCREASE IN THE PERCENTAGE OF SATURATED FATTY ACIDS IN THE LIPID BILAYER [DJ]

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

TOSS-UP

10) Math – *Short Answer* [6] A tree has 2020 vertices. What is the maximum number of edges that it could have?

ANSWER: 2019 [Com - Graph, CT]

BONUS

10) Math – *Short Answer* [6] A computer prints the integers from 100 to 999 inclusive. What is the arithmetic mean of all 2700 digits that it printed?

ANSWER: 14/3 [CT]
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

11) Chemistry – *Short Answer* [5] How many stereoisomers exist for a molecule with 6 chiral centers?

ANSWER: 64 [PJ]

BONUS

11) Chemistry – *Short Answer* Identify all of the following three compounds whose phase diagrams have a positively-sloped liquid-solid phase boundary: 1) Argon; 2) Carbon dioxide; 3) Water.

ANSWER: 1 AND 2 [CK]

~~~~~~

TOSS-UP

12) Physics – *Short Answer* What is the energy stored in a capacitor with a capacitance of 10 farads and a voltage of 6 volts?

ANSWER: 180 JOULES [TZ]

BONUS

12) Physics – *Multiple Choice* [4] Which of the following is most accurate for objects moving close to the speed of light?

W) Energy is proportional to momentum
X) Energy is proportional to the square of momentum
Y) Energy approaches a constant
Z) Momentum approaches a constant

ANSWER: W) ENERGY IS PROPORTIONAL TO MOMENTUM [SR, DK]
~~~~~~

TOSS-UP

13) Biology – *Short Answer* [] Uncoupling proteins are commonly found in what type of connective tissue to promote the production of heat in the mitochondria?

ANSWER: BROWN ADIPOSE TISSUE [Animal Physiology - Tissues, SF]

BONUS

13) Biology – *Short Answer* [] Identify all of the following three statements regarding hemoglobin that are true: 1) It has an increased affinity for oxygen in the R state; 2) It possesses a Hill coefficient of more than one; 3) Fetal hemoglobin has an increased affinity for 2,3 BPG when compared to adult hemoglobin.

ANSWER: ALL [Biochemistry - Proteins, SF]

~~~~~~

TOSS-UP

14) Math – *Multiple Choice* [5] A basis for R cubed consists of 3 vectors. Which of the following statements must be true about these vectors?

W) They are pairwise independent
X) They are all parallel
Y) They are pairwise orthonormal
Z) They are pairwise orthogonal

ANSWER: W) THEY ARE PAIRWISE INDEPENDENT [Alg - Vec, CT]

BONUS

14) Math – *Short Answer* [5] 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 [CT]
~~~~~~

TOSS-UP

15) Earth and Space – *Short Answer* [3] Given that T and R stand for temperature and radius respectively, order the following three stars in terms of increasing luminosity: 1) A star with temperature T and radius R; 2) A star with temperature 2T and radius R/2; 3) A star with temperature T/4 and radius 4R.

ANSWER: 3, 1, 2 [SF]

BONUS

15) Earth and Space – *Short Answer* [7] Identify all of the following three statements regarding the Friedmann 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 [SF]

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

TOSS-UP

16) Physics – *Multiple Choice* [5] Which of the following pairs of statements are true of the tension in a hanging chain?
W) Both vertical and horizontal tension are constant
X) Vertical tension is constant, horizontal tension is highest at the center
Y) Vertical tension is highest at the center, horizontal tension is constant
Z) Both vertical and horizontal tension are highest at the center

ANSWER: Y) Vertical tension is highest at the center, horizontal tension is constant [Mech, DK]

BONUS

16) Physics – *Short Answer* What principle states that every point on a wavefront can be modeled as the source of spherical wavelets?

ANSWER: HUYGENS PRINCIPLE (ACCEPT: HUYGENS-FRESNEL PRINCIPLE) [TZ]
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

17) Energy – *Multiple Choice* Researchers at Los Alamos National Lab are studying the Earth's interior. Which of the following marks the boundary between the mantle and the outer core?
W) Moho Discontinuity
X) Gutenberg Discontinuity
Y) Lehmann Discontinuity
Z) D'' (**D-double-prime**) layer

ANSWER: X) Gutenberg Discontinuity [TZ]

BONUS

17) Energy – *Short Answer* Researchers at Brookhaven National Lab are synthesizing large single crystals for neutron scattering experiments. One method of determining crystal structures is Bragg diffraction, where incident X-rays on a crystal cause the electronic cloud to move. This causes what phenomenon, where light is scattered by particles smaller than its wavelength?

ANSWER: RAYLEIGH SCATTERING (ACCEPT: ELASTIC SCATTERING) [TZ]

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

TOSS-UP

18) Chemistry – *Multiple Choice* Which of the following reagents is most suitable for converting aldehydes into secondary alcohols?

W) Phenyllithium
X) Boron trihydride
Y) Lithium aluminum hydride
Z) Hydrogen peroxide

ANSWER: W) PHENYLLITHIUM [CK]

BONUS

18) Chemistry – *Short Answer* What is the term given to the region produced in infrared spectroscopy in which compounds create characteristic patterns that can be used to identify them?

ANSWER: FINGERPRINT REGION [CK]
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

19) Biology – *Short Answer* From what amino acid is serotonin derived?

ANSWER: TRYPTOPHAN [SF]

BONUS

19) Biology – *Short Answer* [7] Identify all of the following three statements that are true of the endocrine system: 1) ACTH is a tropic hormone; 2) Parathyroid hormone is released when blood calcium levels are high; 3) Diabetes insipidus is due to a lack in oxytocin secretion.

ANSWER: 1 ONLY [Animal Physiology - Misc, SF]

~~~~~~

TOSS-UP

20) Math – *Short Answer* [5] How many terms are in the binomial expansion of open parentheses $x^2 + xy + y^2$ close parentheses squared?

ANSWER: 5 [CT]

BONUS

20) Math – *Short Answer* [4] How many ways are there to choose 3 vertices of a regular octagon so that they form a right triangle?

ANSWER: 24 [CT]
~~~~~~

TOSS-UP

21) Earth and Space – *Short Answer* [6] What group of greenish phyllosilicate minerals are formed from the low grade metamorphism of mafic rock?

ANSWER: CHLORITE GROUP [Geology - Minerals; YL]

BONUS

21) 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

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

ANSWER: MORSE POTENTIAL [CK]

BONUS

22) Chemistry – *Short Answer* What is the oxidation state of the carbon atom in methanol?

ANSWER: -2 [DJ]
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

TOSS-UP

23) Physics – *Multiple Choice* [5] Soap bubbles appear to have iridescent, rainbow-colored appearances. This occurs due to the varying effects of what optical phenomenon at different wavelengths?
W) Emission
X) Absorption
Y) Refraction
Z) Interference

ANSWER: Z) INTERFERENCE [Optics, 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

ANSWER: 2 AND 3 [Particle, DK]

~~~~~~

TOSS-UP

Chemistry – *Short Answer* [5] In a hypothetical reaction, one molecule of A decomposes into two molecules of B in a zeroth order reaction. Identify all of the following 3 statements that are true of this reaction: 1) The half life of the reaction increases over time; 2) Plotting concentration of molecule A over time yields a straight line; 3) The reciprocal of the reaction rate increases linearly with respect to temperature.

ANSWER: 2 ONLY[CT]

BONUS

Chemistry – *Short Answer* What is the oxidation state of the carbon atom in methanol?

ANSWER: -2 [DJ]

~~~~~~

TOSS-UP

Chemistry – *Multiple Choice* [4] Which of the following solvents would NOT favor the SN2 mechanism over the SN1 mechanism?

W) Acetonitrile
X) DMSO
Y) Water
Z) Acetone

ANSWER: Y) WATER

BONUS

Chemistry – *Multiple Choice* [4]