SBL FALL FINALS 1

TOSS-UP

1) Math – *Short Answer* [7] What is the divergence of the vector field $f(x, y, z) = xy\ \mathrm{i} + yz\ \mathrm{j} + xz\ \mathrm{k}$?

ANSWER: $x + y + z$ [Calc - Vec, CT]

BONUS

1) Math – *Short Answer* [8] What is the largest positive integer x such that $x^2 + 7x + 41$ is a perfect square?

ANSWER: 25 [NT - idk, CT]

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TOSS-UP

2) Earth and Space – *Multiple Choice* Which of the following igneous rocks is not correctly paired with its composition?

W) Granite, felsic
X) Andesite, intermediate
Y) Rhyolite, mafic
Z) Komatiite, ultramafic

ANSWER: Y) RHYOLITE, MAFIC [TZ]

BONUS

2) Earth and Space – *Short Answer* [7] What mecha nism, 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]
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TOSS-UP

3) Physics – *Short Answer* To two significant figures, and in scientific notation, what is the De Broglie wavelength of an object with a mass of 3 kg moving at a velocity of 4 m/s.

ANSWER: 5.5*10^-35 m [TZ]

BONUS

3) Physics – *Multiple Choice* [7] A particle with its spin in the same direction as its motion is said to be which of the following?

W) spin-up

X) spin-down

Y) left-handed

Z) right-handed

ANSWER: Z) RIGHT-HANDED [Particle, DK]

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TOSS-UP

4) Biology – *Short Answer* What extracellular matrix glycoprotein binds to cell-surface receptor proteins and plays a role in intercellular adhesion ?

ANSWER: FIBRONECTIN [SF]

BONUS

4) Biology – *Short Answer* What term is given to animals which develop embryo within the body of a parent

ANSWER: VIVIPARITY [SF]
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TOSS-UP

5) Chemistry – Short Answer What is the value of the radial distribution function of a 1s orbital at r = 0?

ANSWER: 0 [AS]

BONUS

5) Chemistry – *Multiple Choice* 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?

W) Thixotropy
X) Anisotropy
Y) Rheopexy
Z) Isotropy

ANSWER: W) THIXOTROPY [TZ]

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TOSS-UP

6) Energy – *Short Answer* Researchers at Brookhaven National Lab have begun building a quantum-enhanced x-ray microscope. The microscope will split an x-ray beam into two different streams, with one stream hitting a molecular sample and the other hitting a detector. What quantum mechanical phenomenon will the researchers use to figure out the structure of the sample?

ANSWER: QUANTUM ENTANGLEMENT [AS]

BONUS

6) Energy – *Short Answer* Researchers at Pacific Northwest national lab are studying speciation. What type of speciation occurs when two geographically adjacent populations of a species develop reproductive isolation from each other?

ANSWER: PARAPATRIC [TZ]

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TOSS-UP

7) Biology – *Short Answer* Elevated levels of glucagon normally stimulate which of the following biological pathways?

W) Glycolysis
X) Glycogenesis
Y) Pentose Phosphate Pathway
Z) Glycogenolysis

ANSWER: Z) GLYCOGENOLYSIS [DJ]

BONUS

7) Biology – *Short Answer* Identify all of the following 3 molecules that are intermediates in the urea cycle: 1) HMG-CoA; 2) Ornithine; 3) Succinate.

ANSWER: 2 ONLY [DJ]

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TOSS-UP

8) Earth and Space – *Short Answer* [4] What is the most massive galaxy in the Local Group?

ANSWER: ANDROMEDA GALAXY [Astronomy - Astrophysics, YL]

BONUS

8) Earth and Space – *Short Answer* [7] 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 – *Multiple Choice* The Stern-Gerlach experiment revealed electrons' property of spin. What paramagnetic atom was used in this experiment?

ANSWER: SILVER [AS]

BONUS

9) Chemistry – *Short Answer* Identify all of the following 3 molecules that have E/Z stereoisomers: 1) Acetylene; 2) Isobutylene; 3) Formaldehyde.

ANSWER: NONE [DJ]

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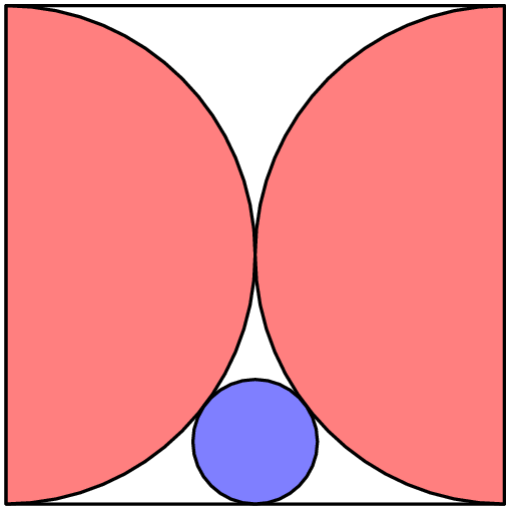
TOSS-UP

10) Math – *Short Answer* [7] If $x + 1$ over x equals 9, what is $x^2 + 1$ over x^2?

ANSWER: 79 [Alg - LinSys, CT]

VISUAL BONUS

10) Math – *Short Answer* [7] Shown in the image is a unit square with red semicircles of radius 0.5 centered on opposite midpoints. A blue circle is tangent to both semicircles and the square. What is the radius of the blue circle?



ANSWER: 1/8 [Geo - Circ, CT]
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TOSS-UP

11) Energy – *Short Answer* Scientists at Lawrence Berkeley National Lab have been studying the methyl transferases for the post translational modification of other proteins. Which of the following metabolites is a major donor of methyl groups?

W) Porphyrin
X) Glutathione
Y) SAM
Z) Melanin

ANSWER: Y) SAM [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 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* [6] Which of the following can be placed in parallel with a motor in an AC circuit to increase the real power delivered to it?
W) Capacitor
X) Inductor
Y) Resistor
Z) Rectifier

ANSWER: W) CAPACITOR [Circuits, DK]

BONUS

12) Physics – *Short Answer* Two identical blocks, A and B, each have an edge length of 8 cm and a density of 100 kg/m^3. Block A is placed in a container with water of density 1000 kg/m^3, while Block B is placed in an identical container with ethanol of density 800 kg/m^3. In cubic cm, how much more of Block B is submerged in the liquid than Block A?

ANSWER: 12.8 (ACCEPT: 64/5) [CK]
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TOSS-UP

13) Chemistry – *Short Answer* What olefination in organic chemistry uses a phosphorus ylide to generate alkenes from carbonyl species?

ANSWER: WITTIG ***(read: VIT-ig)*** [DJ]

BONUS

13) Chemistry – *Short Answer* Identify all of the following 3 statements that are generally true of high-spin complexes: 1) They favor trigonal planar molecular geometries; 2) The order of electron filling follows Hund's rules; 3) They have a large crystal field splitting energy.

ANSWER: 2 ONLY [CT]

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TOSS-UP

14) Biology – *Short Answer* What term describes the amount of air that moves in and out of the lungs during a normal breath?

ANSWER: TIDAL VOLUME [DJ]

BONUS

14) Biology – *Short Answer* Encounters with pathogens in the hemolymph cause hemocytes to secrete what type of molecule that inactivates or kills fungi and bacteria by disrupting their plasma membranes.

ANSWER: ANTIMICROBIAL PEPTIDES [DJ]
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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, CT]

BONUS

15) Math – *Short Answer* [7] Alice is standing on the x-axis at $x = 1$. Every second, she flips a coin; if it's heads, she moves one unit to the right. Otherwise, she moves one unit to the left. What is the probability that she first reaches $x = 3$ before reaching $x = 0$?

ANSWER: 1/3 [Com - idk, CT]

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TOSS-UP

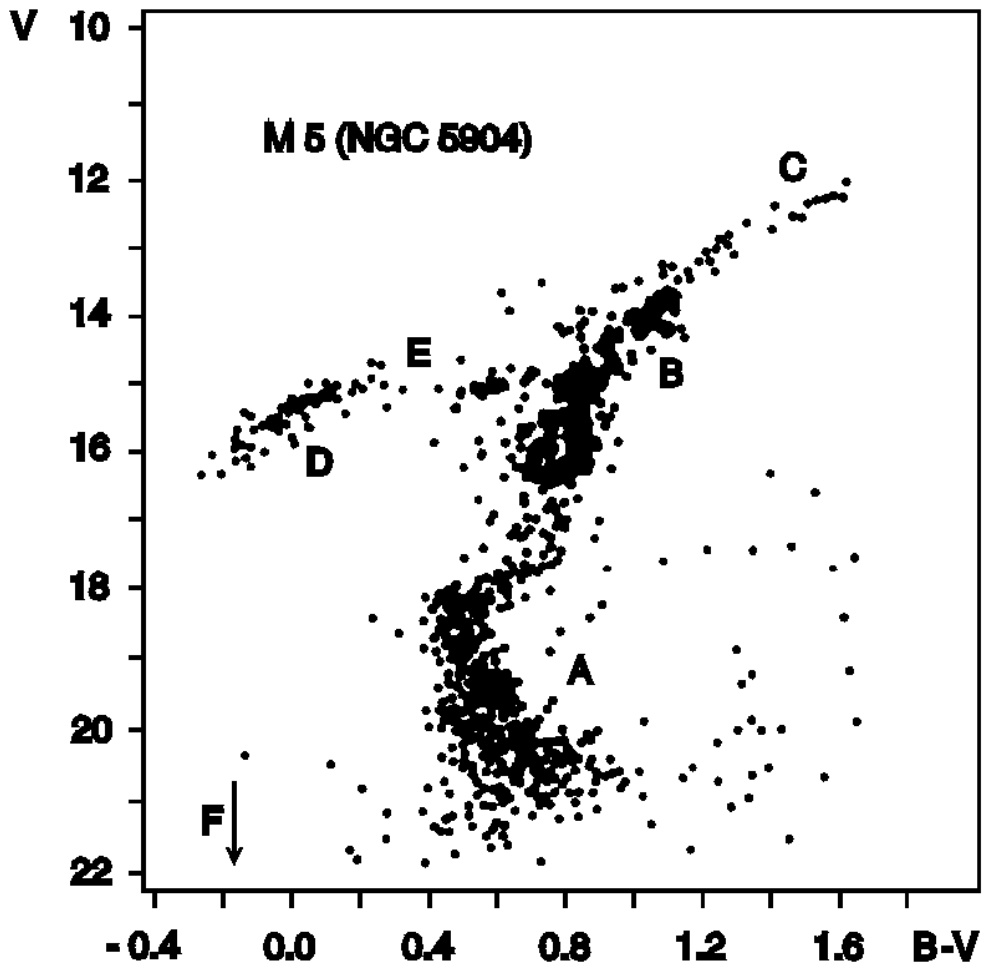
16) Earth and Space – *Multiple Choice* [6] The catastrophic collision hypothesis suggests that a large celestial body may have collided with Earth to create the Moon. Which of the following is not evidence in support of this hypothesis?

W) Lunar rocks have an average density similar to that of the Earth's mantle and crust
X) Lunar rocks have composition similar to that of Earth's mantle
Y) The Moon has a higher density than Earth
Z) Lunar rocks have revealed that the lunar surface was once molten

ANSWER: Y) THE MOON HAS A HIGHER DENSITY THAN THE EARTH [AS]

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 – *Short Answer* Scientists at Brookhaven National Lab are studying the synthetic applications of the Staudinger amine synthesis that goes through an azide intermediate. What molecule acts as the leaving group in order to generate the amine?

ANSWER: N_2 (ACCEPT: NITROGEN) [DJ]

BONUS

17) Energy – *Short Answer* Researchers at Argonne National Lab have been studying the drug Remdesivir, a drug that has been heavily researched in its effects to combat Covid-19. The drug Remdesivir is a sugar based drug that has an amino acid derivative with an R group of a methyl group attached to it. What amino acid would the drug most likely be derived from?

ANSWER: ALANINE [DJ]

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TOSS-UP

18) Physics – *Short Answer* What unsolved problem describes the unequal amount of matter and antimatter produced by the Big Bang?

ANSWER: BARYON ASYMMETRY [ACCEPT: MATTER ASYMMETRY; MATTER-ANTIMATTER ASYMMETRY] [TZ]

BONUS

18) Physics – *Short Answer* A plane is flying at a supersonic speed, creating a shock wave with a vertex angle of 60 degrees. To the nearest 100 m/s, what is the speed of the plane?

ANSWER: 700 [CK]
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TOSS-UP

19) Math – *Short Answer* [6] A 10 meter ladder is leaning against a wall. It starts slipping so that its top end slides down the wall and its bottom end slides out along the ground. At a certain time *t*, the speeds of the top and bottom ends are equal. At that point, what is the height of the top end?

ANSWER: 5 ROOT 2 [Calc - Der, CT]

BONUS

19) Math – *Short Answer* [6] What is the sum of the reciprocals of the roots of the polynomial $f(x)$ equals $x^3 + 12x^2 + 17x - 36$?

ANSWER: 17/36 [Alg - Poly, CT]

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TOSS-UP

20) Earth and Space – *Multiple Choice* [9] The internal heat of Jupiter and Saturn is generated mostly through what mechanism?

W) Radioactive decay
X) Kelvin-Helmholtz mechanism
Y) Deuterium fusion
Z) Triple alpha process

ANSWER: X) KELVIN-HELMHOLTZ MECHANISM [Astronomy - Solar System, YL]

BONUS

20) Earth and Space – *Short Answer* [7] Identify all of the following three statements that are true regarding travertine deposits: 1) They are associated with hot springs because carbonate solubility increases with increasing temperature and decreasing pH; 2) The precipitation of carbonates is driven by the degassing of CO2, which raises water pH; 3) Aragonite is more thermodynamically stable than calcite, and is thus preferentially precipitated at lower temperatures.

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

21) Chemistry – *Short Answer* What is the oxidation state of carbon in the oxalate ion?

ANSWER: +3 [AS]

BONUS

21) Chemistry – *Short Answer* Order the following 3 ideal gas samples from least to greatest standard deviation of their Maxwell-Boltzmann distributions: 1) Helium at 500 K; 2) Carbon dioxide at 400 K; 3) Molecular hydrogen at 300 K.

ANSWER: 2, 3, 1

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TOSS-UP

22) Biology – *Short Answer* What condition involves a partial paralysis of the face for up to 6 months,, causing half of the face to appear as if drooping?

ANSWER: BELL'S PALSY [TZ]

BONUS

22) Biology – *Multiple Choice* The chlorophyll molecule consists of a hydrophobic tail which interacts with proteins and a porphyrin ***[read as: PORE-FRIN]***ring which absorbs light. What metal atom is found at the center of porphyrin rings?

W)Manganese
X) Copper
Y) Magnesium
Z) Iron

ANSWER: Y) MAGNESIUM [AS]
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TOSS-UP

23) Physics – *Short Answer* A solid sphere is at rest on a horizontal surface with a small but nonzero amount of friction. It is suddenly given a horizontal speed of 35 m/s. When the sphere stops slipping, what is its speed in m/s?

ANSWER: 25 [CK]

BONUS

23) Physics – *Short Answer* Photon A is emitted from an electron in a hydrogen atom dropping from the $n = 3$ level to the $n = 1$ level. Photon B is emitted from an electron in a hydrogen atom dropping from the $n = 3$ level to the $n = 2$ level. What is the ratio of the frequency of photons A to the frequency of photon B?

ANSWER: 32/27 [CK]