TOSS-UP

1) Physics – *Multiple Choice* Which of the following shapes best describes the trajectory of an undamped oscillator through phase space?

W) Spiral
X) Circle
Y) Ellipse
Z) Line

ANSWER: Y) ELLIPSE [GW, SHO]

BONUS

1) Physics – *Short Answer* A system consists of 2 identical particles, each taking one of 4 equally likely states. In terms of Boltzmann's constant k, how much is the entropy of the system increased by if 7 more particles are added?

ANSWER: k ln(12) (accept k log(12), don't be a little bitch) [LY, statmech]

TOSS-UP

2) Biology – *Multiple Choice* Which of the following continental coasts do NOT contain a significant chaparral biome where most plant life is dominated by shrubs and small trees?

W) North coast of Africa
X) South coast of South Africa
Y) East coast of Australia
Z) West coast of America

ANSWER: Y) EAST COAST OF AUSTRALIA [JH, GEOGUESSR]

BONUS

2) Biology – *Short Answer* Identify all of the following 3 post-translational modifications that are considered prenylations: 1) Geranylgeranylation; 2) Myristoylation; 3) Farnesylation

ANSWER: 1 AND 3 [DJ, CRINGE]

TOSS-UP

3) Math – *Short Answer* Jonathan flips a coin 4 times. What is the probability he flips at least 3 heads in a row?

ANSWER: 3/16 [LY, coins]

BONUS

3) Math – *Short Answer* What is the line integral of $x^2 + y^2$ over the line segment with endpoints at (3, 0) and (0, 3)?

ANSWER: 18 ROOT 2 [LY, INTEGRAL]

TOSS-UP

4) Earth and Space – *Multiple Choice* According to the Rayleigh criterion, just resolution between two point sources A and B occurs when which of the following is true about their Airy disks?

W) A's principal maximum coincides with B's principal maximum
X) A's principal maximum coincides with B's first minimum
Y) A's principal maximum coincides with B's second maximum
Z) A's principal maximum coincides with B's second minimum

ANSWER: X) A'S PRINCIPAL MAXIMUM COINCIDES WITH B'S FIRST MINIMUM [JH, 8.03]

BONUS

4) Earth and Space – *Short Answer* The image shown is the Schwarzchild metric in Schwarzschild coordinates. Answer the following two questions about the Schwarzchild metric: 1) What Lorentz scalar quantity does the letter tau represent? 2) What is the analogous metric for a rotating and charged black hole?

$$g = -c^2\,d\tau^2 = -\left(1 - \frac{r_\mathrm{s}}{r}\right)c^2\,dt^2 + \left(1 - \frac{r_\mathrm{s}}{r}\right)^{-1}dr^2 + r^2 g_\Omega,$$

ANSWER: 1) PROPER TIME (DO NOT ACCEPT: TIME); 2) KERR-NEWMAN [JH, STOCK]

TOSS-UP

5) Chemistry – *Multiple Choice* Which of the following aromatic molecules is most reactive towards nucleophilic aromatic substitution?

W) Toluene
X) Nitrobenzene
Y) p-fluorotoluene

Z) p-fluoronitrobenzene

ANSWER: Z) P-FLUORONITROBENZENE [BZ, orgo]

BONUS

5) Chemistry – *Short Answer* In the balanced chemical reaction of dichromic acid with carbon monoxide, how many net water molecules are produced per dichromate consumed?

ANSWER: 6 [BZ, electro]

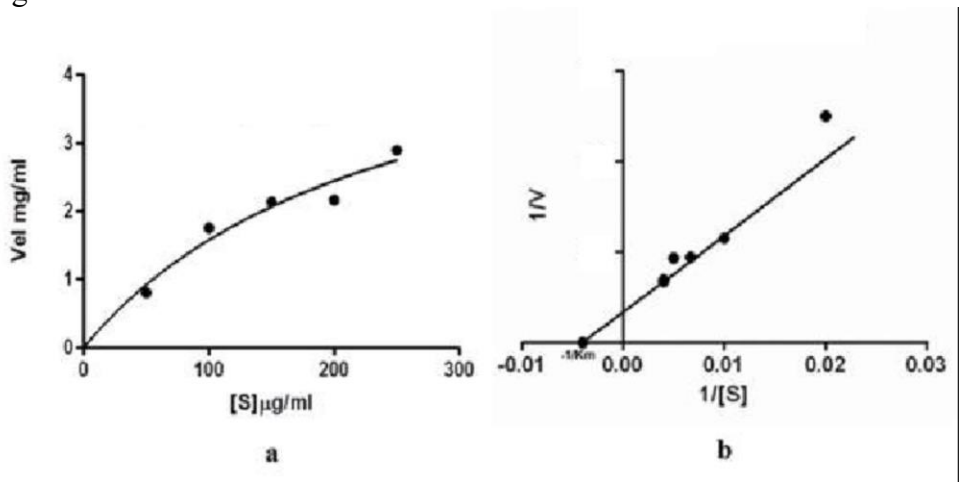
TOSS-UP

6) Energy – *Short Answer* Researchers go tip tap on their keyboards, calling reduce to find the product of all of the elements in an array of integers. Write an appropriate lambda function for this task that takes in the two arguments (previous, current) ***[previous comma current]***.

ANSWER: PREVIOUS * CURRENT (ACCEPT ANY ANSWERS THAT CONTAIN THE PRODUCT OF THE TWO ARGUMENTS; ACCEPT: CURRENT * PREVIOUS) [DJ/GW, JOY]

VISHWAL BONUS

6) Energy – *Short Answer* Researchers do love researching ya? Especially enzymes. Answer the following 2 questions regarding the image below: 1) What is the name of these two graphs?; 2) Given that Km is 250 and Vmax is 5. What is the y-intercept of graph B to 1 significant figure?



ANSWER: 1) MICHAELIS MENTEN AND LINEWEAVER BURK; 2) 0.2 [DJ, MORE CRINGE ASS ENZYMES]

TOSS-UP

7) Physics – *Short Answer* Identify all of the following 3 particles that could be Weyl fermions: 1) Electron; 2) Up quark; 3) Electron neutrino.

ANSWER: NONE [GW, Particle]

BONUS

7) Physics – *Short Answer* A sample of diatomic oxygen gas and a sample of ammonia gas have the same pressure and density. What is the ratio of the speed of sound in the oxygen gas to the ammonia?

ANSWER: ROOT 5 OVER 2 [GW, Waves]

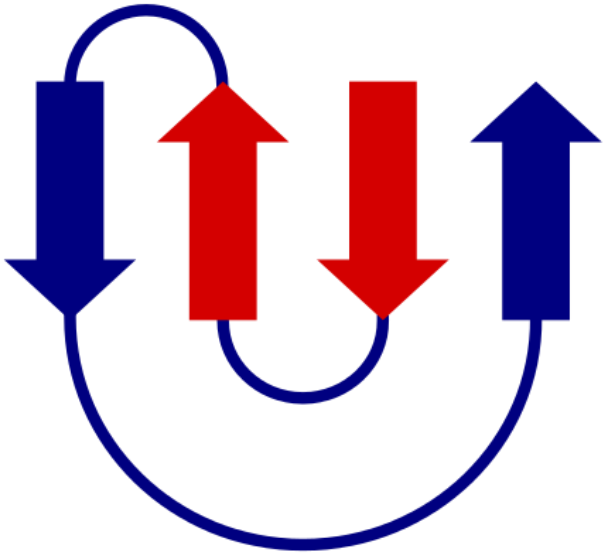
TOSS-UP

8) Biology – *Short Answer* Identify all of the following three ions whose concentration in guard cells increases during stomatal opening: 1) H^+; 2) K^+; 3) Cl^-

ANSWER: 2 AND 3 [JH, PLANT]

VISHWAL BONUS

8) Biology – *Short Answer* Answer the following 2 questions regarding the image shown below: 1) What is the motif shown below?; 2) How many beta sheets and alpha helices are in this motif?



ANSWER: GREEK KEY AND 4, 0 [DJ, MOTIFS]

TOSS-UP

9) Math – *Short Answer* Identify all of the following 3 functions that are Lipschitz continuous on the nonnegative reals: 1) square root of x; 2) sine of x^2; 3) 1 over quantity $x + 1$.

ANSWER: 3 ONLY [LY, anal]

BONUS

9) Math – *Short Answer* Alice is playing a game on the number line. She starts at $x = 0$ and, every second, she flips a coin. If it's heads, she moves to the right by 2 units. Otherwise, she moves to the right by 1 unit. What's the probability that she first reaches or passes $x = 10$ after exactly six flips?

ANSWER: 5/16 [LY, PROB]

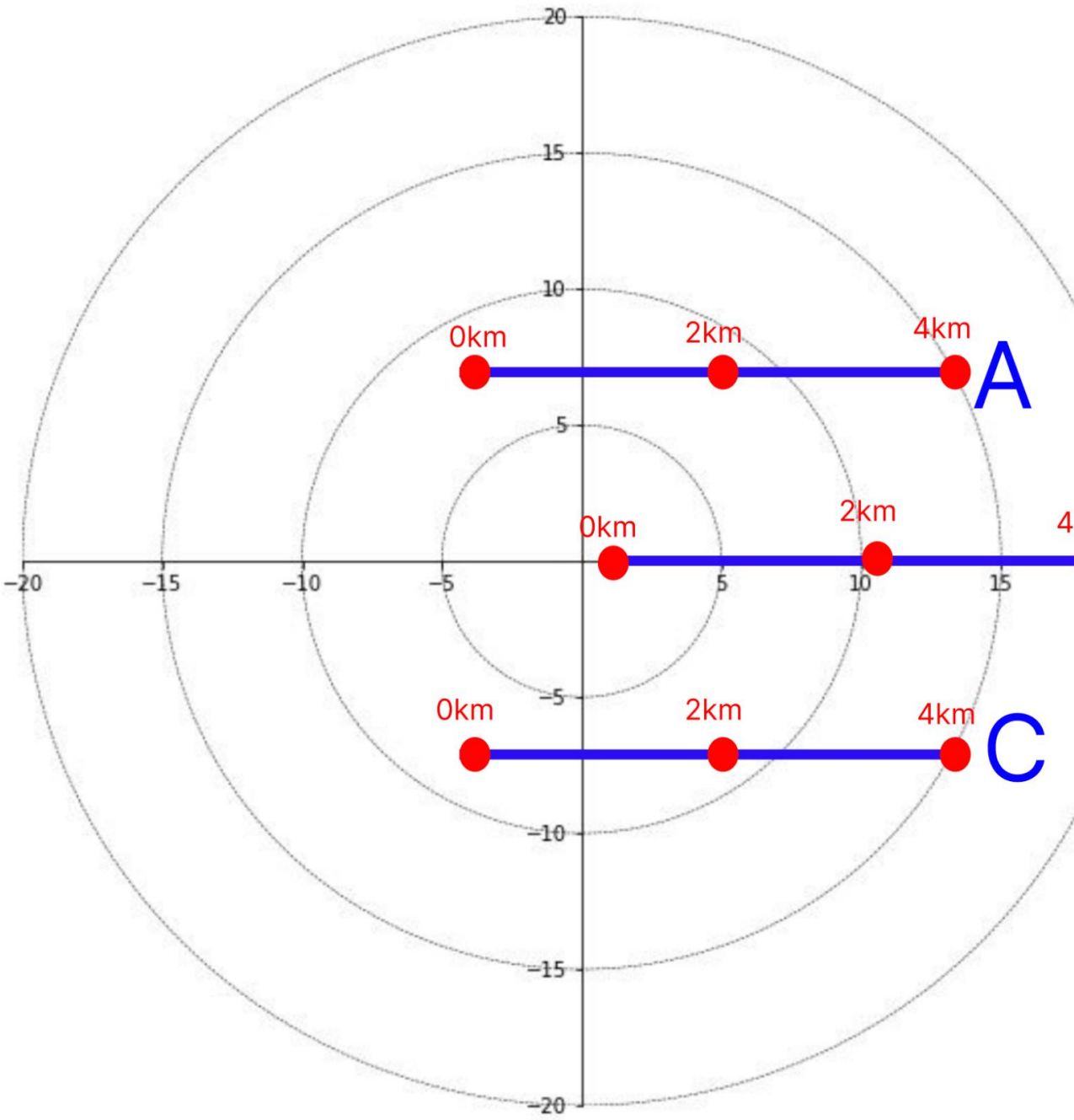
TOSS-UP

10) Earth and Space – *Multiple Choice* Which of the following does NOT correctly match a mineral with its primary constituent element?

W) Sphalerite and zinc
X) Cinnabar and mercury
Y) Gypsum and magnesium
Z) Cassiterite and tin

ANSWER: Y) GYPSUM AND MAGNESIUM [LY, R7]

VISUAL BONUS



10) Earth and Space – *Short Answer* Shown in the image are 3 vertical wind profiles A, B, and C plotted on the same hodograph. Use them to answer the following 2 questions:

I) Which profile of A, B, or C is the most likely to generate a supercell thunderstorm?
II) Identify the type of thermal advection, if present, for each wind profile.

ANSWER: I) A; II) WARM ADVECTION, NO ADVECTION, COLD ADVECTION FOR A, B, C [JY, soft as air]

TOSS-UP

11) Chemistry – *Multiple Choice* The active IR and Raman vibrational modes in a molecule are mutually exclusive if they possess which of the following symmetry operations?

W) C_2
X) E
Y) S
Z) i

ANSWER: Z) i [BZ, inorgo]

BONUS

11) Chemistry – *Short Answer* Rank the following 3 molecules in order of increasing rotational energy in the first excited state according to the rigid rotor model: 1) Hydrogen; 2) Nitrogen; 3) Fluorine.

ANSWER: 2, 3, 1 [BZ, quantum]