Winter Science Bowl Tournament 2022-2023

Playoff Round 8

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TOSS-UP

1) Biology – *Short Answer* Identify all of the following 3 statements that are correct regarding a culture that has been gram-stained red.

1) Their cell membrane is composed primarily of peptidoglycan;
2) Their cell wall contains a barrier primarily of lipopolysaccharides;
3) A peptidoglycan layer exists between the cell wall and membrane.

ANSWER: 2 and 3

BONUS

1) Biology - *Short Answer* What hormone, stored in the corpora cardiaca of insects, regulates insect development and metamorphosis?

ANSWER: PTTH (ACCEPT: Prothoracicotropic hormone)

TOSS-UP

2) Earth and Space – *Short Answer* What process involving water molecules was the first to increase the concentration of molecular oxygen in Earth's atmosphere?

ANSWER: PHOTODISSOCIATION [3, METEO]
Rishabh

BONUS

2) Earth and Space – *Multiple Choice* Which of the following statements is most accurate regarding hydrothermal vents?

W) Black smokers are often farther from their heat source than white smokers
X) Most hydrothermal vents remain active for hundreds of years
Y) Black smokers are only found in the abyssal zone
Z) Black smokers mostly emit sulfide minerals

ANSWER: Z) BLACK SMOKERS MOSTLY EMIT SULFIDE MINERALS [3, GEO] Tony

TOSS-UP

3) Math – *Short Answer* Let f(x) be equal to $x - \lfloor x \rfloor$, i.e. the fractional part of x. For example, $f(5.2) = 0.2$. If $y = \frac{1+\sqrt{5}}{2}$, determine the value of $y \cdot f(y)$.

ANSWER: 1

BONUS

3) Math – *Short Answer* Evaluate the following: $\Sigma_{x=1}^{\infty} \blacksquare \Sigma_{y=1}^{\infty} \blacksquare \frac{1}{x^2 y^2}$

ANSWER: $\frac{\pi^4}{36}$ [Algebra] <spencerd>

TOSS-UP

4) Physics – *Short Answer* A large particle undergoes decay and splits into two parts, with the larger one being 200 times more massive than the smaller one. If the smaller part is traveling at a speed of $6*10^7$ m/s, what is the speed of the larger part?

ANSWER: $3*10^5$ m/s
Vivek

BONUS

4) Physics – *Short Answer* A circuit is composed of a 12V battery, and two 6F capacitors connected in parallel, connected in series with a 4F capacitor. After a long time, what is the charge stored on one of the 6F capacitors?

ANSWER: 18C
Vivek

TOSS-UP

5) Chemistry – *Multiple Choice* In which of the following compounds is the central atom d^2sp^3 hybridized?

W) PCl_5 (Phosphorus Pentachloride)
X) $XeBr_4$ (Xenon Tetrabromide)
Y) I_3^- (Tri-iodide minus)
Z) BF_4 (Boron Tetrafluoride)

ANSWER: X) $XeBr_4$

BONUS

5) Chemistry – *Short Answer* What chemical technique allows for studying molecules with unpaired electrons, by flipping it between both of its spin orientations?

ANSWER: Electron Paramagnetic Resonance (ACCEPT: EPR)

TOSS-UP

6) Energy – *Short Answer* Lawrence Berkeley Lab cosmologists observe that density inequalities in the early universe were made more uniform via the shift of photons from hot regions of space to cold ones. What process did they observe?

ANSWER: Diffusion damping, Silk damping

BONUS

6) Energy – *Short Answer* Lawrence Berkeley Lab nuclear physicists observe that the mushroom cloud effect is caused by a fluid instability. What type of instability, which is characterized by a lighter fluid pushing a heavier fluid, do they observe?

ANSWER: Rayleigh-Taylor instability

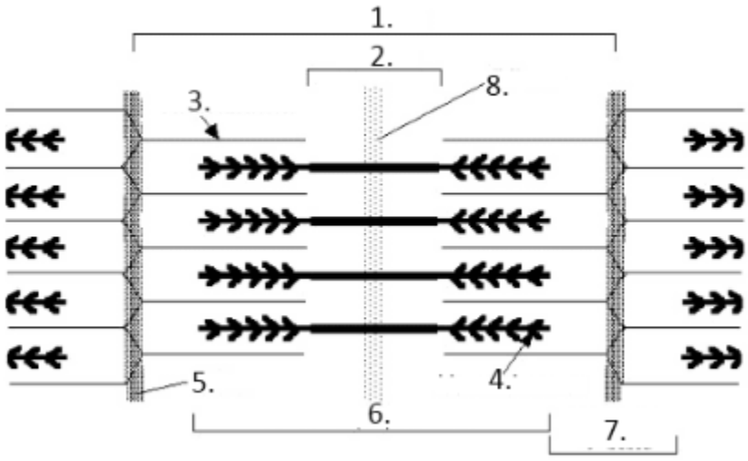
TOSS-UP

7) Biology – *Short Answer* What thought process of protein folding states that it is impossible to determine the three dimensional conformation of a polypeptide from its sequence alone due to the infinite degrees of freedom?

ANSWER: Levinthal's Paradox

VISUAL BONUS

7) Biology – *Short Answer*



Using the image that represents the sarcomere of a striated muscle cell. Answer the following 3 questions.

1) Identify all of the locations that do not shorten during muscle contraction.
2) What are the names for the locations numbered 2, 5, and 7
3) What elastic protein connects the thick filaments to the Z disc

ANSWER:
1) H ZONE, Z LINE/DISC, AND I BAND (DO NOT ACCEPT: H BAND)
2) THICK (4) AND THIN (3) FILAMENTS (ACCEPT: MYOSIN AND ACTIN)
3) TITIN

TOSS-UP

8) Earth and Space – *Short Answer* What astronomer found a discrepancy between observed and theoretical galaxy rotation curves, providing the first evidence of dark matter?

ANSWER: VERA RUBIN (ACCEPT: VERA FLORENCE COOPER RUBIN) [3, SPACE]

BONUS

8) Earth and Space – *Multiple Choice* Which of the following limits is best defined as the maximum radius of a star with a given mass?

W) Chandrasehkar Limit

X) Roche Limit

Y) Eddington Limit

Z) Hayashi Limit

ANSWER: Z) HAYASHI LIMIT

TOSS-UP

9) Math – *Short Answer* Find the closed form of the result when Stirling's approximation is used to approximate 10! **[10 factorial]**.

ANSWER: $\sqrt{20\pi} \cdot (\frac{10}{e})^{10}$ [Calc III] <spencerd>

BONUS

9) Math – *Short Answer* Given that 3 is a primitive root modulo 31, what is the remainder when 3^45 is divided by 31?

ANSWER: 30

TOSS-UP

10) Physics – *Short Answer* What principle states that at high quantum numbers, quantum mechanical systems must resemble classical behaviour?

ANSWER: Correspondence Principle

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BONUS

10) Physics – *Short Answer* A charged particle of spin ½ is placed in a magnetic field with strength 0.2 T. The resulting oscillation has angular frequency 1 rad/s. If the external magnetic field is doubled, what is the new angular frequency?

ANSWER: 2 rad/s

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TOSS-UP

11) Chemistry – *Multiple Choice* Which of the following would a Wittig Reagent be used to produce?

W) Aldehyde

X) Ketone

Y) Alkene

Z) Ether

ANSWER: Y) Alkene

BONUS

11) Chemistry – *Multiple Choice* Which of the following point groups does phosphorus trichloride belong to?

W) C3v

X) D3d

Y) C3h

Z) D3h

ANSWER: W) C3v

TOSS-UP

12) Energy - *Short Answer* Rank the following epochs of the early universe in chronological order. 1) Electroweak epoch 2) Planck epoch 3) Grand unification epoch

ANSWER: 2, 3, 1

BONUS

12) Energy – *Short Answer* What term describes waves with rapidly decaying amplitude in a certain direction, which occurs in the immediate vicinity of where total internal reflection occurs?

ANSWER: Evanescent wave

TOSS-UP

13) Biology – *Short Answer* Identify all of the following 4 neurological disorders that could be caused by deficiencies in biogenic amines. 1) Parkinson's Disease 2) Depression 3) Schizophrenia 4) ADHD

ANSWER: ALL

BONUS

13) Biology – *Multiple Choice* Which of the following supergroups do diatoms and other major phot belong to?

W) Excavata
X) SAR
Y) Unikonta
Z) Archaeplastida

ANSWER: X) SAR
Written by: APLegends1#3363

TOSS-UP

14) Earth and Space – *Short Answer* Identify all of the following three statements that are true regarding retrograde metamorphism: 1) It is mostly endothermic; 2) It follows a decrease in temperature; 3) It can occur as a result of uplift.

ANSWER: 2 AND 3 [2, GEO] Tony

VISUAL BONUS

14) Earth and Space – *Short Answer* Consider the image below:



Answer the following questions regarding where the red arrow points:

a) Which soil horizon is depicted?
b) This soil horizon often harbors what type of layer that results from the accumulation of leached clay?

ANSWER: a) B (HORIZON); b) HARDPAN [2, GEO]

TOSS-UP

15) Math – *Short Answer* Evaluate $\frac{\Gamma(100)}{\Gamma(99)}$ **[Gamma of 100 divided by gamma of 99]**

ANSWER: 99 [Calc III] <spencerd>

BONUS

15) Math – *Short Answer* Evaluate the following: $\prod_P \frac{1}{1-\frac{1}{P^2}}$ **[The product across all primes p of 1 divided by open parenthesis 1 minus p to the negative 2 close parentheses.]**

ANSWER: $\pi^2/6$ [Calc III] <spencerd>

TOSS-UP

16) Physics - *Short Answer* The position of a particle is given by the function $x(t) = 2t^3 - 8t^2 + 8t + 18$. At what times t is the particle not moving?

ANSWER: t=1.5 and t=2
dannyridel#2256

BONUS

16) Physics - *Short Answer* Electrons are being released from a metal as a result of the photoelectric effect due to incoming light. Which of the following three changes would increase the maximum kinetic energy of the electrons released?
1) increasing the work function of the metal
2) increasing the wavelength of incoming light
3) increasing the intensity of incoming light

ANSWER: NONE
Vivek

TOSS-UP

17) Chemistry – *Short Answer* What thought experiment based on an object controlling a door between two chambers of gas could theoretically violate the second law of thermodynamics?

ANSWER: MAXWELL'S DEMON

BONUS

17) Chemistry – *Short Answer* Identify the following molecules that undergo condensation with a phosphine for carbonate synthesis. 1) Carboxylic Acid; 2) Ether; 3) Nitriles.

ANSWER: NONE

TOSS-UP

18) Energy - *Short Answer* What device, which uses twisting magnetic fields to trap high temperature plasma in a torus, is used in the pursuit of fusion power?

ANSWER: Stellerator

BONUS

18) Energy - *Short Answer* What term refers to the regions of the heliosphere where the polarity of the Sun's magnetic field changes from north to south?

ANSWER: Heliospheric current sheet

TOSS-UP

19) Biology - *Short Answer* The presence of what element promotes diatom blooms and increases pumping of carbon dioxide to the ocean floor?

ANSWER: Iron

BONUS

19) Biology - Multiple Choice Which of the following is NOT true regarding Indole-3-acetic acid or IAA ?
W) IAA is the most abundant natural auxin
X) IAA can only enter parenchyma cells through passive transport
Y) PIN transport proteins allow for the efflux of deprotonated IAA out of the cell
Z) IAA is also synthesized by environmental bacteria

ANSWER: X) IAA can only enter parenchyma cells through passive transport

TOSS-UP

20) Earth and Space – *Short Answer* Order the following three regions of the Sun by increasing distance from the core: 1) Tachocline; 2) Supergranules; 3) Radiative Zone.

ANSWER: 3 1 2 [3, SPACE] Tony

BONUS

20) Earth and Space – *Short Answer* What class of astronomical objects possess characteristics of asteroids and comets, and have orbits between or crossing Jovian planets?

ANSWER: CENTAUR [4, SPACE] Tony

TOSS-UP

21) Math – *Short Answer* For a specific set S, we know that $E(x) = 10$ and $E(x^2) = 144, x \in S$ **[for a random element x of the set S, The expected value of x is 10 and the expected value of x^2 is 144]** Find the variance of this set.

ANSWER: 44 [Statistics] <spencerd>

BONUS

21) Math – *Short Answer* Find the exact solution to the equation $x^x = 10$ in terms of the Lambert W function.

ANSWER: $e^{W(ln(10))}$ [Calc II] <spencerd>

TOSS-UP

22) Physics - *Short Answer* What is the analog of the displacement from the equilibrium position of a simple harmonic oscillator in an RLC circuit?
ANSWER: Stored Charge
dannyridel#2256

BONUS

22) Physics - *Short Answer* Which of the following are true about a process that has a positive entropy change but is reversible?
1) The process must be adiabatic
2) The process is not possible
3) The process must have a positive heat flow
ANSWER: 3 only
dannyridel#2256

TOSS-UP

23) Chemistry – *Short Answer* Order the following three compounds in order of decreasing ring strain. 1. Cyclobutane, 2. Cyclohexane, 3. Cyclopropane

ANSWER: 3, 1, 2 (ACCEPT: CYCLOPROPANE, CYCLOBUTANE, CYCLOHEXANE)

BONUS

23) Chemistry - Short Answer Order the following 4 ligands by their increasing influence on the trans effect.

1) Hydroxide Anion
2) Ammonia
3) Phosphines
4) Hydride

ANSWER: 1,2,3,4