Winter Science Bowl Tournament 2022-2023

Playoff Round 6

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Past and Present Sponsors

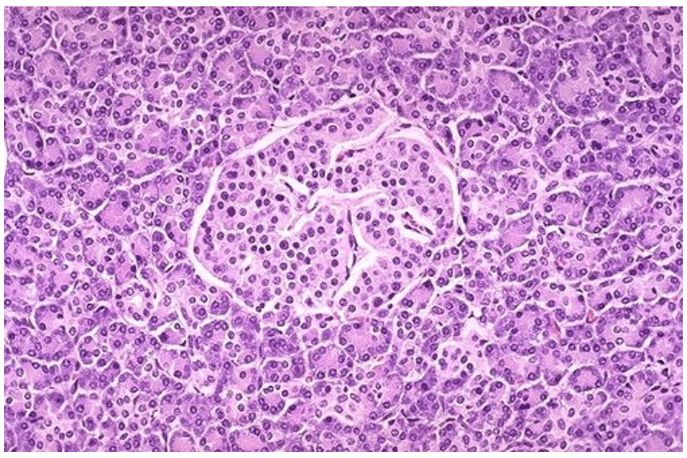
TOSS-UP

1) Biology - Short Answer Identify the following which are stimulated by luteinizing hormones.

1) Sertoli Cells
2) Granulosa Cells
3) Theca Cells
4) Leydig Cells

ANSWER: 3 AND 4

VISUAL BONUS



1) Biology - Short Answer Shown on the image is a structure that regulates the production of insulin, glucagon, and somatostatin. Answer the following 2 questions regarding the image:

1) What is the name for this structure?
2) What cells is it primarily composed of?

ANSWER: ISLETS (ISLANDS) OF LANGERHAN and BETA CELLS
Written by: APLegends1#3363

TOSS-UP

2) Earth and Space – *Multiple Choice* Which of the following is a warm-water ocean current?

W) Antarctic Circumpolar Current
X) Peru Current
Y) Kuroshio Current
Z) Benguela Current

ANSWER: Y) KUROSHIO CURRENT [3, OCE] Eric

BONUS

2) Earth and Space – *Short Answer* Identify all of the following 3 ores that commonly occur in hydrothermal deposits: 1) galena; 2) pyrolusite; 3) hematite.

ANSWER: 1 ONLY [3, GEO] Rishabh

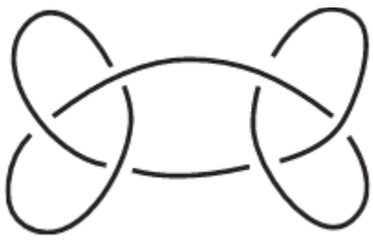
TOSS-UP

3) Math – *Short Answer* What is the half derivative of x^2?

ANSWER: ❑ [Calc III] <spencerd>

VISUAL BONUS

3) Math – *Short Answer* Identify the name of the knot that is shown in this image:



ANSWER: Square Knot

TOSS-UP

4) Physics – *Short Answer* Consider an infinite square potential well with a zero point energy of 25 electron Volts. How many total energy levels are there with an energy below 650 electron Volts?

ANSWER: 5
dannyridel#2256

BONUS

4) Physics – *Short Answer* A train of proper length L is traveling at a speed of 0.96c. Two clocks are placed on the train, one in the front and one in the rear. In terms of L and c, what is the difference in times shown on the two clocks as measured by an external observer?

ANSWER: 24L/25c
dannyridel#2256

TOSS-UP

5) Chemistry - Multiple Choice Which of the following is true regarding the Michael Reaction?

W) It utilizes the Grignard Reagent
X) It is a conjugate addition
Y) The Michael Donor is generally an unsaturated carbonyl
Z) The Michael Acceptor is generally an enolate

ANSWER: X) It is a conjugate addition

BONUS

5) Chemistry - Multiple Choice Which of the following is INCORRECT regarding the Gilman's Reagent?

W) They contain both lithium and copper
X) They can convert an acid halide to an alcohol
Y) Their R group can be a vinyl
Z) They attack the β position of an α,β-unsaturated ketone

ANSWER: X) They can convert an acid halide to an alcohol
Written by APLegends1#3363/Org

TOSS-UP

6) Energy – *Short Answer* Ames Lab physicists often represent delocalized electrons in a model in which free electrons interact with a uniform background positive charge, as well as with themselves. What model, which does not introduce the atomic lattice, do they use?

ANSWER: Jellium; uniform/homogenous electron gas

BONUS

6) Energy – *Short Answer* Ames Lab physicists theorize that a star's mass has a theoretical upper limit at which the star's outward radiation pressure balances its inward gravitational force. What limit do they theorize?

ANSWER: Eddington mass limit

TOSS-UP

7) Biology - *Multiple Choice* Which of the following is NOT true regarding RNA splicing?

W) Group I introns require a guanine nucleoside to carry out self-splicing
X) Group II introns are self-splicing but do not form a lariat-like structure
Y) Group III introns form a lariat-like structure catalyzed by the spliceosome
Z) Group I and II introns are present in bacteria

ANSWER: X) Group II introns are self splicing but do not form a lariat-like structure
Written by: APLegends1#3363

BONUS

7) Biology - *Short Answer* Identify all of the following 3 statements that are NOT true regarding phospholipid transporters: 1) Flippases catalyze the movement of amino-phospholipids preventing apoptosis; 2) Flippases are P-type ATPases while Floppases are ABC transporters; 3) Floppases catalyze the movement of lipids from the outer to cytosolic leaflet.

ANSWER: 3 only
Written by: APLegends1#3363

TOSS-UP

8) Earth and Space – *Short Answer* Armaan is studying a star that exhibits strong absorption bands of Titanium Oxide in its spectrum. What is the most likely spectral classification of this star?

ANSWER: M [2, SPACE] Tony

BONUS

8) Earth and Space – *Short Answer* Identify all of the following 3 statements that are generally true about asteroids in Hirayama families:

1) They have similar semimajor axes;
2) They have similar orbital eccentricities;
3) They have similar orbital periods.

ANSWER: ALL [3, SPACE] Tony

TOSS-UP

9) Math – *Short Answer* What is the multiplicative order of 2 modulo 5?
ANSWER: 4 [Number Theory] <spencerd>

BONUS

9) Math – *Short Answer* What mathematical term refers to the local properties of functions, is defined as all values of f(x) for all x in a closed set Z, and uniquely determines analytic functions?

ANSWER: Germ [Topology] <spencerd>

TOSS-UP

10) Physics - *Multiple Choice* The theta meson is composed of what quark and its antiparticle, theorized to never be observed in nature because its components decay too fast?
W) Up
X) Down
Y) Bottom
Z) Top
ANSWER: Z) Top
dannyridel#2256

BONUS

10) Physics - *Short Answer* What meson mediates the strong force in the nucleus of an atom?
ANSWER: Pion
dannyridel#2256

TOSS-UP

11) Chemistry - Multiple Choice Which of the following rate-determining steps will result in the most negative Hammett reaction constant, ρ?

W) Nucleophilic attack on a carbonyl group
X) Nucleophilic aromatic substitution by addition-elimination mechanism
Y) Formation of cationic ring during Electrophilic Aromatic Substitution
Z) Pericyclic reactions with no charge accumulation

ANSWER: Y) Formation of cationic ring during Electrophilic Aromatic Substitution
Written by APLegends1#3363/Org (Clayden)

BONUS

11) Chemistry - Short Answer Identify all of the following which are TRUE regarding diazomethane.

1) Reactions with diazomethane generally involve a dinitrogen leaving group
2) Diazomethane can be used to produce a methyl ester from a carboxylic acid
3) The photolysis of diazomethane can directly produce a carbene

ANSWER: ALL
Written by APLegends1#3363/Org (Clayden)

TOSS-UP

12) Energy – *Short Answer* Argonne Lab scientists research a flavorless meson constituted of a heavy quark and its own antiquark. What quasiparticle, which is both a neutral particle and its own antiparticle, do they observe?

ANSWER: Quarkonium

BONUS

12) Energy – *Short Answer* Argonne Lab scientists work with excited atoms with very high principal quantum numbers, giving them abnormal qualities such as exaggerated response to electric and magnetic fields. What types of atoms do they encounter?

ANSWER: Rydberg atom

TOSS-UP

13) Biology - Short Answer Identify all the following that are correct regarding the perception of gravity by plants.

1) In roots, the perception of gravity correlates to the sedimentation of specialized amyloplasts known as statoliths
2) Statocytes are localized in the columella of the root cap
3) In stems, the perception of gravity is carried out by the starch sheath

ANSWER: NONE
Written by: APLegends1#3363

BONUS

13) Biology - *Multiple Choice* Which of the following is generally NOT true regarding molluscs?

W) Molluscs have a closed circulatory system
X) Molluscs use the radula, a straplike organ, used to collect food
Y) Molluscs contain a water-filled cavity holding the anus and gills
Z) Molluscs contain a nerve ring around the esophagus, from where the nerves extends

ANSWER: W) Molluscs contain a closed circulatory system
Written by: APLegends1#3363

TOSS-UP

14) Earth and Space – *Short Answer* What unit is defined as the resulting height if all of a trace gas in a column of Earth's atmosphere was collected, and is commonly used to measure the thickness of the ozone layer?

ANSWER: DOBSON UNIT (ACCEPT: DOBSON) [2, METEO] Eric

BONUS

14) Earth and Space – *Short Answer* The Deccan Traps of India are an example of what igneous structure, that is formed from the bulbous head of a mantle plume?

ANSWER: FLOOD BASALT (ACCEPT: PLATEAU BASALT) [3, GEO] Tony

TOSS-UP

15) Math – *Multiple Choice* In hyperbolic geometry, for a line L, a point P not on L, and a plane containing both L and P, which of the following is always true?
W) There are at least 3 distinct lines through P parallel to L
X) There are at least 2 distinct lines through P parallel to L
Y) There are at most 3 distinct lines through P parallel to L
Z) There are at most 2 distinct lines through P parallel to L
ANSWER: X [Geometry] <spencerd>

BONUS

15) Math – *Short Answer* John will arrive at the airport in t minutes, where t is chosen uniformly and at random from the closed interval [0, 100]. John's plane will take off in minutes, where x is chosen uniformly and at random from the closed interval [0, 10]. What is the probability that John will arrive in time to catch his flight?

ANSWER:

TOSS-UP

16) Physics - *Short Answer* What region in a bipolar junction transistor is analogous to the gate in a field effect transistor?
ANSWER: Base
dannyridel#2256

BONUS

16) Physics - *Short Answer* Identify all of the following 3 statements that are true about semiconductors:

1) The Fermi-Dirac distribution function dictates the probability that a certain fermion occupies a state with a particular energy
2) The density of electron states is zero between the conduction and valence bands
3) Doping a semiconductor will result in a change in its Fermi energy

ANSWER: All
dannyridel#2256

TOSS-UP

17) Chemistry– *Short Answer* Identify all the following procedures that are known to increase semiconductor conductivity, 1) Doping with impurities; 2) Increasing semiconductor temperature; 3) Gating with electric fields

ANSWER: All

BONUS

17) Chemistry - *Multiple Choice* Alice is searching through his lab desk and he finds an old lab procedure involving the formation of esters from ketones. She later finds that this reaction requires the use of a peroxy acid to help insert an oxygen atom into the ketone. Which of the following processes is the process described by the lab manual?

W) Baeyer-Villiger Oxidation
X) Fischer Esterification
Y) Claisen Condensation
Z) Wittig Reaction

ANSWER: W) Baeyer-Villiger Oxidation
Written by APLegends1#3363/Org

TOSS-UP

18) Energy - *Short Answer* In 2011, LHC scientists successfully created what dense state of matter, which contains free colour charges and is believed to have permeated the universe fractions of a second after the Big Bang?

ANSWER: Quark-gluon plasma
dannyridel#2256

BONUS

18) Energy – *Short Answer* Lawrence Berkeley Lab cosmologists believe there to be a web of plasma that exists between galaxies, currently containing 40-50% of the universe's baryons. What medium, which is a proposed solution to the missing baryon problem, do they believe in?

ANSWER: Warm-hot intergalactic medium

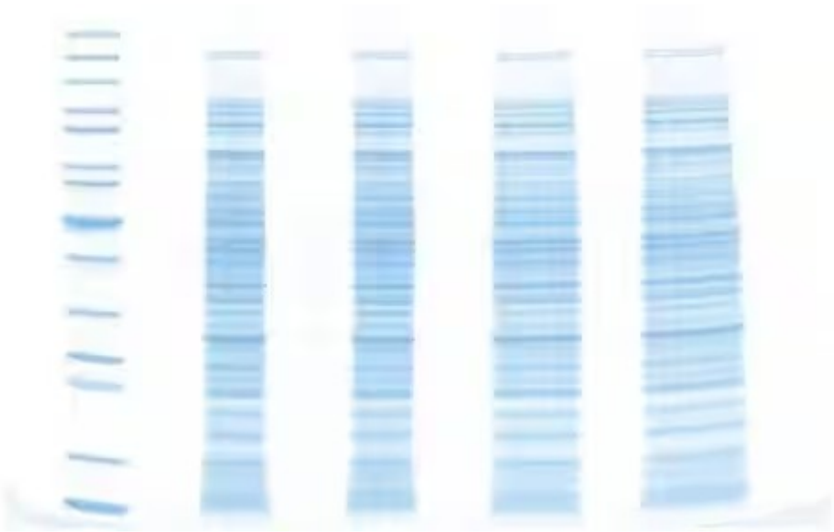
TOSS-UP

19) Biology - *Short Answer* Identify all of the following 3 choices that are true regarding antibodies:

1) IgG and IgM antibodies provide the biggest specific immunity against bacteria
2) IgA antibodies is secreted by mammary glands and line genitourinary tracts
3) IgE antibodies participate in defenses against multicellular parasites

ANSWER: ALL

VISUAL BONUS



19) Biology - Short Answer Alice notices that during Western Blotting, her sample lanes begin to greatly widen. Identify which of the following 4 choices CAN be attributed to this widening.

1) Excess Sodium Chloride during Gel Electrophoresis
2) Excess SDS detergent during Gel Electrophoresis
3) Excess Primary Antibody present during blotting
4) Excess Radioimmunoprecipitation (RIPA) buffer present

ANSWER: 1, 2 AND 4

TOSS-UP

20) Earth and Space – *Short Answer* How many times greater is the lifetime of a main-sequence star of 4 solar masses than one of 16 solar masses?

ANSWER: 32 [3, SPACE] Tony

BONUS

20) Earth and Space – *Multiple Choice* According to Kramer's law of opacity, which of the following conditions will produce the greatest opacity?

W) Low temperature, high density
X) Low temperature, low density
Y) High temperature, high density
Z) High temperature, low density

ANSWER: Z) HIGH TEMPERATURE, LOW DENSITY [3, THRY] Tony

TOSS-UP

21) Math – *Multiple Choice* Let f(x) denote the number of positive integers less than or equal to x that are relatively prime to x. What is ?

W) 76
X) 77
Y) 78
Z) 70

ANSWER: X [Number Theory] <spencerd>

BONUS

21) Math – *Short Answer* What is the antiderivative with respect to x of

ANSWER: (accept:)

TOSS-UP

22) Physics - *Short Answer* Both hadrons and leptons typically follow Fermi-Dirac statistics, which is governed by the Fermi function. The Fermi function at a certain energy has a dependence on what intrinsic physical quantity, usually referring to the energy difference between the highest and lowest occupied single-particle states in a quantum system?

ANSWER: Fermi energy (ACCEPT: Fermi level, band gap)
dannyridel#2256

BONUS

22) Physics– *Multiple Choice* If a loop of conducting wire is traveling at speed v parallel to an infinitely long wire carrying current I, what direction is the current in the wire?

W) Clockwise
X) Counter-clockwise
Y) Either clockwise or counter-clockwise depending on the values of v and I
Z) There is no current in the wire

ANSWER: Z) There is no current in the wire

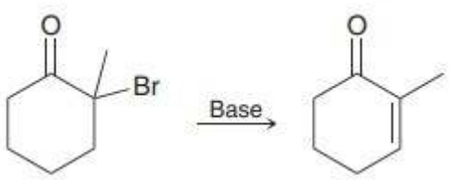
TOSS-UP

23) Chemistry - *Short Answer* Identify the following 4 choices which are INCORRECT regarding the polymers produced by plasma polymerization.

1) These polymers are characterized by a high degree of crosslinking
2) These polymers contain repeating subunits
3) These polymers are generally soluble
4) These polymers generally contain free radicals

ANSWER: 1 and 4
Written by APLegends#3363

VISUAL BONUS



23) Chemistry - Short Answer Identify the following 3 reagents which can be used as a reagent to carry out the reaction above.

1) Pyridine
2) Lithium carbonate
3) Potassium tert-butoxide

ANSWER: ALL
Written by APLegends1#3363/Org