2025 Texas Science Bowl Invitational

Double Elimination 6

Authors

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TOSS UP

1) PHYSICS *Multiple Choice* A positive charge with charge Q is placed next to a grounded hollow metal sphere. From far away, the electric field looks like the electric field of what other arrangement?

W) Point charge with charge less than Q
X) Point charge with charge equal to Q
Y) Point charge with charge greater than Q
Z) Electric dipole

ANSWER: W) Point charge with charge less than Q

BONUS

1) PHYSICS *Short Answer* Krutharth hangs a glass rod of length 7 meters and mass 3 kilograms from a pivot and measures the time period of small oscillations. He then gives the rod a uniform charge of 5 Coulombs and turns on an electric field of 8 Newtons per Coulomb to the left, shifting the equilibrium position of the pendulum. Taking the gravitational acceleration to be 10 meters per second squared, by what factor is the time period multiplied by?

ANSWER: $\sqrt{15}/5$

TOSS UP

2) CHEMISTRY *Multiple Choice* In nitrogen-centered oxoacids, how does an increase in the oxidation state of nitrogen affect the oxidizing strength and acidity of the oxoacid respectively?

W) Increase, increase
X) Increase, decrease
Y) Decrease, increase
Z) Decrease, decrease

ANSWER: W) Increase, increase

BONUS

2) CHEMISTRY *Multiple Choice* Which of the following spectroscopic techniques is most appropriate to characterize the geometry of the methyl radical?

W) Nuclear magnetic resonance
X) Electron paramagnetic resonance
Y) Infrared absorption spectroscopy
Z) X-ray diffractometry

ANSWER: X) Electron paramagnetic resonance

TOSS UP

3) EARTH AND SPACE *Multiple Choice* During which of the following pairs of months does Earth sweep out equal areas in its orbit?

W) December and January
X) January and February
Y) February and March
Z) March and April

ANSWER: W) December and January

BONUS

3) EARTH AND SPACE *Multiple Choice* The Kraft break is understood to separate stars with deep convective envelopes and effective magnetic dynamos from those without. This break refers to the decrease of which of the following quantities at temperatures at about 6200 Kelvin?

W) Surface gravity
X) Core hydrogen fraction
Y) Metallicity
Z) Rotation rate

ANSWER: Z) Rotation rate

TOSS UP

4) MATH *Short Answer* An arithmetic sequence and a geometric sequence both have their first two terms as 8 and 12. What is the absolute difference between the fourth terms in both sequences?

ANSWER: 7

BONUS

4) MATH *Short Answer* What is the sum of the roots of the equation $8^x - 6 \cdot 4^x - 3 \cdot 2^x + 4 = 0$ [READ: *8 to the power of x minus 6 times 4 to the power of x minus 3 times 2 to the power of x plus 4 equals 0*]?

ANSWER: 2

TOSS UP

5) BIOLOGY *Multiple Choice* Honeybees have highly light-sensitive organs called ocelli [READ: *oh-sell-eye*] which are theorized to help bees detect the direction of sunlight and quickly adjust their compound eyes to varying light levels. Which of the following pairs of anatomical adjectives best describe the location of the ocelli in a Honeybee?

W) Anterior, dorsal
X) Anterior, ventral
Y) Posterior, dorsal
Z) Posterior, ventral

ANSWER: W) Anterior, dorsal

BONUS

5) BIOLOGY *Short Answer* Identify all of the following three statements which are true about primary and secondary growth in woody shoots:

1) All dermal tissue originates from the protoderm
2) All vascular tissue originates from the procambium
3) All ground tissue originates from the ground meristem

ANSWER: 2 and 3 only

TOSS UP

6) PHYSICS *Multiple Choice* Aprameya measures the period of a pendulum and plots it as a function of its amplitude, as it varies between 0 and $\pi/2$. What is the shape of the resulting graph?

W) Decreasing and concave down
X) Decreasing and concave up
Y) Increasing and concave down
Z) Increasing and concave up

ANSWER: Z) Increasing and concave up

BONUS

6) PHYSICS *Short Answer* A cylindrical bucket of water with radius r is spun about its central axis at constant angular velocity ω. If the difference in water level between the center of this bucket and its rim is 10 centimeters, what is the difference in water level, in centimeters, between the center and rim of a similar bucket of radius $4r$ spinning at the same angular velocity?

ANSWER: 160

TOSS UP

7) CHEMISTRY *Short Answer* By name or number, order the following three conformations of butane in terms of increasing energy:

1) Anti
2) Eclipsed
3) Gauche [*gow-shh*]

ANSWER: 1, 3, 2

BONUS

7) CHEMISTRY *Multiple Choice* Which of the following statements best describes the driving force of a Claisen rearrangement?

W) A carbon-carbon single bond is replaced with a carbon-carbon double bond
X) A carbon-oxygen single bond is replaced with a carbon-oxygen double bond
Y) A carbon-carbon double bond is replaced with a carbon-oxygen double bond
Z) A carbon-oxygen double bond is replaced with a carbon-carbon double bond

ANSWER: Y) A carbon-carbon double bond is replaced with a carbon-oxygen double bond

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TOSS UP

8) EARTH AND SPACE *Multiple Choice* Which of the following rocks has the highest degree of silica saturation?

W) Kimberlite
X) Nephelinite [*NE-fe-li-nite*]
Y) Dacite [*da-SITE*]
Z) Phonolite [*FO-no-lite*]

ANSWER: Y) Dacite

BONUS

8) EARTH AND SPACE *Short Answer* Identify all of the following statements that are true regarding cells in Langmuir [READ: *lang-myoor*] circulation:

1) Windrows form at the convergence of two Langmuir cells
2) Adjacent Langmuir cells rotate in opposite directions
3) The rotation of Langmuir cells is perpendicular to the wind direction

ANSWER: All

TOSS UP

9) MATH *Multiple Choice* What is the limit of the quantity $\frac{1-\cos(x)}{\sin(x)}$ [READ: *fraction with numerator 1 minus cos x and denominator sin x*] as x approaches 0?

W) -1
X) 0
Y) 1
Z) $\sqrt{2}$

ANSWER: X) 0

BONUS

9) MATH *Multiple Choice* What is the slope of the tangent line at $(3, 1)$ to the curve $x^3 + y^3 = 28$?

W) -9
X) -3
Y) 3
Z) 9

ANSWER: W) -9

TOSS UP

10) BIOLOGY *Short Answer* Research has shown that cultivating endomycorrhizae [READ: *en-do-my-co-rie-zay*] -forming fungi in soil can inhibit the growth of parasitic plants like Dodder [READ: *daughter*], likely because pathways regulating arbuscular growth can also inhibit the growth of what root-like structure involved in host-to-parasite nutrient transfer?

ANSWER: Haustoria

BONUS

10) BIOLOGY *Multiple Choice* Aryan is studying the clutch size of Carolina Chickadees, a species of bird, in a stable pine forest. The parental generation in his experiment produces an average of 4 eggs per mating pair. The following generations mate randomly, not necessarily within their generation. The females in the F1 generations produce an average of 2 eggs, and the females in the F2 generation produce an average of 4 eggs. Which of the following is most likely true about the clutch size trait?

W) Clutch size is determined entirely by incubation conditions
X) Clutch size exhibits a maternal effect
Y) Clutch size is determined by a set of additive alleles
Z) Clutch size is a uniform random variable

ANSWER: X) Clutch size exhibits a maternal effect

TOSS UP

11) PHYSICS *Short Answer* Ben Lin is moving chocolate sauce from his fridge to his mouth through a thin tube, resulting in a laminar flow. Given that he wants to maintain a constant flow rate of chocolate, the required pressure difference at the ends of the tube depends on what power of the radius of the tube?

ANSWER: -4

BONUS

11) PHYSICS *Short Answer* Ben Lin connects three 10 ohm resistors together at one point into a Y shape. He then uses magic to set the free ends to 2 Volts, 7 Volts, and 9 Volts. Find the current, in Amperes, that flows through the terminal at 2 Volts.

ANSWER: 0.4

TOSS UP

12) CHEMISTRY *Short Answer* By name or number, order the following three elements by increasing band gap in their most stable elemental forms:

1) Carbon
2) Silicon
3) Germanium

ANSWER: 3, 2, 1

BONUS

12) CHEMISTRY *Short Answer* By name or number, order the following three ligands in terms of increasing maximum denticity:

1) Porphine [*POOR-fin*]
2) EDTA
3) Oxalate

ANSWER: 3, 1, 2

TOSS UP

13) EARTH AND SPACE *Multiple Choice* Compared to Population II stars, Population I stars have a smaller value for which of the following quantities?

W) Metallicity
X) Temperature
Y) Luminosity
Z) B-V index

ANSWER: Z) B-V index

BONUS

13) EARTH AND SPACE *Short Answer* Two stars of unequal masses are in a binary star system. Identify all of the following orbital properties of both stars that will be the same:

1) Eccentricity
2) True anomaly
3) Orbital period

ANSWER: All

TOSS UP

14) MATH *Multiple Choice* Which of the following functions is continuous over all real numbers?

W) $x^{1/3} + x^{2/3}$ [READ: *cube root of x plus cube root of x squared*]
X) $\sqrt{x^2 - 1}$ [READ: *square root of open parenthesis x squared minus 1 close parenthesis*]
Y) $\sin(\lfloor x \rfloor)$ [READ: *sin of the floor of x*]
Z) $x + \frac{1}{x}$ [READ: *x plus the inverse of x*]

ANSWER: W) $x^{1/3} + x^{2/3}$

BONUS

14) MATH *Short Answer* What is the curvature of the parabola $3x^2 + 4x$ [READ: *3 x squared plus 4 x*] at its vertex?

ANSWER: 6

TOSS UP

15) BIOLOGY *Multiple Choice* Yale is conducting an indirect ELISA [READ: *ell-eye-sah*] test and has a monoclonal primary antibody that binds to his antigen of interest. Which of the following properties would be most desired in an effective secondary antibody?

W) Specificity to exactly one site on the antigen
X) Specificity to exactly one site on the primary antibody
Y) Ability to bind to multiple sites on the antigen
Z) Ability to bind to multiple sites on the primary antibody

ANSWER: Z) Ability to bind to multiple sites on the primary antibody

BONUS

15) BIOLOGY *Short Answer* Which beta 1,3-glucan [READ: *glue-can*] polymer is found in cell plates during cytokinesis and plays a major role in controlling the size-exclusion limit of plasmodesmata?

ANSWER: Callose

TOSS UP

16) PHYSICS *Multiple Choice* Aldric is practicing his baseball throwing. He can throw a baseball at 30 meters per second in any direction. Big Bird wants to avoid any region of space where he might get hit by Aldric. What shape does the region of space that he should avoid form?

W) Hyperboloid
X) Paraboloid
Y) Hemisphere
Z) None of the above

ANSWER: X) Paraboloid

BONUS

16) PHYSICS *Short Answer* Two one kilogram objects are travelling towards each other at $0.8c$. Find the rest mass in kilograms of the resulting two body system.

ANSWER: $\frac{10}{3}$

TOSS UP

17) CHEMISTRY *Multiple Choice* Which of the following best describes why nucleophilic attack at a carbonyl group occurs at the carbon-end of the carbon-oxygen double-bond?

W) The pi bonding orbital has greater contribution from the carbon atomic orbital than the oxygen atomic orbital
X) The pi bonding orbital has less contribution from the carbon atomic orbital than the oxygen atomic orbital
Y) The pi antibonding orbital has greater contribution from the carbon atomic orbital than the oxygen atomic orbital
Z) The pi antibonding orbital has less contribution from the carbon atomic orbital than the oxygen atomic orbital

ANSWER: Y) The pi antibonding orbital has greater contribution from the carbon atomic orbital than the oxygen atomic orbital

BONUS

17) CHEMISTRY *Short Answer* By name or number, order the following three hydrocarbons in terms of increasing amount of heat released per mole during complete combustion:

1) 1,2-pentadiene [READ: *penta-die-ene*]
2) 1,3-pentadiene
3) 1,4-pentadiene

ANSWER: 2, 3, 1

TOSS UP

18) EARTH AND SPACE *Short Answer* The remnants of Theia [READ: *tay-a*] that likely coalesced to form large low-shear-velocity provinces are located closest to which of the following discontinuities?

W) Gutenberg
X) Conrad
Y) Lehmann [READ: *LEE-man*]
Z) Repetti [READ: *re-PE-tee*]

ANSWER: W) Gutenberg

BONUS

18) EARTH AND SPACE *Multiple Choice* An elliptical galaxy has a minor axis of 3 parsecs and a major axis of 5 parsecs. According to the Hubble sequence, what is the classification of this galaxy?

W) E3
X) E4
Y) E5
Z) E6

ANSWER: X) E4

TOSS UP

19) MATH *Multiple Choice* A circle is tangent to the parabola $x = y^2 - 4y + 6$ [READ: *x equals y squared minus 4 y plus 6*] at two points. If one of these points is $(3, 1)$, what is the sum of the coordinates of the other point?

W) 3
X) 4
Y) 5
Z) 6

ANSWER: Z) 6

BONUS

19) MATH *Multiple Choice* How many planes of symmetry does a cube have?

W) 6
X) 8
Y) 9
Z) 12

ANSWER: Y) 9

TOSS UP

20) BIOLOGY *Multiple Choice* The gut microbiome of human adults infected with *Helicobacter pylori* [READ: *Heel-ih-coh-bac-ter pie-lor-eye*] is primarily composed of bacteria from which of the following phyla?

W) Actinobacteria
X) Proteobacteria
Y) Bacteroidetes [READ: *back-teer-roid-de-tees*]
Z) Firmicutes

ANSWER: X) Proteobacteria

BONUS

20) BIOLOGY *Short Answer* Group A and Group B both consist of mutant organisms that are homozygous for recessive mutations A and B, respectively, and display the same phenotype. Individuals from Group A are crossed with individuals from Group B, producing an F1 generation consisting entirely of phenotypically wild-type individuals. Identify all of the following that could be true about mutations A and B:

1) Mutation A is on the same gene as Mutation B
2) The mutations are on different genes, whose products are involved in the same biochemical pathway
3) The products of mutations A and B form a functional heterodimer

ANSWER: 2 and 3 only

TOSS UP

21) PHYSICS *Short Answer* In statistical mechanics, the temperature of a system is defined to be proportional to the derivative of energy with respect to entropy. What physical constant is equal to the constant of proportionality in this definition?

ANSWER: Boltzmann constant [ACCEPT: Reciprocal of Boltzmann constant]

BONUS

21) PHYSICS *Short Answer* Aldric builds a frictionless slide in the Cartesian plane described by $y = 3x^2$, where x and y are measured in meters. He climbs to a height of 10 meters and slides down. To two significant figures, when Aldric reaches the origin, what is his acceleration in meters per second squared?

ANSWER: 1200

TOSS UP

22) CHEMISTRY *Short Answer* What sulfur anion is unstable in an acidic medium and disproportionates into sulfur dioxide gas and a suspension of colloidal sulfur in a common demonstration of Rayleigh [READ: *RAY-lee*] scattering?

ANSWER: Thiosulfate [ACCEPT: $S_2O_3{}^{2-}$]

BONUS

22) CHEMISTRY *Multiple Choice* Which of the following statements best explains why dihydrogen is not IR-active?

W) The stretching frequency of dihydrogen is not in the infrared region
X) The stretching mode of dihydrogen does not change its dipole moment
Y) The sigma to sigma-star transition is forbidden
Z) The sigma to pi-star transition is forbidden

ANSWER: X) The stretching mode of dihydrogen does not change its dipole moment

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TOSS UP

23) EARTH AND SPACE *Short Answer* Wave-like clouds that form due to velocity shear between two layers of air are caused by what instability?

ANSWER: Kelvin-Helmholtz instability

BONUS

23) EARTH AND SPACE *Short Answer* Rocks containing olivine [READ: *AW-le-veen*] exposed on the seafloor due to faulting react with seawater at temperatures below 400 degrees Celsius. These reactions form hydrous magnesium silicates and magnetite. What is the name of this process?

ANSWER: Serpentinization

TOSS UP

24) MATH *Short Answer* Which of the following three triangle centers are always contained strictly within the triangle?

1) Symmedian point
2) Circumcenter
3) Centroid

ANSWER: 1 and 3 only

BONUS

24) MATH *Short Answer* What is the value of the sum of $\sqrt{10000 - x^2}$ [READ: *square root of the quantity ten thousand minus x squared*] from $x = 1$ to 100 rounded to the nearest multiple of 100?

ANSWER: 7800

TOSS UP

25) BIOLOGY *Short Answer* In what type of mimicry does the mimic live along with the model in a nest or colony?

ANSWER: Wasmannian mimicry [ACCEPT: Myrmecophily [READ: *mir-me-CAW-fully*]]

BONUS

25) BIOLOGY *Multiple Choice* Which of the following protists would not contain a plastid originating from secondary endosymbiosis?

W) Diatoms
X) Euglenids
Y) Alveolates
Z) Green algae

ANSWER: Z) Green algae
