2025 Texas Science Bowl Invitational

Double Elimination 5

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TOSS UP

1) PHYSICS *Multiple Choice*   Two point charges with charges 1 coulomb and -2 coulombs are placed in free space. How many distinct points in space have zero electric field?

  W) 0
  X) 1
  Y) 2
  Z) Infinitely many

ANSWER: X) 1

BONUS

1) PHYSICS *Multiple Choice*   Aryan is standing on a sidewalk 2 meters to the right of a road. A fire truck is traveling down the road, initially towards Aryan, emitting a siren at constant frequency in the frame of the truck. Aryan plots the frequency he hears as a function of time and notices two horizontal asymptotes. Which of the following best relates the AVERAGE of the two asymptotes to the true frequency of the siren in the frame of the truck?

  W) Less than the true frequency
  X) Equal to the true frequency
  Y) Greater than the true frequency
  Z) Depends on the speed of the truck

ANSWER: Y) Greater than the true frequency

TOSS UP

2) CHEMISTRY *Multiple Choice*   Which of the following borane halides is the weakest Lewis acid?

  W) Boron trifluoride
  X) Boron trichloride
  Y) Boron tribromide
  Z) Boron triiodide

ANSWER: W) Boron trifluoride

BONUS

2) CHEMISTRY *Short Answer*   When treated with excess sodium hydroxide, methyl iodide reacts to form methanol via an SN2 reaction. The amount of time since the beginning of the reaction is denoted by the letter t. At t = 10 seconds, half of the methyl iodide has been consumed. In seconds, what is the value of t when 87.5% of the methyl iodide is consumed?

ANSWER: 30

TOSS UP

3) EARTH AND SPACE *Short Answer*   What mineral, commonly found in high-pressure low-temperature metamorphic rocks, is responsible for the blue color of blueschist?

ANSWER: Glaucophane

BONUS

3) EARTH AND SPACE *Multiple Choice*   In which of the following geothermal environments is the geotherm slope the steepest?

  W) Mid-ocean ridge
  X) Subduction zone
  Y) Hotspot
  Z) Wadati-Benioff zone

ANSWER: W) Mid-ocean ridge

4) BIOLOGY *Short Answer*   Three species of plants are identical in every way except for the divergence angle between successive leaves of the plant's stem. Order the following divergence angles of the species in terms of increasing corresponding leaf area index:

  1) 180
  2) 137
  3) 120

ANSWER: 1, 3, 2

BONUS

4) BIOLOGY *Multiple Choice*   Western blots are semiquantitative, meaning that it is important to use a loading control such as GAPDH [READ: *Gap-D-H*] to validate the significance of differing intensities of a protein of interest across multiple blots. Which of the following does NOT describe a desirable similarity between such a loading control and a protein of interest?

  W) Subcellular localization
  X) Wild-type abundance
  Y) Molecular weight
  Z) Stability across experimental conditions

ANSWER: Y) Molecular weight

TOSS UP

5) MATH *Multiple Choice*   Which of the following integers maximizes the totient [READ: *TOH-shent*] function?

  W) 100
  X) 101
  Y) 102
  Z) 103

ANSWER: Z) 103

BONUS

5) MATH *Short Answer*   How many odd positive integers less than 105 are relatively prime to 105?

ANSWER: 24

6) PHYSICS *Short Answer*   Apra takes a uniform rod of length 6 meters and balances it upright on a frictionless surface. He nudges the tip of the rod, causing it to fall over. At the moment of impact, what is the total distance travelled by the bottom of the rod?

ANSWER: 3

BONUS

6) PHYSICS *Multiple Choice*   Aldric is studying the magnetic and electric susceptibilities of a theoretical material and is surprised to find that the calculated index of refraction is less than one, indicating that light travels faster than c in the material. What is the best explanation for this observation?

   W) Due to relativistic effects, the actual speed of light in the material will be less than c
   X) This material cannot exist because a diamagnetic material is always strongly polarizable
   Y) The index of refraction measures the phase velocity of light, which can be greater than c
   Z) Special relativity does not apply outside of a vacuum

ANSWER: Y) The index of refraction measures the phase velocity of light, which can be greater than c

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TOSS UP

7) CHEMISTRY *Short Answer*   By name or number, identify which of the following 3 compounds will form benzoic acid when reacting with potassium permanganate:

1) Isopropylbenzene
2) Tert-butylbenzene
3) Ethylbenzene

ANSWER: 1 and 3 only

BONUS

7) CHEMISTRY *Short Answer*   By name or number, order the following 3 hydride reagents by increasing nucleophilicity [READ: *NOO-klee-oh-fill-IH-si-tee*]:

1) Sodium hydride
2) Sodium borohydride
3) Lithium aluminum hydride

ANSWER: 1, 2, 3

TOSS UP

8) EARTH AND SPACE *Multiple Choice*   Which of the following is closest to the absolute magnitude of the Sun?

W) −25
X) −15
Y) −5
Z) 5

ANSWER: Z) 5

BONUS

8) EARTH AND SPACE *Short Answer*   Given that the orbital period of Ganymede is 7.2 days, what is the orbital period of Io, in days, to two significant figures?

ANSWER: 1.8

TOSS UP

9) BIOLOGY *Multiple Choice*   Niko Tinbergen, famed for his work in proximate causation, did NOT write papers about which of the following phenomenon?

  W) Sign stimuli in stickleback fish
  X) Landmark usage in digger wasps
  Y) Superstimuli in herring gulls
  Z) Sexual dimorphism in elk

ANSWER: Z) Sexual dimorphism in elk

BONUS

9) BIOLOGY *Short Answer*   Which large, polar, tetrapyrrolic methionine synthase cofactor is commonly involved in methyltransferase reactions?

ANSWER: Vitamin B12 [ACCEPT: Cobalamin]

TOSS UP

10) MATH *Short Answer*   Which of the four following shapes are always cyclic?

  1) Triangle
  2) Square
  3) Rhombus
  4) Isosceles trapezoid

ANSWER: 1, 2, 4

BONUS

10) MATH *Short Answer*   How many pairs of distinct integers have least common multiple 1000?

ANSWER: 25

TOSS UP

11) PHYSICS *Short Answer*   Which of the following are true about gravitational fields:

1) They are curl free
2) They are divergence free
3) They cannot admit stable equilibria

ANSWER: 1 and 3 only

BONUS

11) PHYSICS *Multiple Choice*   An electron is circling around the x-axis, producing radiation. What type of polarization is observed by an observer on the positive x-axis?

W) Circular polarization
X) Linear polarization in the positive x direction
Y) Linear polarization in the negative x direction
Z) Unpolarized

ANSWER: W) Circular polarization

TOSS UP

12) CHEMISTRY *Multiple Choice*   According to the equipartition [READ: *EE-kwee-partition*] theorem, what is the heat capacity of a noble gas at constant volume?

  W) 3/2 R [READ: *three-halves R*]
  X) 5/2 R [READ: *five-halves R*]
  Y) 3 R [READ: *three R*]
  Z) 4 R [READ: *four R*]

ANSWER: W) 3/2 R

BONUS

12) CHEMISTRY *Short Answer*   By name or number, identify which of the following radioactive decay pathways are expected to stabilize nuclei below the belt of stability:

  1) Positron emission
  2) Beta-minus decay
  3) Electron capture

ANSWER: 1 and 3 only

TOSS UP

13) EARTH AND SPACE *Multiple Choice*   In a water column, internal waves propagate along which of the following boundaries?

  W) Thermocline
  X) Pycnocline
  Y) Halocline
  Z) Lutocline

ANSWER: X) Pycnocline

BONUS

13) EARTH AND SPACE *Short Answer*   Order the following three minerals in terms of increasing number of cleavage planes:

  1) Sphalerite
  2) Fluorite
  3) Amethyst

ANSWER: 3, 2, 1

TOSS UP

14) BIOLOGY *Short Answer*   Identify all of the following three quantities that when increased will most likely lead to an increase in pulse pressure:

  1) Heart rate
  2) Atrial elasticity
  3) Blood volume

ANSWER: 1 and 3 only

BONUS

14) BIOLOGY *Short Answer*   Identify all of the following fruits which are accessory fruits:

  1) Apple
  2) Tomato
  3) Strawberry

ANSWER: 1 and 3 only

TOSS UP

15) MATH *Short Answer*   What is the largest possible value of $4\sin(x) + 5\cos(x)$ [READ: *4 sine of x plus 5 cosine of x*]?

ANSWER: $\sqrt{41}$

BONUS

15) MATH *Short Answer*   Alice and Bob play a game by flipping a fair coin. If the coin lands HHHH [READ: *heads heads heads heads*] consecutively before landing THHH [READ: *tails heads heads heads*] consecutively, Alice wins. Otherwise, Bob wins. Find the probability that Bob wins.

ANSWER: $\frac{15}{16}$

TOSS UP

16) PHYSICS *Short Answer*   Two point charges with charges 1 coulomb and -1 coulombs are placed apart on the x-axis. Aldric stands far on the positive x-axis and measures an electric field of 1 Newton per coulomb. If he moves twice as far along the x-axis and the distance between the charges is halved, find the magnitude of the new electric field he measures, in Newtons per Coulomb.

ANSWER: 0.0625 [ACCEPT: $\frac{1}{16}$]

BONUS

16) PHYSICS *Short Answer*   Krutharth sets up an electric field of $(2x + y)\hat{i} + e^x\hat{j}$ Newtons per coulomb in the x-y plane, where x and y are measured in meters. He then places an ideal electric dipole with dipole moment $10\hat{i}$ coulomb-meters at the origin. What is the force, in Newtons, felt by the dipole?

ANSWER: $20\hat{i}$

17) CHEMISTRY *Multiple Choice*   Which of the following single bonds has the greatest homolytic bond dissociation energy?

  W) Nitrogen-nitrogen single bond
  X) Carbon-hydrogen single bond
  Y) Silicon-fluorine single bond
  Z) Oxygen-hydrogen single bond

ANSWER: Y) Silicon-fluorine single bond

BONUS

17) CHEMISTRY *Multiple Choice*   What type of bond connects the axial chlorines to the central phosphorus in PCl5?

  W) 2-center 2-electron bond
  X) 3-center 2-electron bond
  Y) 3-center 4-electron bond
  Z) 5-center 10-electron bond

ANSWER: Y) 3-center 4-electron bond

TOSS UP

18) EARTH AND SPACE *Short Answer*   Identify all of the following three objects that can be used as standard candles:

  1) RR Lyrae variables
  2) Type II supernovae
  3) Stars at the tip of the red-giant branch

ANSWER: 1 and 3 only

BONUS

18) EARTH AND SPACE *Short Answer*   The Schwarzschild solution to Einstein's field equations assumes that two of the three external characteristics of black holes is 0. What are these two characteristics?

ANSWER: Charge and Spin [ACCEPT: Angular Momentum for Spin]

19) BIOLOGY *Short Answer*   Tendrils of sweet pea plants are modified forms of what major plant organ?

ANSWER: Leaf

BONUS

19) BIOLOGY *Multiple Choice*   Shreyas introduces a large variety of single guide RNAs into a population of mouse cells that all express Cas9. After a few generations, he notices that some sgRNAs are highly enriched in the population. These sgRNAs could possibly be complementary to genes coding for which of the following proteins?

  W) Cas9
  X) Histone H3
  Y) P53
  Z) CDK2

ANSWER: Y) P53

TOSS UP

20) MATH *Multiple Choice*   What is the slope of the intersection chord [READ: *kord*] of the two circles given by the equations $x^2 + y^2 + 4x - 6y = 0$ [READ: *x squared plus y squared plus 4 x minus 6 y equals 0*] and $x^2 + y^2 - 4x - 2y = 4$ [READ: *x squared plus y squared minus 4 x minus 2 y equals 4*]?

  W) 1
  X) 2
  Y) 3
  Z) 4

ANSWER: X) 2

BONUS

20) MATH *Short Answer*   Which postulate, proven by Chebyshev [READ: *cheh-bee-shev*], states that for every positive integer n greater than 1, there exists a prime number strictly between n and 2n?

ANSWER: Bertrand's Postulate

TOSS UP

21) PHYSICS *Short Answer*   The inertia tensor of a rigid body can be represented as a symmetric three by three matrix. The fact that this matrix can be diagonalized is commonly known as what theorem in physics?

ANSWER: Principal Axis Theorem [DO NOT ACCEPT: Spectral theorem]

BONUS

21) PHYSICS *Short Answer*   Krutharth is trying to make circularly polarized light. He passes linearly polarized light with intensity I through two ideal quarter wave-plates oriented 30 degrees and 45 degrees with respect to the original polarization of the light. What is the intensity of the resulting light wave?

ANSWER: I

TOSS UP

22) CHEMISTRY *Multiple Choice*   Which of the following gases is released when aluminum carbide reacts with water?

  W) H_2
  X) CO_2
  Y) CH_4
  Z) C_2H_6

ANSWER: Y) CH_4

BONUS

22) CHEMISTRY *Short Answer*   By name or number, order the following 3 radicals in terms of increasing stability:

  1) Allyl
  2) Alkyl
  3) Phenyl

ANSWER: 3, 2, 1

TOSS UP

23) EARTH AND SPACE *Multiple Choice*   Which of the following minerals primarily composes the foliation bands of phyllite?

  W) Talc
  X) Mica
  Y) Amphibole
  Z) Hornblende

ANSWER: X) Mica

BONUS

23) EARTH AND SPACE *Multiple Choice*   NGC 4555 is a solitary elliptical galaxy containing a significant amount of hot gas in its halo. Which of the following is the most plausible reason for the high amounts of hot gas that do not escape in NGC 4555?

  W) Gravitational interactions with the Coma supercluster
  X) Large amounts of dark matter to prevent the gas from escaping
  Y) High amounts of OB and Wolf-Rayet stars that are able to contain the gas
  Z) Quenching occurred in the early stages of the lifetime of the galaxy

ANSWER: X) Large amounts of dark matter to prevent the gas from escaping

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TOSS UP

24) BIOLOGY *Short Answer*   Andrew is using a sphygmomanometer [READ: *ss-fig-mo-man-o-meter*] to measure a patient's blood pressure, which yields a result of 120/80 mmHg [READ: *120 over 80 millimeters of mercury*]. During the measurement, identify all of the following pressure readings on the gauge at which Andrew could hear Korotkoff [READ: *core-oat-cough*] sounds:

1) 50
2) 100
3) 150

ANSWER: 2 only

BONUS

24) BIOLOGY *Short Answer*   What is the term for a shared, derived trait that is believed to have originated in the most recent common ancestor of a group of taxa?

ANSWER: Synapomorphy

TOSS UP

25) MATH *Short Answer*   A point in 3d space has spherical coordinates $(2, \frac{\pi}{4}, \frac{\pi}{4})$. What are its rectangular coordinates?

ANSWER: $(1, 1, \sqrt{2})$

BONUS

25) MATH *Short Answer*   Vectors **v** and **w** have magnitudes 5 and 6 respectively. If the magnitude of the cross product of **v** and **w** is 24, find the possible values for the dot product of **v** and **w**.

ANSWER: -18 and 18