

2021 MIT Science Bowl High School Invitational

Round 3

TOSS UP

1) BIOLOGY *Short Answer* Which reproductive plant organ contains the stigma, style, and ovary?

ANSWER: Carpel (accept: pistil)

BONUS

1) BIOLOGY *Multiple Choice* In plants, which ion is released in the cytoplasm immediately after gamete fusion?

- W) Potassium
- X) Calcium
- Y) Magnesium
- Z) Sodium

ANSWER: X) Calcium

TOSS UP

2) EARTH AND SPACE *Short Answer* A star has a temperature 5 times that of the sun and a radius 2 times that of the sun. The luminosity of this star is how many times greater than the solar luminosity?

ANSWER: 2500

BONUS

2) EARTH AND SPACE *Multiple Choice* Approximately how thin is the earth's oceanic crust?

- W) 1 kilometer
- X) 10 kilometers
- Y) 100 kilometers
- Z) 1000 kilometers

ANSWER: X) 10 kilometers

TOSS UP

3) ENERGY *Short Answer* The Lamason group at MIT studies the life cycle of *Listeria monocytogenes* (*lis-TEER-ee-uh MON-oh-SAI-toh-jeenz*), which causes listeriosis after consumption of contaminated foods. This bacterium, though capable of surviving in the absence or presence of oxygen, prefers aerobic respiration, and is termed what kind of anaerobe?

ANSWER: Facultative

BONUS

3) ENERGY *Multiple Choice* The Lamason group at MIT studies the intracellular life cycle of *Rickettsia parkeri* (*rick-KETT-see-uh par-KEHR-ee*), a small bacterium whose genus causes many human diseases. Which of the following diseases is NOT caused by rickettsias?

- W) Lyme disease
- X) Spotted fever
- Y) Typhus fever
- Z) Scrub typhus

ANSWER: W) Lyme disease

TOSS UP

4) PHYSICS *Short Answer* By name or number, identify all the following four units that are base SI units:

- 1) Meter
- 2) Gram
- 3) Coulomb
- 4) Second

ANSWER: 1 and 4

BONUS

4) PHYSICS *Short Answer* What is the shape of an object's orbit if it is moving at above escape velocity?

ANSWER: Hyperbola

TOSS UP

5) CHEMISTRY *Short Answer* Magnetite has chemical formula Fe_3O_4 . In one formula unit of magnetite, how many iron II ions are there?

ANSWER: 1

BONUS

5) CHEMISTRY *Short Answer* By name or number, identify all of the following statements which are true of the anion $[\text{FeO}_4]^{2-}$:

- 1) It is a strong oxidizing agent.
- 2) It is only stable in acidic conditions
- 3) The oxidation state of iron in this compound is +6.

ANSWER: 1 and 3

TOSS UP

6) MATH *Short Answer* What is the taxicab distance (also known as the Manhattan distance) between the points (3, 4) and (6, 2)?

ANSWER: 5

BONUS

6) MATH *Short Answer* If two points in the Cartesian plane are at a Euclidean distance of 6, then what are the minimum and maximum possible taxicab distance between them?

ANSWER: 6 and $6\sqrt{2}$

TOSS UP

7) CHEMISTRY *Short Answer* By name or number, rank the following three neutral atoms in order of increasing electron affinity:

- 1) Chlorine
- 2) Gold
- 3) Oxygen

ANSWER: 3, 2, 1

BONUS

7) CHEMISTRY *Short Answer* In the most stable resonance structure of the cyanate anion, what is the formal charge on the oxygen atom?

ANSWER: -1

TOSS UP

8) BIOLOGY *Multiple Choice* Which of the following terms best characterizes the movement of a fly moving towards a sample of strongly-scented food?

- W) Positive chemotaxis
- X) Negative chemotaxis
- Y) Positive phototaxis
- Z) Negative phototaxis

ANSWER: W) Positive chemotaxis

BONUS

8) BIOLOGY *Short Answer* What type of distribution best characterizes populations in environments in which resources are scarce?

ANSWER: Clumped

TOSS UP

9) PHYSICS *Short Answer* Two springs with spring constants 4 newtons per meter and 2 newtons per meter are attached in series to a box weighing 10 kilograms. What is the effective spring constant of the system, in newtons per meter?

ANSWER: $4/3$ newtons per meter

BONUS

9) PHYSICS *Short Answer* By name or number, rank the following three types of radiation in terms of increasing ability to penetrate through barriers:

- 1) Alpha
- 2) Beta
- 3) Gamma

ANSWER: 1, 2, 3

TOSS UP

10) ENERGY *Short Answer* Researchers in the Center for Theoretical Physics at MIT are working on designing quantum computers to tackle large datasets which are challenging to analyze by classical means. What basic unit of information is used to build quantum computers?

ANSWER: Qubits

BONUS

10) ENERGY *Short Answer* Scientists in the Guth group at MIT have been studying the physics of the early universe. To do so, they have been analyzing data from WMAP, a probe which measures temperature differences in what energy remnant from the Big Bang?

ANSWER: Cosmic microwave background radiation (accept: CMBR)

TOSS UP

11) EARTH AND SPACE *Short Answer* By name or number, arrange the following four minerals in order of increasing melting point:

- 1) Amphibole
- 2) Biotite
- 3) Olivine
- 4) Quartz

ANSWER: 4, 2, 1, 3

BONUS

11) EARTH AND SPACE *Short Answer* On a psychrometer, if the dry bulb and the wet bulb temperatures are the same, what is the relative humidity?

ANSWER: 100%

TOSS UP

12) MATH *Multiple Choice* Which mathematician is credited with the first proof that there are infinitely many prime numbers?

- W) Euclid
- X) Leonhard Euler
- Y) Carl Friedrich Gauss
- Z) Bernhard Riemann

ANSWER: W) Euclid

BONUS

12) MATH *Short Answer* What is the smallest possible surface area of a solid which has a volume of 12?

ANSWER: $12\sqrt[3]{3\pi}$ (accept: $12(3\pi)^{1/3}$)

TOSS UP

13) CHEMISTRY *Multiple Choice* Which of the following gas molecules will have the largest constant volume molar heat capacity at standard conditions?

- W) Diatomic hydrogen
- X) Hydrogen chloride
- Y) Sulfur dioxide
- Z) Diatomic nitrogen

ANSWER: Y) Sulfur dioxide

BONUS

13) CHEMISTRY *Short Answer* By name or number, identify all of the following three statements that would be true of the boiling of water at a temperature T above its normal boiling point of 373 kelvin.

- 1) The enthalpy of vaporization for water at T is more positive than the enthalpy of vaporization at 373 kelvin.
- 2) The Gibbs free energy of vaporization for water at T is more positive than the Gibbs free energy of vaporization at 373 kelvin.
- 3) The change in internal energy for the boiling of water at T is more positive than the change in internal energy at 373 kelvin.

ANSWER: None of them

TOSS UP

14) MATH *Short Answer* How many zeroes does the number $33!$ (read: 33 factorial) end in?

ANSWER: 7

BONUS

14) MATH *Short Answer* How many ways can a 2-by-2 grid of squares be painted such that each square is either red, green, or blue, and no two squares that share a side have the same color?

ANSWER: 18

TOSS UP

15) PHYSICS *Short Answer* A simple pendulum with length L is released 50 degrees from the vertical. Which of the following describes the period of the resulting oscillations?

W) The pendulum will not oscillate

X) Less than $2\pi\sqrt{L/g}$

Y) $2\pi\sqrt{L/g}$

Z) More than $2\pi\sqrt{L/g}$

ANSWER: Z) More than $2\pi\sqrt{L/g}$

BONUS

15) PHYSICS *Short Answer* A mass is placed on an inclined plane, which is angled 45 degrees from horizontal and has a coefficient of friction of 0.14. To the nearest meter per second squared, what is the acceleration of the mass?

ANSWER: 6 meters per second squared

TOSS UP

16) BIOLOGY *Multiple Choice* How many cotyledons (*CAW-tuhl-LEE-duhns*) does the seed of a tulip exhibit?

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

ANSWER: W) 1

BONUS

16) BIOLOGY *Multiple Choice* Which of the following is NOT a trait of a dicot plant?

- W) Taproots
- X) Net-like veins
- Y) 4 to 5 petals
- Z) Two pollen furrows

ANSWER: Z) Two pollen furrows

TOSS UP

17) EARTH AND SPACE *Short Answer* By name or number, order the following three layers of the sun from outermost to innermost:

- 1) Chromosphere
- 2) Photosphere
- 3) Corona

ANSWER: 3, 1, 2

BONUS

17) EARTH AND SPACE *Multiple Choice* What is the name of the semiarid climate region characterized by grassland plains without trees occurring in temperate climates?

- W) Desert
- X) Steppe
- Y) Chaparral
- Z) Taiga

ANSWER: X) Steppe

TOSS UP

18) ENERGY *Short Answer* Researchers in the Ceyer group at MIT are studying the reaction of xenon difluoride with a silicon surface, in which the silicon abstracts a fluorine atom from the compound. What is the electron pair geometry of xenon difluoride?

ANSWER: Trigonal bipyramidal

BONUS

18) ENERGY *Short Answer* The Danheiser group at MIT is working on annulation strategies to form rings of various sizes in organic synthesis. One of the strategies is to use allenes and tosyl cyanide. In an allene structure, what is the hybridization of the middle carbon?

ANSWER: *sp*

TOSS UP

19) BIOLOGY *Short Answer* Proteolipid protein accounts for a majority of what general substance that is absent from the nodes of Ranvier?

ANSWER: Myelin

BONUS

19) BIOLOGY *Multiple Choice* Which of the following best explains the reason why action potentials only proceed in one direction?

- W) The region behind the action potential has its sodium channels closed
- X) The region behind the action potential has its sodium channels open
- Y) The region behind the action potential has its potassium channels closed
- Z) The region behind the action potential has its potassium channels open

ANSWER: W) The region behind the action potential has its sodium channels closed

TOSS UP

20) PHYSICS *Short Answer* By name or number, identify all of the following three colors of light which have wavelengths greater than green light:

- 1) Red
- 2) Violet
- 3) Orange

ANSWER: 1 and 3

BONUS

20) PHYSICS *Multiple Choice* Which of the following fundamental forces are sterile neutrinos thought to be able to interact with?

- W) Strong nuclear
- X) Weak nuclear
- Y) Electromagnetic
- Z) Gravitational

ANSWER: Z) Gravitational

TOSS UP

21) CHEMISTRY *Short Answer* By name or number, identify all of the following three diatomic molecules which have a bond order of 3:

- 1) O_2^-
- 2) CN^-
- 3) CO

ANSWER: 2 and 3

BONUS

21) CHEMISTRY *Multiple Choice* In which of the following compounds is the N–O (read: *N O*) bond order the least?

- W) N_2O
- X) NO
- Y) NO_2
- Z) NO_2^-

ANSWER: W) N_2O

TOSS UP

22) MATH *Multiple Choice* Which of the following statements follows from the statement "If A, then B?"

- W) If B, then A
- X) If not A, then not B
- Y) If not B, then not A
- Z) If not A, then B

ANSWER: Y) If not B, then not A

BONUS

22) MATH *Short Answer* Three ordinary six-sided dice are rolled. What is the probability that the product of the numbers shown is composite?

ANSWER: 103/108

TOSS UP

23) EARTH AND SPACE *Multiple Choice* The last ice age occurred during which of the following epochs?

- W) Eocene
- X) Miocene
- Y) Pleistocene
- Z) Holocene

ANSWER: Y) Pleistocene

BONUS

23) EARTH AND SPACE *Multiple Choice* Which of the following is closest to the ratio of the luminosity of a main sequence star to another main sequence star with half the mass?

- W) 1.6
- X) 3
- Y) 8
- Z) 11

ANSWER: Z) 11