FE!M 2025

Round 2

TOSS UP

1) BIOLOGY *Short Answer* Select ALL of the following plant cell types that are living at functional maturity:

1) Sieve-tube element
2) Collenchyma
3) Tracheid

ANSWER: 1 and 2 [TS]

BONUS

1) BIOLOGY *Multiple Choice* Students at Saratoga High School are investigating flowering patterns in plants. If a flower has a critical night length of 14 hours, under which of the following conditions would it flower?

W) Eight hours of night, a short flash of red light, and seven more hours of night.

X) Five hours of night, a short flash of far-red light, a short flash of red light, and ten more hours of night.

Y) Twelve uninterrupted hours of night.

Z) Seven hours of night, a short flash of red light, a short flash of far-red light, and seven more hours of night.

ANSWER: Z) SEVEN HOURS OF NIGHT, A SHORT FLASH OF RED LIGHT, A SHORT FLASH OF FAR-RED LIGHT, AND SEVEN MORE HOURS OF NIGHT [ArK]

TOSS UP

2) PHYSICS *Short Answer* An ambulance with a loud siren travels at 20 m/s away from Roshan and towards Theenash. Taking the speed of sound to be 340 m/s, what is the ratio of the apparent frequencies of the siren as observed by Theenash and Roshan?

ANSWER: 9/8 [RuA]

BONUS

2) PHYSICS *Short Answer* Theenash, who weighs 90 kg, falls from a very tall building and experiences quadratic drag with a proportionality constant of $b = 2\,Ns^2/m^2$ (read: *newton seconds squared per meter squared*). In meters per second, what is Theenash's terminal velocity?

ANSWER: 21 m/s [RuA]

TOSS UP

3) CHEMISTRY *Multiple Choice* Under which of the following sets of conditions will real gas most closely resemble an ideal gas?

W) High temperature and low pressure

X) Low temperature and high pressure

Y) High temperature and high pressure

Z) Low temperature and low pressure

ANSWER: W) High temperature and low pressure [AA]

BONUS

3) CHEMISTRY *Short Answer* How many millileters of a 10 molar solution of *NaOH* are needed to prepare 200 millileters of a 2.50 molar NaOH solution?

Answer: 50 mL [AA]

TOSS UP

4) MATH *Multiple Choice* How many points are needed to uniquely determine a conic section?

W) 3

X) 4

Y) 5

Z) 6

ANSWER: Y) 5 [AdM]

BONUS

4) MATH *Short Answer* Theenash is running a gambling den with just one game, Goon. If a player wins the game, they double their money. Otherwise, they lose their bet. A player is given 3:5 (read: 3 *to* 5) odds to win a game of Goon. Given that Theenash wants to make an expected profit of 0.25 per game, how much should he charge to play?

ANSWER: 1 [AdM]

TOSS UP

5) ESS *Multiple Choice* While mapping a subduction zone, Advai observes a thick layer of dolomite that has undergone extensive folding and compression during mountain building. Which of the following metamorphic rocks is he most likely observing?

W) Marble

X) Schist

Y) Quartzite

Z) Migmatite

ANSWER: W) Marble [RoA]

BONUS

5) ESS *Short Answer* Order the following three carbon sinks by increasing residence time: 1) Atmosphere 2) Deep ocean 3) Mantle

ANSWER: 123 [AS]

TOSS UP

6) BIOLOGY *Short Answer* Despite the presence of 61 amino acid codons, there are approximately 45 distinct tRNAs coded by the genome. This is due to what phenomenon in which one tRNA can bind to multiple codons?

ANSWER: Wobble [TS]

BONUS

6) BIOLOGY *Short Answer* Order the following three organisms by increasing number of heart chambers:

1) Salmon

2) Eagle

3) Frog

ANSWER: 1, 3, 2 [TS]

TOSS UP

7) PHYSICS *Multiple Choice* A block slides down a plane with friction inclined at 30o at constant velocity. Which of the following is closest to the coefficient of static friction between the block and the plane?

W) 0.3

X) 0.4

Y) 0.5

Z) 0.6

ANSWER: Z) 0.6 [RoA]

BONUS

7) PHYSICS *Short Answer* Identify all of the following materials that display the triboelectric effect: 1) Wool sweater; 2) Copper penny; 3) Teflon tape; 4) Steel spoon

ANSWER: 1 and 3 [RuA]

TOSS UP

8) CHEMISTRY *Short Answer* Scientists at Lawrence Berkeley National Laboratory are utilizing advanced electron microscopes to observe subcellular structures. Electron microscopes provide higher resolution than light microscopes because of the increased uncertainty in particle momentum, as explained by what fundamental physical principle?

ANSWER: Heisenberg Uncertainty Principle [AnA]

BONUS

8) CHEMISTRY *Multiple Choice* Ribose is a five carbon sugar that contains three chiral carbon atoms. How many distinct stereoisomers are there for ribose?

W) 4

X) 8

Y) 16

Z) 32

ANSWER: X) 8 [AA]

TOSS UP

9) MATH *Multiple Choice* Which of the following numbers is expressible as the sum of two squares?

W) 31

X) 103

Y) 179

Z) 193

ANSWER: Z) 193 [AdM]

BONUS

9) MATH *Short Answer* Two integers a and b are such that $a > b$. If the least common multiple of a and b is 72 and the greatest common divisor of a and b is 9, then what is a?

ANS: 72 [AdM]

TOSS UP

10) ESS *Multiple Choice* Which of the following layers of the atmosphere is the least homogeneous?

W) Troposphere

X) Stratosphere

Y) Mesosphere

Z) Thermosphere

ANSWER: Z) Thermosphere [RoA]

BONUS

10) ESS *Short Answer* While analyzing the chemical composition of a particular igneous rock, Advai finds that it contains 0.3% P_2O_5. The presence of what mineral is most likely responsible for this chemical signature?

ANSWER: Apatite [RoA]

TOSS UP

11) BIOLOGY *Short Answer* What nitrogenous polymer, also comprising arthropod exoskeletons, is used by fungi to build cell walls?

ANSWER: Chitin [TS]

BONUS

11) BIOLOGY *Multiple Choice* The coding sequence of a gene is composed of 20% cytosine. If base pairs are equally distributed among strands, Which of the following is closest to the percentage uracil of the resulting mRNA?

W) 15

X) 25

Y) 35

Z) 45

ANSWER: Y) 35 [TS]

TOSS UP

12) PHYSICS *Multiple Choice* In degrees, which of the following is closest to the mach angle of an object traveling at twice the speed of sound?

W) 20

X) 30

Y) 40

Z) 50

ANSWER: X) 30 [RuA]

BONUS

12) PHYSICS *Short Answer* A ball is thrown upward from the top of a 20.0 m high building with an initial speed of 15.0 m/s. How long does it take to hit the ground in seconds, assuming g = 10 m/s^2?

ANSWER: 4 [RuA]

TOSS UP

13) CHEMISTRY *Multiple Choice* Which of the following molecules is least stable under standard conditions?

W) BF_3

X) NF_3

Y) PF_5

Z) NF_5

ANSWER: Z) NF_5 [AA]

BONUS

13) CHEMISTRY *Multiple Choice* Which of the following would not adopt a linear molecular geometry as predicted by VSEPR theory?

W) Hydrogen cyanide

X) Carbon dioxide

Y) Water

Z) Nitrogen gas

ANSWER: Y) Water

TOSS UP

14) MATH *Short Answer* A polygon can be triangulated into 20 triangles. How many sides does the polygon have?

ANSWER: 22 [AdM]

BONUS

14) MATH *Short Answer* What is the sum of all 4 digit numbers such that each digit is either 0 or 1? Note that the same digit may be used multiple times.

ANSWER: 8444 [AdM]

TOSS UP

15) ESS *Short Answer* Theenash jumps into the Mississippi River and gets carried out to the Gulf of Mexico. At the Mississippi River's mouth he notices a significant lack of life. This dead zone formed as a result of what phenomenon, in which extreme algal blooms occur due to increased nutrient levels from runoff?

ANSWER: Eutrophication [RoA]

BONUS

15) ESS *Multiple Choice* Advai has a well-graded sediment mixture with sediments of different sizes ranging from silt to gravel. He dumps the mixture from rest into a very deep water column. After the sediments settle, which of the following would Advai most likely observe about the sediment distribution?

W) Larger particles concentrated toward the bottom

X) Smaller particles concentrated toward the bottom

Y) Uniform distribution of all particle sizes throughout

Z) Alternating layers of small and large particles

ANSWER: W) Larger particles concentrated toward the bottom [RoA]

TOSS UP

16) BIOLOGY *Short Answer* Some amino acids exist with a protonated positively-charged amine and a deprotonated negatively-charged carboxyl group. What is the name of the general class of neutral molecules that have formal charges in their most stable structures?

ANSWER: Zwitterions [TS]

BONUS

16) BIOLOGY *Multiple Choice* The drug levodopa is often prescribed to patients with Parkinson's disease to temporarily restore dopaminergic neuronal activity. Which of the following options correctly identifies why dopamine cannot be used directly?

W) Dopamine is highly addictive in its pure form

X) The blood-brain-barrier is impermeable to dopamine

Y) Dopamine is easily degraded in the stomach

Z) The stereochemically active form of dopamine is unstable

ANSWER: X) The blood-brain-barrier is impermeable to dopamine [TS]

TOSS UP

17) PHYSICS *Short Answer* In Newtons, what is the force exerted by a magnetic field of magnitude 2 T on a circular loop of wire with radius 1 m and a constant current of 5 Amps?

ANSWER: 0 [RoA]

BONUS

17) PHYSICS *Short Answer* Identify all of the following statements that are true of the photoelectric effect:

1) The velocity of ejected electrons is proportional to frequency of incident light

2) The kinetic energy of ejected electrons is proportional to energy of incident light

3) The momentum of ejected electrons is proportional to momentum of incident light

ANSWER: None [AdM]

TOSS UP

18) CHEMISTRY *Short Answer* While working on a chemistry homework, Daniel was asked to determine how many water molecules are there in 4 moles of H_2O. What is the name of the fundamental constant which can be used to calculate this?

ANSWER: Avagadro's Constant [AA]

BONUS

18) CHEMISTRY *Multiple Choice* What is the approximate bond order of the S-O bond in sulfite ion?

W) 1

X) 1/2

Y) 4/3

Z) 2/3

ANSWER: Y) 4/3 [AA]

TOSS UP

19) MATH *Short Answer* What is x% of 12, given that 3% of x is 12?

ANSWER: 48 [AdM]

BONUS

19) MATH *Short Answer* The domain of $\log(\log(\log(x)))$ can be represented as an open interval from a to infinity. What is the value of a?

ANSWER: 10 [AdM]

TOSS UP

20) ESS *Short Answer* In a stream, flowing water near the bed can be deflected upward by large grains in the bed load, generating a slight lift force on sediment particles. This process results in what type of sediment transport, characterized by bouncing or hopping along the streambed?

ANSWER: Saltation [RoA]

BONUS

20) ESS *Multiple Choice* Despite their high surface areas, Jovian planets can retain very light gases such as hydrogen and helium. Which of the following best explains this?

W) Their magnetic fields trap light gases near the surface

X) Their escape velocities are higher than the average speeds of these gases

Y) Their strong solar wind interactions prevent gas loss

Z) Their rapid rotation flings heavy gases outward, leaving light gases behind

ANSWER: X) Their escape velocities are higher than the average speeds of these gases [AS]
