FE!M 2025

Round 3

TOSS UP

1) BIOLOGY *Short Answer* Identify all of the following three pathways that produce acetyl-CoA:

1) Beta oxidation
2) Pyruvate oxidation
3) Calvin cycle

ANSWER: 1 and 2 [TS]

BONUS

1) BIOLOGY *Multiple Choice* Which of the following types of bacterial appendages functions in horizontal gene transfer?

W) Fimbriae
X) Flagella
Y) Villi
Z) Pili

ANSWER: Z) Pili [TS]

TOSS UP

2) PHYSICS *Short Answer* How much power, measured over a long period of time, does a motor need to circulate 1000 kg of water along a circular loop of pipe with cross-section radius 20 cm at a constant speed of 10 m/s? Neglect the viscosity of water.

ANSWER: 0 W [RuA]

BONUS

2) PHYSICS *Short Answer* A 1kg mass is connected to the wall with a horizontal string and connected to the ceiling with a string angled at 45°. Find the tension in the horizontal string, to the nearest tenth of a Newton.

ANSWER: 9.8 N [RuA]

TOSS UP

3) CHEMISTRY *Short Answer* At 25 degrees Celsius, what is the change in standard Gibbs free energy for a reaction when the equilibrium constant is 1?

ANSWER: 0 [AA]

BONUS

3) CHEMISTRY *Short Answer* The combustion of one mole of an alkane results in the production of 11 moles of gas particles. How many moles of oxygen gas are needed to fully combust two moles of this alkane?

ANSWER: 16 [AA]

TOSS UP

4) MATH *Short Answer* What is the distance from the focus to the vertex of the parabola with equation $y = 3x^2 + 4x + 9$

ANSWER: 1/12 [AdM]

BONUS

4) MATH *Short Answer* How many 6-digit numbers are greater than $700,000$ and have their digits in strictly descending order?

ANSWER: 203 [AdM]

TOSS UP

5) ESS *Short Answer* Identify all of the following three types of plate boundaries at which shallow-focus earthquakes frequently occur: 1) Transform; 2) Divergent; 3) Convergent

ANSWER: 123 [RoA]

BONUS

5) ESS *Multiple Choice* Which of the following minerals has the most similar internal crystal structure to hematite, which has chemical formula Fe_2O_3?

W) Pyrite

X) Corundum

Y) Magnetite

Z) Quartz

ANSWER: X) Corundum [RoA]

TOSS UP

6) BIOLOGY *Short Answer* A hexaploid wheat cultivar hybridizes with a diploid species to form a new tetraploid species of wheat. This is an example of what general process in which multiple genomes contribute to the formation of a new species?

ANSWER: Allopolyploidy (DO NOT ACCEPT: Autopolyploidy) [TS]

BONUS

6) BIOLOGY *Multiple Choice* Production of inhibin in the testes is inactivated by RNA interference in a mouse model. Which of the following hormonal concentrations would increase the most as a result?

W) Androstenedione

X) Follicle-stimulating hormone

Y) Luteinizing hormone

Z) Testosterone

ANSWER: X) Follicle-stimulating hormone [TS]

TOSS UP

7) PHYSICS *Short Answer* A common solution to the brachistochrone problem, originally discovered by Bernoulli, uses what principle which states that light takes the path of least time when traveling from one point to another?

ANSWER: Fermat's principle [RoA]

BONUS

7) PHYSICS *Short Answer* Eight equal charges are placed at the vertices of a cube with edge length L. The net force on any one of the charges is proportional to L raised to what power?

ANSWER: -2 [RuA]

TOSS UP

8) CHEMISTRY *Multiple Choice* What is the hybridization of the Xe atom in XeF_4?

W) sp^3

X) dsp^3

Y) d^2sp^3

Z) d^2sp^2

ANSWER: Y) d^2sp^3 [AA]

BONUS

8) CHEMISTRY *Short Answer* Arrange the following ionic compounds in order of increasing lattice energy:

1) Sodium bromide

2) Lithium oxide

3) Calcium chloride

ANSWER: 132 [AA]

TOSS UP

9) MATH *Short Answer* In base 10, how many trailing zeroes are there in the product of 24! (read: *twenty-four factorial*) and 25! (read: *twenty-five factorial*)?

ANSWER: 10 [JW]

BONUS

9) MATH *Short Answer* What is the smallest triangular number greater than 36 which is also a perfect square?

ANSWER: 1225 [AdM]

TOSS UP

10) ESS *Multiple Choice* At a certain location in the North Pacific Ocean, the prevailing wind blows from the south. In which of the following directions will the surface ocean water most likely move as a result of this wind?

W) Northeast

X) Northwest

Y) Southeast

Z) Southwest

ANSWER: W) Northeast [RoA]

BONUS

10) ESS *Multiple Choice* On average, how does the altitude of the tropopause change during summer and during winter, respectively?

W) Increases, increases

X) Increases, decreases

Y) Decreases, increases

Z) Decreases, decreases

ANSWER: X) Increases, decreases [IK]

TOSS UP

11) BIOLOGY *Multiple Choice* A man has fallen into the river. In the hospital, a probe determines that the effective radius of his arteries is abnormally deficient. Which of the following could be a cause for his condition?

W) Accumulation of HDLs in arterial walls

X) Accumulation of LDLs in arterial walls

Y) Overproduction of prostaglandins

Z) A staphylococcal infection

ANSWER: X) Accumulations of LDLs in arterial walls [ArK]

BONUS

11) BIOLOGY *Short Answer* Scientists at the University of Maryland have been studying the effects of hormone response element activation on transcriptional load in liver cells. Select ALL of the following hormones whose cognate receptors bind to a hormone response element:

1) Thyroxine
2) Vasopressin
3) Estradiol

ANSWER: 1 and 3 [TS]

TOSS UP

12) PHYSICS *Short Answer* An Atwood machine consists of two masses with mass 1 kg and 13 kg. Expressing your answer in terms of g, what is the acceleration of the system?

ANSWER: $6g/7$ [RuA]

BONUS

12) PHYSICS *Short Answer* A 2 kg rock moving at 3 m/s collides elastically with a 6 kg rock at rest. What is the ratio of the final speed of the 2 kg rock to that of the 6 kg rock after the collision?

ANSWER: 1 [RuA]

TOSS UP

13) CHEMISTRY *Short Answer* What phenomenon best explains why heavier p-block elements such as bismuth and thallium favor lower oxidation states compared to other elements in their respective groups?

ANSWER: Inert pair effect [AA]

BONUS

13) CHEMISTRY *Short Answer* Rutvik is studying radioactive decay of Thorium-232 for his PhD. As Thorium-232 decays down to Lead-208, he records the emission of alpha particles. How many alpha particles are emitted during the entire decay process?

ANSWER: 6 [AA]

TOSS UP

14) MATH *Multiple Choice* The 16^{th} Fibonacci number is 987. What is the 18^{th} Fibonacci number?

W) 2347

X) 2584

Y) 2792

Z) 2936

ANSWER: X) 2584 [RoA]

BONUS

14) MATH *Short Answer* What is the best fractional approximation for e with a denominator less than 10?

ANSWER: 19/7 [AdM]

TOSS UP

15) ESS *Multiple Choice* Which of the following specific minerals commonly forms as a foliated, platy mass as a result of metamorphic processes?

W) Quartz

X) Muscovite

Y) Plagioclase

Z) Olivine

ANSWER: X) Muscovite [RoA]

BONUS

15) ESS *Short Answer* Astronomical seeing refers to the distortion of light received by telescopes due to turbulence in Earth's atmosphere. Identify all of the following three telescopes that are affected by astronomical seeing: 1) Chandra X-ray Observatory; 2) Arecibo Observatory; 3) James Webb Telescope

ANSWER: 2 only [RoA]

TOSS UP

16) BIOLOGY *Multiple Choice* Which of the following island geographies would harbor the highest species diversity?

W) Large, close to the mainland

X) Large, far from the mainland

Y) Small, close to the mainland

Z) Small, far from the mainland

ANSWER: W) Large, close to the mainland [TS]

BONUS

16) BIOLOGY *Short Answer* Select ALL of the following that are characteristics of deuterostomes:

1) Holoblastic cleavage
2) Enterocoelous mesoderm development
3) Determinate cleavage

ANSWER: 2 only [TS]

TOSS UP

17) PHYSICS *Multiple Choice* A ball is moving in a circular path with constant speed v. The rate of change of the object's linear momentum is directly proportional to its velocity raised to which of the following powers?

W) -1
X) 0
Y) 1
Z) 2

ANSWER: Z) 2 [RoA]

BONUS

17) PHYSICS *Multiple Choice* Which of the following constants has the same units as angular momentum?

W) Speed of light

X) Gravitational constant

Y) Planck's constant

Z) Boltzmann's constant

ANSWER: Y) Planck's constant [AdM]

TOSS UP

18) CHEMISTRY *Multiple Choice* Which of the following elements could be used to create an n-type semiconductor when added to pure silicon?

W) Gallium

X) Aluminum

Y) Magnesium

Z) Phosphorus

ANSWER: Z) Phosphorus [AA]

BONUS

18) CHEMISTRY *Short Answer* What is the bond angle between equatorial chlorine atoms in phosphorus pentachloride?

ANSWER: 120° [AA]

TOSS UP

19) MATH *Short Answer* Expressing your answer in exponent form, what is the sum of the coefficients of terms with odd degree in the expansion of $(x + 1)^{1000}$?

ANSWER: 2^{999} [AdM]

BONUS

19) MATH *Short Answer* What are the last two digits of the sum from $n = 1$ to $n = 100$ of $n!$ (read: *n factorial*)?

ANS: 13 [AdM]

TOSS UP

20) ESS *Multiple Choice* Ground-level fog is essentially the same in structure and composition as which of the following major types of clouds that appear as a low, uniform, gray layer often covering the entire sky?

W) Cumulonimbus

X) Stratus

Y) Mammatus

Z) Altocumulus

ANS: X) Stratus [RoA]

BONUS

20) ESS *Short Answer* Roshan is floating in a slightly underinflated raft in the North Atlantic Ocean. Identify all of the following three processes that would help Roshan float better:

1) Evaporation

2) Sea ice formation

3) Precipitation

ANSWER: 12 [AS]
