FE!M 2025

Round 9

TOSS UP

1) CHEMISTRY *Multiple Choice* Which of the following functional groups is found in the product formed when pyrrolidine reacts with formaldehyde in an acidic solution?

W) Enamine

X) Imine

Y) Amine

Z) Amide

ANSWER: W) Enamine [AA]

BONUS

1) CHEMISTRY *Multiple Choice* Which of the following four options correctly identifies the highest occupied d orbital in the square planar complex $Pt(CN)_4^{2-}$?

W) d_{z^2}

X) $d_{x^2-y^2}$

Y) d_{xy}

Z) d_{xz}

ANSWER: Y) d_{xy} [TS]

TOSS UP

2) PHYSICS *Multiple Choice* A particle moving in 3D space experiences simple harmonic motion in the x, y, and z directions. If the oscillations in all three directions are perfectly in phase, which of the following best describes the shape of the particle's trajectory?

W) Linear

X) Parabolic

Y) Sinusoidal

Z) Spiral

ANSWER: W) Linear [RoA]

BONUS

2) PHYSICS *Short Answer* Advai, who weighs 50kg, stands at one end of a 90 meter long boat of mass 100kg in a lake. He starts running at a speed of 8 m/s with respect to still water towards the opposite end of the boat. Assuming drag is negligible, how many seconds does it take him to fall off the edge of the boat?

ANSWER: 7.5 [RuA]

TOSS UP

3) ESS *Multiple Choice* Which of the following best describes the shape of the thalweg in a meandering river?

W) It curves away from both cut banks and point bars

X) It curves away from cut banks and curves towards point bars

Y) It curves towards cut banks and curves away from point bars

Z) It curves away from both cut banks and point bars

ANSWER: Y) It curves toward cut banks and curves away from point bars [RoA]

BONUS

3) ESS *Multiple Choice* Some of the main Koppen climate groups can be divided into subgroups by assigning a second letter based on seasonal precipitation variation and a third letter based on temperature. Which of the following is not a real Koppen climate classification?

W) Aw

X) BWh

Y) Dwa

Z) Ew

ANSWER: Z) Ew [RoA]

TOSS UP

4) MATH *Multiple Choice* Which of the following always equals x for all real x?

W) $\sqrt{x^2}$

X) $\arcsin(\sin x))$

Y) $\ln(e^x)$

Z) x^2/x

ANSWER: Y) $\ln(e^x)$

BONUS

4) MATH *Short Answer* The apothem of a regular polygon is the distance from the center to one of its sides. What is the area of a regular dodecagon with an apothem of length 2?

ANSWER: $96 - 48\sqrt{3}$

TOSS UP

5) BIOLOGY *Short Answer* Select ALL of the following three characteristics that are homoplasies:

1) Pseudocoelom
2) Camera lens-type eye
3) Bilateral symmetry

ANSWER: 12 [TS]

BONUS

5) BIOLOGY *Short Answer* Epiphytes such as orchids and bromeliads cannot draw moisture from the soil and must therefore rely on other sources of water. What specialized tissue covering the aerial roots of such plants facilitates moisture absorption from the surface of their host tree?

ANSWER: Velamen [TS]

TOSS UP

6) CHEMISTRY *Short Answer* When calculating the lattice energy of a compound, the arrangement of atoms around each center must be accounted for along with coulombic effects. What correction factor is generally used for this purpose?

ANSWER: Madelung Constant [ThS]

BONUS

6) CHEMISTRY *Short Answer* Identify all of the following statements that are true regarding conformation locking groups on a cyclohexane ring.

1) Trans-decalin analogues can undergo ring flips while cis-decalin analogues cannot
2) The t-butyl group generally prefers the equatorial position
3) Most decalin junctions in steroids are trans

ANSWER: 23

TOSS UP

7) PHYSICS *Multiple Choice* Which of the following quantities describes the inverse of impedance in an electrical circuit?

W) Elastance
X) Admittance
Y) Conductance
Z) Capacitance

ANSWER: X) Admittance [RoA]

BONUS

7) PHYSICS *Short Answer* The modulus of resilience is a measure of the energy per unit volume a material can absorb without permanent deformation and can be calculated as the area under the stress-strain curve. What is the modulus of resilience of a rubberband with a yield strength of 40 Mpa and a Young's modulus of 80 Mpa?

ANSWER: 10 [RoA]

TOSS UP

8) ESS *Multiple Choice* Which of the following best describes how ocean waves interact with coastal headlands and bays?

W) Waves diverge at headlands and diverge at bays

X) Waves diverge at headlands and converge at bays

Y) Waves converge at headlands and diverge at bays

Z) Waves converge at headlands and converge at bays

ANSWER: Y) Waves converge at headlands and diverge at bays [RoA]

BONUS

8) ESS *Multiple Choice* Which of the following best explains the concentration of rare-earth elements found on the surface of the moon?

W) Rich in rare-earth elements due to early stage crystallization

X) Rich in rare-earth elements due to late stage crystallization

Y) Poor in rare-earth elements due to early stage crystallization

Z) Poor in rare-earth elements due to late stage crystallization

ANSWER: X) Rich in rare-earth elements due to late stage crystallization [RoA]

TOSS UP

9) MATH *Short Answer* Which of the following four sets of logical operations are functionally complete?

1) AND, OR

2) IMPLIES, NOT

3) NAND

4) AND, NOT

ANSWER: 234

BONUS

9) MATH *Short Answer* The Hamming weight of a number is the sum of its digits in binary. What is the largest Hamming weight of an integer between 1 and 600, inclusive?

ANSWER: 7

TOSS UP

10) BIOLOGY *Short Answer* Order the following three compounds in eicosanoid synthesis from earliest to latest in the pathway:

1) Cyclic endoperoxides
2) Arachidonic acid
3) Thromboxanes

ANSWER: 213

BONUS

10) BIOLOGY *Multiple Choice* Which of the following types of speciation is most commonly associated with a hybrid zone?

W) Allopatric
X) Parapatric
Y) Peripatric
Z) Sympatric

ANSWER: X) Parapatric

TOSS UP

11) CHEMISTRY *Short Answer* Order the following three radicals by increasing energy:

1) OH

2) CH_2NH_2

3) CH_2F

ANSWER: 132

BONUS

11) CHEMISTRY *Multiple Choice* A Fischer de-esterification reaction can be utilized in the ring-opening of cyclohexanone. However, which of the following reactions must be performed first before Fischer esterification can be used?

W) Wittig reaction

X) Lithium aluminum hydride reduction

Y) Grignard reaction

Z) Baeyer-Villiger Oxidation

ANSWER: Z) Baeyer-Villiger Oxidation [EdH]

TOSS UP

12) PHYSICS *Short Answer* The linear coefficient of thermal expansion of a particular substance is $2.1 \cdot 10^{-6}$ per degree Celsius. What is the volumetric coefficient of thermal expansion for this substance?

ANSWER: $6.3 \cdot 10^{-6}$

BONUS

12) PHYSICS *Short Answer* The charge passing through an inductor with inductance 10H can be modeled by the function $Q(t) = 8t^3 + 6t^2 + 2$. In volts, what is the voltage across the inductor at time $t = 0.25$ seconds?

ANSWER: 45 [RoA]

TOSS UP

13) ESS *Multiple Choice* While observing the Sun, Advai notices a slight Doppler shift in the light from solar granules. Which of the following best describes the Doppler effect at the center and the edges of a granule, respectively?

W) Blueshift, blueshift

X) Blueshift, redshift

Y) Redshift, blueshift

Z) Redshift, redshift

ANSWER: X) Blueshift, redshift [RoA]

BONUS

13) ESS *Short Answer* Identify all of the following three changes that would increase the severity of a tidal bore:

1) Increasing beach slope
2) Increasing tidal range
3) Increasing estuary width

ANSWER: 2 [RoA]

TOSS UP

14) MATH *Short Answer* Triangle ABC has an altitude with length 4 and an altitude with length 5. What is the minimum integer length of the third altitude?

ANSWER: 3

BONUS

14) MATH *Short Answer* What point on the circle with equation $(x-1)^2 + (y+3)^2 = 100$ is closest to the point $(16, 17)$?

ANSWER: $(7, 5)$ [JW]

TOSS UP

15) BIOLOGY *Short Answer* While the fungal lineage is derived from the amoeboid nucleariids, animals are derived from what other group of colonial eukaryotes?

ANSWER: Choanoflagellates

BONUS

15) BIOLOGY *Multiple Choice* Which of the following ecological distributions would be observed for a population of plants exhibiting allelopathy?

W) Clumped

X) Random

Y) Irregular

Z) Uniform

ANSWER: Z) Uniform

TOSS UP

16) CHEMISTRY *Short Answer* In the mechanism of hydroboration-oxidation, identify all of the following three compounds that nucleophilically attack boron:

1) Water

2) Hydroxide

3) Hydroperoxide anion

ANSWER: 23 [EdH]

BONUS

16) CHEMISTRY *Short Answer* When phenyl chloride is exposed to sodium amide, an unstable diradical species forms with chemical formula C_6H_4. What is the name of this intermediate?

ANSWER: Benzyne

TOSS UP

17) PHYSICS *Short Answer* Identify all of the following three particles have strangeness 0:

1) Pion
2) Kaon
3) Proton

ANSWER: 13

BONUS

17) PHYSICS *Short Answer* What fundamental unit of resistance is equal to Planck's constant divided by the elementary charge squared?

ANSWER: von Klitzing constant [RuA]

TOSS UP

18) ESS *Short Answer* Advai performs a hardness test on a mineral by scratching it with a piece of orthoclase. He finds that the mineral is scratched when he applies the orthoclase in one direction, but it resists scratching when he tries in the perpendicular direction. What is the identity of this mineral?

ANSWER: Kyanite [RoA]

BONUS

18) ESS *Multiple Choice* During the day, the F layer of the ionosphere splits into two sublayers called F_1 and F_2. At night, these layers merge back into one. Which of the following best explains this difference between day and night?

W) Daytime solar radiation increases ionization, producing separate regions of electron density

X) Nighttime heating of the atmosphere causes the layers to expand and combine

Y) The magnetic field weakens at night, allowing recombination of charged particles

Z) The ozone layer absorbs more ultraviolet radiation at night, reducing ionization

ANSWER: W) Daytime solar radiation increases ionization, producing separate regions of electron density [IK]

TOSS UP

19) MATH *Multiple Choice* Which of the following types of curve is represented by the polar equation $r = \sec\theta$?

W) Horizontal line

X) Vertical Line

Y) Circle

Z) Cardioid

ANSWER: X) Vertical line

BONUS

19) MATH *Short Answer* What is the area bounded by the curves $y = sqrt(16 - x^2)$ and $y = |x| - 4$?

ANSWER: $8\pi + 16$

TOSS UP

20) BIOLOGY *Multiple Choice* In an open-heart surgery gone wrong, the sinoatrial node of a patient is completely destroyed. Which of the following would most likely result?

W) Atrial fibrillation

X) Bradycardia

Y) Atrial flutter

Z) Heart Block

ANSWER: X) Bradycardia

BONUS

20) BIOLOGY *Short Answer* Two plants heterozygous for each of the ABC floral homeotic genes are mated. What is the probability that a selected offspring has exactly two distinct whorls?

ANSWER: 27/64

TOSS UP

21) CHEMISTRY *Short Answer* Select ALL of the following molecules that are IR-active:

1) Acetone
2) Acetylene
3) Acetamide

ANSWER: ALL [TS]

BONUS

21) CHEMISTRY *Multiple Choice* The root mean square velocity of a sample of helium gas is 173 m/s. Which of the following is closest to its modal speed in meters per second?

W) 184
X) 179
Y) 163
Z) 141

ANSWER: Z) 141

TOSS UP

22) PHYSICS *Short Answer* Roshan shines a beam of light through a linear polarizer and notices that the outgoing light has an intensity of I. He then rotates the polarizer and observes that the intensity of outgoing light remains constant. Which of the following could the incoming light be?

1) Linearly polarized light
2) Circularly polarized light
3) Unpolarized light

ANSWER: 23

BONUS

22) PHYSICS *Short Answer* A small ball of mass 1kg is attached to the end of a 1kg rod of length 2 meters. The rod's free end is then fixed and the system is swung around the fixed end like a pendulum. To the nearest second, what is the period of this pendulum?

ANSWER: 3s

TOSS UP

23) ESS *Multiple Choice* In stars, the first dredge-up, where fusion products are surfaced through convection, occurs between which two stellar stages?

W) Main sequence and red giant branch
X) Red giant branch and horizontal branch
Y) Horizontal branch and asymptotic giant branch
Z) Asymptotic giant branch and white dwarf

ANSWER: W) Main sequence and red giant branch [AS]

BONUS

23) ESS *Short Answer* Abhiraam is building a planet in his solar system simulation and needs help understanding factors designing an atmosphere. Identify all of the following three changes that would increase the rate of atmospheric escape on his planet:

1) Replacing all the protium in the atmosphere with deuterium
2) Increasing the semi-major axis of the planet's orbit
3) Increasing the size of the planet

ANSWER: None [RoA]

TOSS UP

24) MATH *Short Answer* If the people in Roshan's biology class are arranged into rows of 6, 3 people are left over. If they are arranged into rows of 7, 1 person is left over. What is the third smallest possible number of people in Roshan's class?

ANSWER: 99

BONUS

24) MATH *Short Answer* Two numbers are chosen randomly and without replacement from the set of integers from 1 to 20. What is the expected value of the minimum of the two numbers?

ANSWER: 7

TOSS UP

25) BIOLOGY *Multiple Choice* Which of the following proteins involved in excitation-contraction coupling is most responsible for calcium-induced calcium release?

W) Nicotinic acetylcholine receptor

X) Ryanodine receptor

Y) Phospholipase C

Z) Dihydropyridine receptor

ANSWER: X) Ryanodine receptor

BONUS

25) BIOLOGY *Short Answer* Roshan creates a transgenic plant whose leaf area index increases throughout its lifetime. As the area index exceeds a critical value, the plant undergoes what abortive process resulting in leaf abscission?

ANSWER: Self-pruning