



MOSFET 2025 - Round 8

TOSS-UP

1) BIOLOGY *Multiple Choice* Which of the following plant cells does NOT contain a nucleus?

- W) Palisade mesophyll cell
- X) Companion cell
- Y) Collenchyma cell
- Z) Tracheid

ANSWER: Z) TRACHEID [SY]

BONUS

- 1) BIOLOGY *Multiple Choice* Which of the following statements is true regarding the difference between eukaryotic and prokaryotic ribosomes?
- W) Eukaryotes have 80s ribosomes, while prokaryotes have 70s ribosomes
X) Eukaryotic ribosomes have a protein catalytic component, while prokaryotic ribosomes use an rRNA catalytic component
Y) The large subunit of both eukaryotic and prokaryotic ribosomes is assembled in the cytosol
Z) Both eukaryotic and prokaryotic ribosomes contain the same number of rRNA molecules

ANSWER: W) EUKARYOTES HAVE 80S RIBOSOMES, WHILE PROKARYOTES HAVE 70S RIBOSOMES [OW]

TOSS-UP

- 2) MATH *Multiple Choice* Apple Joe is planting his saplings. If he plants the saplings into rows of 7, he will have 5 left over. If he instead plants them in rows of 10, he will have 8 left over. What is the least possible number of saplings he could have?

- W) 38
X) 48
Y) 58
Z) 68

ANSWER: Z) 68 [JW]

BONUS

2) MATH *Short Answer* Apple Joe has a pile of apples. If Joe removes 3, 4, or 5 apples at a time, he will have 2, 1, and 0 apples left over, respectively. If Joe arranges the apples into the largest square grid possible, he will have 4 apples left over. What is the minimum number of apples Joe can have in his pile?

ANSWER: 125 [JW]

TOSS-UP

3) CHEMISTRY *Multiple Choice* What equation, which accounts for the effects of molecular volume and intermolecular forces, extends the ideal gas law to describe real gases?

- W) Van der Waals equation
- X) Arrhenius equation
- Y) Henderson-Hasselbalch equation
- Z) Clausius-Clapeyron equation

ANSWER: W) VAN DER WAALS EQUATION [HJ]

BONUS

3) CHEMISTRY *Short Answer* Cindy is attempting to find chloride concentration in a solution, so she adds several drops of sodium chromate and then titrates with standardized silver nitrate. What is the chemical formula of the reddish precipitate formed at the endpoint of the titration?

ANSWER: Ag_2CrO_4 [YL]

TOSS-UP

4) EARTH AND SPACE *Multiple Choice* Which of the following isotopes would NOT be useful in radiometric dating of fossils originating from the Cambrian period?

- W) Uranium-238
- X) Rubidium-87
- Y) Potassium-40
- Z) Carbon-14

ANSWER: Z) CARBON-14 [HJ]

BONUS

4) EARTH AND SPACE *Short Answer* Order the following three spectral emission series by increasing wavelength:

- 1) Balmer
- 2) Lyman
- 3) Paschen

ANSWER: 2, 1, 3 [SE]

TOSS-UP

5) PHYSICS *Short Answer* Young's double slit experiment can be explained by what principle, which states that every point on a wavefront generates secondary waves in turn?

ANSWER: HUYGENS' PRINCIPLE [YL]

BONUS

5) PHYSICS *Multiple Choice* Suzuko wants to poke a nucleus. Which of the following regions of the electromagnetic spectrum best corresponds to the energy scale of nuclear processes?

- W) Visible
- X) Ultraviolet
- Y) X-ray
- Z) Gamma

ANSWER: Z) GAMMA [CZ]

TOSS-UP

6) ENERGY *Short Answer* Researchers at Boston University are computationally studying ligand binding in biological macromolecules. Ligands are generally classified as what type of chemical species, which are capable of donating an electron pair to form a coordinate covalent bond?

ANSWER: LEWIS BASE (ACCEPT: NUCLEOPHILE, DO NOT ACCEPT: BASE) [HJ]

BONUS

6) ENERGY *Short Answer* Scientists in the U.S. Fish and Wildlife Service are studying human impacts on food chains. What is the name of the process in which a toxin builds up in an organism over its lifetime?

ANSWER: BIOACCUMULATION [SO, EDE]

TOSS-UP

7) BIOLOGY *Multiple Choice* XIST, an RNA transcript that plays a major role in X-chromosome inactivation, is classified as which of the following types of noncoding RNA?

W) lncRNA

X) siRNA

Y) miRNA

Z) snRNA

ANSWER: W) lncRNA [KD]

BONUS

7) BIOLOGY *Short Answer* Carriers of cystic fibrosis often have slight resistance against tuberculosis. This is an example of what phenomenon, where carriers possess higher fitness compared to either homozygous genotype?

ANSWER: HETEROZYGOTE ADVANTAGE [SY]

TOSS-UP

8) MATH *Multiple Choice* A fair coin is repeatedly flipped, with heads having a value of 1 and tails a value of -1. If the set of all the flips' values is taken to be a population, how does the standard deviation of this population change as the number of times the coin is flipped approaches infinity?

- W) Approaches 0
- X) Approaches 1
- Y) Approaches a value between 0 and 1
- Z) Remains constant

ANSWER: X) APPROACHES 1 [JW]

BONUS

8) MATH *Short Answer* Three circles with radii 6, 7, and 8 are pairwise externally tangent. What is the area of the triangle formed by connecting the centers of the circles?

ANSWER: 84 [EZ]

TOSS-UP

9) CHEMISTRY *Multiple Choice* Which of the following orbitals contains the most total nodes?

- W) 1s
- X) 2p
- Y) 3d
- Z) 4f

ANSWER: Z) 4f [CZ]

BONUS

9) CHEMISTRY *Multiple Choice* Which of the following statements is NOT true regarding the autoprotolysis constant of water, K_w?

- W) In the full expression of K_w, the denominator is equal to 1
- X) The value of K_w remains constant at all temperatures
- Y) The product of K_a and K_b values in a conjugate acid-base pair is equal to K_w
- Z) Increasing the hydroxide ion concentration does not alter the value of K_w

ANSWER: X) THE VALUE OF K SUB W REMAINS CONSTANT AT ALL TEMPERATURES [HJ]

TOSS-UP

10) EARTH AND SPACE *Short Answer* Very large asteroids, such as Ceres and Vesta, grew large enough such that their interiors melted and separated into several distinct compositional layers. What is the name for this process?

ANSWER: DIFFERENTIATION [HJ]

BONUS

10) EARTH AND SPACE *Multiple Choice* Which of the following choices best describes the vertical temperature profile of falling sleet?

- W) Starts above freezing, then decreases below freezing
- X) Starts below freezing, then increases above freezing
- Y) Starts above freezing, decreases below freezing, then increases above freezing
- Z) Starts below freezing, increases above freezing, then decreases below freezing

ANSWER: Z) STARTS BELOW FREEZING, INCREASES ABOVE FREEZING, THEN DECREASES BELOW FREEZING [HJ]

TOSS-UP

11) PHYSICS *Multiple Choice* Kirchhoff's Loop Rule, which states that the sum of the voltages around a closed circuit must be zero, is a direct consequence of the conservation of which of the following quantities?

- W) Charge
- X) Energy
- Y) Momentum
- Z) Angular momentum

ANSWER: X) ENERGY [YL]

BONUS

11) PHYSICS *Short Answer* Kian is playing with a spring-mass system. If he replaces the 4-kilogram mass with a toy train, the period doubles. In kilograms, what is the mass of the toy train?

ANSWER: 16 [OW]

TOSS-UP

12) ENERGY *Short Answer* Researchers at Boston University are modeling the effects of planted vegetation on urban areas. What is the phenomenon where urban areas are higher in temperature than surrounding rural areas, due to a high prevalence of heat-absorbing materials such as concrete?

ANSWER: URBAN HEAT ISLAND (ACCEPT: HEAT ISLAND) [HJ]

BONUS

12) ENERGY *Multiple Choice* Researchers at the University of Maryland are studying how temperatures change after various chemicals are added to water. Which of the following compounds would decrease the temperature of water when dissolved?

- W) NH_4NO_3
- X) NaOH
- Y) CaCl_2
- Z) Li_2CO_3

ANSWER: W) NH_4NO_3 [KD]

TOSS-UP

13) BIOLOGY *Multiple Choice* Some parasitic worm infections can cause edema, the excessive buildup of interstitial fluid. Interference with what anatomical system causes edema?

- W) Excretory
- X) Lymphatic
- Y) Respiratory
- Z) Circulatory

ANSWER: X) LYMPHATIC [SO]

BONUS

13) BIOLOGY *Multiple Choice* Which of the following correctly describes the ploidy of the endosperm of angiosperms?

W) n

X) 2n

Y) 3n

Z) 4n

ANSWER: Y) 3n [AF] Plant

TOSS-UP

14) MATH *Short Answer* Kian finds that the sine of an angle in the 3rd quadrant is -20/29. What is the cotangent of the angle?

ANSWER: 21/20 [EZ]

BONUS

14) MATH *Short Answer* The position vector of a particle on the 2D cartesian plane at time t can be expressed parametrically as open parenthesis $12t^3 + 5t^2$ close parenthesis $\mathbf{i} + 5t^3 \mathbf{j}$. What is the magnitude of the jerk vector of the particle at time $t = 2$, where jerk is the third derivative of position with respect to time?

ANSWER: 78 [JW]

TOSS-UP

15) CHEMISTRY *Multiple Choice* Tollens reagent can be used to differentiate between a ketone and which of the following functional groups?

- W) Aldehyde
- X) Ether
- Y) Carboxylic Acid
- Z) Alcohol

ANSWER: W) ALDEHYDE [SK]

BONUS

15) CHEMISTRY *Multiple Choice* Which of the following choices best describes the change in sulfur's formal charge as SO_2 is oxidized to H_2SO_4 ?

- W) -2 to 0
- X) 0 to 0
- Y) +2 to +2
- Z) +4 to +6

ANSWER: X) 0 TO 0 [HJ]

TOSS-UP

16) EARTH AND SPACE *Multiple Choice* Identifiable by its characteristic sheen, which of the following foliated metamorphic rocks is formed by the metamorphism of shale under intermediate pressures?

- W) Slate
- X) Phyllite
- Y) Gneiss
- Z) Migmatite

ANSWER: X) PHYLLITE [SE]

BONUS

16) EARTH AND SPACE *Short Answer* Identify all of the following three locations that are typically dominated by population 1 stars:

- 1) Galactic bulge
- 2) Globular cluster
- 3) Spiral arms

ANSWER: 3 ONLY [SE]

TOSS-UP

17) PHYSICS *Multiple Choice* Which of the following particles obeys Fermi-Dirac statistics?

- W) Kaon
- X) Gluon
- Y) Tauon
- Z) Alpha particle

ANSWER: Y) TAUON [YL]

BONUS

17) PHYSICS *Short Answer* A force with equation $F = 3t^2 - 4t + 1$ acts on a particle from $t = 0$ to $t = 5$, where F is in newtons. If the particle has a mass of 10 kilograms, what is the final speed of the particle, in meters per second?

ANSWER: 8 [YL]

TOSS-UP

18) ENERGY *Short Answer* Scientists at the Boyer lab are studying treatments to atherosclerosis, including statins. Statins are a class of medications that inhibit the production of what molecule, found in high concentration in LDLs?

ANSWER: CHOLESTEROL [SY]

BONUS

18) ENERGY *Multiple Choice* Scientists at the University of Maryland are studying soil horizons. Which of the following soil horizons is characterized by the accumulation of clay leached from upper levels?

- W) A
- X) B
- Y) E
- Z) O

ANSWER: X) B [KD]

TOSS-UP

19) BIOLOGY *Multiple Choice* Which of the following neurotransmitters acts on nicotinic receptors?

- W) Epinephrine
- X) Acetylcholine
- Y) Dopamine
- Z) Glutamate

ANSWER: X) ACETYLCHOLINE [AF]

BONUS

19) BIOLOGY *Short Answer* Identify all of the following three characteristics that are shared by all chordates:

- 1) Vertebral column
- 2) Notochord
- 3) Hollow dorsal nerve cord

ANSWER: 2 AND 3 [OW]

TOSS-UP

20) MATH *Multiple Choice* Vectors a and b have magnitudes 3 and 4. What are the maximum and minimum possible values of $a \cdot b$ [a dot b], respectively?

- W) 12 and 7
X) 12 and 0
Y) 12 and -12
Z) 7 and 0

ANSWER: Y) 12 AND -12 [JW]

BONUS

20) MATH *Short Answer* Circle A is translated 2 units to the right and 1 unit down, producing circle B with equation quantity $x - 4$ squared + quantity $y - 2$ squared = 12. What are the coordinates of the center of circle A?

ANSWER: (2, 3) [EZ]

TOSS-UP

21) Chemistry *Multiple Choice* Which of the following pure elements, at STP and in its most stable allotrope, would have the highest molar entropy?

- W) Boron
- X) Carbon
- Y) Nitrogen
- Z) Oxygen

ANSWER: Z) OXYGEN [HJ]

BONUS

21) CHEMISTRY *Short Answer* Identify all of the following three statements about organic functional groups which are true:

- 1) Both alkenes and alkynes always exhibit cis-trans isomerism
- 2) Carboxylic acids are more acidic than alcohols due to resonance
- 3) Both aldehydes and ketones contain a carbonyl group

ANSWER: 2 AND 3 [HJ]

TOSS-UP

22) EARTH AND SPACE *Multiple Choice* According to Bowen's reaction series, which of the following minerals is first to crystallize out of a typical magma?

- W) Quartz
- X) Orthoclase
- Y) Pyroxene
- Z) Amphibole

ANSWER: Y) PYROXENE [VM]

BONUS

22) EARTH AND SPACE *Short Answer* Identify all of the following three features that are more likely to form along active continental margins than passive margins:

- 1) Oceanic trench
- 2) Steep continental slope
- 3) Thick accumulations of sediment

ANSWER: 1 AND 2 [SE]

TOSS-UP

23) PHYSICS *Short Answer* A ball launched vertically at a speed v can reach a maximum height of 35 meters. If the ball is launched on flat ground at an arbitrary angle at speed v , what is the maximum range it can reach?

ANSWER: 70 [YL]

BONUS

23) PHYSICS *Short Answer* What is the term used to describe the combined magnetic and electric force on a particle?

ANSWER: LORENTZ FORCE [OW]