



MOSFET 2025 - Round 11

TOSS-UP

1) BIOLOGY *Short Answer* What percent of energy is lost from the primary producer to the secondary consumer?

ANSWER: 99% [SY]

BONUS

1) BIOLOGY *Multiple Choice* Which of the following changes is most likely to result in right ventricular hypertrophy?

- W) Decrease in peripheral arterial pressure
- X) Decrease in pulmonary arterial pressure
- Y) Increase in peripheral arterial pressure
- Z) Increase in pulmonary arterial pressure

ANSWER: Z) INCREASE IN PULMONARY ARTERIAL PRESSURE [SK]

TOSS-UP

2) MATH *Multiple Choice* If the length of the longest diagonal of a regular n -sided polygon is 2, as n approaches infinity, what is the limit of the ratio of the numerical value of its perimeter to its area?

W) 2

X) 4

Y) 6

Z) 8

ANSWER: W) 2 [JW]

BONUS

2) MATH *Multiple Choice* Dishonest Diana tells her parents that she ate every vegetable on her plate. Her parents, being expert logicians, interpret her claim as the material conditional "If there were vegetables on my plate, then I ate all of them," and realises that Diana has technically not lied, as there were no vegetables on her plate to begin with. What logical concept does Diana's claim demonstrate?

W) Tautology

X) De Morgan's laws

Y) Vacuous truth

Z) Fallacy of the converse

ANSWER: Y) VACUOUS TRUTH [JW]

TOSS-UP

3) CHEMISTRY *Short Answer* Potassium-40 is radioactive and often undergoes beta-minus decay. Identify all of the following 3 quantities that are higher in the end product than in potassium-40:

- 1) Atomic number
- 2) Atomic mass
- 3) Atomic radius

ANSWER: 1 ONLY [KD]

BONUS

3) CHEMISTRY *Short Answer* Identify all of the following three reaction mechanisms which proceed via a carbocation intermediate:

- 1) SN1
- 2) SN2
- 3) E1

ANSWER: 1 AND 3 [HJ]

TOSS-UP

4) EARTH AND SPACE *Short Answer* The helium flash marks the end of a star's time in what region of the HR diagram?

ANSWER: RED GIANT BRANCH [SE]

BONUS

4) EARTH AND SPACE *Multiple Choice* Limb darkening is a phenomenon where the edges of a star appear darker than the center. Which of the following best explains why this phenomenon occurs?

W) Exoplanets tend to orbit around the edges of stars, preventing light from reaching observers

X) The edges of a star are more opaque than the center

Y) Temperature varies with depth in the stellar atmosphere

Z) Composition varies with depth in the stellar atmosphere

ANSWER: Y) TEMPERATURE VARIES WITH DEPTH IN THE STELLAR ATMOSPHERE [SE]

TOSS-UP

5) PHYSICS *Short Answer* The Sunyaev-Zeldovich effect distorts the CMBR through the inverse form of what phenomenon, where a high-energy photon scatters inelastically off of a free electron?

ANSWER: COMPTON SCATTERING [YL]

BONUS

5) PHYSICS *Multiple Choice* Kwanga constructs a simple pendulum with length 9.8 meters and places it inside a box. She then begins to shake the box up and down. With what angular frequency, in Hertz, should she shake the box to maximize the amplitude of the pendulum's resulting motion?

W) 0

X) 0.5

Y) 1

Z) 2

ANSWER: Z) 2 [YL]

TOSS-UP

6) ENERGY *Multiple Choice* Geologists at Princeton University are performing radiometric dating with uranium. Which of the following minerals is the gold standard in this kind of dating, because it preserves uranium samples from chemical attack?

W) Quartz

X) Bauxite

Y) Kyanite

Z) Zircon

ANSWER: Z) ZIRCON [KW]

BONUS

6) ENERGY *Multiple Choice* Scientists at the Bioenergy Technologies Office are studying botanical modification of crops by using the compound colchicine [KOL-chiss-een], which hinders the polymerization of tubulin proteins. In which of the following botanical processes is colchicine used?

- W) Helping propagate plants in grafting by promoting cellulose synthesis
- X) Controlling the opening and closing of flowers by altering turgor pressure
- Y) Preventing deciduous plants from shedding leaves by inhibiting the formation of the abscission layer
- Z) Creating seedless fruits such as watermelons by inducing triploidy

ANSWER: Z) CREATING SEEDLESS FRUITS SUCH AS WATERMELONS BY INDUCING TRIPLOIDY
[JW]

TOSS-UP

7) BIOLOGY *Short Answer* The tube cell of a mature pollen develops into a pollen tube that enters the ovule through what opening?

ANSWER: MICROPYLE [AF]

BONUS

7) BIOLOGY *Short Answer* Identify all of the following 3 statements about codons which are true:

- 1) The starting codon codes for a sulfur-containing amino acid
- 2) Two of the three stop codons code for the amino acid arginine
- 3) "AUG" is the sequence for one of the stop codons

ANSWER: 1 ONLY [AF]

TOSS-UP

8) MATH *Short Answer* Zero is said to be the identity element with respect to addition over the set of real numbers, as any real number plus 0 equals itself. An identity element can be similarly defined for any binary operation over a set. What is the identity element for the least common multiple operation over the set of positive integers?

ANSWER: 1 [JW]

BONUS

8) MATH *Multiple Choice* Trapezoid ABCD with bases AB and CD has $AB = 6$, $BC = 8$, $CD = 14$, and $AD = 16$. If BC is perpendicular to AB, what is the measure of angle DAC in degrees?

- W) 15
- X) 30
- Y) 45
- Z) 60

ANSWER: Z) 60 [SE]

TOSS-UP

9) CHEMISTRY *Multiple Choice* Which of the following molecules has the largest dipole moment?

W) NH_3

X) H_2O_2

Y) SO_3

Z) HCl

ANSWER: W) NH_3 [HJ]

BONUS

9) Chemistry *Multiple Choice* Yunyi adds a 5-gram sample of water to an evacuated container with adjustable volume. He keeps the temperature constant at 90 degrees Celsius while increasing the container's volume. Which of the following choices best describes the graph of pressure as a function of volume in this container?

W) Always increasing

X) Always decreasing

Y) Constant, then increasing

Z) Constant, then decreasing

ANSWER: Z) CONSTANT, THEN DECREASING [KD]

TOSS-UP

10) EARTH AND SPACE *Multiple Choice* Seismic waves travel the fastest in which of the following layers of the Earth?

- W) Asthenosphere
- X) Lithospheric Mantle
- Y) Continental Crust
- Z) Oceanic Crust

ANSWER: X) LITHOSPHERIC MANTLE [HJ]

BONUS

10) EARTH AND SPACE *Short Answer* Identify all of the following three rocks and minerals that exhibit conchoidal fracture:

- 1) Quartz
- 2) Biotite
- 3) Obsidian

ANSWER: 1 AND 3 [KW]

TOSS-UP

11) PHYSICS *Short Answer* Identify all of the following three processes that are depicted as straight lines on a T-S diagram:

- 1) Isochoric heating
- 2) Isothermal compression
- 3) Adiabatic expansion

ANSWER: 2 AND 3 [YL]

BONUS

11) PHYSICS *Short Answer* Michael holds one end of a ball of yarn and drops it, keeping his hand stationary. If the ball of yarn can be modelled as a uniform solid sphere, what is the acceleration of the ball in meters per second squared?

ANSWER: 7 [YL]

TOSS-UP

12) ENERGY *Multiple Choice* Researchers at Columbia University are developing methods to recover nitrogen from recycled wastewater. In the nitrogen cycle, the process of denitrification converts nitrates into which of the following forms of nitrogen?

- W) Ammonia
- X) Ammonium
- Y) Nitrite
- Z) Nitrogen gas

ANSWER: Z) NITROGEN GAS [HJ]

BONUS

12) ENERGY *Multiple Choice* Researchers at UW-Madison are using mass spectrometry to analyze organic compounds. Which of the following molecules will have a different molecular ion peak than the other three due to differing mass?

- W) 2,2-dimethylpropan-1-ol
- X) methyl propyl ether
- Y) 2-methyl-propan-2-ol
- Z) n-butanol

ANSWER: W) 2,2-DIMETHYLPROPAN-1-OL [CZ]

TOSS-UP

13) BIOLOGY *Multiple Choice* Osmosis the bunny wants to study RNA. Which of the following methods would he most likely use?

- W) Western blot
- X) Northern blot
- Y) Southern blot
- Z) Eastern blot

ANSWER: X) NORTHERN BLOT [SY] cell bio

BONUS

13) BIOLOGY *Multiple Choice* The alpha, beta, and gamma hemoglobin subunits in the human genome have what relation to each other?

- W) paralogous genes
- X) orthologous genes
- Y) homologous structures
- Z) analogous structures

ANSWER: W) PARALOGOUS GENES [SY] genetics

TOSS-UP

14) MATH *Multiple Choice* Yun and Yi are playing a game. They take turns rolling a fair six-sided die and the first player to roll a 6 wins. If Yun rolls the die first, what is the probability she wins the game?

W) $\frac{3}{5}$

X) $\frac{4}{7}$

Y) $\frac{5}{9}$

Z) $\frac{6}{11}$

ANSWER: Z) $\frac{6}{11}$ [EZ]

BONUS

14) MATH *Multiple Choice* Which of the following choices describes the domain of the function $\log(-\sqrt{4-x} + 3)$ [READ SLOWLY: log of the quantity: open parenthesis negative square root of the quantity $4-x$, plus 3, close parenthesis]?

W) x greater than or equal to -5 and less than or equal to 4

X) x greater than -5 and less than or equal to 4

Y) x greater than or equal to -5 and less than 4

Z) x greater than -5 and less than 4

ANSWER: X) x GREATER THAN -5 AND LESS THAN OR EQUAL 4 [EZ]

TOSS-UP

15) CHEMISTRY *Short Answer* A certain gas at a temperature of 100 kelvin has root mean square velocity V . In kelvin, what temperature would the gas have to be in order to have a root mean square velocity of $4V$?

ANSWER: 1600 K [KD]

BONUS

15) Chemistry *Multiple Choice* Selena monitors electrical conductivity as she adds concentrated H_2SO_4 to an aqueous solution of NaOH until it is fairly acidic. For this titration, which of the following choices best describes the graph with conductivity on the y-axis and volume of titrant added on the x-axis?

- W) Always increasing
- X) Increases, then decreases
- Y) Decreases, then increases
- Z) Decreases, then remains constant

ANSWER: Y) DECREASES, THEN INCREASES [HJ]

TOSS-UP

16) EARTH AND SPACE *Short Answer* What paradox states that the night sky should be bright because light streams in from an infinite universe filled with stars, and was refuted by the discovery of the universe's expansion?

ANSWER: OLBER'S PARADOX [SE]

BONUS

16) EARTH AND SPACE *Short Answer* Identify all of the following three types of telescopes that are unaffected by chromatic aberration:

- 1) Newtonian
- 2) Galilean
- 3) Cassegrain

ANSWER: 1 AND 3 [IC]

TOSS-UP

17) PHYSICS *Short Answer* What type of curve is formed by a massive cable hanging under its own weight between two fixed points?

ANSWER: CATENARY [YL]

BONUS

17) PHYSICS *Short Answer* Identify all of the following three components of an AC circuit whose impedance depends on the oscillation frequency:

- 1) Resistor
- 2) Inductor
- 3) Capacitor

ANSWER: 2 AND 3 [YL]

TOSS-UP

18) ENERGY *Multiple Choice* Scientists at Pacific Northwest National Lab are studying quicksort, a common coding algorithm. Quicksort has a big O time complexity of which of the following?

- W) O of n
- X) O of n squared
- Y) O of n log n
- Z) O of n factorial

ANSWER: Y) O OF n LOG n [KD]

BONUS

18) ENERGY *Short Answer* Researchers at Boston University are studying sediment dynamics in coastal transport processes. What is the name for underwater currents of sediment-laden water which flow down continental slopes and carve out submarine canyons?

ANSWER: TURBIDITY CURRENT [HJ] LDE

TOSS-UP

19) BIOLOGY *Multiple Choice* Nociceptors are activated by which of the following stimuli?

- W) Light
- X) Sound
- Y) Pain
- Z) Odor

ANSWER: Y) PAIN [KD]

BONUS

19) BIOLOGY *Short Answer* Order the following 3 compounds of the tricarboxylic acid cycle by increasing number of carbons.

- 1) α -Ketoglutarate
- 2) Isocitrate
- 3) Malate

ANSWER: 3, 1, 2 [AF]

TOSS-UP

20) MATH *Short Answer* Nelly bought a mixture of two types of her favorite candies, costing 40 cents and 50 cents per ounce, respectively. The cost of 50 ounces of her mixture was \$21.80. How many ounces of the 50-cent candy were in the mixture?

ANSWER: 18 [MW]

BONUS

20) MATH *Short Answer* On a standard 8-by-8 chessboard, there are 2 ways for a rook to move from one corner to the opposite corner in exactly 2 moves. How many ways are there for a rook to move from one corner to the opposite corner in exactly 3 moves?

ANSWER: 36 [JW]

TOSS-UP

21) CHEMISTRY *Multiple Choice* Which of the following compounds has the highest lattice energy?

W) AlCl_3

X) Li_2O

Y) KI

Z) BeBr_2

ANSWER: W) AlCl_3 [CZ]

BONUS

21) Chemistry *Multiple Choice* Sodium azide, with chemical formula NaN_3 , detonates to form sodium metal and nitrogen gas. An airbag containing sodium azide is detonated and comes to rest at STP with a volume of 6.7 liters. Which of the following is closest to the amount of sodium azide originally in the airbag, in moles?

W) 0.1

X) 0.2

Y) 0.3

Z) 0.4

ANSWER: X) 0.2 [JW]

TOSS-UP

22) EARTH AND SPACE *Multiple Choice* Which of the following geologic structures is formed by tensile stress?

W) Syncline

X) Reverse fault

Y) Horst

Z) Volcanic arc

ANSWER: Y) HORST [KW]

BONUS

22) EARTH AND SPACE *Multiple Choice* Which of the following cold-water oceanic currents is found off the west coast of South Africa?

- W) Canary Current
- X) Labrador Current
- Y) Benguela Current
- Z) Oyashio Current

ANSWER: Y) BENGUELA CURRENT [VM]

TOSS-UP

23) PHYSICS *Multiple Choice* Which of the following tubes will have the lowest fundamental frequency?

- W) 3-meter tube open at one end
- X) 3-meter tube open at both ends
- Y) 5-meter tube open at one end
- Z) 5-meter tube open at both ends

ANSWER: Y) 5-METER TUBE OPEN AT ONE END [YL]

BONUS

23) PHYSICS *Short Answer* Evan is looking for an electron. According to the Born Interpretation, the probability density of his electron is proportional to what power of its wavefunction?

ANSWER: 2 [CZ]