



## MOSFET 2025 - Round 5

### TOSS-UP

1) BIOLOGY *Multiple Choice* Euna is running a Gram stain on a sample of E. coli. Which of the following options gives both the expected color of her E. coli and the reason why?

- W) Purple, because they have a thick layer of peptidoglycan
- X) Pink, because they have a thick layer of peptidoglycan
- Y) Purple, because they have a thin layer of peptidoglycan
- Z) Pink, because they have a thin layer of peptidoglycan

ANSWER: Z) PINK, BECAUSE THEY HAVE A THIN LAYER OF PEPTIDOGLYCAN [OW]

### BONUS

1) BIOLOGY *Short Answer* Identify all of the following three molecules that are derived from cholesterol:

- 1) Estrogen
- 2) Progesterone
- 3) Norepinephrine

ANSWER: 1 AND 2 [OW]

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**TOSS-UP**

2) MATH *Multiple Choice* To the nearest ten, what is the sum of the two largest prime numbers less than 100?

W) 170

X) 180

Y) 190

Z) 200

ANSWER: Y) 190 [JW]

**BONUS**

2) MATH *Short Answer* A trapezoid has an area of 21 square units, with bases measuring 6 and 8 units. What is the new area if the shorter base is doubled and the longer base is tripled?

ANSWER: 54 [EZ]

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**TOSS-UP**

3) CHEMISTRY *Short Answer* In a racemic mixture of 1-chloroethanol, what percent of the total molecules have an absolute stereochemical configuration of S?

ANSWER: 50 [HJ]

### BONUS

3) CHEMISTRY *Multiple Choice* In the reaction between hydrogen peroxide and permanganate in acidic solution, which of the following best describes the role of the permanganate ion?

W) Catalyst

X) Base

Y) Oxidizing agent

Z) Reducing agent

ANSWER: Y) OXIDIZING AGENT [HJ]

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### TOSS-UP

4) EARTH AND SPACE *Multiple Choice* As a star moves off the main sequence, it expands, causing its luminosity to increase while its temperature decreases. This causes the star to move in which of the following directions on the HR diagram?

W) Up and to the left

X) Up and to the right

Y) Down and to the left

Z) Down and to the right

ANSWER: X) UP AND TO THE RIGHT [SE]

### **BONUS**

4) EARTH AND SPACE *Multiple Choice* While on Earth, Peter observes that he has rotated exactly 360 degrees relative to background stars. Which of the following best describes the amount of time that has passed during this rotation?

- W) Slightly less than one day
- X) Slightly more than one day
- Y) Exactly one day
- Z) Depends on the season

ANSWER: W) SLIGHTLY LESS THAN ONE DAY [SE]

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### **TOSS-UP**

5) PHYSICS *Multiple Choice* Which of the following particles has no mass?

- W) W boson
- X) Z boson
- Y) Photon
- Z) Electron

ANSWER: Y) PHOTON [YL]

### BONUS

5) PHYSICS *Multiple Choice* Yunyi claims he can throw a ball twice as far as Katherine. They both throw with the same initial velocity, but can choose different angles above the horizontal to throw at. In degrees, what is the largest angle Katherine can throw at such that it is impossible for Yunyi to throw twice as far as her?

W) 50

X) 60

Y) 65

Z) 75

ANSWER: Z) 75 [EZ]

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### TOSS-UP

6) ENERGY *Short Answer* Researchers at Oak Ridge National Laboratory are studying the applications of piezoelectric minerals. What common piezoelectric mineral is often used in clocks and has a Mohs hardness rating of 7?

ANSWER: QUARTZ [SO]

### BONUS

6) ENERGY *Short Answer* Scientists at the Environmental Protection Agency are studying the negative impacts of phenols on the environment. Phenols are comprised of an alcohol group attached to what simple aromatic molecule?

ANSWER: BENZENE [SO]

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### TOSS-UP

7) BIOLOGY *Multiple Choice* Gonadotropin-releasing hormone, produced by the hypothalamus, most directly stimulates the production of which of the following hormones?

- W) Luteinizing hormone
- X) Testosterone
- Y) Estrogen
- Z) Progesterone

ANSWER: W) LUTEINIZING HORMONE [SY]

### BONUS

7) BIOLOGY *Short Answer* In what order does filtrate flow through the following three structures in the kidney?

- 1) Loop of Henle
- 2) Bowman's capsule
- 3) Distal convoluted tubule

ANSWER: 2, 1, 3 [SO]

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### TOSS-UP

8) MATH *Multiple Choice* Given that  $a + b = 90$  degrees, which of the following statements must be true?

W)  $\tan a = \tan b$

X)  $\sin a = \sin b$

Y)  $\sin a = \cos b$

Z)  $\cos a = \cos b$

ANSWER: Y)  $\sin a = \cos b$  [MW]

### BONUS

8) MATH *Short Answer* Kian has a bag with 2 red balls, 2 yellow balls, and 2 blue balls. If he draws 2 balls at random, what is the probability the balls he draws are different colors?

ANSWER: 4/5 (ACCEPT: 0.8) [EZ]

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### TOSS-UP

9) CHEMISTRY *Short Answer* Azeotropic mixtures cannot be separated by distillation because their boiling points deviate from what law, which describes the vapor pressure of solutions?

ANSWER: RAOULT'S LAW [CZ]

### BONUS

9) CHEMISTRY *Multiple Choice* Which of the following reactions has a greater standard change in enthalpy than change in internal energy?

W)  $\text{N}_2$  gas +  $3\text{H}_2$  gas yields  $2\text{NH}_3$  gas

X)  $\text{H}_2\text{O}_2$  aqueous yields  $\text{H}_2\text{O}$  liquid +  $\frac{1}{2}\text{O}_2$  gas

Y)  $\text{Fe}_2\text{O}_3$  solid +  $2\text{Al}$  solid yields  $2\text{Fe}$  liquid +  $\text{Al}_2\text{O}_3$  solid

Z)  $\text{CH}_4$  gas +  $2\text{O}_2$  gas yields  $\text{CO}_2$  gas +  $2\text{H}_2\text{O}$  gas

ANSWER: X)  $\text{H}_2\text{O}_2$  AQUEOUS YIELDS  $\text{H}_2\text{O}$  LIQUID +  $\frac{1}{2}\text{O}_2$  GAS [CZ]

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### TOSS-UP

10) EARTH AND SPACE *Multiple Choice* The Atacama Desert in Chile is located next to a cold ocean current that cools the surrounding air and decreases its moisture content. This makes it an example of which of the following types of desert?

W) Rainshadow

X) Semi-arid

Y) Coastal

Z) Polar

ANSWER: Y) COASTAL [KW]



### **BONUS**

10) EARTH AND SPACE *Multiple Choice* To the nearest integer, how many parsecs are there in ten light years?

W) 1

X) 2

Y) 3

Z) 4

ANSWER: Y) 3 [SE]

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### **TOSS-UP**

11) PHYSICS *Multiple Choice* Assuming that they all have the same mass and radius, which of the following objects will have the greatest linear acceleration as it rolls without slipping down an inclined plane?

W) Solid sphere

X) Hollow sphere

Y) Solid disk

Z) Ring

ANSWER: W) SOLID SPHERE [YL]

### **BONUS**

11) PHYSICS *Multiple Choice* Which of the following changes would increase the capacitance of a parallel plate capacitor?

W) Increasing the amount of charge stored on each plate

X) Increasing the potential difference between the plates

Y) Increasing the area of each plate

Z) Increasing the distance between the plates

ANSWER: Y) INCREASING THE AREA OF EACH PLATE [EZ]

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### **TOSS-UP**

12) ENERGY *Short Answer* Researchers at Argonne National Lab are studying a certain list of numbers, which include 6, 28, and 496, that are equivalent to the sum of their proper divisors. What is the name for such numbers?

ANSWER: PERFECT NUMBERS [KD]

### **BONUS**

12) ENERGY *Short Answer* Students at Middleton High School are fed up with their HVAC and are looking for ways to improve its efficiency. Assuming Middleton High School is under ideal conditions, what thermodynamic cycle should their system use to achieve the highest efficiency?

ANSWER: CARNOT CYCLE [DL]

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### TOSS-UP

13) BIOLOGY *Multiple Choice* Which of the following choices best describes how the demethylation of DNA in a gene generally affects transcription levels of the gene?

- W) increase
- X) decrease
- Y) stay the same
- Z) no correlation

ANSWER: W) INCREASE [SY]

### BONUS

13) BIOLOGY *Short Answer* Identify all of the following three structures that are part of the male reproductive organ in angiosperms:

- 1) Filament
- 2) Stigma
- 3) Anther

ANSWER: 1 AND 3 [OW]

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### TOSS-UP

14) MATH *Multiple Choice* Given that the function  $f$  of  $x$  has a zero at  $x = 6$ , at what  $x$ -value must  $2 + f$  of  $x$  have a zero?

W) 3

X) 4

Y) 8

Z) Not enough information to tell

ANSWER: Z) NOT ENOUGH INFORMATION TO TELL [MW]

### BONUS

14) MATH *Multiple Choice* Many of the largest known prime numbers may be expressed in the form  $2^n - 1$ , where  $n$  is some integer. What is the name for this type of prime number?

W) Chen prime

X) Mersenne prime

Y) Fermat prime

Z) Twin prime

ANSWER: X) MERSENNE PRIME [JW]

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### TOSS-UP

15) CHEMISTRY *Multiple Choice* According to molecular orbital theory, which of the following diatomic gases is commonly found as a diradical, explaining its high reactivity?

W) Nitrogen

X) Oxygen

Y) Fluorine

Z) Chlorine

ANSWER: X) OXYGEN [HJ]

### BONUS

15) CHEMISTRY *Short Answer* Order the following three elements by increasing boiling point of their most stable allotrope:

1) Carbon

2) Nitrogen

3) Oxygen

ANSWER: 2, 3, 1 [HJ]

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### TOSS-UP

16) EARTH AND SPACE *Short Answer* Order the following three rock types by increasing metamorphic grade:

- 1) Slate
- 2) Gneiss
- 3) Schist

ANSWER: 1, 3, 2 [IC]

### BONUS

16) EARTH AND SPACE *Short Answer* Identify all of the following three planets that have atmospheres primarily composed of carbon dioxide:

- 1) Venus
- 2) Mars
- 3) Jupiter

ANSWER: 1 AND 2 [VM]

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### TOSS-UP

17) PHYSICS *Short Answer* When a Beyblade is spun at a tilt, its central axis revolves in a circle. What is the name for this phenomenon?

ANSWER: PRECESSION [YL]

### **BONUS**

17) PHYSICS *Multiple Choice* An object is placed 10 centimeters away from a convex lens with focal length 5 centimeters. Which of the following best describes the image of the object?

- W) Real and upright
- X) Real and inverted
- Y) Virtual and upright
- Z) Virtual and inverted

ANSWER: X) REAL AND INVERTED [YL]

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### **TOSS-UP**

18) ENERGY *Short Answer* Scientists at the University of Washington Quantum Devices Lab are studying semiconducting carbon structures. What stiff, cylindrical allotrope of carbon are they most likely interested in?

ANSWER: CARBON NANOTUBES (ACCEPT: BUCKYTUBES) [DL]

### BONUS

18) ENERGY *Short Answer* Scientists at the University of Alabama are studying applications of ionic solvents, which give off very little fumes. Identify all of the following three properties that are characteristic of ionic solvents:

- 1) Low vapor pressure
- 2) High boiling point
- 3) Low intermolecular forces

ANSWER: 1 AND 2 [HJ]

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### TOSS-UP

19) BIOLOGY *Multiple Choice* The fungi *Penicillium* produces the antibiotic penicillin, which kills *Staphylococcus* bacteria without benefiting itself. What term best describes this type of symbiotic interaction?

- W) Commensalism
- X) Parasitism
- Y) Amensalism
- Z) Mutualism

ANSWER: Y) AMENSALISM [AF]



### BONUS

19) BIOLOGY *Multiple Choice* The bunnies Osmosis and Molybdenum can eat both Alfalfa and Timothy hay. However, when living together, Osmosis only eats Alfalfa hay while Molybdenum only eats Timothy hay. What is the name of this phenomenon?

- W) Character displacement
- X) Niche partitioning
- Y) Disruptive selection
- Z) Phenotypic plasticity

ANSWER: X) NICHE PARTITIONING [SY]

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### TOSS-UP

20) MATH *Multiple Choice* A fair coin is flipped three times. Given that at least one of the flips is a head, what is the probability that at least two flips were heads?

- W)  $\frac{1}{4}$
- X)  $\frac{1}{2}$
- Y)  $\frac{4}{7}$
- Z)  $\frac{3}{4}$

ANSWER: Y)  $\frac{4}{7}$  [MW]

### BONUS

20) MATH *Short Answer* A complex number has a magnitude of 8. Given that the number plus its conjugate equals 14, what is the sine of the absolute value of its argument?

ANSWER:  $\frac{\sqrt{15}}{8}$  [MW]

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### TOSS-UP

21) CHEMISTRY *Multiple Choice* Which of the following quantities is NOT present in the expression of the acidity constant,  $K_a$ , for acetic acid?

W) Concentration of  $\text{CH}_3\text{COOH}$

X) Concentration of  $\text{CH}_3\text{COO}^-$

Y) Concentration of  $\text{H}_3\text{O}^+$

Z) Concentration of  $\text{H}_2\text{O}$

ANSWER: Z) CONCENTRATION OF  $\text{H}_2\text{O}$  [HJ]

### BONUS

21) CHEMISTRY *Multiple Choice* Which of the following pairs of elements would form the most polar covalent bond?

W) Hydrogen and silicon

X) Nitrogen and chlorine

Y) Oxygen and phosphorus

Z) Carbon and bromine

ANSWER: Y) OXYGEN AND PHOSPHORUS [HJ]

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### TOSS-UP

22) EARTH AND SPACE *Multiple Choice* Which of the following volcanic hazards often forms due to melting snow, and is characterized by a mixture of ash, volcanic debris, and water?

W) Pyroclastic flow

X) Tephra

Y) Landslide

Z) Lahar

ANSWER: Z) LAHAR [HJ]

### BONUS

22) EARTH AND SPACE *Multiple Choice* Which of the following depths, in meters, is closest to the average depth of abyssal plains?

W) 2,000

X) 5,000

Y) 8,000

Z) 11,000

ANSWER: X) 5,000 [HJ]

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### **TOSS-UP**

23) PHYSICS *Short Answer* What statistical distribution gives the probability that a molecule of gas is moving at a certain speed?

ANSWER: MAXWELL-BOLTZMANN DISTRIBUTION (ACCEPT: MAXWELL DISTRIBUTION, DO NOT ACCEPT: BOLTZMANN DISTRIBUTION) [OW]

### **BONUS**

23) PHYSICS *Short Answer* Superconductors expel magnetic fields via what effect?

ANSWER: MEISSNER EFFECT [YL]