



MOSFET 2025 - Round 9

TOSS-UP

1) BIOLOGY *Short Answer* Identify all of the following three pieces of evidence that support the endosymbiotic theory:

- 1) presence of circular DNA in mitochondria
- 2) mitochondria possess a double membrane
- 3) presence of a vestigial nucleus between the two membranes of chloroplasts

ANSWER: ALL [OW]

BONUS

1) BIOLOGY *Multiple Choice* As an embryo, Kelly's endoderm failed to develop properly. Which of the following organs would be the most affected?

- W) Heart
- X) Brain
- Y) Liver
- Z) Epidermis

ANSWER: Y) LIVER [OW]

TOSS-UP

2) MATH *Short Answer* A dartboard is composed of concentric circles with radii of 1, 3, 5, and 7, respectively. Each ring alternates in color from those around it, starting with red in the center and white next. If a dart is randomly thrown at the board, what is the probability that the dart hits a red region?

ANSWER: 17/49 [MW]

BONUS

2) MATH *Short Answer* Identify all of the following three statements that are true about the circumcenter of a triangle:

- 1) The circumcenter is formed by the intersection of a triangle's perpendicular bisectors
- 2) The circumcenter minimizes the sum of the distances to the three vertices of the triangle
- 3) The circumcenter always lies inside the triangle

ANSWER: 1 ONLY [EZ]

TOSS-UP

3) CHEMISTRY *Multiple Choice* Harry is given an unknown molecule and wants to know if it contains a carbonyl group. Which of the following techniques would be best for Harry to use?

- W) IR spectroscopy
- X) Mass spectrometry
- Y) Proton NMR
- Z) Thin layer chromatography

ANSWER: W) IR SPECTROSCOPY [YL]

BONUS

3) Chemistry *Multiple Choice* When silicon is doped with arsenic, electrons are introduced into what electronic region?

- W) Fermi level
- X) Band gap
- Y) Valence band
- Z) Conduction band

ANSWER: Z) CONDUCTION BAND [CZ]

TOSS-UP

4) EARTH AND SPACE *Multiple Choice* Which of the following elements is typically found in the lowest concentrations in mafic magmas?

W) Potassium

X) Iron

Y) Magnesium

Z) Calcium

ANSWER: W) POTASSIUM [SE]

BONUS

4) EARTH AND SPACE *Multiple Choice* Which of the following minerals is most commonly found in the Moon's lightly-colored highlands?

W) Orthoclase

X) Quartz

Y) Plagioclase

Z) Olivine

ANSWER: Y) PLAGIOCLASE [HJ]

TOSS-UP

5) PHYSICS *Multiple Choice* Which of the following experiments conclusively determined the constancy of the speed of light and disproved the existence of a luminiferous ether?

W) Stern-Gerlach experiment

X) Davisson-Germer experiment

Y) Michelson-Morley experiment

Z) Millikan oil drop experiment

ANSWER: Y) MICHELSON-MORLEY EXPERIMENT [YL]

BONUS

5) PHYSICS *Short Answer* A submarine is traveling through a viscous fluid where the drag force is proportional to its velocity. If the submarine wanted to triple its speed, by what factor should its power output be multiplied?

ANSWER: 9 [YL]

TOSS-UP

6) ENERGY *Multiple Choice* Scientists at Argonne National Lab are studying polymers. Which of the following polymers is a synthetic polyamide with wide applications in fabric manufacturing?

W) cotton

X) polyethylene

Y) nylon

Z) teflon

ANSWER: Y) NYLON [SO]

BONUS

6) ENERGY *Multiple Choice* Scientists at Argonne National Lab are studying the extent of ionization of various acids in solution. Which of the following solutions would have the greatest percent ionization of acid?

W) 1 molar acetic acid

X) 0.1 molar acetic acid

Y) 1 molar fluoroacetic acid

Z) 0.1 molar fluoroacetic acid

ANSWER: Z) 0.1 MOLAR FLUOROACETIC ACID [KD]

TOSS-UP

7) BIOLOGY *Multiple Choice* Which of the following digestive hormones is responsible for the release of bicarbonate from the pancreas?

W) Cholecystokinin

X) Secretin

Y) Gastrin

Z) PYY

ANSWER: X) SECRETIN [OW]

BONUS

7) BIOLOGY *Short Answer* Identify all of the following three blood types that are possible for a child that has a mother with type A- blood and a father with type B- blood:

1) AB-

2) O-

3) O+

ANSWER: 1 AND 2 [OW]

TOSS-UP

8) MATH *Multiple Choice* A set is said to be *closed* under a given operation if performing that operation on members of the set always returns a member of the set. Which of the following elementary operations are the set of integers NOT closed under?

- W) Addition
- X) Subtraction
- Y) Multiplication
- Z) Division

ANSWER: Z) DIVISION [JW]

BONUS

8) MATH *Short Answer* Identify all of the following three sets of numbers which are closed under division, assuming that division by zero is excluded:

- 1) The set of rational numbers
- 2) The set of complex numbers
- 3) The set of real numbers

ANSWER: ALL [JW]

TOSS-UP

9) CHEMISTRY *Multiple Choice* Which of the following salts has the lowest K_{sp} value?

- W) Copper (II) sulfide
- X) Calcium carbonate
- Y) Lead (II) chloride
- Z) Magnesium hydroxide

ANSWER: W) COPPER (II) SULFIDE [HJ]

BONUS

9) Chemistry *Multiple Choice* Some atomic nuclei have a magic number of nucleons, granting them unusual stability. Which of the following isotopes does not have a magic number of protons?

- W) Helium-4
- X) Oxygen-16
- Y) Argon-40
- Z) Lead-208

Answer: Y) ARGON-40 [CZ]

TOSS-UP

10) EARTH AND SPACE *Multiple Choice* Many arid regions have ephemeral streams, which are streams that only flow after major rain events. Which of the following choices best explains why ephemeral streams are so prevalent in arid regions?

- W) The water table is very low in arid regions, causing rivers to lose water to groundwater
- X) The hot climate causes high amounts of evaporation, leading rivers to run dry
- Y) The lack of vegetation in deserts prevents rivers from retaining water
- Z) The fine-grained desert sediment prevents water from percolating into rivers

ANSWER: W) THE WATER TABLE IS VERY LOW IN ARID REGIONS, CAUSING RIVERS TO LOSE WATER TO GROUNDWATER [SE]

BONUS

10) EARTH AND SPACE *Multiple Choice* For a constant orbital period, which of the following spin-orbit resonance ratios denotes the shortest day?

- W) 1 to 2
- X) 2 to 3
- Y) 3 to 2
- Z) 2 to 1

ANSWER: Z) 2 TO 1 [KW]

TOSS-UP

11) PHYSICS *Short Answer* The omega baryon contains three strange quarks. These three quarks differ in only what property, unique to quarks and gluons, which must sum to zero in any freely-existing particle?

ANSWER: COLOR CHARGE (ACCEPT: COLOR) [CZ]

BONUS

11) PHYSICS *Short Answer* Identify all of the following three quantities that, when changed, will change the drag force acting on a falling object:

- 1) Surface area
- 2) Velocity
- 3) Air density

ANSWER: ALL [YL]

TOSS-UP

12) ENERGY *Short Answer* Researchers at UW-Madison are studying how RNA polymerase binds to DNA. What is the term for the DNA sequence found in eukaryotes, located roughly 25 to 35 base pairs upstream from the transcriptional start site, that is critical for proper binding of RNA polymerase?

ANSWER: TATA BOX [OW]

BONUS

12) ENERGY *Multiple Choice* Scientists at the Sabeti Lab are using statistical methods to identify regions in the genome that are undergoing positive selection. Which of the following genetic mutations is most likely to undergo positive selection in humans?

- W) A mutation that disables cooperativity in hemoglobin
- X) A mutation that increases the expression of KRAS
- Y) A mutation that confers resistance to HIV
- Z) A mutation that reduces expression of GADPH

ANSWER: Y) A MUTATION THAT CONFERS RESISTANCE TO HIV [SY]

TOSS-UP

13) BIOLOGY *Short Answer* What monomeric class of antibody, found in the secondary immune response, is responsible for causing hemolytic disease of the newborn?

ANSWER: IMMUNOGLOBULIN G (ACCEPT: IgG)

BONUS

13) BIOLOGY *Short Answer* Order the following 3 layers of a woody vascular plant stem from outermost to innermost:

- 1) Secondary phloem
- 2) Secondary xylem
- 3) Cork cambium

ANSWER: 3, 1, 2 [OW]

TOSS-UP

14) MATH *Multiple Choice* If it takes 10 MOSFET writers 10 minutes to write 10 math questions, how many minutes will it take 50 writers to write 500 questions?

W) 10

X) 50

Y) 100

Z) 500

ANSWER: Y) 100 [MW]

BONUS

14) MATH *Short Answer* Due to a worker strike, MOSFET's 50 writers are leaving! It always takes 10 writers 10 minutes to write 10 math questions. Every 10 minutes, one writer leaves. After all the writers leave, how many questions have been written?

ANSWER: 1275 [MW]

TOSS-UP

15) Chemistry *Multiple Choice* Which of the following molecules is most likely to dimerize in the gas phase?

W) O₂

X) CO₂

Y) NO₂

Z) SO₂

ANSWER: Y) NO₂ [KD]

BONUS

15) CHEMISTRY *Multiple Choice* Vishnu has a sample of the mineral mirabilite and knows that it is a hydrate of sodium sulfate, but does not know its hydration number. Vishnu heats 2 moles of mirabilite until water stops escaping and finds that the mass of the sample has decreased from 644 grams to 284 grams. What is the hydration number of sodium sulfate in mirabilite?

W) 6

X) 10

Y) 15

Z) 20

ANSWER: X) 10 [JW]

TOSS-UP

16) EARTH AND SPACE *Short Answer* What term describes moons like Saturn's Prometheus, which clear out gaps in the planet's ring system?

ANSWER: SHEPHERD MOONS

BONUS

16) EARTH AND SPACE *Multiple Choice* In a certain region of the atmosphere, the environmental lapse rate is 5.5 degrees Celsius per kilometer, the dry adiabatic lapse rate is 10 degrees Celsius per kilometer, and the moist adiabatic lapse rate is 8 degrees Celsius per kilometer. Which of the following best describes this region's stability?

- W) Absolutely stable
- X) Conditionally unstable
- Y) Absolutely unstable
- Z) Not enough information to determine

ANSWER: W) ABSOLUTELY STABLE [HJ]

TOSS-UP

17) PHYSICS *Multiple Choice* The speed of sound in a liquid is proportional to the half power of what constant, which measures a fluid's resistance to compression?

- W) Young's modulus
- X) Shear modulus
- Y) Bulk modulus
- Z) Reynold's number

ANSWER: Y) BULK MODULUS [YL]

BONUS

17) PHYSICS *Short Answer* If the potential energy of a certain particle has formula $U = 3 \sin x + 2 \cos x$, what is the force acting on the particle at $x = \pi/2$?

ANSWER: 2 [YL]

TOSS-UP

18) ENERGY *Multiple Choice* Scientists at the Hewitt Lab at the University of Nebraska are studying the role of gene regulation in blood cell differentiation. Which of the following blood cell types is correctly matched with its progenitor?

W) Platelet, lymphoid progenitor

X) Plasma cell, B cell

Y) T cell, myeloid progenitor

Z) NK cell, megakaryocyte

ANSWER: X) PLASMA CELL, B CELL [SY]

BONUS

18) ENERGY *Short Answer* Researchers at UW-Madison are using chemical models to study ozone transport in North American forests. Identify all of the following three statements about ozone which are true:

1) Ozone is a radical

2) Ozone is polar

3) Ozone is a strong oxidizing agent

ANSWER: 2 AND 3 [HJ] LDE

TOSS-UP

19) BIOLOGY *Multiple Choice* Which of the following groups is included in Ecdysozoa?

W) Platyhelminthes

X) Molluscs

Y) Echinoderms

Z) Nematodes

ANSWER: Z) NEMATODES [SY]

BONUS

19) BIOLOGY *Short Answer* In bacteria, the start codon AUG codes for what modified amino acid?

ANSWER: FORMYL-METHIONINE [SY] cell

TOSS-UP

20) MATH *Multiple Choice* What is the maximum number of intersection points between 5 non-identical ellipses?

W) 20

X) 30

Y) 40

Z) 50

ANSWER: Y) 40 [EZ]

BONUS

20) MATH *Short Answer* A knight moves 2 units in one direction and one unit in a direction perpendicular to that. If it starts at the origin and makes 4 moves at random, what is the probability it ends up at the point (6, 6)?

ANSWER: 3/2048 [EZ]

TOSS-UP

21) CHEMISTRY *Short Answer* Order the following three metals by increasing oxidation potential:

- 1) Ag
- 2) Fe
- 3) Li

ANSWER: 1, 2, 3 [HJ]

BONUS

21) Chemistry *Short Answer* Order the following three thermodynamic quantities from lowest to highest:

- 1) Enthalpy of dissolution of CaCl_2
- 2) Enthalpy of formation of graphite at 25 degrees Celsius
- 3) Enthalpy of formation of graphite at 50 degrees Celsius

ANSWER: 1, 2, 3 [HJ]

TOSS-UP

22) EARTH AND SPACE *Short Answer* What is the name of the technique by which multiple smaller telescopes can be used in combination to attain the same resolution as a larger telescope?

ANSWER: INTERFEROMETRY [IC]

BONUS

22) EARTH AND SPACE *Multiple Choice* Which of the following measurement scales would be most useful for determining the direct danger posed to humans by an earthquake?

- W) Modified Mercalli scale
- X) Moment magnitude scale
- Y) Saffir-Simpson scale
- Z) Fujita scale

ANSWER: W) MODIFIED MERCALLI SCALE [HJ]

TOSS-UP

23) PHYSICS *Multiple Choice* An electron is traveling in the positive y-direction through a magnetic field that is oriented in the positive x-direction. What is the direction of the magnetic force on the electron?

W) Negative z

X) Positive z

Y) Negative x

Z) Positive x

ANSWER: X) POSITIVE Z [OW]

BONUS

23) PHYSICS *Short Answer* What is the efficiency of a Carnot engine with a hot reservoir of 500 kelvin and a cold reservoir of 200 kelvin?

ANSWER: 0.6 (ACCEPT $\frac{3}{5}$, 60%) [OW]