



MOSFET 2025 - Round 4

TOSS-UP

1) BIOLOGY *Short Answer* Creutzfeldt-Jakob disease and mad cow disease are both caused by what non-living pathogenic molecules?

ANSWER: PRION [SY]

BONUS

1) BIOLOGY *Short Answer* What prosthetic group, found in several oxygen-binding proteins, is made up of an iron atom coordinated by a ring-shaped porphyrin molecule?

ANSWER: HEME [SO]

TOSS-UP

2) MATH *Short Answer* How many diagonals does a regular dodecagon have?

ANSWER: 54 [MW]

BONUS

2) MATH *Short Answer* How many ways can a team of five Science Bowlers be chosen from 7 people, if Anu and Shreyas will only compete if they are both on the team?

ANSWER: 11 [SE]

TOSS-UP

3) CHEMISTRY *Multiple Choice* Which of the following electronic transitions in a hydrogen atom involves the greatest change in energy?

W) $n = 1$ to $n = 2$

X) $n = 2$ to $n = 3$

Y) $n = 3$ to $n = 4$

Z) $n = 4$ to $n = 5$

ANSWER: W) $n = 1$ TO $n = 2$ [CZ]

BONUS

3) CHEMISTRY *Short Answer* Kian dilutes a 5 milliliter solution with pH of 3 to a final volume of 500 milliliters. What is the pH of his resulting solution?

ANSWER: 5 [YL]

TOSS-UP

4) EARTH AND SPACE *Multiple Choice* Which of the following choices is NOT an example of chemical weathering?

- W) Limestone is dissolved by acidic groundwater
- X) Iron-rich basalt rusts and weakens
- Y) Coastal rock is forced apart by salt crystal growth
- Z) Silicates in granite are broken down by hydrolysis

ANSWER: Y) COASTAL ROCK IS FORCED APART BY SALT CRYSTAL GROWTH [HJ]

BONUS

4) EARTH AND SPACE *Multiple Choice* Which of the following igneous intrusions is tabular?

- W) Laccolith
- X) Dike
- Y) Stock
- Z) Batholith

ANSWER: X) DIKE [KW]

TOSS-UP

5) PHYSICS *Short Answer* Jack pushes a block with a constant force of 6 newtons at an angle of 60 degrees to the horizontal. If he does 27 joules of work, how far, in meters, did he push the block?

ANSWER: 9 [OW, RR]

BONUS

5) PHYSICS *Short Answer* What is the moment of inertia of a uniform solid sphere with a mass of 6 kilograms and a radius of 2 meters about its central axis?

ANSWER: 48/5 (ACCEPT: 9.6) [OW]

TOSS-UP

6) ENERGY *Multiple Choice* Researchers at Pacific Northwest National Lab are studying carbon capture by mafic and ultramafic rocks. Which of the following rocks would these researchers be most interested in studying?

W) Andesite

X) Pumice

Y) Gabbro

Z) Rhyolite

ANSWER: Y) GABBRO [KW]

BONUS

6) ENERGY *Multiple Choice* Researchers at Boston University are investigating pathways for redox-dependent catalysis. Catalysts speed up reactions by reducing the energy of which of the following species?

- W) Reactants
- X) Products
- Y) Intermediates
- Z) Transition states

ANSWER: Z) TRANSITION STATES [HJ]

TOSS-UP

7) BIOLOGY *Short Answer* Notably found in bird legs, what heat-conserving mechanism relies on the transfer of heat between fluids moving in opposite directions?

ANSWER: COUNTERCURRENT EXCHANGE [OW]

BONUS

7) BIOLOGY *Short Answer* Identify all of the following three hormones that are secreted by the posterior pituitary gland:

- 1) Antidiuretic hormone
- 2) Oxytocin
- 3) Follicle-stimulating hormone

ANSWER: 1 AND 2 [OW]

TOSS-UP

8) MATH *Multiple Choice* Which of the following sets of numbers is defined using recursion?

- W) Prime numbers
- X) Fibonacci numbers
- Y) Perfect squares
- Z) Perfect numbers

ANSWER: X) FIBONACCI NUMBERS [MW]

BONUS

8) MATH *Short Answer* Michelle has an arithmetic sequence with first term 5 and second term 20. Michael has a geometric sequence with first term 1 and second term 2. What is the smallest number n such that the n th number of Michael's sequence is bigger than the n th number of Michelle's sequence?

ANSWER: 8 [SE]

TOSS-UP

9) CHEMISTRY *Multiple Choice* From which of the following combinations of electrolytes is it impossible to make a buffer solution?

- W) Weak acid and weak base
- X) Weak acid and strong base
- Y) Strong acid and weak base
- Z) Strong acid and strong base

ANSWER: Z) STRONG ACID AND STRONG BASE [CZ]

BONUS

9) CHEMISTRY *Multiple Choice* Which of the following molecules is NOT a Lewis acid?

- W) BF_3
- X) SO_3
- Y) AlCl_3
- Z) CH_4

ANSWER: Z) CH_4 [KD]

TOSS-UP

10) EARTH AND SPACE *Multiple Choice* Which of the following rocks is most similar in chemical composition to quartz?

- W) Andesite
- X) Shale
- Y) Sandstone
- Z) Gneiss

ANSWER: Y) SANDSTONE [HJ]

BONUS

10) EARTH AND SPACE *Short Answer* White dwarfs are approximately a million times denser than the Sun and thus have very high gravity. What force counteracts gravity and prevents white dwarfs from collapsing in on themselves?

ANSWER: ELECTRON DEGENERACY PRESSURE [HJ]

TOSS-UP

11) PHYSICS *Multiple Choice* Phoebe attempts to construct a magnetic monopole in her basement but utterly fails. Which of the following laws best explains her failure?

- W) Gauss's Law for Electricity
- X) Gauss's Law for Magnetism
- Y) Ampere's Law
- Z) Faraday's Law

ANSWER: X) GAUSS'S LAW FOR MAGNETISM [KD]

BONUS

11) PHYSICS *Short Answer* Yuni hypothesizes that the Higgs field is in a metastable false vacuum state, separated from the true vacuum by a large energy barrier. What quantum phenomenon involves an object, such as the Higgs field, passing through a classically impenetrable energy barrier?

ANSWER: QUANTUM TUNNELING [CZ]

TOSS-UP

12) ENERGY *Multiple Choice* Researchers at NIST are studying the factorization of large numbers in order to develop safer cryptographic methods. Which of the following is not a possible last digit of a perfect square?

W) 4

X) 5

Y) 6

Z) 7

ANSWER: Z) 7 [EZ]

BONUS

12) ENERGY *Short Answer* Researchers at the National Renewable Energy Laboratory are studying photosynthesis for its biofuel applications. In plants, what molecule undergoes photolysis in order to release hydrogen ions and electrons?

ANSWER: WATER (ACCEPT: H₂O) [SO]

TOSS-UP

13) BIOLOGY *Multiple Choice* In trees, what tissue is responsible for producing the outermost layer of bark?

- W) vascular cambium
- X) apical meristem
- Y) cork cambium
- Z) secondary xylem

ANSWER: Y) CORK CAMBIUM [SY]

BONUS

13) BIOLOGY *Short Answer* In a population of rabbits in Hardy-Weinberg equilibrium, the long ears allele is dominant to the short ears allele. If 91% of the rabbits have long ears, what percent of rabbits are heterozygous for the trait?

ANSWER: 42% [SY]

TOSS-UP

14) MATH *Multiple Choice* Which of the following complex numbers does not have magnitude 5?

- W) $3 - 4i$
- X) $\sqrt{23} - 2i$
- Y) $\sqrt{5} + 2\sqrt{5}i$
- Z) $-4 + 3i$

ANSWER: X) $\sqrt{23} - 2i$ [MW]

BONUS

14) MATH *Short Answer* Frances poured sand into a box measuring 18 centimeters by 25 centimeters by 60 centimeters until it was completely full, then dumped all the sand into a plastic cube and discovered that the cube held the exact same amount of sand. In centimeters, what was the length of the edge of the cube?

ANSWER: 30 [MW]

TOSS-UP

15) CHEMISTRY *Multiple Choice* Adding which of the following salts is most effective to precipitate chloride ions out of solution?

- W) Silver fluoride
- X) Rubidium chloride
- Y) Barium hydroxide
- Z) Zinc acetate

ANSWER: W) SILVER FLUORIDE [HJ]

BONUS

15) CHEMISTRY *Multiple Choice* In kilojoules, which of the following is closest to the heat absorbed by a 200-gram sample of water if its temperature is raised from 20 degrees Celsius to 50 degrees Celsius?

W) 25.1

X) 31.8

Y) 66.8

Z) 75.6

ANSWER: W) 25.1 [SK]

TOSS-UP

16) EARTH AND SPACE *Multiple Choice* Which of the following statements does NOT correctly compare the terrestrial planets to the Jovian planets?

W) Closer to the sun

X) Lower density

Y) Thinner atmosphere

Z) Richer in rocky materials

ANSWER: X) LOWER DENSITY [SE]

BONUS

16) EARTH AND SPACE *Multiple Choice* Which of the following best describes the cause of spring tides, which have particularly large tidal ranges?

W) The Earth is at perihelion, strengthening tidal forces due to proximity with the Sun

X) The Moon is at perigee, strengthening tidal forces due to proximity with the Moon

Y) The Sun and Moon are aligned, strengthening tidal forces by compounding the two effects

Z) Cycles of precession change axial tilt, strengthening tidal forces by increasing the tidal bulge

ANSWER: Y) THE SUN AND MOON ARE ALIGNED, STRENGTHENING TIDAL FORCES BY COMPOUNDING THE TWO EFFECTS [HJ]

TOSS-UP

17) PHYSICS *Short Answer* What is the term for particles such as neutrons and kaons that are composed of multiple quarks held together by the strong force?

ANSWER: HADRONS [CZ]

BONUS

17) PHYSICS *Short Answer* A planet orbits a star in a circular orbit. Identify all of the following three quantities that are conserved for the planet as it orbits:

- 1) Energy
- 2) Linear momentum
- 3) Angular momentum about the star

ANSWER: 1 AND 3 [YL]

TOSS-UP

18) ENERGY *Short Answer* Researchers from DoE labs are presenting their findings at a conference. If there are 13 researchers at the conference, and each pair of researchers shakes hands exactly one time, how many total handshakes will there be at this conference?

ANSWER: 78 [SO, RR]

BONUS

18) ENERGY *Short Answer* Researchers at UW-Madison are using nanomaterials to construct new renewable energy solutions. These researchers are taking advantage of what branch of geometry, in which the three angles of a triangle sum to greater than 180 degrees?

ANSWER: SPHERICAL GEOMETRY [OW, EDE]

TOSS-UP

19) BIOLOGY *Multiple Choice* Osmosis the sea otter is essential for maintaining the health and diversity of his ecosystem. Which of the following roles does Osmosis play in his marine ecosystem?

- W) Keystone species
- X) Decomposer
- Y) Dominant species
- Z) Primary producer

ANSWER: W) KEYSTONE SPECIES :D [SY]

BONUS

19) BIOLOGY *Multiple Choice* Which of the following is NOT a part of the innate immune system?

- W) Complement system
- X) Natural killer cells
- Y) Cytotoxic T cells
- Z) Toll-like receptors

ANSWER: Y) CYTOTOXIC T CELLS [SY]

TOSS-UP

20) MATH *Short Answer* Kian rolls a standard four-sided die and a standard six-sided die. What is the expected value of the sum of the numbers on the bottom faces of the two dice?

ANSWER: 6 [EZ]

BONUS

20) MATH *Short Answer* The average of a set of nine numbers is 5. When x is added to the set, the average increases by 3. What is the value of x ?

ANSWER: 35 [MW]

TOSS-UP

21) CHEMISTRY *Multiple Choice* Lydia is studying the beta decay of carbon-14 into nitrogen-14. She starts with a mass of carbon in an isolated environment. Which of the following best describes the slope of a graph with the mass of nitrogen-14 plotted on the y-axis and time on the x-axis?

- W) Positive and increasing
- X) Positive and decreasing
- Y) Negative and increasing
- Z) Negative and decreasing

Answer: X) POSITIVE AND DECREASING [CZ]

BONUS

21) CHEMISTRY *Multiple Choice* Which of the following statements is NOT true regarding chemical isotopes?

- W) Isotopes differ in the number of neutrons present
- X) At high atomic numbers, stable isotopes have considerably more neutrons than protons
- Y) The most common isotope of fluorine is fluorine-19
- Z) Hydrogen has no radioactive isotopes

ANSWER: Z) HYDROGEN HAS NO RADIOACTIVE ISOTOPES [HJ]

TOSS-UP

22) EARTH AND SPACE *Short Answer* What mid-latitude atmospheric circulation cell is responsible for the formation of the westerlies?

ANSWER: FERREL CELL [KW]

BONUS

22) EARTH AND SPACE *Multiple Choice* Once the Sun reaches the end of its stellar life cycle, it will lose its outer layers, leaving behind a white dwarf core surrounded by a nebula. Which of the following terms best describes the type of nebula that the Sun will form?

- W) Reflection
- X) Absorption
- Y) Planetary
- Z) Dark

ANSWER: Y) PLANETARY [HJ]

TOSS-UP

23) PHYSICS *Short Answer* Penelope's clarinet is out of tune. Given that her tuner plays at 440 hertz, what is the beat frequency, in hertz, if she plays her clarinet at 435 hertz?

ANSWER: 5 [YL]

BONUS

23) PHYSICS *Short Answer* Evan, a gas, expands from a volume of 3 cubic meters to a volume of 5 cubic meters against a constant pressure of 1 atmosphere. In scientific notation and to 1 significant figure, how much work, in joules, does Evan do in this process?

ANSWER: 2 TIMES 10^5 [KD]