MOSFET 2025 - Round 10

TOSS-UP

1) BIOLOGY *Multiple Choice* In a dihybrid cross following Mendelian genetics, what is the ratio of the number of offspring with both dominant traits to the number of offspring with only one dominant trait?

W) 3 to 1

X) 9 to 1

Y) 3 to 2

Z) 9 to 2

ANSWER: Y) 3 TO 2 [SO]

BONUS

1) BIOLOGY *Short Answer* What type of respiratory pigment, commonly found in crabs and scorpions, is characteristic of an open circulatory system?

ANSWER: HEMOCYANIN [SY]

TOSS-UP

2) MATH *Short Answer* Yunyi is buying pizza to share with his friends. To cut the pizza, he draws diameters of the circle, dividing the pizza into congruent slices. If each slice has a perimeter of 12 + pi inches, how many slices did Yunyi cut the pizza into?

ANSWER: 12 [EZ]

BONUS

2) MATH *Short Answer* The Dodgers, with their superstar Shohei Ohtani, are facing the White Sox in a best of 5 series, where the series ends as soon as one team has won three games. The Dodgers have a probability of winning each game of 0.9. Treating each game as an independent event, what is the probability, to three decimal places, that the series lasts 5 games?

ANSWER: 0.049 [MW]

TOSS-UP

3) CHEMISTRY *Multiple Choice* Which of the following organic compounds has the greatest mass percentage of carbon?

W) Propane
X) Toluene
Y) Acetylene
Z) Cyclohexane

Answer: Y) ACETYLENE [CZ]

BONUS

3) CHEMISTRY *Multiple Choice* Which of the following octahedral complexes would be diamagnetic?

W) d5 complex with strong-field ligands
X) d6 complex with strong-field ligands
Y) d5 complex with weak-field ligands
Z) d6 complex with weak-field ligands

ANSWER: X) D6 COMPLEX WITH STRONG-FIELD LIGANDS [KD]

TOSS-UP

4) EARTH AND SPACE *Multiple Choice* Caloris Planitia is located on which of the following solar system bodies?

W) Mercury
X) Venus
Y) The Moon
Z) Mars

ANSWER: W) MERCURY [PB]

BONUS

4) EARTH AND SPACE *Multiple Choice* Which of the following choices best describes the metamorphic conditions found in a subducting accretionary wedge?

W) High temperature, high pressure
X) High temperature, low pressure
Y) Low temperature, high pressure
Z) Low temperature, low pressure

ANSWER: Y) Low temperature, high pressure [HJ]

TOSS-UP

5) PHYSICS *Short Answer* Order the following three materials in order of increasing dielectric constant at 25 degrees Celsius:

1) Air
2) Rubber
3) Pure water

ANSWER: 1, 2, 3 [OW]

BONUS

5) PHYSICS *Short Answer* Unpolarized light with intensity i passes through three successive polarizers A, B, and C. B is tilted at 30 degrees with respect to A, and C is tilted at 90 degrees with respect to A. In terms of i, what is the final intensity of the light after passing through all three polarizers?

ANSWER: 3i/32 [YL]

TOSS-UP

6) ENERGY *Multiple Choice* Researchers at the IceCube Neutrino Observatory are attempting to detect sterile neutrinos. These theorized neutrinos are thought to only interact with what fundamental force?

W) Electromagnetic
X) Gravity
Y) Weak
Z) Strong

ANSWER: X) GRAVITY [OW, MDE]

BONUS

6) ENERGY *Short Answer* Scientists at the Joint Genome Institute are studying gene regulation in prokaryotes. In the lac operon in E. coli, what molecule acts as an inducer by reducing the binding affinity of the repressor to DNA?

ANSWER: ALLOLACTOSE [SO, LDE]

TOSS-UP

7) BIOLOGY *Short Answer* What term describes bacteriophages that can take part in both the lysogenic and lytic cycle?

ANSWER: TEMPERATE [OW]

BONUS

7) BIOLOGY *Short Answer* A fetus is treated with a drug that affects the development of the diencephalon. Identify all of the following 3 parts of the brain that will be targeted by this drug:

1) Thalamus
2) Hypothalamus
3) Epithalamus

ANSWER: ALL [KD] Anatomy

TOSS-UP

8) MATH *Short Answer* Two checkers are placed on different squares of an 8 by 8 board. What is the probability that they are not in the same row or column?

ANSWER: 7/9 [EZ]

BONUS

8) MATH *Short Answer* Find the remainder when 15 factorial is divided by 17.

ANSWER: 1 [SE]

TOSS-UP

9) CHEMISTRY *Multiple Choice* A 1-molar solution of which of the following ions would have the lowest pH?

W) Fe^{3+}

X) NH_4^+

Y) Na^+

Z) Ca^{2+}

ANSWER: W) Fe^{3+} [KD]

BONUS

9) CHEMISTRY *Short Answer* What is the ratio of the energies of the second excited state to the first excited state of a Bohr hydrogen atom?

ANSWER: 4/9 [YL]

TOSS-UP

10) EARTH AND SPACE *Short Answer* For the maria to have such a lack of craters, they must have formed after what period in the Moon's history, characterized by continuous meteor impacts on the Moon and other solar system objects?

ANSWER: LATE HEAVY BOMBARDMENT [SE]

BONUS

10) EARTH AND SPACE *Multiple Choice* Mars is at aphelion in the Northern Hemisphere summer. Based on this knowledge, which of the Martian ice caps is bigger and why?

W) The Northern ice cap, because the Northern hemisphere has more extreme seasons
X) The Northern ice cap, because the Northern hemisphere has more moderate seasons
Y) The Southern ice cap, because the Southern hemisphere has more extreme seasons
Z) The Southern ice cap, because the Southern hemisphere has more moderate seasons

ANSWER: X) THE NORTHERN ICE CAP, BECAUSE THE NORTHERN HEMISPHERE HAS MORE MODERATE SEASONS [SE]

TOSS-UP

11) PHYSICS *Short Answer* Evan has a planar object in the xy plane. If he knows the moments of inertia about the x- and y-axes, what theorem would he use to find the moment of inertia about the z-axis?

ANSWER: PERPENDICULAR AXIS THEOREM [YL]

BONUS

11) PHYSICS *Short Answer* Kian holds a charged particle a distance d away from a dipole oriented along the z-axis. If Kian moves the particle to a distance 3d away along the z-axis, by what factor is the electrostatic potential energy between the dipole and the particle multiplied by?

ANSWER: 1/9 [YL MDE]

TOSS-UP

12) ENERGY *Multiple Choice* Scientists at the National Genome Institute are studying the application of matrices in genomic data analysis. In order to take the determinant of a matrix, it must have which of the following properties?

W) Square
X) Diagonalizable
Y) Invertible
Z) Singular

ANSWER: W) SQUARE [SO, EDE]

BONUS

12) ENERGY *Short Answer* The Wiseman Lab at Scripps Research is studying heat shock proteins and their cellular roles in times of stress. Many heat shock proteins fall under what category of proteins that assist other proteins to fold properly?

ANSWER: CHAPERONINS [SY]

TOSS-UP

13) BIOLOGY *Short Answer* In neurons, what term is used to describe the apparent jumping of action potentials between consecutive nodes of Ranvier?

ANSWER: SALTATORY CONDUCTION [OW]

BONUS

13) BIOLOGY *Multiple Choice* Which of the following best explains why, on average, one molecule of $FADH_2$ produces less ATP than one molecule of NADH?

W) $FADH_2$ carries fewer electrons than NADH
X) $FADH_2$ delivers electrons to complex 2, which doesn't pump protons across the inner mitochondrial membrane
Y) $FADH_2$ is produced in glycolysis and thus requires energy to enter the mitochondria
Z) $FADH_2$ is more unstable than NADH and loses electrons more frequently

ANSWER: X) $FADH_2$ DELIVERS ELECTRONS TO COMPLEX 2, WHICH DOESN'T PUMP PROTONS ACROSS THE INNER MITOCHONDRIAL MEMBRANE [OW]

TOSS-UP

14) MATH *Multiple Choice* Certain equations such as $a^2 + b^2 = c^2$ have infinitely many real solutions, but only integer solutions are of interest. What is the adjective which describes these equations?

W) Integral
X) Gaussian
Y) Euclidean
Z) Diophantine

ANSWER: Z) DIOPHANTINE [JW]

BONUS

14) MATH *Multiple Choice* Not including face diagonals along the faces of the pentagons, how many space diagonals does a dodecahedron have if it has 12 pentagonal faces and 20 vertices?

W) 60

X) 80

Y) 100

Z) 120

ANSWER: Y) 100 [MW]

TOSS-UP

15) CHEMISTRY *Short Answer* Identify all of the following three quantities which must be equal for a substance at its triple point:

1) Enthalpy of fusion and enthalpy of vaporization
2) Gibbs free energy of fusion and Gibbs free energy of vaporization
3) Gibbs free energy of fusion and Gibbs free energy of sublimation

ANSWER: 2 AND 3 [HJ]

BONUS

15) CHEMISTRY *Multiple Choice* Yunyi finds a molecule with 2 chiral centers and magically inverts the configuration of one of the chiral centers. Which of the following terms best describes the relationship between the original molecule and the molecule following the inversion?

W) Diastereomers
X) Enantiomers
Y) Constitutional isomers
Z) Cis-trans isomers

ANSWER: W) DIASTEREOMERS [KD]

TOSS-UP

16) EARTH AND SPACE *Short Answer* In 1991, the eruption of Mount Pinatubo caused a significant drop in global temperatures over the next two years. What volcanic gas emitted during this eruption was most directly the cause of this temperature drop?

ANSWER: SULFUR DIOXIDE (ACCEPT: SO_2) [HJ]

BONUS

16) EARTH AND SPACE *Short Answer* What two measurements, analogous to longitude and latitude on Earth, are used to pinpoint objects on the celestial sphere?

ANSWER: DECLINATION AND RIGHT ASCENSION [SE]

TOSS-UP

17) PHYSICS *Multiple Choice* A rocket in free space expels fuel behind it at a constant rate and velocity relative to itself until it runs out of fuel, after which it begins coasting at a constant velocity. Which of the following correctly describes how the final velocity of the rocket is related to its initial mass?

W) Linear

X) Inverse

Y) Exponential

Z) Logarithmic

ANSWER: Z) LOGARITHMIC [YL]

BONUS

17) PHYSICS *Short Answer* Tia is running on a hill inclined at 45 degrees and exerts a constant power to propel herself up at a speed of 5 meters per second. The hill then levels off to an inclination of 30 degrees. If Tia exerts the same constant power on herself, what is her new traveling speed, in meters per second and in simplest radical form?

ANSWER: 5 SQRT(2) [DL]

TOSS-UP

18) ENERGY *Multiple Choice* Scientists at Lawrence Livermore National Lab's National Ignition Facility are developing fusion energy technology. The deuterium fusion processes they are working on would be most similar to fusion in which of the following classes of stars?

W) Type A
X) Type G
Y) Type K
Z) Type L

ANSWER: Z) TYPE L [HJ]

BONUS

18) ENERGY *Short Answer* Scientists at the Space Sciences Lab at UC Berkeley are studying the interaction of the Sun's magnetic field with solar spectra. What effect characterizes the splitting of spectral lines due to the presence of a strong magnetic field, such as in sunspots?

ANSWER: ZEEMAN EFFECT (ACCEPT: PASCHEN-BACK EFFECT)[SY]

TOSS-UP

19) BIOLOGY *Multiple Choice* Which of the following cell types is not derived from a myeloid progenitor cell?

W) Macrophage
X) Eosinophil
Y) Lymphocyte
Z) Basophil

ANSWER: Y) LYMPHOCYTE [OW]

BONUS

19) BIOLOGY *Short Answer* What gaps in the bark allow for gas exchange between a tree and the atmosphere?

ANSWER: LENTICELS [SY]

TOSS-UP

20) MATH *Short Answer* Mad Madison is in a hurry, and plans to drive her car on top of a train, which runs from her home to her school at 200 miles per hour. If she drives her car towards school at 50 miles per hour relative to the train, she will reach school in 18 minutes. In miles, how far is her school from her home?

ANSWER: 75 [JW]

BONUS

20) MATH *Multiple Choice* Mad Madison checks her phone and her car falls off the train. She sees that the current time is 8:00, and is concerned that she will be late to school. Madison calculates that she will reach her first class on time if she drives at 108 miles per hour, and be an hour late if she drives at 27 miles per hour. When does her first class start?

W) 8:10

X) 8:20

Y) 8:30

Z) 8:40

ANSWER: X) 8:20 [JW]

TOSS-UP

21) CHEMISTRY *Short Answer* Order the following three single bonds by increasing strength:

1) C-H
2) C-F
3) C-Cl

ANSWER: 3, 1, 2 [HJ]

BONUS

21) CHEMISTRY *Short Answer* The rate constant of a first order reaction is 0.07 inverse seconds. To one significant figure, how much time in seconds will it take for the concentration of the reactants to reach ⅛ of their original concentrations?

ANSWER: 30 SECONDS [CZ]

TOSS-UP

22) EARTH AND SPACE *Multiple Choice* Which of the following water masses would hold the most dissolved oxygen?

W) Cold saltwater
X) Warm saltwater
Y) Cold freshwater
Z) Warm freshwater

ANSWER: Y) COLD FRESHWATER [SE]

BONUS

22) EARTH AND SPACE *Short Answer* What point on the HR diagram, often used to date globular clusters, is the point where a star moves off the main sequence and begins evolving into a giant star?

ANSWER: TURNOFF POINT [SE]

TOSS-UP

23) PHYSICS *Short Answer* Daniel's pet needs a PET scan! PET scans use the beta-plus decay of fluorine-18 to oxygen-18. This process is mediated by what charged elementary particle?

ANSWER: W+ BOSON (DO NOT ACCEPT: W BOSON) [CZ]

BONUS

23) PHYSICS *Short Answer* Order the following three objects by increasing de Broglie wavelength:

1) A 50 kg truck driving at 10 meters per second
2) Earth orbiting the Sun at a distance of 1 AU
3) An electron accelerated through a 1-eV potential

ANSWER: 2, 1, 3 [YL MDE]