



MOSFET Invitational Double Elimination 5

TOSS-UP

1) BIOLOGY *Short Answer* A very small, hormone-like signaling molecule has been discovered to be an important local regulator in both plants and animals. Identify all of the following junctions that this molecule could pass through to go from one cell to an adjacent cell:

- 1) Tight junction
- 2) Gap junction
- 3) Plasmodesmata

ANSWER: 2 AND 3 [W: OW, E: EB; MDE Bio-CB]

BONUS

1) BIOLOGY *Multiple Choice* Jimmy is studying a flower that is completely blue, but under further examination also has ultraviolet markings. Which of the following animals would most likely pollinate this flower?

- W) Moth
- X) Butterfly
- Y) Bee
- Z) Bat

ANSWER: Y) BEE [OW, E: EB; MDE Bio-P]

TOSS-UP

2) CHEMISTRY *Short Answer* What laboratory technique involves use of a stationary phase and a mobile phase, in order to separate a mixture of substances?

ANSWER: CHROMATOGRAPHY [W: HJ, E: AS; MDE Chem-Other]

BONUS

2) CHEMISTRY *Short Answer* Identify all of the following three statements which are true regarding the change in Gibbs free energy of a reaction:

- 1) A decrease in Gibbs free energy corresponds to a decrease in entropy of the universe
- 2) Reactions tend towards conditions with lower Gibbs Free energy
- 3) Gibbs free energy of reaction always decreases as temperature increases.

ANSWER: 2 ONLY [W: HJ, E: AS; MDE Chem-T]

TOSS-UP

3) EARTH AND SPACE *Multiple Choice* Which of the following types of metamorphism occurs at the lowest pressure?

- W) Burial
- X) Regional
- Y) Contact
- Z) Shock

ANSWER: Y) CONTACT [W: HJ, E: EB; MDE ESS-RM]

BONUS

3) EARTH AND SPACE *Short Answer* What class of galaxy typically forms after several mergers and tends to be relatively old?

ANSWER: ELLIPTICAL [W: SC, E: EB; MDE ESS-OA]

TOSS-UP

4) MATH *Short Answer* What is the dot product of the vectors $\langle 2, 1, -1 \rangle$ and $\langle 0, -3, 2 \rangle$ [**open bracket 2 comma 1 comma -1 close bracket** etc etc]?

ANSWER: -5 [W: SC, E: EB; MDE Math-A]

BONUS

4) MATH *Short Answer* How many ways can a teacher divide a class of 8 students into pairs of 2?

ANSWER: 105 [W: KR, E: SC; MDE Math-C]

TOSS-UP

5) PHYSICS *Short Answer* Identify all of the following three types of reference frames in which fictitious forces may be observed:

- 1) Linearly accelerating
- 2) Rotating
- 3) Inertial

ANSWER: 1 AND 2 [W: JW, E: SC; MDE Phys-ME]

BONUS

5) PHYSICS *Short Answer* Identify all of the following three properties of a physical pendulum that, when increased while keeping the others constant, would increase the period of the pendulum:

- 1) Mass of the bob
- 2) Moment of inertia of the bob
- 3) Distance from the pivot to the bob's center of mass

ANSWER: 2 ONLY [W: JW, E: SC; MDE Phys-ME]

TOSS-UP

6) ENERGY *Short Answer* Argonne National Lab scientists are collaborating with UNC Chapel Hill researchers to study so-called “nuclear popcorn,” the conformational changes of the Ni-64 nucleus in response to higher or lower energy conditions. The results from this study can help them better understand what force, which is responsible for holding the nucleus together?

ANSWER: STRONG FORCE (ACCEPT: STRONG NUCLEAR FORCE) [W: EB, E: SC; MDE]

BONUS

6) ENERGY *Short Answer* Scientists at UT Dallas are studying fluoro-linking in lanthanide organometallic frameworks. Identify all of the following three results that are advantages of using fluoro-linking instead of typical oxygen

- 1) Higher melting point
- 2) Enhanced magnetic properties
- 3) Tighter frameworks

ANSWER: 2 AND 3 [W: EB, E: SC; MDE]

TOSS-UP

7) BIOLOGY *Multiple Choice* Which of the following statements is NOT true regarding the endocrine system?

W) Tropic hormones cause the release of other hormones

X) Hormones released by the posterior pituitary gland are synthesized in the hypothalamus

Y) Androgens are produced in both males and females

Z) The thyroid gland is responsible for the synthesis and secretion of cortisol and other glucocorticoids

ANSWER: Z) THE THYROID GLAND IS RESPONSIBLE FOR THE SYNTHESIS AND SECRETION OF CORTISOL AND OTHER GLUCOCORTICIDS [W: OW, E: EB; MDE Bio-AP]

BONUS

7) BIOLOGY *Short Answer* What group of proteins in mammals detect structures commonly found in pathogens, such as flagellin and double stranded RNA?

ANSWER: TOLL-LIKE RECEPTORS (ACCEPT: TLRs; DO NOT ACCEPT: TOLL RECEPTOR OR TOLL PROTEIN) [W: OW, E: EB; MDE Bio-AP]

TOSS-UP

8) CHEMISTRY *Multiple Choice* According to the Aufbau principle, which of the following subshells is NOT filled after the 6s subshell?

- W) 4d
- X) 4f
- Y) 5d
- Z) 5f

ANSWER: W) 4D [W: AS, E: HJ; MDE Chem-AM]

BONUS

8) CHEMISTRY *Multiple Choice* An atomic nucleus that is proton poor will most likely undergo which of the following types of decay?

- W) Alpha
- X) Beta minus
- Y) Beta plus
- Z) Electron capture

ANSWER: X) BETA MINUS [W: HJ, E: AS; MDE Chem-Other]

TOSS-UP

9) EARTH AND SPACE *Short Answer* A type 1a supernova occurs when a white dwarf accretes mass beyond what physical limit, where the balance between gravity and electron degeneracy pressure can no longer be maintained?

ANSWER: CHANDRASEKHAR LIMIT [W: JW, E: EB; MDE ESS-SA]

BONUS

9) EARTH AND SPACE *Short Answer* Identify all of the following three conditions which would decrease the viscosity of a magma:

- 1) Decrease in silica content
- 2) Lower temperature
- 3) Decrease in dissolved gas

ANSWER: 1 ONLY [W: HJ, E: SC; MDE ESS-G]

TOSS-UP

10) MATH *Short Answer* What is the volume of a square pyramid with a base side length and slant height of 6?

ANSWER: 36 SQUARE ROOT 3 [W: KR, E: SC; MDE Math-G]

BONUS

10) MATH *Short Answer* Identify all of the following three numbers that are quadratic residues modulo 6:

- 1) 1
- 2) 2
- 3) 3

ANSWER: 1 AND 3 [W: SC, E: EB; MDE Math-NT]

TOSS-UP

11) PHYSICS *Short Answer* What general integral equation gives the magnetic field generated by a constant electric current? Special cases of Ampere's law can be validated using this formula.

ANSWER: BIOT-SAVART LAW [W: KR, E: SC; MDE Phys-ET]

BONUS

11) PHYSICS *Multiple Choice* Claire has three objects: a solid ball, a thin spherical shell, and a thin cylindrical shell. All of these objects have the same radius and the same mass. If they are placed at the top of the same ramp and are released at the same time, which one rolls to the bottom first?

- W) The solid ball
- X) The spherical shell
- Y) The cylindrical shell
- Z) All three objects will reach the bottom at the same time

ANSWER: W) THE SOLID BALL [W: SC, E: RF; MDE Phys-ME]

TOSS-UP

12) ENERGY *Multiple Choice* Researchers at UW Madison are studying gas effusion to prevent dangerous gas leaks. If both gases are at the same temperature, which of the following is closest to the ratio of the effusion rate of hydrogen gas to that of oxygen gas?

- W) 2:1
- X) 4:1
- Y) 8:1
- Z) 16:1

ANSWER: X) 4:1 [W: OW, E: EB; MDE]

BONUS

12) ENERGY *Short Answer* Researchers at UT-Austin are studying how best to improve the practice of radiometric dating. Place the following four radioisotopes in order of increasing half-life:

- 1) Carbon-14
- 2) Uranium-235
- 3) Uranium-238
- 4) Potassium-40

ANSWER: 1, 2, 4, 3 [W: EB, E: HJ; MDE]

TOSS-UP

13) BIOLOGY *Multiple Choice* Which of the following clades is most likely to contain organisms with polyploid genomes?

- W) Plantae
- X) Animalia
- Y) Fungi
- Z) Monera

ANSWER: W) PLANTAE [W: OW, E: EB; MDE Bio-G]

BONUS

13) BIOLOGY *Short Answer* Order the following three events of mitosis in chronological order:

- 1) The cleavage furrow begins to form
- 2) Nuclear envelope breaks down
- 3) Spindle apparatus disassembles

ANSWER: 2, 1, 3 [W: OW, E: EB; MDE Bio-CB]

TOSS-UP

14) CHEMISTRY *Short Answer* A molecule of a certain diatomic gas is diamagnetic. How many unpaired electrons does it have?

ANSWER: ZERO [W: HJ, E: AS, MDE Chem-Other]

BONUS

14) CHEMISTRY *Short Answer* Identify all of the following three compounds whose central atoms are sp² hybridized:

- 1) SO₃
- 2) CO₂
- 3) CH₂O

ANSWER: 1 AND 3 [W: HJ, E: AS, MDE Chem-AM]

TOSS-UP

15) EARTH AND SPACE *Short Answer* What is the name for the area of a glacier below the snow line that experiences a net loss of ice mass?

ANSWER: ZONE OF ABLATION [W: EB, E: SC; MDE ESS-G]

BONUS

15) EARTH AND SPACE *Short Answer* Order the following four stages of a roughly solar mass star's life in order from earliest to latest:

- 1) Horizontal branch
- 2) Main sequence
- 3) Formation of planetary nebula
- 4) White dwarf

ANSWER: 2, 1, 3, 4 [W: RF, E: SC; MDE ESS-SA]

TOSS-UP

16) MATH *Short Answer* Two positive integers a and b multiply to 136. What is the minimum value of $a + b$?

ANSWER: 25 [W: SC, E: EB; MDE Math-NT]

BONUS

16) MATH *Multiple Choice* What is the derivative of $f(x) = x \cdot e^x$ evaluated at $x = 4$?

- W) 20
- X) $4e^4$
- Y) $5e^4$
- Z) e^9

ANSWER: Y) $5e^4$ [W: JW, E: SC; MDE Math-A]

TOSS-UP

17) PHYSICS *Short Answer* A particle with charge seven coulombs is moving at speed fifteen meters per second in a magnetic field of fifty teslas perpendicular to the velocity. What is the magnitude, in Newtons, of the force experienced?

ANSWER: 5250 [W: EB, E: SC; MDE Phys-ET]

BONUS

17) PHYSICS *Multiple Choice* A point charge of magnitude q is positioned at the origin. A sphere of radius R is centered at the origin, and has an electric flux through it. The sphere is now redrawn to have radius $2R$. Which of the following correctly describes the effect this has on net electric flux through the sphere?

W) Net flux doubles

X) Net flux halves

Y) Net flux stays the same

Z) Magnitude of net flux stays the same, but the sign changes

ANSWER: Y) NET FLUX STAYS THE SAME [W: RF, E: SC; MDE Phys-ET]

TOSS-UP

18) ENERGY *Multiple Choice* Scientists at the DOE's National Renewable Energy Laboratory are using silicon oxide to coat perovskite photovoltaic cells for use in space. Which of the following best describes the main purpose for this coating?

- W) Reducing cell weight
- X) Protecting against space debris
- Y) Protecting against radiation damage
- Z) Allowing the cell to conduct electricity

ANSWER: Y) PROTECTING AGAINST RADIATION DAMAGE [W: EB, E: SC; MDE]

BONUS

18) ENERGY *Multiple Choice* Researchers at the University of Maryland are studying small, highly charged lewis acid cations and their applications as catalysts for polymerization. Which of the following metal cations is NOT a Lewis acid?

- W) Al^{3+}
- X) Ca^{2+}
- Y) Fe^{3+}
- Z) Cu^{2+}

ANSWER: X) Ca^{2+} [W: HJ, E: EB; MDE]

TOSS-UP

19) BIOLOGY *Multiple Choice* In which of the following biomes would you expect to have both moderate temperatures and moderate rainfall levels?

- W) Desert shrubland
- X) Boreal forest
- Y) Savannah
- Z) Montane grassland

ANSWER: Y) SAVANNAH [W: EB, E: OW; MDE Bio-EEB]

BONUS

19) BIOLOGY *Multiple Choice* Bob is studying the extracellular portion of a membrane protein. Which of the following amino acids is most likely to be found in this portion of the protein?

- W) Phenylalanine
- X) Alanine
- Y) Tyrosine
- Z) Valine

ANSWER: Y) TYROSINE [W: OW, E: EB; MDE Bio-Other]

TOSS-UP

20) CHEMISTRY *Multiple Choice* In the gas phase synthesis of water, which of the following would shift reaction equilibrium towards products?

- W) Adding Argon gas
- X) Decreasing pressure
- Y) Decreasing temperature
- Z) Adding liquid water

ANSWER: Y) DECREASING TEMPERATURE [W: HJ, E: AS; MDE Chem-EK]

BONUS

20) CHEMISTRY *Short Answer* Identify all of the following three groups of ionic compounds which are generally insoluble:

- 1) Phosphates
- 2) Carbonates
- 3) Sulfides

ANSWER: ALL [W: HJ, E: AS; MDE Chem-R]

TOSS-UP

21) EARTH AND SPACE *Short Answer* Identify all of the following pressure systems which would exhibit clockwise flow:

- 1) Cyclone in the northern hemisphere
- 2) Anticyclone in the northern hemisphere
- 3) Anticyclone in the southern hemisphere.

ANSWER: 2 ONLY [W: HJ, E: EB; MDE ESS-AO]

BONUS

21) EARTH AND SPACE *Short Answer* Identify all of the following three statements which are true of lunar regolith:

- 1) It is heavily ionized by the solar wind
- 2) It is largely anhydrous
- 3) It is very coarse-grained

ANSWER: 12 [W: SC, E: EB; MDE ESS-SS]

TOSS-UP

22) MATH *Short Answer* How many ways are there to divide 8 people into 2 groups of 3 and 1 group of 2?

ANSWER: 280 [W: OW, E: SC; MDE Math-C]

BONUS

22) MATH *Short Answer* Right triangle ABC has right angle B. The length of leg AB is 1. The sum of the length of the hypotenuse AC and leg BC is 3. What is the difference between the lengths of AC and BC?

ANSWER: $\frac{1}{3}$ [W: KR, E: SC; MDE Math-G]

TOSS-UP

23) PHYSICS *Short Answer* What kind of particle accelerator uses a continuously varying magnetic field to boost particles to relativistic speeds?

ANSWER: SYNCHROTRON [W: SC, E: EB; MDE Phys-MO]

BONUS

23) PHYSICS *Multiple Choice* A photon strikes a nucleus, causing pair production to occur. Which of the following could not be the two resulting particles?

- W) Electron and positron
- X) Electron and electron neutrino
- Y) Proton and antiproton
- Z) Muon and antimuon

ANSWER: X) ELECTRON AND ELECTRON NEUTRINO [W: RF, E: SC; MDE Phys-MO]