MOSFET Invitational
Double Elimination 4

TOSS-UP

1) BIOLOGY *Multiple Choice* Which of the following enzymes catalyzes the formation of fructose-1,6 bisphosphate in glycolysis?
W) hexokinase
X) fructokinase
Y) phosphofructokinase
Z) phosphoglucose isomerase

ANSWER: Y) PHOSPHOFRUCTOKINASE [W: SG, E: OW; MDE Bio-Other]

BONUS

1) BIOLOGY *Short Answer* The loss of neurons in the substantia nigra in patients with Parkinson's Disease leads to the underproduction of what neurotransmitter?

ANSWER: DOPAMINE [W: OW, E: EB; MDE Bio-AP]

TOSS-UP

2) CHEMISTRY *Short Answer* What quantity is equal to the sum of the latent heats of fusion and vaporization?

ANSWER: LATENT HEAT OF SUBLIMATION [W: AS, E: HJ, MDE Chem-T]

BONUS

2) CHEMISTRY *Short Answer* In the ground state 2p subshell of oxygen, there are four electrons that can each occupy one of the three 2p orbitals x, y, and z. Identify all of the following three allotments of electrons that are always disallowed:
1) one in x, two in y, one in z;
2) two in x, two in y, none in z;
3) one in x, one in y, two in z.

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

TOSS-UP

3) EARTH AND SPACE *Short Answer* What is the name given to a layer of a mostly-impermeable layer of rock separating two aquifers that transmits water at very slow rates?

ANSWER: AQUITARD [W: EB, E: SC; MDE ESS-G]

BONUS

3) EARTH AND SPACE *Short Answer* Identify all of the following three types of supernovae which, when observed, would lack hydrogen lines in their emission spectra:
1) Type Ia
2) Type Ib
3) Type II

ANSWER: 1 AND 2 [W: RF, E: EB; MDE ESS-SA]

TOSS-UP

4) MATH *Multiple Choice* Which of the following numbers leaves a remainder of 1 when multiplied by 5 and divided by 32?
W) 11
X) 13
Y) 19
Z) 23

ANSWER: X) 13 [W: KR, E: SC; MDE Math-NT]

BONUS

4) MATH *Short Answer* Two numbers, A and B, have a greatest common divisor of 16 and a least common multiple of 320. How many possible ordered pairs (A,B) exist if A and B are positive integers?

Answer: 4 [W: OW, E: SC; MDE Math-NT]

TOSS-UP

5) PHYSICS *Multiple Choice* Which of the following physical laws is not included in Maxwell's equations?
W) Lenz's Law
X) Gauss's Law
Y) Ampere's Circuital Law
Z) Faraday's Law of Induction

ANSWER: W) LENZ'S LAW [W: RF, E: SC; MDE Phys-ET]

BONUS

5) PHYSICS *Short Answer* A very massive Sanjay kicks a very light, stationary soccer ball. Modeling the situation as a perfectly elastic collision, if the speed of Sanjay's foot is 12 m/s, what is the speed of the ball directly after the collision, in meters per second and to two significant figures?

ANSWER: 24 [W: JW, E: RF; MDE Phys-ME]

TOSS-UP

6) ENERGY *Multiple Choice* Researchers at UW Madison are studying population dynamics and how allele frequencies change over time. Assuming Hardy-Weinberg equilibrium, what is the frequency of the dominant allele if 64% of the population shows the recessive phenotype?

W) 0.2

X) 0.4

Y) 0.6

Z) 0.8

ANSWER: W) 0.2 [W: OW, E: EB; MDE]

BONUS

6) ENERGY *Multiple Choice* Researchers at UW-Madison are using radioactive nitrogen to follow certain biological pathways in the cell. Which of the following molecules could NOT be studied using radioactive nitrogen?

W) Tryptophan

X) Alanine

Y) Thymine

Z) Linoleic acid

ANSWER: Z) LINOLEIC ACID [W: OW, E: EB; MDE]

7) BIOLOGY *Short Answer* A modified form of what nucleobase forms the 5' cap of an mRNA molecule?

ANSWER: GUANINE [W: SG, E: EB; MDE Bio-CB]

BONUS
7) BIOLOGY *Short Answer* In Arachnoids, the gene for pincer size is epistatically controlled by gene B such that little b little b individuals have a second set of pincers. Otherwise, small pincers are dominant to large pincers. If an arachnoid heterozygous for both genes mates with an arachnoid with two sets of small pincers, what is the probability that their first baby bug has two sets of large pincers?

ANSWER: 1/24 [W: EB, E: OW; MDE Bio-G]

TOSS-UP
8) CHEMISTRY *Multiple Choice* Which of the following combinations of angular momentum and magnetic quantum numbers is NOT possible for an electron?
W) $l = 0$, m_l [*M sub L*] $= 1$
X) $l = 1$, $m_l = -1$
Y) $l = 2$, $m_l = 0$
Z) $l = 3$, $m_l = -3$

ANSWER: W) $l = 0$, $m_l = 1$ [W: HJ, E: AS; MDE Chem-AM]

BONUS
8) CHEMISTRY *Short Answer* Identify all of the following four kinetic reaction orders that go to completion in a finite amount of time:
1) Zeroth
2) First
3) Second
4) Third

ANSWER: 1 ONLY [W: AS, E: HJ; MDE Chem-EK]

TOSS-UP

9) EARTH AND SPACE *Multiple Choice* Which of the following Galilean moons is not involved in the Laplace resonance?
W) Io
X) Europa
Y) Ganymede
Z) Callisto

ANSWER: Z) CALLISTO [W: SC, E: EB; MDE ESS-SS]

BONUS

9) EARTH AND SPACE *Short Answer* You are studying a geologic formation with two rock layers, a fault, and an unconformity. Rock layer A is composed of sandstone, and it is directly underlain by layer B, which is composed of granite. Fault C cuts through layer B but not layer A. Place the following four geologic structures from oldest to youngest:
1) Layer A
2) Layer B
3) Fault C
4) Unconformity D

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

TOSS-UP

10) MATH *Multiple Choice* A comet orbiting a star has an orbital eccentricity of exactly 1. Which of the following adjectives best describes its path?
W) Circular
X) Elliptical
Y) Hyperbolic
Z) Parabolic

ANSWER: Z) PARABOLIC [W: EB, E: SC; MDE Math-G]

BONUS

10) MATH *Short Answer* Let a,b,c be roots of the cubic $x^3 - 3x^2 + 5x - 9$. Determine the sum $1/a + 1/b + 1/c$.

ANSWER: 5/9 [W: KR, E: SC; MDE Math-A]

TOSS-UP

11) PHYSICS *Short Answer* For an ideal Hookean spring, the restoring force is proportional to the spring constant k. What intensive property of an isotropic material is defined as the amount of stress per unit of strain felt on an object, and is analogous to the spring constant?

ANSWER: YOUNG'S MODULUS [W: JW, E: RF; MDE Phys-ME]

BONUS

11) PHYSICS *Multiple Choice* In free space, muons decay with a lifetime of 2.2 microseconds. However, even traveling at near light speeds, muons created in the upper atmosphere due to scattering would take close to 50 microseconds to reach the ground. Which of the following effects most directly explains the apparently impossible detection of muons at sea level?
W) Light cones
X) Length dilation
Y) Minkowski spacetime
Z) Time dilation

ANSWER: Z) TIME DILATION [W: RF, E: EB; MDE Phys-MO]

TOSS-UP

12) ENERGY *Short Answer* Researchers at UW Madison are studying the effects of heat loss due to nonconservative forces. Identify all of the following forces that are nonconservative:

1) Spring force
2) Gravity
3) Friction

ANSWER: 3 ONLY [W: OW, E: SC; MDE]

BONUS

12) ENERGY *Short Answer* DOE researchers are working in conjunction with a team at Washington University St. Louis to examine the effects of copper on the nitrogen cycle - in particular, denitrification. These researchers have found that increasing copper levels will prevent the release of what nitrogen-containing greenhouse gas three hundred times more potent than CO2?

ANSWER: NITROUS OXIDE [W: EB, E: SC; MDE]

TOSS-UP

13) BIOLOGY *Multiple Choice* What vitamin is a cofactor of proline hydroxylase and is required for proper formation of collagen?
W) Vitamin A
X) Vitamin C
Y) Vitamin D
Z) Vitamin K

ANSWER: X) VITAMIN C [W: OW, E: EB; MDE Bio-CB]

BONUS

13) BIOLOGY *Short Answer* Identify all of the following 3 statements that correctly describe a characteristic of a k-selected species:

1) Rapid development
2) Small body size
3) Long life span

ANSWER: 3 ONLY [W: OW, E: EB; MDE Bio-EEB]

TOSS-UP

14) CHEMISTRY *Short Answer* Ozone molecules in the atmosphere undergo decomposition by a reaction mechanism involving what type of reactive intermediates, which have at least one unpaired electron?

ANSWER: RADICAL (ACCEPT: FREE RADICAL) [W: HJ, E: AS; MDE Chem-Other]

BONUS

14) CHEMISTRY *Short Answer* Identify all of the following three metals which would be able to reduce H+ ions to hydrogen gas:
   1) Silver
   2) Copper
   3) Zinc

ANSWER: 3 ONLY [W: HJ, E: AS; MDE Chem-R]

TOSS-UP

15) EARTH AND SPACE *Multiple Choice* The halocline is a vertical zone where which of the following properties of seawater rapidly changes with depth?
W) Temperature
X) Pressure
Y) Salinity
Z) Density

ANSWER: Y) SALINITY [W: HJ, E: EB; MDE ESS-AO]

BONUS

15) EARTH AND SPACE *Multiple Choice* Olber's paradox suggests that if the universe is homogeneous and infinite, we should see an infinite number of stars in the sky, and thus the night sky would be infinitely bright instead of mostly dark. Which of the following best explains this apparent paradox?
W) At large scales, the universe is not homogenous
X) Dark matter interferes with the observation of distant stars at visible wavelengths
Y) The universe is expanding at an accelerating rate
Z) Supermassive black holes between us and faraway stars deflect light away from Earth via gravitational lensing

ANSWER: Y) THE UNIVERSE IS EXPANDING AT AN ACCELERATING RATE [W: SC, E: RF; MDE ESS-OA]

TOSS-UP

16) MATH *Short Answer* Real number a satisfies sin(a) = 12/13. What two values are possible for the value of sec(a)?

ANSWER: ±13/5 [W: JW, E: KR; MDE Math-A]

BONUS

16) MATH *Multiple Choice* What is the area of a rhombus with side length 2 and one angle equal to 75 degrees?
W) 2 sqrt(3)
X) sqrt(6) + sqrt(2)
Y) sqrt(6) - sqrt (2)
Z) 3 sqrt(2)

ANSWER: X) sqrt(6) + sqrt(2) [W: JW, E: SC; MDE Math-G]

TOSS-UP

17) PHYSICS *Short Answer* Harry shoots a rubber ball at a stationary pendulum. Order the following three situations by increasing maximum heights of the pendulum's bob:
1) The ball bounces backwards after hitting the bob
2) The ball sticks to the bob
3) The ball punctures the bob and continues forwards

ANSWER: 3, 2, 1 [W: JW, E: SC; MDE Phys-ME]

BONUS

17) PHYSICS *Short Answer* A circular conducting loop with radius 4m has a current of 10A flowing through it. What is the magnitude of the loop's magnetic dipole moment?

ANSWER: 160pi A m^2 [W: JW, E: SC; MDE Phys-ET]

TOSS-UP

18) ENERGY *Multiple Choice* Researchers at UW-Madison are studying perovskite materials. Many oxides adopt perovskite structures, with formula unit ABO_3, where A and B denote metal cations. If A is Ca^{2+}, which of the following elements could be cation B?
W) Rb^+
X) Sr^{2+}
Y) Sc^{3+}
Z) Ti^{4+}

ANSWER: Z) Ti^{4+} [W: HJ, E: EB; MDE]

BONUS

18) ENERGY *Short Answer* Researchers at UW Madison are studying reaction kinetics of transition metal complexes. Identify all of the following three changes that would increase the forward rate of a reaction:
1) Increasing the temperature
2) Decreasing the surface area of a metal reactant
3) Decreasing the concentration of reactants

ANSWER: 1 ONLY [W: OW, E: SC; MDE]

TOSS-UP

19) BIOLOGY *Multiple Choice* Which of the following immune cells cannot perform phagocytosis?
W) Macrophage
X) Dendritic Cell
Y) Neutrophil
Z) Cytotoxic T-Cell

ANSWER: Z) CYTOTOXIC T-CELL [W: OW, EB; MDE Bio-AP]

BONUS

19) BIOLOGY *Short Answer* Order the following three zones from closest to farthest from the root cap:
1) Zone of differentiation
2) Zone of division
3) Zone of elongation

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

TOSS-UP

20) CHEMISTRY *Multiple Choice* Which of the following acids could be added to a solution of potassium hydroxide to prepare a buffer?
W) Hydrofluoric
X) Hydrochloric
Y) Hydrobromic
Z) Hydroiodic

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

BONUS

20) CHEMISTRY *Multiple Choice* Which of the following does NOT correctly describe an assumption of Kinetic Molecular Theory?
W) Gas particles occupy non-negligible volume
X) All collisions are elastic
Y) Gas particles are in constant motion
Z) There is no attraction between gas particles

ANSWER: W) GAS PARTICLES OCCUPY NON-NEGLIGIBLE VOLUME [W: HJ, E: AS; MDE Chem-Other]

TOSS-UP

21) EARTH AND SPACE *Multiple Choice* Oumuamua is an interstellar object that passed through the Solar System with enough energy to fully escape the Sun's gravity. What shape did this object's trajectory around the Sun take?
W) Circle
X) Ellipse
Y) Parabola
Z) Hyperbola

ANSWER: Z) HYPERBOLA [W: SC, E: EB; MDE ESS-OA]

BONUS

21) EARTH AND SPACE *Short Answer* Place the following three minerals in order of increasing melting point:
1) Olivine
2) Plagioclase Feldspar
3) Quartz

ANSWER: 3, 2, 1 [W: HJ, E: EB; MDE ESS-RM]

TOSS-UP

22) MATH *Short Answer* A spinner for a game is divided into 6 sections numbered 1-6. Each section's size is proportional to the number in it. What is the probability of spinning a 5?

ANSWER: 5/21 [W: OW, E: RF; MDE Math-C]

BONUS

22) MATH *Multiple Choice* Which of the following numbers is not a prime factor of $2^{16} - 1$?
W) 3
X) 5
Y) 11
Z) 17

ANSWER: Y) 11 [W: KR, E: SC; MDE Math-NT]

TOSS-UP

23) PHYSICS *Multiple Choice* De Broglie was the first to introduce the concept that, contrary to classical intuition, quantum particles can be described by a wave with wavelength that is inversely proportional to what property of the particle?
W) Position
X) Velocity
Y) Momentum
Z) Energy

ANSWER: Y) MOMENTUM [W: RF; E: SC; MDE Phys-MO]

BONUS

23) PHYSICS *Short Answer* Gauss' Law for Magnetism states that the divergence of the magnetic flux density is zero. This is equivalent to requiring the nonexistence of what kind of hypothetical object?

ANSWER: MAGNETIC MONOPOLE [W: JW, E: SC; MDE Phys-ET]