MOSFET ROUND 12

TOSS-UP

1) Physics – *Short Answer* [12] If a photon has a high enough energy, it may spontaneously convert to an electron and a positron. What is the name of this process?

ANSWER: PAIR PRODUCTION [Quantum, GW]

BONUS

1) Physics – *Multiple Choice* [12] Let c be the speed of light. Particle A, which is traveling at a speed of 0.5c in the +x direction, is moving toward particle B, which is traveling at a speed of 0.5c in the –x direction. In A's reference frame, what is the speed of particle B?

W) 0.5c
X) 0.72c
Y) 0.8c
Z) 0.96c

ANSWER: Y) 0.8c [Modern, GW]

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TOSS-UP

2) Biology – *Short Answer* [12] What phenomenon occurs when excess root pressure causes droplets of xylem sap to accumulate on the edges of plant leaves?

ANSWER: GUTTATION [Plants, BZ]

BONUS

2) Biology – *Short Answer* [12] Identify all of the following three eukaryotic cellular structures which have a "9 + 2" arrangement of microtubules: 1) Flagella; 2) Centrioles; 3) Basal body.

ANSWER: 1 ONLY (ACCEPT: FLAGELLA) [Organelle, RSS]
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TOSS-UP

3) Earth and Space – *Short Answer* [12] What general term is used to describe any product of condensation or deposition of atmospheric water vapor in the atmosphere or at Earth's surface, such as clouds, fog, rain, snow, or hail?

ANSWER: HYDROMETEOR [Meteorology, JS]

BONUS

3) Earth and Space – *Short Answer* [12] What is the ratio of the number of silicon atoms to the number of oxygen atoms in a pyroxene mineral?

ANSWER: 1 TO 3 (ACCEPT: 1/3) [Mineralogy, BZ]

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TOSS-UP

4) Math – *Multiple Choice* [12] Each interior angle of a regular polygon has a degree measure of 156. How many sides does this regular polygon have?

W) 36
X) 30
Y) 24
Z) 15

ANSWER: Z) 15 [Geometry, SS]

BONUS

4) Math – *Short Answer* [12] What is the limit as x approaches pi/4 of the fraction with numerator $\tan(x) - 1$ and denominator $x - \pi/4$?

ANSWER: 2 [Calculus, GW]
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TOSS-UP

5) Chemistry – *Short Answer* [12] What cycle is used to calculate the lattice energy of a crystalline solid using applications of Hess's law?

ANSWER: BORN–HABER CYCLE [Lattice Energy, DJ]

BONUS

5) Chemistry – *Short Answer* [12] At low temperatures where vibrational degrees of freedom can be ignored, what is the constant pressure molar heat capacity of acetylene in terms of the ideal gas constant R?

ANSWER: 7/2 R (ACCEPT: 3.5R) [Thermo, BZ]

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TOSS-UP

6) Energy – *Multiple Choice* [12] Researchers at Northwestern University are using atomic force microscopy to measure the Casimir effect. The Casimir effect arises when two plates are separated by which of the following?

W) Vacuum
X) Superconductor
Y) Ferromagnet
Z) Strong dielectric

ANSWER: W) VACUUM [Misc, GW]

BONUS

6) Energy – *Short Answer* [12] Researchers in the Wagener group at the University of Florida are studying the properties of polymers that contain boronic acids and esters. What is the chemical formula of the acid that boronic acids are derived from, which is the only triprotic boron based oxyacid?

ANSWER: H_3BO_3 (ACCEPT: $B(OH)_3$)[BZ]
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TOSS-UP

7) Physics – *Short Answer* [12] Transformers and motors rely on what effect, where the current from one coil generates a magnetic flux that induces a current in another coil?

ANSWER: MUTUAL INDUCTANCE (ACCEPT: MUTUAL INDUCTION; INDUCTANCE; INDUCTION) [E&M, GW]

BONUS

7) Physics – *Short Answer* [12] A water tank is 10 meters tall and is completely filled. A hole is drilled 5 meters above the bottom of the tank and water flows out the side. To one significant figure, in meters per second, what is the speed of the water flowing out the side of the tank?

ANSWER: 10 [Mech, SS]

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TOSS-UP

8) Biology – *Short Answer* [12] Bacteria in the genus Mycoplasma are the only known bacteria to lack what structure?

ANSWER: CELL WALL (DO NOT ACCEPT: CELL MEMBRANE) [Systematics, GW]

BONUS

8) Biology – *Multiple Choice* [12] Which of the following statements regarding cytochrome C is NOT true?

W) It is found in the inner mitochondrial membrane
X) It contains a heme group
Y) It is a cofactor in the citric acid cycle
Z) It is released into the cytoplasm during apoptosis

ANSWER: Y) IT IS A COFACTOR IN THE CITRIC ACID CYCLE [Biochem, DJ]
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TOSS-UP

9) Earth and Space – *Short Answer* [12] What paradox in astronomy states that the darkness of the night sky conflicts with the assumption of an infinite, static universe?

ANSWER: OLBERS' PARADOX [Cosmology, SS]

BONUS

9) Earth and Space – *Short Answer* [12] What moon of Saturn has the highest albedo?

ANSWER: ENCELADUS [Meteorology, JS]

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TOSS-UP

10) Math – *Short Answer* [12] Identify all of the following three centers that must always lie inside a triangle: 1) Centroid; 2) Orthocenter; 3) Circumcenter.

ANSWER: 1 ONLY (ACCEPT: CENTROID) [Geometry, GW]

BONUS

10) Math – *Multiple Choice* [12] Which of the following chi-squared tests has exactly 6 degrees of freedom?

W) 3 rows by 2 columns
X) 8 rows by 1 column
Y) 3 rows by 4 columns
Z) 2 rows by 1 column

ANSWER: Y) 3 ROWS BY 4 COLUMNS [Statistics, GW]
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TOSS-UP

11) Chemistry – *Short Answer* [12] Rank the following three solvents in terms of increasing rate at which an S_N2 reaction would occur: 1) Diethyl ether; 2) DMSO; 3) Water

ANSWER: 3, 1, 2 [Orgo, BZ]

BONUS

11) Chemistry – *Short Answer* [12] When redox reactions are carried out, the minimum voltage supplied to make the reaction occur is often greater than the theoretically predicted voltage. What term describes the difference between the practical and theoretical voltage necessary to make a reaction occur?

ANSWER: OVERPOTENTIAL [Electrochem, ND]

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TOSS-UP

12) Energy – *Multiple Choice* [12] Researchers at UW Madison are studying the Schlosser modification Wittig reaction mechanism, an olefination of a carbonyl functional group. Which of the following statements regarding the carbonyl functional group is NOT true?

W) Ketones, aldehydes, and carboxylic acids all have the carbonyl functional group.
X) An oxygen atom is double bonded to a carbon atom.
Y) The carbonyl carbon is sp2 hybridized
Z) There is a partial negative charge on the carbon.

ANSWER: Z) THERE IS A PARTIAL NEGATIVE CHARGE ON THE CARBON. [Chemistry, DJ]

BONUS

12) Energy – *Short Answer* [12] Researchers at UW Madison are studying the depolarization of neurons for patients with multiple sclerosis. Multiple sclerosis is a debilitating disease affecting movement. What specific part of the neuron is affected by multiple sclerosis?

ANSWER: MYELIN SHEATH [Animal, DJ]
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TOSS-UP

13) Physics – *Short Answer* [12] What principle says that in the limit of large quantum numbers, quantum physics 'merges smoothly' with classical physics?

ANSWER: CORRESPONDENCE PRINCIPLE [Quantum, ND]

BONUS

13) Physics – *Short Answer* [12] Order the following 3 pendulums in order of increasing period of oscillation: 1) Ball on a string of length 5 cm; 2) Uniform rod of length 8 cm; 3) Ball on a string of length 8 cm.

ANSWER: 2, 1, 3 [Mech, CT]

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TOSS-UP

14) Biology – *Short Answer* [12] What enzyme, found in red blood cells, synthesizes carbonic acid from water and carbon dioxide?

ANSWER: CARBONIC ANHYDRASE [RSS, CIRCULATORY]

BONUS

14) Biology – *Multiple Choice* [12] Which of the following genuses of bacteria is most likely to cause inflammation of the tonsils?

W) Staphylococcus
X) Streptococcus
Y) Streptomyces
Z) Bacillus

ANSWER: X) STREPTOCOCCUS [Diseases, GW]
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TOSS-UP

15) Earth and Space – *Short Answer* [12] Rank the following three forms of stellar nucleosynthesis by increasing temperature dependence: 1) Proton-proton chain; 2) CNO cycle; 3) Triple alpha process.

ANSWER: 1, 2, 3 (ACCEPT: PROTON-PROTON CHAIN; CNO CYCLE; TRIPLE ALPHA PROCESS) [Stellar Astronomy, BZ]

BONUS

15) Earth and Space – *Multiple Choice* [12] Which of the following classes of substances is dissolved in water vented from black smokers and forms coatings on nearby rocks?

W) Iron oxides
X) Silicates
Y) Carbonates
Z) Metal sulfides

ANSWER: Z) METAL SULFIDES [Oceanography, JS]

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TOSS-UP

16) Math – *Short Answer* [12] What is the definite integral from 0 to 2pi of $\sin(x) - \cos(x)$ with respect to x?

ANSWER: 0 [Calculus, SS]

BONUS

16) Math – *Short Answer* [12] Given that log base 10 of 2 equals 0.30 and the log base ten of 3 equals 0.48, find the value of log base 10 of 45 to the nearest hundredth.

ANSWER: 1.66 [Algebra, GW]
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TOSS-UP

17) Chemistry – *Multiple Choice* [12] The oxidation of a primary alcohol with sodium dichromate in acidic solution results in which of the following functional groups?

W) Ester
X) Aldehyde
Y) Carboxylic acid
Z) Secondary alcohol

ANSWER: Y) CARBOXYLIC ACID [Orgo, ND]

BONUS

17) Chemistry – *Short Answer* [12] Considering resonance effects, what is the hybridization about the nitrogen atom in a secondary amide?

ANSWER: sp^2 [Hybridization, ND]

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TOSS-UP

18) Energy – *Short Answer* [12] Researchers at Iowa State University are studying the Shine-Dalgarno sequence, a binding site in prokaryotic ribosomes. The 70S prokaryotic ribosome is composed of what two other subunits?

ANSWER: 30S AND 50S [Cyto, DJ]

BONUS

18) Energy – *Multiple Choice* [12] Scientists at the University of Chicago are using the Advanced Photon Source to generate X-rays, which can be used to study the internal structure of crystals. Suppose that a beam of light with a wavelength of 1 nanometer is shone on a crystal, and the angle at which the maximum constructive interference occurs is 45 degrees with respect to the lattice. Which of the following is closest to the lattice separation of the crystal?

W) 0.5 nanometers
X) 0.7 nanometers
Y) 1 nanometer
Z) 1.2 nanometers

ANSWER: X) 0.7 NANOMETERS [Physics, GW]
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TOSS-UP

19) Physics – *Multiple Choice* [12] Which of the following particles does NOT obey the Pauli Exclusion principle?

W) Gluon
X) Electron
Y) Proton
Z) Positron

ANSWER: W) GLUON [Quantum, GW]

BONUS

19) Physics – *Short Answer* [12] SQUIDs are devices that rely on the Josephson effect to measure extremely sensitive magnetic fields. They typically consist of two of what type of material separated by a weak link?

ANSWER: SUPERCONDUCTOR [Misc, SS]

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TOSS-UP

20) Biology – *Multiple Choice* [12] Which of the following techniques could be used to detect for the presence of collagen?

W) Northern blot
X) Western blot
Y) Eastern blot
Z) Southern blot

ANSWER: X) WESTERN BLOT [Biotechnology, GW]

BONUS

20) Biology – *Short Answer* [12] What viscous fluid helps reduce friction between the cartilage of joints during movement?

ANSWER: SYNOVIAL FLUID [Connective, GW]
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TOSS-UP

21) Earth and Space – *Short Answer* [12] Pyroxenes are inosilicates that contain chains of silica tetrahedra. Indicating sign, what is the charge of the silicate ion in pyroxenes?

ANSWER: 2- [Geochem, YL]

BONUS

21) Earth and Space – *Short Answer* [12] What is the name for the region of the Atlantic ocean that has no land boundaries, but is instead bound by four oceanic surface currents?

ANSWER: SARGASSO SEA [Oceanography, BZ]

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TOSS-UP

22) Math – *Multiple Choice* [12] Suppose the number one-six-nine in base b is equal to 400 in base 10. What is the value of b?

W) 15
X) 17
Y) 18
Z) 20

ANSWER: X) 17 [Number Theory, GW]

BONUS

22) Math – *Short Answer* [12] Quadrilateral ABCD has side lengths of 3, 9, 7, and x, in that order, and it is known that a circle can be inscribed inside ABCD. What is the value of x, the length of the fourth side?

ANSWER: 1 [Geometry, GW]
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TOSS-UP

23) Chemistry – *Multiple Choice* [12] The change in which of the following quantities equals the heat transferred to a system under constant volume?

W) Enthalpy
X) Internal energy
Y) Work
Z) Helmholtz free energy

ANSWER: X) INTERNAL ENERGY [Thermo, BZ]

BONUS

23) Chemistry – *Multiple Choice* [12] When a solution of silver diamine nitrate, also known as Tollens' reagent, is added to a solution of an unknown organic compound, a silver mirror appears. Which of the following functional groups is most likely to be part of the unknown organic compound?

W) Nitrile
X) Amide
Y) Aldehyde
Z) Ketone

ANSWER: Y) ALDEHYDE [Lab, ND]