

ROUND 4A

TOSS-UP

1) Physics – *Short Answer* According to the Standard Model of Particle Physics, what group of particles includes electrons and neutrinos?

ANSWER: LEPTONS (ALSO ACCEPT: FERMIONS)

BONUS

1) Physics – *Short Answer* What particle was first proposed by Wolfgang Pauli as a means to resolve the apparent violation of the law of conservation of energy in beta decay?

ANSWER: NEUTRINOS

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### TOSS-UP

2) Math – *Short Answer* Evaluate the following expression:  $-i^{25}$ .

ANSWER:  $-i$

### BONUS

2) Math – *Short Answer* A wire, 36 centimeters long, is bent into the shape of a regular hexagon. What is the area of the hexagon in square centimeters?

Answer: 54 times the square root of 3

### TOSS-UP

3) Energy – *Multiple Choice* The cost of generating electricity has many different components. Fuel, maintenance, and transmission are examples of which of the following costs?

- W) Variable
- X) Fixed
- Y) Environmental
- Z) Corporate

ANSWER: W) VARIABLE

### BONUS

3) Energy – *Short Answer* What is the general name for the metabolic process that converts sugars to acids, gases, and sometimes alcohol?

ANSWER: FERMENTATION

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TOSS-UP

4) Earth and Space – *Multiple Choice* Unconformities in the geologic record can form because of which of the following?

- W) Continuous deposition
- X) Erosion
- Y) Volcanism
- Z) Wind-blown deposition

ANSWER: X) EROSION

BONUS

4) Earth and Space – *Multiple Choice* During an El Niño event, what wind pattern falters, causing cold, nutrient-rich water to be trapped underneath warmer waters?

- W) Jet stream
- X) Horse latitudes
- Y) Trade winds
- Z) Westerlies

ANSWER: Y) TRADE WINDS

TOSS-UP

5) Biology – *Short Answer* The nucleus is enveloped by a net-like array of protein filaments that maintain the shape of the nucleus. What is this array known as?

ANSWER: NUCLEAR LAMINA

BONUS

5) Biology – *Multiple Choice* Which of the following structures does dynein [*dye-neen*] travel along?

- W) Actin filaments
- X) Keratin filaments
- Y) Myosin filaments
- Z) Microtubules

ANSWER: Z) MICROTUBULES

TOSS-UP

6) Chemistry – *Short Answer* What type of solid, examples of which include thin films, gels, and glasses, is characterized by only short to medium range order and lacks crystallinity?

ANSWER: AMORPHOUS

BONUS

6) Chemistry – *Short Answer* What is the VSEPR [*vesper*]-predicted hybridization of the xenon atom in xenon hexafluoride?

ANSWER: sp^3d^3

TOSS-UP

7) Physics – *Short Answer* Rank the masses of the following 4 particles in increasing order: 1) alpha particle; 2) proton; 3) neutron; 4) electron.

ANSWER: 4, 2, 3, 1

BONUS

7) Physics – *Short Answer* A closed cube with a height of 20 centimeters is immersed in a uniform electric field of 18 volts per meter. What is the electric flux through the cube?

ANSWER: ZERO



TOSS-UP

8) Math – *Multiple Choice* In the expansion of open parenthesis $2x - y$ close parenthesis to the 5th power, what is the coefficient of the term that contains x^3y^2 ?

- W) -80
- X) -8
- Y) 8
- Z) 80

ANSWER: Z) 80

BONUS

8) Math – *Multiple Choice* Consider a basketball tournament in which 100 teams enter. In the first round, 28 teams are given a bye and the remaining teams are paired off to play. After each round, the remaining teams are paired off in the next round. How many matches are played in the first 3 rounds?

- W) 84
- X) 88
- Y) 92
- Z) 99

ANSWER: W) 84

TOSS-UP

9) Biology – *Short Answer* GABA [*gab-a*], glycine, and acetylcholine are all examples of what group of signaling molecules?

ANSWER: NEUROTRANSMITTERS

BONUS

9) Biology – *Short Answer* What specific type of plant tissue is composed of undifferentiated cells and is found in locations undergoing growth?

ANSWER: MERISTEMATIC TISSUE



TOSS-UP

10) Physics – *Short Answer* For each of the following three situations, identify whether the collision is elastic or inelastic: 1) Molecules of an ideal gas colliding; 2) Two cars running into each other; 3) A basketball hitting a wall and returning.

ANSWER: 1 – ELASTIC; 2- INELASTIC; 3- INELASTIC

BONUS

10) Physics – *Short Answer* The reason you are safe in your car during a lightning storm is because the body of the car forms an enclosure that blocks external electric fields. What is the name used to describe this type of enclosure?

ANSWER: FARADAY CAGE (DO NOT ACCEPT: SHIELDING)

TOSS-UP

11) Energy – *Multiple Choice* An elastic collision conserves which of the following?

- W) Momentum but not kinetic energy
- X) Kinetic energy but not momentum
- Y) Both momentum and kinetic energy
- Z) Neither momentum nor kinetic energy

ANSWER: Y) BOTH MOMENTUM AND KINETIC ENERGY

BONUS

11) Energy – *Multiple Choice* What uranium isotope is the primary fuel component for a nuclear power plant?

- W) U-235
- X) U-237
- Y) U-238
- Z) U-234

Answer: W) U-235

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### TOSS-UP

12) Chemistry – *Multiple Choice* According to molecular orbital theory, which of the following diatomic molecules is paramagnetic?

- W) Dicarbon
- X) Dinitrogen
- Y) Dioxygen
- Z) Difluorine

ANSWER: Y) DIOXYGEN

### BONUS

12) Chemistry – *Multiple Choice* Which of the following fluoride salts is insoluble in water at STP?

- W) Potassium fluoride
- X) Silver fluoride
- Y) Beryllium fluoride
- Z) Calcium fluoride

ANSWER: Z) CALCIUM FLUORIDE

### TOSS-UP

13) Earth and Space – *Multiple Choice* Identify the fog that forms as warm moist air passes over a cooler surface?

- W) Adiabatic fog
- X) Radiation fog
- Y) Frontal fog
- Z) Advection fog

ANSWER: Z) ADVECTION FOG

### BONUS

13) Earth and Space – *Multiple Choice* Which of the following processes created the volcano Mount Nyiragongo [*nee-ira-gong-oh*] in the Democratic Republic of Congo?

- W) Subduction
- X) Hot spot
- Y) Sea floor spreading
- Z) Continental rifting

ANSWER: Z) CONTINENTAL RIFTING

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TOSS-UP

14) Biology – *Multiple Choice* Which of the following genes would initially establish the axes of the *Drosophila* body?

- W) Homeotic genes
- X) Hox genes
- Y) Maternal effect genes
- Z) Embryonic lethal genes

ANSWER: Y) MATERNAL EFFECT GENES

BONUS

14) Biology – *Short Answer* What autoimmune disease results in damage to cartilage and the bones of joints, resulting in painful inflammation?

ANSWER: RHEUMATOID ARTHRITIS

TOSS-UP

15) Chemistry – *Short Answer* What is the name given to ions, such as the sulfate ion in the reaction of aluminum sulfate and sodium hydroxide, that do not participate in the reaction, but are written in the total ionic equation?

ANSWER: SPECTATOR IONS (ACCEPT: SPECTATORS)

BONUS

15) Chemistry – *Multiple Choice* Maple tree sap has a density of 1.010 grams per centimeter cubed and is approximately 3.0% sucrose by mass in water. What is the molarity of sucrose in sap?

W) 0.074

X) 0.089

Y) 0.101

Z) 0.890

ANSWER: X) 0.089



TOSS-UP

16) Math – *Short Answer* Determine all of the prime factors of 111.

Answer: 3 and 37

BONUS

16) Math – *Short Answer* In a collection of red, blue, and green marbles, there are 25% more red marbles than blue marbles, and there are 60% more green marbles than red marbles. Suppose that there are 50 red marbles. What is the total number of marbles in the collection?

ANSWER: 170

TOSS-UP

17) Earth and Space – *Multiple Choice* Which sedimentary rock is impacted by ocean acidification as pH values fall?

- W) Limestone
- X) Sandstone
- Y) Shale
- Z) Mudstone

ANSWER: W) LIMESTONE

BONUS

17) Earth and Space – *Multiple Choice* Which of the following gases is released when calcite effervesces with acid?

- W) Hydrogen gas
- X) Oxygen gas
- Y) Carbon dioxide
- Z) Carbon monoxide

ANSWER: Y) CARBON DIOXIDE

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### TOSS-UP

18) Energy – *Multiple Choice* In electricity transmission, at consistent current and resistance, which of the following changes over long distances?

- W) Ohms
- X) Energy
- Y) Charge
- Z) Voltage

ANSWER: Z) VOLTAGE

### BONUS

18) Energy – *Multiple Choice* Which of the following is true regarding light bulbs?

- W) Incandescent bulbs have about one-tenth of the lifespan as compact fluorescent lamps
- X) Compact fluorescent lamps produce light by exciting argon gas
- Y) The cost to buy a single incandescent bulb is generally higher than the cost to buy an equivalent CFL
- Z) LED lamps are highly stable at high temperatures

ANSWER: W) INCANDESCENT BULBS HAVE ABOUT ONE-TENTH OF THE LIFESPAN AS COMPACT FLUORESCENT LAMPS

### TOSS-UP

19) Biology – *Multiple Choice* Which of the following organisms would use the highest percentage of its energy budget for homeostatic regulation?

- W) Marine hydra
- X) Desert bird
- Y) Desert insect
- Z) Marine jellyfish

ANSWER: X) DESERT BIRD

### BONUS

19) Biology – *Short Answer* Identify all of the following three structures that are examples of convergent evolution: 1) Whale flippers and human hands; 2) Butterfly wings and bird wings; 3) Spider pedipalps and shrimp antennae.

ANSWER: 2

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TOSS-UP

20) Physics – *Multiple Choice* You have just crystallized a new compound. You shine light through it and observe the internal reflection as the light attempts to pass into the air on the opposite side of the crystal. You measure the critical angle of the crystal to be 45 degrees. Taking the index of refraction of air to be 1, what is the index of refraction of the crystal?

- W) Square root of 2
- X) $\frac{1}{2}$ times square root of 2
- Y) 2
- Z) 2 times square root of 2

ANSWER: W) SQUARE ROOT OF 2

BONUS

20) Physics – *Short Answer* A rock is thrown horizontally off a cliff at 15 meters per second. The cliff is 200 meters above a river. How long, in seconds to the nearest integer, will it take the rock to land in the river?

ANSWER: 6

TOSS-UP

21) Chemistry – *Short Answer* Identify all of the following three statements concerning second order reactions that are true: 1) The reaction half-life is independent of time; 2) The rate constant can be given in units of liters per mole-seconds; 3) Graphing the reciprocal of reactant concentration versus time shows a positive sloping line.

ANSWER: 2 AND 3

BONUS

21) Chemistry – *Multiple Choice* Which of the following lattices is an example of cubic closest packing?

- W) Hexagonal unit cell
- X) Body centered cubic unit cell
- Y) Simple cubic unit cell
- Z) Face centered cubic unit cell

ANSWER: Z) FACE CENTERED CUBIC UNIT CELL

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### TOSS-UP

22) Earth and Space – *Multiple Choice* Planetary nebulae expand with what range of speeds?

- W) 1-3 centimeters per second
- X) 1-3 meters per second
- Y) 10-30 kilometers per second
- Z) 1000-3000 kilometers per second

Answer: Y) 10-30 KILOMETERS PER SECOND

### BONUS

22) Earth and Space – *Short Answer* Most ocean shore areas have how many tidal extremes per day?

ANSWER: 4

### **TOSS-UP**

23) Math – *Short Answer* Consider the set of all positive integers that are the differences of the squares of two positive integers. What is the least element of the set?

ANSWER: 3

### **BONUS**

23) Math – *Short Answer* In a 30-60-90 right triangle, the 60 degree angle is bisected. What is the ratio of the lengths of the segments into which the bisector divides the opposite leg?

ANSWER: ONE HALF (Accept: 2, 1:2, 2:1)