

ROUND 15A

TOSS-UP

1) Chemistry – *Multiple Choice* Which of the following ligands induces the largest electronic d orbital splitting in a transition metal complex?

- W) Chloro
- X) Aqua
- Y) Cyano
- Z) Ethylenediamine

ANSWER: Y) CYANO

BONUS

1) Chemistry – *Short Answer* Consider an organic compound with no rings in its structure, and with the chemical formula $C_{12}H_{16}O_2$ [**C twelve H sixteen O two**]. What is the number of double bonds in its structure?

ANSWER: 5

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### TOSS-UP

2) Physics – *Short Answer* If the radial dependence of the electric field of a monopole is  $1/r^2$ , what is the long range radial dependence of an electric dipole?

ANSWER:  $1/r^3$

### BONUS

2) Physics – *Short Answer* A weight is sinking in a fluid. The drag force on the weight is equal to a constant times its velocity squared times the density of the fluid. In SI base units, give the dimensions of the constant.

ANSWER: METERS SQUARED

### TOSS-UP

3) Biology – *Multiple Choice* Which of the following cell types is associated with haversian [**ha-VER-zhen**] canals?

W) Osteocytes [**AW-steo-sites**]

X) Chondrocytes [**KON-droh-sites**]

Y) Fibroblasts

Z) Leukocytes [**LOO-koh-sites**]

ANSWER: W) OSTEOCYTES

### BONUS

3) Biology – *Short Answer* Identify all of the following four plants that have evolved mechanisms to reduce bio-energetically wasteful photorespiration: 1) Cactus; 2) Oak trees; 3) Potatoes; 4) Rice.

ANSWER: 1

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TOSS-UP

4) Earth and Space – *Short Answer* The greenhouse effect on Venus is primarily attributed to what gas?

ANSWER: CARBON DIOXIDE (ACCEPT: CO₂)

BONUS

4) Earth and Space – *Short Answer* To the nearest power of ten, how many times as intense is the light we receive from a star with apparent magnitude negative 1 as that of another star with apparent magnitude 4?

ANSWER: 100

TOSS-UP

5) Math – *Short Answer* If 6 dice are rolled and the numbers on the top faces are added together, how many different sums are possible?

ANSWER: 31

BONUS

5) Math – *Short Answer* What is the largest prime factor of the quantity $4^{2014} + 4^{2015} + 4^{2016} + 4^{2017}$?

ANSWER: 17

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### TOSS-UP

6) Energy – *Multiple Choice* The Advanced Light Source can be used to identify elements in batteries and fuel cells. Which of the following tools is most likely used for these purposes at the ALS?

- W) Fluorescence microscopy
- X) X-ray absorption spectroscopy [*spek-TRAW-scuH-pee*]
- Y) NMR spectroscopy [*spek-TRAW-scuH-pee*]
- Z) Confocal microscopy

ANSWER: X) X-RAY ABSORPTION SPECTROSCOPY

### BONUS

6) Energy – *Multiple Choice* Researchers at the Joint Genome [*JEE-nome*] Institute have been using new types of fungi [*fun-ji*] to produce biofuels from plant material. Where are these fungi naturally found?

- W) Forest soils
- X) Coral reefs
- Y) Animal guts
- Z) Swamps

ANSWER: Y) ANIMAL GUTS

### TOSS-UP

7) Physics – *Short Answer* Compton scattering is the scattering of X-ray photons from what particle?

ANSWER: ELECTRON

### BONUS

7) Physics – *Multiple Choice* Which of the following is closest to the half-life of a free neutron?

- W) 1 second
- X) 10 minutes
- Y) 100 hours
- Z) 1000 years

ANSWER: X) 10 MINUTES

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TOSS-UP

8) Energy – *Short Answer* In fluidized bed combustors used for clean coal, what is added to the coal to keep pollutants in check?

ANSWER: LIMESTONE (ACCEPT: CALCIUM CARBONATE)

BONUS

8) Energy – *Short Answer* The great majority of the transistors in integrated circuits are of the CMOS type. What do the letters of the acronym represent?

ANSWER: COMPLEMENTARY METAL OXIDE SEMICONDUCTOR

TOSS-UP

9) Chemistry – *Multiple Choice* Consider the hypothetical reaction $2A$, aqueous, plus $2B$, gaseous, yields $3C$, aqueous, plus D , gaseous, where the change in enthalpy of the reaction is -22 kilojoules. Which of the following will drive the reaction toward the products?

- W) Increasing the temperature
- X) Increasing the volume of the reaction vessel at constant temperature
- Y) Increasing the pressure
- Z) Increasing the amount of D

ANSWER: Y) INCREASING THE PRESSURE

BONUS

9) Chemistry – *Multiple Choice* Which of the following solvents would most accelerate an S_N2 reaction?

- W) Hexane
- X) Dichloromethane
- Y) DMSO
- Z) Ethyl acetate

ANSWER: Y) DMSO

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### TOSS-UP

10) Math – *Short Answer* In the integers mod 12, what is 5 times 8?

ANSWER: 4

### BONUS

10) Math – *Short Answer*  $f$  of  $x$  is a twice differentiable function such that  $f'$  prime of  $x$  and  $f''$  double prime of  $x$  are both less than 0 for all real numbers. If  $f$  of 3 equals 12 and  $f$  of 5 equals 8, what is the largest possible integer value for  $f$  of 7?

ANSWER: 3

### TOSS-UP

11) Biology – *Short Answer* What is the genus [**JEE-nus**] of the harmless gut bacterium that can be transformed by a bacteriophage [**bak-TEER-ee-oh-fayj**] into a virulent [**VEER-yoo-lent**] form associated with cholera [**CALL-ur-ah**]?

ANSWER: VIBRIO

### BONUS

11) Biology – *Multiple Choice* A disease-linked, spontaneous, congenital [**kon-GEH-nih-tul**] germ line mutation creates a restriction site for HaeIII [**HAY-three**]. A diagnostic test for this mutation involves restriction digestion with endonuclease [**en-doh-NEW-klee-ase**] HaeIII. If the DNA of a patient with this mutation is tested and imaged using an agarose [**AH-gah-rohs**] gel, which of the following is expected?

- W) No diagnostic point mutation exists on either maternal or paternal chromosomes
- X) Both maternal and paternal chromosomes have the diagnostic point mutation
- Y) Either the maternal or the paternal chromosome has the point mutation, but not both
- Z) The test was inconclusive

ANSWER: Y) EITHER THE MATERNAL OR THE PATERNAL CHROMOSOME HAS THE POINT MUTATION, BUT NOT BOTH

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TOSS-UP

12) Earth and Space – *Short Answer* According to the Stefan-Boltzmann law, a star with surface temperature in kelvins that is three times that of the Sun would emit how many times as much energy as the Sun?

ANSWER: 81

BONUS

12) Earth and Space – *Short Answer* The closed universe is a solution of Einstein's equations of general relativity in which the mass density of the Universe exceeds what parameter?

ANSWER: CRITICAL DENSITY

TOSS-UP

13) Biology – *Short Answer* What viral reproductive cycle kills the infected host cell while the virus is dividing?

ANSWER: LYTIC CYCLE

BONUS

13) Biology – *Short Answer* What is the number of cells present in a mature male angiosperm gametophyte?

ANSWER: 3

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### TOSS-UP

14) Energy – *Multiple Choice* Brookhaven National Lab scientists recently made strides on understanding the nature of Cooper pairs. To which of the following disciplines is this discovery most relevant?

- W) Particle physics
- X) Superconductor physics
- Y) Nuclear physics
- Z) Computational chemistry

ANSWER: X) SUPERCONDUCTOR PHYSICS

### BONUS

14) Energy – *Multiple Choice* Scientists at Argonne National Lab are using x-rays to probe porosity in 3D-printed titanium alloys. Which of the following best explains why porosity is undesirable?

- W) Porosity decreases resistance to fatigue
- X) Porosity decreases flexibility
- Y) A large range of pore sizes reduces printing resolution
- Z) Porosity limits the size of the structures that can be printed

ANSWER: W) POROSITY DECREASES RESISTANCE TO FATIGUE

### TOSS-UP

15) Earth and Space – *Short Answer* Identify all of the following three statements that are true of the inner planets:

1) Mercury has an atmosphere of primarily methane; 2) All of the inner planets revolve in the same direction around the sun; 3) All of the inner planets rotate in the same direction around their axes.

ANSWER: 2

### BONUS

15) Earth and Space – *Multiple Choice* Which of the following is most directly responsible for ocean water downwelling in the mid-ocean gyres?

W) Ekman transport

X) High surface water density

Y) High organic carbon content

Z) Sea floor spreading

ANSWER: W) EKMAN TRANSPORT

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TOSS-UP

16) Physics – *Short Answer* By what phenomenon can materials emit electrons in response to incident light?

ANSWER: PHOTOELECTRIC EFFECT

BONUS

16) Physics – *Short Answer* CPT symmetry is a fundamental concept of nuclear science and theoretical physics. What do the C, P, and T stand for?

ANSWER: CHARGE CONJUGATION (ACCEPT: CHARGE), PARITY INVERSION (ACCEPT: PARITY), AND TIME REVERSAL (ACCEPT: TIME)

TOSS-UP

17) Chemistry – *Short Answer* Rank the following three elements in terms of increasing electron affinities: 1) Carbon; 2) Nitrogen; 3) Oxygen.

ANSWER: 2, 1, 3

BONUS

17) Chemistry – *Short Answer* What effect, which applies to the chemistry of real gases and is exploited in the liquefaction of air, causes a gas's temperature to decrease in an adiabatic [*ad-ee-ah-BAT-ik*] isenthalpic expansion?

ANSWER: JOULE-THOMSON EFFECT (ACCEPT: JOULE-THOMSON EXPANSION, JOULE-KELVIN EFFECT)

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### TOSS-UP

18) Math – *Short Answer* What is the volume of a circular cylinder formed by rotating a 5 by 6 rectangular region about one of its shorter sides?

ANSWER:  $180\pi$

### BONUS

18) Math – *Short Answer* The sums of three whole numbers taken in pairs are 11, 13, and 14. What is the product of these three numbers?

ANSWER: 240

### TOSS-UP

19) Earth and Space – *Short Answer* What type of extrusive igneous rock is considered intermediate between basalt and dacite and possesses approximately 60% silica content?

ANSWER: ANDESITE

### BONUS

19) Earth and Space – *Multiple Choice* What ocean water mass has the oldest carbon-14 age, meaning it has spent the most time isolated from the atmosphere?

W) North Atlantic Deep Water

X) Antarctic Bottom Water

Y) North Pacific Deep Water

Z) Circumpolar Deep Water

ANSWER: Y) NORTH PACIFIC DEEP WATER

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TOSS-UP

20) Math – *Short Answer* If exactly 10 diagonals of a particular convex polygon contain the same vertex, how many total sides does the polygon have?

ANSWER: 13

BONUS

20) Math – *Short Answer* In a particular year, if April 15 is on a Wednesday, on what day of the week is December 25?

ANSWER: FRIDAY

TOSS-UP

21) Biology – *Short Answer* The Ti (tie) plasmid can be used to stably transfect some plants with recombinant DNA. What is the genus of the bacterium that is a vector for this plasmid?

ANSWER: AGROBACTERIUM

BONUS

21) Biology – *Short Answer* Identify all of the following four cell types involved in plant transport physiology that are non-living yet functional when mature: 1) Parenchyma [*pah-REN-kimma*]; 2) Sclereid [*SKLAIR-ee-id*]; 3) Sieve tube; 4) Tracheid [*TRAY-kee-id*]

ANSWER: 2 AND 4

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### TOSS-UP

22) Physics – *Short Answer* Identify all of the following three particles that, according to the standard model, can be affected by gravity: 1) Electron; 2) Pion; 3) Gluon.

ANSWER: 1 AND 2

### BONUS

22) Physics – *Short Answer* In fluorescence microscopy, energy from absorbed photons is re-emitted as new photons. If the new photons have only two-thirds of the momentum of the absorbed photons, what is the ratio of the wavelength of the new photons to that of the absorbed photons?

ANSWER: 1.5 (ACCEPT: 3/2, 1 ½, 3 TO 2)

### TOSS-UP

23) Chemistry – *Short Answer* What is the IUPAC name for the cyclic saturated hydrocarbon containing four carbon atoms?

ANSWER: CYCLOBUTANE

### BONUS

23) Chemistry – *Short Answer* Identify all of the following three functional groups that commonly participate in addition reactions: 1) Aldehyde [**AL-deh-hide**]; 2) Alkene ; 3) Alkyl [**AL-kill**] halide [**HAY-lide**].

ANSWER: 1 AND 2