

ROUND 16A

TOSS-UP

1) Physics – *Short Answer* Kirchoff's loop rule is a consequence of what conservation principle?

ANSWER: CONSERVATION OF ENERGY (ACCEPT: ENERGY)

BONUS

1) Physics – *Short Answer* A spacecraft approaches Jupiter head-on for a gravitational slingshot maneuver. Jupiter has an orbital velocity of 13 kilometers per second. If the spacecraft was originally moving at 20 kilometers per second, what is the maximal final speed, in kilometers per second, it can attain?

ANSWER: 46

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### TOSS-UP

2) Math – *Short Answer* What is the distance from the point (1, 3, 5) to the origin?

ANSWER:  $\sqrt{35}$

### BONUS

2) Math – *Short Answer* Consider an infinite geometric series with sum equal to  $\frac{8}{3}$  and first term  $\frac{7}{5}$ . What is the value of the common ratio  $r$  for this series?

ANSWER:  $\frac{19}{40}$

**TOSS-UP**

3) Biology – *Multiple Choice* Which of the following organisms possesses cnidocytes [*NYE-doh-sites*]?

- W) Tapeworm
- X) Jellyfish
- Y) Starfish
- Z) Sea cucumber

ANSWER: X) JELLYFISH

**BONUS**

3) Biology – *Short Answer* Rank the following four proteins in order of increasing oxygen-binding affinity:

1) Adult hemoglobin at pH 7.4; 2) Fetal hemoglobin; 3) Adult hemoglobin at pH 7.2; 4) Myoglobin.

ANSWER: 3, 1, 2, 4

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TOSS-UP

4) Energy – *Multiple Choice* Which of the following sources of electricity had the largest increase in capacity in the US between 1990 and 2013?

- W) Nuclear
- X) Coal
- Y) Natural gas
- Z) Petroleum

ANSWER: Y) NATURAL GAS

BONUS

4) Energy – *Multiple Choice* Most lignite is used for what purpose in the US?

- W) Municipal heating
- X) Electricity
- Y) Automobile fuel
- Z) Liquefaction

ANSWER: X) ELECTRICITY

TOSS-UP

5) Earth and Space – *Multiple Choice* Saturn's rings are mostly composed of which of the following materials?

- W) Ice
- X) Silicates
- Y) Carbonates
- Z) Iron

ANSWER: W) ICE

BONUS

5) Earth and Space – *Short Answer* The flattening of a protostellar disk in new stars is primarily due to the conservation of what physical quantity?

ANSWER: ANGULAR MOMENTUM

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### TOSS-UP

6) Chemistry – *Multiple Choice* Which of the following is not true about early transition metals in comparison to late transition metals?

- W) Easier to oxidize
- X) More electropositive
- Y) Higher oxidation states
- Z) Larger radii

ANSWER: W) EASIER TO OXIDIZE

### BONUS

6) Chemistry – *Short Answer* Rank the following three hydrogen atoms in terms of increasing pKa: 1) Hydrogen atom in a water molecule; 2) Hydrogen atom in acetylene [*ah-SET-ihl-een*]; 3) Hydroxyl [*high-DROX-il*] hydrogen atom in t-butyl [*t-BYU-til*] alcohol.

ANSWER: 1, 3, 2

**TOSS-UP**

7) Biology – *Short Answer* What is the term for cancers that arise in epithelial [*eh-pih-THEEL-ee-ul*] tissues?

ANSWER: CARCINOMA

**BONUS**

7) Biology – *Short Answer* Identify all of the following three statements that are true regarding tendrils in plants:  
1) They can only be found in dicot vines; 2) They can be modified stems, leaves, or flower stalks; 3) They are primarily used for climbing.

ANSWER: 2 AND 3



**TOSS-UP**

8) Physics – *Short Answer* What is the minimum number of photons created in an electron-positron annihilation in free space?

ANSWER: 2

**BONUS**

8) Physics – *Short Answer* Because of observed neutrino oscillation, what property of the neutrino must be non-zero?

ANSWER: MASS

**TOSS-UP**

9) Chemistry – *Short Answer* Consider a single-reactant reaction that has a rate constant equal to 24 seconds to the negative 1, molar to the negative 2. What is the order of this reaction?

ANSWER: 3 (ACCEPT: THIRD ORDER, TRIMOLECULAR)

**BONUS**

9) Chemistry – *Short Answer* The Heck coupling is a cross-coupling reaction that treats an aryl halide with what functional group?

ANSWER: ALKENE

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TOSS-UP

10) Math – *Short Answer* In a triple-elimination tournament, each game is played by two teams, there are no ties, and teams are eliminated when they have lost 3 times. What is the maximum number of games played if 83 teams enter?

ANSWER: 248

BONUS

10) Math – *Short Answer* What is the remainder when $x^6 + 3x^4 - 2x^3 + 7x - 3$ is divided by $x + 2$?

ANSWER: 111

TOSS-UP

11) Energy – *Short Answer* In 1918, the German mathematician Emmy Noether [*Noh-tur*] published a theorem that shows that every conservation law has a corresponding symmetry of the system. What dynamical quantity is conserved in a system with rotational symmetry?

ANSWER: ANGULAR MOMENTUM

BONUS

11) Energy – *Short Answer* Solid oxide fuel cells can operate at temperatures as high as 1000 degrees Celsius. This high temperature enables these fuel cells to forgo what costly component of low-temperature fuel cells?

ANSWER: CATALYST (ACCEPT: PLATINUM)

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**TOSS-UP**

12) Earth and Space – *Short Answer* What is the term for the flame-like jets of gas that can be seen at the edge of the Sun's disk extending into the chromosphere, dissipating after 5 to 15 minutes?

ANSWER: SPICULES

**BONUS**

12) Earth and Space – *Short Answer* The reciprocal of the age of the universe, when converted to kilometers per second per Megaparsec, approximately equals what physical constant?

ANSWER: HUBBLE

**TOSS-UP**

13) Physics – *Short Answer* In an RLC circuit, the resonance frequency is defined to be at the point at which what quantity is minimized?

ANSWER: IMPEDENCE

**BONUS**

13) Physics – *Short Answer* A 50-centimeter-long wire with mass 10 grams is suspended horizontally from a ceiling, parallel to the  $x$ -axis. There is a uniform 1-tesla magnetic field oriented in the  $y$  direction. Assuming gravity is 10 meters per second squared, what is the magnitude of the current, in amperes to the nearest tenth, that the wire must carry in order to experience no net force?

ANSWER: 0.2

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TOSS-UP

14) Earth and Space – *Short Answer* Eventually, some stars will begin to fuse helium into carbon. What is the name of this process?

ANSWER: TRIPLE ALPHA PROCESS

BONUS

14) Earth and Space – *Multiple Choice* What is the term for the minimum distance a satellite must orbit from a planetary body without being torn apart by tidal forces?

- W) Tidal limit
- X) Roche limit
- Y) Ring minimum
- Z) Moon horizon

ANSWER: X) ROCHE LIMIT

TOSS-UP

15) Chemistry – *Short Answer* Identify all of the following three species that are Lewis acids:

1) Zn^{2+} ; 2) Cl^- ; 3) BH_3 .

ANSWER: 1 AND 3

BONUS

15) Chemistry – *Multiple Choice* Which of the following statements about a valid wave function is true?

W) A wave function must be single-valued

X) A wave function must approach infinity as r approaches zero

Y) The spatial integral of wave functions for different orbitals in an atom must be one

Z) The integral of the wave function times its own complex conjugate must equal zero

ANSWER: W) A WAVE FUNCTION MUST BE SINGLE-VALUED

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### TOSS-UP

16) Math – *Short Answer* The line with equation  $y = -2x + 5$  is reflected across the  $y$ -axis. What is the slope-intercept equation of its image?

ANSWER:  $y = 2x + 5$

### BONUS

16) Math – *Short Answer* Triangle  $ABC$  has all angles with integral degree measures and the measure of angle  $A$  equals 5 times the measure of angle  $B$ . How many possible degree measures are there for angle  $C$ ?

ANSWER: 29



**TOSS-UP**

17) Energy – *Short Answer* Scientists at Argonne National Lab are using computational chemistry to probe the catalytic properties of iridium [*ih-RID-ee-um*] oxide nanoparticles. What computational method, descended from Hartree-Fock theory, is most commonly used for quantum mechanical modeling?

ANSWER: DENSITY FUNCTIONAL THEORY (ACCEPT: DFT)

**BONUS**

17) Energy – *Short Answer* Scientists at Brookhaven National Lab discovered that layering graphene on top of soda-lime glass resulted in a large change in the graphene's electronic properties. What specific element in the glass was found to be responsible for these changes?

ANSWER: SODIUM



**TOSS-UP**

18) Biology – *Short Answer* From what group of organisms are restriction enzymes isolated?

ANSWER: BACTERIA (ACCEPT: EUBACTERIA)

**BONUS**

18) Biology – *Short Answer* What storage polysaccharide that is found in animals contains highly branched chains of sugars containing 1, 4 and 1, 6 linkages?

ANSWER: GLYCOGEN

**TOSS-UP**

19) Earth and Space – *Short Answer* What term is given to the layer of an ocean or lake that extends from the surface to the depth at which 99 percent of the surface light has been absorbed?

ANSWER: PHOTIC ZONE

**BONUS**

19) Earth and Space – *Short Answer* What is the name for a cloud that looks like a pouch and often forms hanging down from the underside of the anvil of a cumulonimbus cloud?

ANSWER: MAMMATUS

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TOSS-UP

20) Physics – *Short Answer* Charged-coupled devices and complementary metal oxide sensors are devices typically used to detect what?

ANSWER: LIGHT (ACCEPT: ELECTROMAGNETIC RADIATION)

BONUS

20) Physics – *Multiple Choice* The resulting kinetic energy of an ejected photo-electron is NOT determined by which of the following?

- W) Speed of light
- X) Energy of light
- Y) Work function of the metal
- Z) Light intensity

ANSWER: Z) LIGHT INTENSITY

TOSS-UP

21) Math – *Short Answer* Using the point names *A, B, C, D,* and *E,* how many different names are there for pentagon *ABCDE*?

ANSWER: 10

BONUS

21) Math – *Short Answer* What is the greatest common divisor of 234 and 2826?

ANSWER: 18

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**TOSS-UP**

22) Chemistry – *Short Answer* What is the bond-order of an oxygen-oxygen bond in ozone?

ANSWER: 1.5

**BONUS**

22) Chemistry – *Short Answer* Identify all of the following three statements that are true regarding atomic nuclei:

1) The maximum number of protons in a stable nucleus is 92; 2) Nuclei with excess neutrons become more stable through beta emission; 3) Nuclei with excess protons can become more stable through electron capture.

ANSWER: 2 AND 3

**TOSS-UP**

23) Biology – *Short Answer* What technique would scientists use if they wanted to amplify a small region of DNA?

ANSWER: PCR (ACCEPT: POLYMERASE CHAIN REACTION)

**BONUS**

23) Biology – *Short Answer* MPF, or mitosis [*my-TOW-sis*] promoting factor, is a complex between a CDK and a protein of what class?

ANSWER: CYCLIN