

## ROUND 11A

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### TOSS-UP

1) Math – *Multiple Choice* Let  $f(x)$  be a continuous and differentiable function on the closed interval  $[3,6]$ . Which of the following could be the  $x$ -value guaranteed by the Mean Value Theorem for this situation?

- W) 2
- X) 3
- Y) 5
- Z) 7

ANSWER: Y) 5

### BONUS

1) Math – *Short Answer* One dimension of a cube is increased by 1, another is decreased by 1, and the other is left unchanged. If the new solid has a volume 5 less than that of the original cube, what was the volume of the original cube?

ANSWER: 125

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### TOSS-UP

2) Biology – *Short Answer* The selective loss of dopaminergic [*dope-ah-min-UR-jik*] neurons in the substantia nigra [*NYE-grah*] is characteristic of what neurodegenerative disease?

ANSWER: PARKINSON'S DISEASE (ACCEPT: PARKINSONISM)

### BONUS

2) Biology – *Short Answer* Chondrocytes are associated with what structural material found in joints and spinal disks?

ANSWER: CARTILAGE

### TOSS-UP

3) Energy – *Short Answer* If a solar power farm doesn't operate for 28% of the time in a month, what is its month-averaged capacity factor?

ANSWER: 72% (ACCEPT: 0.72)

### BONUS

3) Energy – *Multiple Choice* Lithium-ion batteries can deliver more than twice the overall voltage compared to a similar alkaline battery. What is the term for this energy-per-volume ratio in batteries?

- W) Power
- X) Energy density
- Y) Electrical output
- Z) Battery density

ANSWER: X) ENERGY DENSITY

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### TOSS-UP

4) Chemistry – *Short Answer* What allotrope of phosphorous is thermodynamically stable at room temperature and pressure and is structured as puckered sheets of linked atoms connected in 6-membered rings?

ANSWER: BLACK PHOSPHORUS

### BONUS

4) Chemistry – *Short Answer* Titanium forms a non-stoichiometric oxide where there are 1.18 oxygen atoms per titanium atom. If the oxide contains  $\text{Ti}^{2+}$  and  $\text{Ti}^{3+}$  cations, what is the ratio of the 2+ ion abundance to the 3+ ion abundance?

ANSWER: 16/9

**TOSS-UP**

5) Physics – *Multiple Choice* Which of the following statements correctly summarizes the zeroth law of thermodynamics?

W) If each of two systems are in thermal equilibrium with a third system, they must be in thermal equilibrium with each other

X) When energy passes as work, heat, or with matter, into or out of a system, its internal energy changes in accord with the law of conservation of energy

Y) In a natural thermodynamic process, the sum of the entropies of the participating thermodynamic systems increases

Z) The entropy of a system approaches a constant value as the temperature approaches absolute zero

ANSWER: W) IF EACH OF TWO SYSTEMS ARE IN THERMAL EQUILIBRIUM WITH A THIRD SYSTEM, THEY MUST BE IN THERMAL EQUILIBRIUM WITH EACH OTHER

**BONUS**

5) Physics – *Short Answer* Water flowing out of a 2.0 centimeter diameter pipe can fill a 300-liter bathtub in 5 minutes. In meters cubed per second, what is the flow rate of the pipe?

ANSWER: 0.001 (ACCEPT: 1/1000; DO NOT ACCEPT:  $1 \times 10^{-3}$ )

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**TOSS-UP**

6) Earth and Space – *Multiple Choice* Which of the following low pressure systems typically has the weakest sustained wind speed?

W) Tropical storm

X) Tropical depression

Y) Hurricane

Z) Tropical wave

ANSWER: Z) TROPICAL WAVE

**BONUS**

6) Earth and Space – *Short Answer* What is the period in years of two stars, each with a mass of two solar masses, in an orbit with a semi-major axis of 1600 AU and an eccentricity of 0.5?

ANSWER: 32000

**TOSS-UP**

7) Math – *Short Answer* How many points of intersection are there for the graphs of  $y = 3^x$  and  $y = -x^2 + 5$ ?

ANSWER: 2

**BONUS**

7) Math – *Multiple Choice* Which of the following is nearest to 1,000,000?

- W) 5 to the 6<sup>th</sup> power
- X) 10 to the 7<sup>th</sup> power
- Y) 2 to the 20<sup>th</sup> power
- Z) 400 squared

ANSWER: Y) 2 TO THE 20<sup>TH</sup> POWER



**TOSS-UP**

8) Chemistry – *Short Answer* What general type of bond is formed when two lobes of an orbital of one atom overlap two lobes of an orbital of the other atom?

ANSWER: PI BOND

**BONUS**

8) Chemistry – *Short Answer* A solution of weak acid that is 0.1 molar is 1% ionized at room temperature. To one significant figure, what is the acid's pKa value?

ANSWER: 5

### TOSS-UP

9) Energy – *Multiple Choice* Which of the following percentages is closest to the percent of energy used in Texas in 2014 that was generated by wind?

- W) 10
- X) 20
- Y) 30
- Z) 40

ANSWER: W) 10

### BONUS

9) Energy – *Short Answer* Before the electricity from a transmission line reaches an end user like a home or business, it passes through a step-down transformer. Identify all of the following changes that occur across an ideal step-down transformer: 1) Current decreases; 2) Voltage decreases; 3) Power decreases.

ANSWER: 2

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### TOSS-UP

10) Biology – *Short Answer* Identify all of the following three macromolecules that are digested primarily in the stomach: 1) Starches; 2) Nucleic acids; 3) Proteins.

ANSWER: 3 (ACCEPT: PROTEINS)

### BONUS

10) Biology – *Short Answer* The white matter in the spinal cord appears white because the neurons are covered with what substance?

ANSWER: MYELIN (ACCEPT: MYELIN SHEATH)

**TOSS-UP**

11) Earth and Space – *Multiple Choice* Which of the following is NOT an example of an ichnofossil?

- W) Shell
- X) Burrow
- Y) Coprolite
- Z) Urolite

ANSWER: W) SHELL

**BONUS**

11) Earth and Space – *Short Answer* In what month does light take longest to travel from the Sun to the Earth?

ANSWER: JULY



**TOSS-UP**

12) Physics – *Short Answer* An ionization chamber smoke detector uses the radiation from a small amount of radioactive material to detect the presence of smoke. What type of radiation is it that ionizes oxygen and nitrogen molecules, providing a steady current in the chamber, and then when impeded by smoke, disrupts the current, triggering the alarm?

ANSWER: ALPHA (ACCEPT: ALPHA PARTICLES OR ALPHA DECAY)

**BONUS**

12) Physics – *Short Answer* Matt throws a baseball horizontally from a height of 4 meters. It lands 25 meters away. What is the horizontal velocity, to the nearest meter per second, of the ball as it leaves Matt's hand?

ANSWER: 28

### TOSS-UP

13) Earth and Space – *Short Answer* From what common halide mineral is hydrofluoric acid manufactured?

ANSWER: FLUORITE

### BONUS

13) Earth and Space – *Short Answer* What formation of porous sand and gravel, covering 450,000 square kilometers just east of the Rocky Mountains, is the largest aquifer in the United States?

ANSWER: OGALLALA FORMATION (ACCEPT: OGALLALA AQUIFER)

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### TOSS-UP

14) Biology – *Short Answer* During DNA replication, what protein is responsible for negatively supercoiling the DNA to relieve strain?

ANSWER: TOPOISOMERASE (ACCEPT: DNA TOPOISOMERASE)

### BONUS

14) Biology – *Short Answer* What type of muscle contraction is NOT associated with a change in length?

ANSWER: ISOMETRIC

**TOSS-UP**

15) Math – *Short Answer* Identify all of the four quadrants in which cosecant is positive.

ANSWER: 1 and 2 (ACCEPT: FIRST and SECOND)

**BONUS**

15) Math – *Short Answer* What is the image of the point (0, 0) when it is reflected across the line  $y = x - 1$ ?

ANSWER: (1, -1)



**TOSS-UP**

16) Physics – *Short Answer* A 100-kilogram box filled with coffee is sitting on your concrete garage floor. You decide to move the box, but you're going to push the box rather than lift it. How much force, in newtons to the nearest integer, must you exert on the box in order to get it moving, if the coefficient of static friction is 0.25?

ANSWER: 245

**BONUS**

16) Physics – *Multiple Choice* An oscillating system has a characteristic frequency of 10 radians per second and an effective spring constant of 200 Newtons per meter. What is the effective mass, in kilograms, of the oscillator?

- W) 1
- X) 2
- Y) 5
- Z) 10

ANSWER: X) 2

### TOSS-UP

17) Chemistry – *Multiple Choice* Which of the following values, in volts, is closest to the standard emf  $[E-M-F]$  produced by the Daniell cell?

- W) 0.6
- X) 0.8
- Y) 1.1
- Z) 1.5

ANSWER: Y) 1.1

### BONUS

17) Chemistry – *Multiple Choice* Which of the following functional groups undergoes a reaction with ozone to generate separate ketones or aldehydes, rapidly decolorizes bromine, and is generated by dehydration reactions?

- W) Alkene
- X) Ester
- Y) Alkane
- Z) Alcohol

ANSWER: W) ALKENE

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### TOSS-UP

18) Energy – *Multiple Choice* Which of the following is the International Energy Agency's stance on energy subsidies?

- W) They should be phased out
- X) There should be greater international collaboration on subsidies
- Y) Subsidies are necessary for energy sustainability
- Z) Subsidies are necessary to reduce greenhouse emissions

ANSWER: W) THEY SHOULD BE PHASED OUT

### BONUS

18) Energy – *Multiple Choice* Which of the following has the greatest energy content in BTUs?

- W) One gallon of gasoline
- X) One cord of wood
- Y) One kilowatt hour
- Z) One therm of natural gas

ANSWER: X) ONE CORD OF WOOD

**TOSS-UP**

19) Earth and Space – *Short Answer* What is the plutonic equivalent of andesite?

ANSWER: DIORITE

**BONUS**

19) Earth and Space – *Short Answer* Identify all of the following four objects around which accretion disks are sometimes present: 1) White dwarfs; 2) Protostars; 3) Stellar mass black holes; 4) Supermassive black holes.

ANSWER: ALL OF THEM



**TOSS-UP**

20) Biology – *Short Answer* Tandem mass spectrometry is a technique that can be used to determine the primary structure of a protein. What two amino acids can mass spectrometry NOT differentiate?

ANSWER: ISOLEUCINE AND LEUCINE

**BONUS**

20) Biology – *Short Answer* A glutamate to valine mutation is well-known to be responsible for what disease that is associated with resistance to malaria?

ANSWER: SICKLE CELL ANEMIA

### TOSS-UP

21) Math – *Short Answer* If  $n$  is an odd integer, how many lines of symmetry does a regular  $n$ -gon have?

ANSWER:  $n$

### BONUS

21) Math – *Short Answer* Solve the following equation for  $x$  over the real numbers: 8 to the power open parenthesis  $2x$  close parenthesis equals 4 to the power open parenthesis  $2x$  minus 1 close parenthesis.

ANSWER:  $-1$

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### TOSS-UP

22) Chemistry – *Short Answer* By what process can a molecule in the singlet excited state relax to the ground state with concomitant [*Kon-koh-MIT-ent*] emission of light?

ANSWER: FLUORESCENCE

### BONUS

22) Chemistry – *Short Answer* An SN1 reaction is performed by reacting sodium bromide with (S)-2-chlorobutane, and generates a 1 molar mixture of 70% (S)-2-bromobutane and 30% (R)-2-bromobutane. If the optical rotation of the solution was  $9.2^\circ$ , what is the optical rotation of pure (S)-2-bromobutane, to the nearest degree?

ANSWER: 23

### TOSS-UP

23) Physics – *Short Answer* An RC circuit contains a 10-ohm resistor and a 20-millifarad capacitor. How long, in milliseconds, would it take for the voltage to fall by a factor of  $e^{-2}$ ?

ANSWER: 400

### BONUS

23) Physics – *Short Answer* To one significant figure, how fast, in meters per second, would you be moving if you started at rest and accelerated at a constant rate of one meter per second squared for an entire year?

ANSWER: 30 MILLION