

ROUND 17A

TOSS-UP

1) Math – *Multiple Choice* Consider the graph of the function $4x^2 - 4y^2 = 0$. Which of the following shapes most resembles the graph of this function?

- W) Circle
- X) Hyperbola
- Y) Pair of intersecting straight lines
- Z) Ellipse

Answer: Y) PAIR OF INTERSECTING STRAIGHT LINES

BONUS

1) Math – *Multiple Choice* If $x + y = 1$ and x minus y equals the product of the square root of 2 and the sine of theta, what is x times y ?

- W) Cosine of 2 theta
- X) Sine of 2 theta
- Y) One-fourth the cosine of 2 theta
- Z) One-fourth the sine of 2 theta

ANSWER: Y) ONE-FOURTH THE COSINE OF 2 THETA

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### TOSS-UP

2) Physics – *Short Answer* Identify all of the following three quantities that are quantized: 1) Atoms of H<sub>2</sub>O in a beaker; 2) Frequencies of light emitted by an excited atom; 3) Charge stored on a parallel-plate capacitor.

ANSWER: 1, 2, AND 3

### BONUS

2) Physics – *Short Answer* Consider the set of quantum numbers, -1, 0, and 1. Which one or ones could be found in a hydrogen atom wave function in which the principle quantum number is equal to 2 and the orbital or angular momentum quantum number is equal to 1?

ANSWER: -1, 0, 1

### TOSS-UP

3) Earth and Space – *Short Answer* Prominent and well-defined arms are the defining characteristics of a grand design galaxy, which is a subset of what larger class of galaxies?

ANSWER: SPIRAL

### BONUS

3) Earth and Space – *Multiple Choice* Which of the following is not a type of metamorphism?

- W) Regional
- X) Impact
- Y) Burial
- Z) Catastrophic

ANSWER: Z) CATASTROPHIC

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TOSS-UP

4) Chemistry – *Multiple Choice* Which of the following methods could be used to separate a pair of enantiomers?

- W) Gravity filtration
- X) Normal silica gel column chromatography
- Y) Mass spectrometry
- Z) Kinetic resolution

ANSWER: Z) KINETIC RESOLUTION

BONUS

4) Chemistry – *Short Answer* Nitrogen monoxide decomposes into diatomic nitrogen and oxygen at high temperatures. A one-liter reaction vessel at 2000°C contains an equilibrium mixture of 192 grams of O₂, 112 grams of N₂, and 3 grams of NO. Using values of 14 grams per mole and 16 grams per mole for the respective molar masses of atomic nitrogen and oxygen, what is the equilibrium constant for the decomposition at this temperature to two significant figures?

ANSWER: 2.4×10^3 (ACCEPT 2400)

TOSS-UP

5) Biology – *Short Answer* What is the name of the specific sugar that animal cells use as input into glycolysis?

ANSWER: GLUCOSE

BONUS

5) Biology – *Short Answer* Identify all of the following three bile components that are secreted by hepatocytes: 1) Bile salts; 2) Bilirubin; 3) Bicarbonate.

ANSWER: 1 AND 2

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### TOSS-UP

6) Energy – *Short Answer* What element is the least dense metal, has the most negative electrochemical potential, and has the greatest energy density, making it an excellent battery half-cell?

ANSWER: LITHIUM

### BONUS

6) Energy – *Multiple Choice* Which of the following are characteristics of an ideal voltmeter?

- W) Infinitely large resistance and no potential difference between its terminals
- X) Infinitely large resistance and no current diverted through it
- Y) Zero resistance and no potential difference between its terminals
- Z) Zero resistance and no current diverted through it

ANSWER: X) INFINITELY LARGE RESISTANCE AND NO CURRENT DIVERTED THROUGH IT

**TOSS-UP**

7) Math – *Short Answer* How many different sequences of 26 coin tosses result in at least 25 ‘heads’?

ANSWER: 27

**BONUS**

7) Math – *Short Answer* In 2004, February 29th was a Sunday. On what day of the week will February 29th be in 2020?

ANSWER: SATURDAY



**TOSS-UP**

8) Physics – *Multiple Choice* Identify all of the following three statements that are true regarding RLC circuits: 1) A series RLC circuit consists of an inductor, a capacitor, and a resistor connected in series; 2) The resonant frequency is defined as the frequency at which input impedance is at a minimum; 3) RLC circuits can be found in wireless radio receivers.

ANSWER: 1, 2, AND 3

**BONUS**

8) Physics – *Short Answer* Identify all of the following three statements that are true of Carnot engines: 1) Carnot’s Theorem limits the efficiency of engines to less than that of a Carnot engine; 2) The Carnot cycle consists of only reversible steps; 3) The concept of entropy arose from the limits stated by the Carnot cycle.

ANSWER: 1, 2, AND 3

### TOSS-UP

9) Earth and Space – *Short Answer* What is the empirical formula and charge of the silicon-oxygen tetrahedron, also known as the fundamental building block of all silicate materials?

ANSWER: EMPIRICAL FORMULA:  $\text{SiO}_4$  , CHARGE: 4-

### BONUS

9) Earth and Space – *Short Answer* What is the dominant gas of the Martian atmosphere?

ANSWER: CARBON DIOXIDE



### TOSS-UP

10) Chemistry – *Multiple Choice* Which of the following allotropes of phosphorous consists of chains of covalently-linked P<sub>4</sub> tetrahedra?

- W) White phosphorous
- X) Red phosphorous
- Y) Black phosphorous
- Z) Violet phosphorous

ANSWER: X) RED PHOSPHOROUS

### BONUS

10) Chemistry – *Short Answer* Identify all of the following three reactions that would result in a precipitate.  
1) Addition of barium nitrate and sodium sulfate; 2) Addition of aluminum nitrate and zinc sulfate; 3) Addition of sodium hydroxide and ammonium sulfate.

ANSWER: 1 ONLY

**TOSS-UP**

11) Biology – *Short Answer* Fruit ripening is promoted by which plant hormone?

ANSWER: ETHYLENE (ACCEPT: ETHENE)

**BONUS**

11) Biology – *Short Answer* What protein structure forms between homologous chromosomes during meiosis and is thought to mediate chromosomal pairing?

ANSWER: SYNAPTONEMAL COMPLEX



**TOSS-UP**

12) Math – *Short Answer* For what integer value of  $k$  is 2015 cubed closest to  $10^k$ ?

ANSWER: 10

**BONUS**

12) Math – *Short Answer* Consider rolling a six-sided die three times. What is the probability that the three results are strictly increasing?

ANSWER: 5/54

### **TOSS-UP**

13) Physics – *Short Answer* The precession of Mercury’s orbit, which cannot be explained via a classical approach, is explained by what theory or principle?

ANSWER: GENERAL THEORY OF RELATIVITY (ACCEPT: GENERAL RELATIVITY)

### **BONUS**

13) Physics – *Short Answer* Identify all of the following 4 heat engine cycles which use internal combustion: 1) Diesel; 2) Carnot; 3) Otto; 4) Rankine.

ANSWER: 1 AND 3



### **TOSS-UP**

14) Earth and Space – *Short Answer* What stadial, also referred to as the Big Freeze, was a period of cold climatic conditions approximately 12,000 years ago?

ANSWER: YOUNGER DRYAS

### **BONUS**

14) Earth and Space – *Short Answer* What cinder cone appeared in 1943 in a Mexican corn field and is one of the most well characterized cinder cone volcanoes?

ANSWER: PARICUTIN

### TOSS-UP

15) Energy – *Short Answer* What cosmic events are the brightest electromagnetic events in the known universe and are characterized by two oppositely-directed jets of energy followed by an X-ray “afterglow?”

ANSWER: GAMMA RAY BURST

### BONUS

15) Energy – *Multiple Choice* Which of the following is a type of diode that allows current to flow not only in the forward direction normally, but also in the reverse direction at or above the breakdown voltage?

- W) Ideal diode
- X) P-n junction
- Y) Zener [*zee-ner*] diode
- Z) Photodiode

ANSWER: Y) ZENER DIODE

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TOSS-UP

16) Chemistry – *Multiple Choice* Heat, Q , is added to a monatomic ideal gas under conditions of constant volume, resulting in a temperature change, ΔT . How much heat will be required to produce the same temperature change, if it is added under conditions of constant pressure?

- W) $3/5 Q$
- X) Q
- Y) $5/3 Q$
- Z) $2 Q$

ANSWER: Y) $5/3 Q$

BONUS

16) Chemistry – *Multiple Choice* Which of the following is the molecular orbital theory prediction for the bond order of the dioxygenyl radical cation, whose chemical formula is O_2^+ ?

- W) 1
- X) 1.5
- Y) 2
- Z) 2.5

ANSWER: Z) 2.5

TOSS-UP

17) Math – *Short Answer* The Seven Bridges of Königsberg was a historically notable problem in graph theory and topology that was resolved by what mathematician?

ANSWER: LEONHARD EULER

BONUS

17) Math – *Short Answer* A particle moves along a curve with equations $x = 4\cos t$; $y = 4\sin t$; $z = 6t$. What is the speed of the particle at time $t = \pi/2$?

ANSWER: 2 times the square root of 13



TOSS-UP

18) Biology – *Short Answer* What 1953 experiment, designed to test the Oparin-Haldane hypothesis, sought to emulate the conditions of early Earth in a laboratory?

ANSWER: MILLER-UREY EXPERIMENT

BONUS

18) Biology – *Short Answer* Identify all of the following three choices that are properties of exoskeletons:
1) Better protection to internal organs; 2) Unlimited growth potential; 3) High resistance to bending.

ANSWER: 1 AND 3

TOSS-UP

19) Physics – *Multiple Choice* When Faraday was investigating the conductive properties of gases, he sealed metal electrodes into a glass tube and attached an electrostatic generator. When he started the generator, he noticed a purple glow. The purple color was dependant on which of the following?

- W) The conductivity of the gas in the tube
- X) The type of gas in the tube
- Y) The type of metal used for the electrodes
- Z) The amount of energy given to the electrodes

ANSWER: X) THE TYPE OF GAS IN THE TUBE

BONUS

19) Physics – *Short Answer* Indicate what Gaussian surface would most simplify the calculation of the flux of the electric field for each of the following three configurations: 1) Point charge; 2) Infinitely long line of uniform charge; 3) Infinitely large sheet of uniform charge

ANSWER: 1 - SPHERE, 2 - CYLINDER, 3 - CYLINDER or PILLBOX



TOSS-UP

20) Energy – *Multiple Choice* Which heavy metal element, used in photovoltaic thin films, has raised concerns about ecological bioaccumulation due to its high toxicity?

- W) Vanadium
- X) Tungsten
- Y) Cadmium
- Z) Cobalt

ANSWER: Y) CADMIUM

BONUS

20) Energy – *Short Answer* Researchers in Sweden discovered that when they placed a protein from fluorescent jellyfish on an aluminum electrode and exposed it to UV light, electrons were released. What is the name of the protein?

ANSWER: GREEN FLUORESCENT PROTEIN (GFP)

TOSS-UP

21) Biology – *Short Answer* Identify all of the following three statements that are true regarding nutrition: 1) Leptin suppresses appetite; 2) Ghrelin [*greh-lihn*] suppresses appetite; 3) A rise in blood sugar stimulates the beta cells of the pancreas.

ANSWER: 1 AND 3

BONUS

21) Biology – *Short Answer* Identify all of the following three choices that are true of fairy rings: 1) The oldest portion of the fungus is at the center of the fairy ring; 2) The center of the fairy ring is absorbing the most nutrients per unit time relative to the rest of the ring; 3) The outer edge of the fairy ring is where one could find basidiocarps.

ANSWER: 1 AND 3

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### TOSS-UP

22) Earth and Space – *Short Answer* What was the first black hole discovered?

ANSWER: CYGNUS X-1

### BONUS

22) Earth and Space – *Short Answer* A parcel of dry air has a temperature of 0° Celsius as it crosses a mountain range at 3 kilometers. If it descends adiabatically, what will its temperature be, rounded up to the next whole Celsius degree, when it reaches sea level?

ANSWER: 30

### TOSS-UP

23) Chemistry – *Short Answer* Name all of the following statements that are true for isothermal reversible expansions of ideal gases: 1) All heat flow into the system is converted into work; 2) The gas increases in pressure; 3) This process is part of Carnot's cycle.

ANSWER: 1, 2, 3

### BONUS

23) Chemistry – *Short Answer* Identify all of the following three statements that are true regarding a chemical reaction where  $\Delta G$  is negative and the change in entropy is negative: 1) Requires energy; 2) Is exergonic; 3) Increases the disorder in a system.

ANSWER: 2