

## ROUND 13

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### TOSS-UP

1) MATH *Multiple Choice* Which of the following statements BEST describes whether or not the magnitude of the standard deviation depends on the location of the center of the data?

- W) Yes, the larger the mean, the larger the standard deviation
- X) Yes, because you have to know the mean in order to calculate the standard deviation
- Y) No, standard deviation is not affected by the location of the center
- Z) No, standard deviation only measures how values differ from each other and not how they differ from the mean

ANSWER: Y) NO, STANDARD DEVIATION IS NOT AFFECTED BY THE LOCATION OF THE CENTER

### BONUS

1) MATH *Short Answer* What is the minimum value of the function  $f(x) = x \ln(x)$  (read as:  $f$  of  $x$  equals  $x$  natural log of  $x$ )?

ANSWER:  $-1/e$

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### TOSS-UP

2) BIOLOGY *Short Answer* Which family of genes, present in all metazoan organisms, is instrumental in specifying the anterior-posterior axis and segment identity during early embryonic development?

ANSWER: HOX

### BONUS

2) BIOLOGY *Short Answer* By name or number, identify all of the following four actions that are caused by parasympathetic nerves: 1) expansion of airways, 2) slowing of heartbeat, 3) constriction of pupils, 4) contraction of bladder.

ANSWER: SLOWING OF HEARTBEAT, CONSTRICTION OF PUPILS, CONTRACTION OF BLADDER (ACCEPT: 2, 3, 4)

### TOSS-UP

3) ENERGY *Short Answer* What kind of fossil-fuel based fuel plant recovers the waste heat that is otherwise lost during conventional thermal power generation, thus achieving effective electric efficiencies of 70% to 90%?

ANSWER: COGENERATION (ACCEPT: COMBINED HEAT AND POWER OR CHP)

### BONUS

3) ENERGY *Short Answer* How do the internal energies compare for dense packings of Janus particles on a cylindrical surface in which each hydrophobic side faces the corresponding hemispheres of all neighbors?

ANSWER: SAME INTERNAL ENERGY

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### TOSS-UP

4) PHYSICS *Multiple Choice* Two long, straight wires are hanging parallel to each other and are 1 centimeter apart. The current in wire 1 is 5 amperes, and the current in wire 2 is 10 amperes in the same direction. Which of the following BEST describes the magnetic force per unit of length felt on wire 1?

- W) It is twice the force per unit of length on wire 2
- X) It is half the force per unit of length on wire 2
- Y) It is 0.001 newtons per meter away from wire 2
- Z) It is 0.001 newtons per meter toward wire 2

ANSWER: Z) IT IS 0.001 NEWTONS PER METER TOWARD WIRE 2

### BONUS

4) PHYSICS *Short Answer* A 2-kilogram object moves in a circle with a radius of 4 meters at a constant speed of 3 meters per second. A net force of 4.5 newtons acts on the object. What is the angular momentum of the object, in kilogram meters squared per second, with respect to an axis perpendicular to the circle and through its center?

ANSWER: 24

**TOSS-UP**

5) BIOLOGY *Short Answer* What is the scientific term for the skeletons of diatoms?

ANSWER: FRUSTULES

**BONUS**

5) BIOLOGY *Short Answer* By number, identify all of the five following characteristics that are TRUE of Humbolt squids: 1) they can reach up to six feet in length; 2) they live about one year on average; 3) they are very passive; 4) they hunt in schools; 5) they can eject themselves from the water into the air to escape predators.

ANSWER: 1, 2, 4, AND 5

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**TOSS-UP**

6) MATH *Short Answer* If  $\sin(2x) = 0.4$ , then what does  $(\cos x + \sin x)^2$  equal?

ANSWER: 1.4

**BONUS**

6) MATH *Short Answer* Give the interval or intervals of values of  $x$  for which the graph of the function  $f(x) = 5 - x^2$  is above the graph of  $g(x) = 2x - 3$ ?

ANSWER:  $(-4, 2)$

### TOSS-UP

7) CHEMISTRY *Multiple Choice* Two solutions are made with equal molarity: one contains sucrose dissolved in water, while the other contains an unknown salt dissolved in water. The freezing point of the sucrose solution is found to be  $-0.75^{\circ}$  Celsius, and the freezing point of the unknown salt solution is  $-2.2^{\circ}$  Celsius. Which of the following is the most likely chemical formula of the salt?

- W) NaCl
- X)  $\text{CaCl}_2$
- Y)  $\text{AlCl}_3$
- Z) AgCl

ANSWER: X)  $\text{CaCl}_2$

### BONUS

7) CHEMISTRY *Short Answer* By name or number, identify all of the following five compounds that would be more soluble in carbon tetrachloride than in water: 1) krypton difluoride, 2) sulfur difluoride, 3) sulfur dioxide, 4) carbon dioxide, 5) magnesium fluoride.

ANSWER: KRYPTON DIFLUORIDE AND CARBON DIOXIDE (ACCEPT: 1 AND 4)

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### TOSS-UP

8) EARTH AND SPACE *Multiple Choice* Which of the following was NOT observed at the Tunguska event?

- W) About eighty million trees were lying on their sides
- X) Night skies glowed
- Y) A massive impact crater was formed
- Z) Energy approximating 2.8 megatons was released

ANSWER: Y) A MASSIVE IMPACT CRATER WAS FORMED

### BONUS

8) EARTH AND SPACE *Short Answer* By name or number, identify all of the following four bodies of water that are currently experiencing a relative drop in sea level: 1) Mediterranean Sea, 2) Yellow Sea, 3) Hudson Bay, 4) Caribbean Sea?

ANSWER: HUDSON BAY (ACCEPT: 3)

### TOSS-UP

9) CHEMISTRY *Multiple Choice* Which of the following elements has the lowest freezing point?

- W) Nitrogen
- X) Oxygen
- Y) Sodium
- Z) Bromine

ANSWER: X) OXYGEN

### BONUS

9) CHEMISTRY *Short Answer* By name or number, identify all of the following five compounds for which London dispersion is the most significant type of interparticle force present in its solid state: 1) argon, 2) hydrogen chloride, 3) calcium chloride, 4) carbon dioxide, 5) hydrogen sulfide.

ANSWER: ARGON, CARBON DIOXIDE (ACCEPT: 1 AND 4)

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### TOSS-UP

10) BIOLOGY *Multiple Choice* Gap junctions in animal cells and plasmodesmata in plant cells permit which of the following?

- W) Adjacent cells to adhere strongly to each other
- X) Secondary messengers produced in one cell to rapidly diffuse into and stimulate events in surrounding cells
- Y) The passage of connexin signals allowing coordinated cellular responses
- Z) Rapid exchange of genetic information between adjacent cells

ANSWER: X) SECONDARY MESSENGERS PRODUCED IN ONE CELL TO RAPIDLY DIFFUSE INTO AND STIMULATE EVENTS IN SURROUNDING CELLS

### BONUS

10) BIOLOGY *Short Answer* Most insects take in oxygen and expel carbon dioxide through spiracles. What tubes connect directly to the spiracles?

ANSWER: TRACHEA (DO NOT ACCEPT: TRACHEOLES)

### TOSS-UP

11) CHEMISTRY *Short Answer* What type of semiconductor would be formed if a small amount of indium impurity is added to pure selenium?

ANSWER: P-TYPE

### BONUS

11) CHEMISTRY *Short Answer* By name or number, put the following five compounds in order from lowest to highest melting point: 1) carbon tetrachloride, 2) water, 3) sodium chloride, 4) molecular oxygen, 5) chloroform.

ANSWER: MOLECULAR OXYGEN, CARBON TETRACHLORIDE, CHLOROFORM, WATER, SODIUM CHLORIDE (ACCEPT: 4, 1, 5, 2, 3)

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### TOSS-UP

12) MATH *Short Answer* You find that your maximum error of estimate in determining a population proportion is  $\pm 4\%$ , based on your sample size. If you were to repeat the experiment with a sample four times as large, what would your maximum error of estimate be?

ANSWER: 2%

### BONUS

12) MATH *Short Answer* By number, identify all of the following three statements that are TRUE: 1) the area under a normal curve is always equal to one; 2) the larger the standard deviation of a normal curve, the higher and narrower the graph; 3) normal curves with different means are centered around different numbers.

ANSWER: 1 AND 3

### TOSS-UP

13) PHYSICS *Short Answer* What is the name of a rotary electrical switch that reverses magnetic field polarity in a DC motor?

ANSWER: COMMUTATOR (ACCEPT: SPLIT RING COMMUTATOR OR COMMUTATOR RING)

### BONUS

13) PHYSICS *Short Answer* A spring mass system is vibrating along a frictionless horizontal floor. The spring constant is 8 newtons per meter, the amplitude is 5 centimeters, and the period is 4 seconds. What is the mass of the system in newtons in terms of pi?

ANSWER:  $\frac{32}{\pi^2}$

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### TOSS-UP

14) BIOLOGY *Short Answer* What is the name of the genus for the human itch mite responsible for causing human scabies?

ANSWER: *SARCOPTES*

### BONUS

14) BIOLOGY *Short Answer* The somatosensory map in the human brain has neurons that sense touch in all parts of the body. Relative to their physical size, which two parts of the body have the largest area of the map devoted to them?

ANSWER: FINGERS AND LIPS

### TOSS-UP

15) CHEMISTRY *Short Answer* What is the name of any material with the same type of crystal structure as calcium titanium oxide and a general chemical formula of  $ABX_3$ , where A and B are two cations of very different sizes, and X is an anion that bonds to both?

ANSWER: PEROVSKITE

### BONUS

15) CHEMISTRY *Short Answer* Classify the order of each reagent and of the reaction overall between nitric oxide and molecular oxygen to form nitrogen dioxide, given the equation:  $2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$  and given that the rate law of this reaction is  $k(NO)^2$ .

ANSWER: ZERO ORDER IN  $O_2$ , SECOND ORDER IN NO, AND SECOND ORDER OVERALL

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### TOSS-UP

16) PHYSICS *Short Answer* An annular ring with inner and outer radii  $r_1$  and  $r_2$ , respectively, is rolling without slipping with a uniform angular speed. What is the ratio of the centripetal forces  $f_1/f_2$  experienced at two points on the inner and outer parts of the ring?

ANSWER:  $r_1/r_2$

### BONUS

16) PHYSICS *Short Answer* A 0.5 kilogram book is dropped from a height of 1.5 meters. Given  $g$  as 10 meters per second squared and providing your answer as a decimal to the nearest tenth, with what kinetic energy, in joules, will it hit the floor?

ANSWER: 7.5



### TOSS-UP

17) EARTH AND SPACE *Short Answer* What is the name for the lobe-shaped cliffs on Mercury formed by contraction of the crust?

ANSWER: SCARPS

### BONUS

17) EARTH AND SPACE *Short Answer* What type of cloud is formed when warm, moist air runs into the surface of a mountain, in which wind flows through the cloud, ascending on the windward side and descending on the lee side?

ANSWER: CAP

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### TOSS-UP

18) PHYSICS *Short Answer* When two tuning forks, fork 1 and fork 2, are sounded simultaneously, 4 beats per second are heard. If the frequency of fork 1 is 200 hertz, then what two values are possible for the frequency of fork 2?

ANSWER: 196 AND 204

### BONUS

18) PHYSICS *Short Answer* Two blocks, A and B, of mass  $3m$  and  $2m$ , respectively, are connected by a massless, inextensible string. They are also suspended by a massless spring, with block A attached directly to the spring and block B hanging below block A. The system is initially at rest, then the string connecting the blocks is suddenly cut. Immediately after the string is cut, what are the accelerations of blocks A and B, respectively?

ANSWER:  $A = 2g/3$  UPWARDS ;  $B = g$  DOWNWARDS

### TOSS-UP

19) ENERGY *Short Answer* What is the name of the non-equilibrium state between a solid and a plasma, with potential energy of the interaction between electrons and nuclei roughly of the same magnitude as the kinetic energy of the electrons?

ANSWER: WARM DENSE MATTER (ACCEPT: WDM)

### BONUS

19) ENERGY *Short Answer* The cyanobacterium *Synechococcus elongatus* (read as: sy-neh-KOH-kōe-kuhs eh-lohn-GAH-tuhs) has a core circadian oscillator that can be reconstituted in vitro from which three purified proteins?

ANSWER: KaiA, KaiB, and KaiC

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### TOSS-UP

20) MATH *Short Answer* Providing your answer as a fraction in simplest form, for a distribution with a mean of 40 and a standard deviation of 8, what is the z-score for a score of 36?

ANSWER:  $-\frac{1}{2}$

### BONUS

20) MATH *Short Answer* How many positive integer divisors does 8640 have?

ANSWER: 56

### TOSS-UP

21) EARTH AND SPACE *Multiple Choice* Which of the following geologic observations would NOT directly assist in the determination of the sequence of geologic events in an area?

- W) An unconformity between a granite and sandstone
- X) A well-exposed dike of basalt in sandstone
- Y) Inclusions of sandstone in a granite pluton
- Z) The feldspar and quartz contents of a granite

ANSWER: Z) THE FELDSPAR AND QUARTZ CONTENTS OF A GRANITE

### BONUS

21) EARTH AND SPACE *Short Answer* What term is used to describe a weather front that is the boundary between two air masses of different moisture content, one of warm, moist air and the other of hot, dry air?

ANSWER: DRY LINE (ACCEPT: DEW POINT LINE, MARFA FRONT)

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### TOSS-UP

22) PHYSICS *Multiple Choice* A moving coil galvanometer has 150 equal divisions. Its current sensitivity is 10 divisions per milliampere and its voltage sensitivity is 2 divisions per millivolt. In order for each division to read 1-volt, what resistance, in ohms, must be connected in series with the coil?

- W) 995
- X) 9,995
- Y) 99,995
- Z) 999,995

ANSWER: X) 9,995

### BONUS

22) PHYSICS *Short Answer* A pilot flying at 700 meters per second experiences an acceleration of 5 g when pulling out of a dive. Given 9.8 meters per second squared as g, what is the radius, in meters, of curvature of the loop in which the plane is flying?

ANSWER: 10,000

### TOSS-UP

23) EARTH AND SPACE *Multiple Choice* Which of the following is NOT a consequence of the apparent stretching of the crust during extension in order to form fault-block mountains?

- W) Episodes of volcanism
- X) Doming of the crust
- Y) Higher heat than average
- Z) Accretion of terranes

ANSWER: Z) ACCRETION OF TERRANES

### BONUS

23) EARTH AND SPACE *Short Answer* Flowville expects significant population growth in the next decade. Obviously, more people will produce more sewage, and, considering that Flowville Wastewater Treatment Facility only performs primary and secondary treatment, the increased sewage will lead to a higher phosphorus discharge into Flow Lake. As a result of these activities, how will Secchi depth (read as: SEK-kee) readings at Flow Lake be affected?

ANSWER: THEY WILL DECREASE

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### TOSS-UP

24) ENERGY *Multiple Choice* In compact fluorescent light bulbs, conversion of electrical energy into radiant energy occurs due to which of the following?

- W) Inelastic scattering
- X) Chemical bonding
- Y) Phase change
- Z) Elastic scattering

ANSWER: W) INELASTIC SCATTERING

### BONUS

24) ENERGY *Multiple Choice* Tsunamis are characterized as shallow-water waves. Given  $g$  as 10 meters per second squared, which of the following is the approximate velocity in kilometers per hour of a tsunami which originates in shallow water, but then propagates in water with a depth of 6100 meters?

- W) 150
- X) 300
- Y) 600
- Z) 900

ANSWER: Z) 900

### TOSS-UP

25) BIOLOGY *Short Answer* Which form of hepatitis is transmitted by ingestion of fecal matter, even in microscopic amounts, and results in an acute but not chronic infection?

ANSWER: A (ACCEPT: E)

### BONUS

25) BIOLOGY *Multiple Choice* Which of the following insects has a unique muscle arrangement that allows them to power their flight directly?

- W) Beetle
- X) Butterfly
- Y) Dragonfly
- Z) Cockroach

ANSWER: Y) DRAGONFLY