

## ROUND 15

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### TOSS-UP

1) MATH *Short Answer* Expressing your answer in simplest form, if  $y = (x^6) \ln(x)$  [**y equals x to the sixth power times the natural log of x**], what is the derivative of y with respect to x?

ANSWER:  $6x^5 \ln(x) + x^5$

### BONUS

1) MATH *Short Answer* A national achievement test is administered. The test has a mean score of 100 and a standard deviation of 15. If Vince's z-score is 1.20, what is his score on the test?

ANSWER: 118

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### TOSS-UP

2) BIOLOGY *Multiple Choice* The amino acid sequence of a protein represents the translation of which of the following?

- W) The template DNA strand
- X) The nontemplate DNA strand
- Y) The tRNA nucleotide sequence [**NOO-klee-uh-tyd**]
- Z) The reverse-complement of the mRNA strand

ANSWER: X) THE NONTEMPLATE DNA STRAND

### BONUS

2) BIOLOGY *Multiple Choice* Which of the following insect orders is characterized by the beak or stylet arising from the posterior part of the head and extending along the insect's sternum?

- W) Hymenoptera [**hy-muh-NOP-ter-uh**]
- X) Homoptera [**hoh-MOHP-tuh-ruh**]
- Y) Coleoptera [**koh-lee-OP-ter-uh**]
- Z) Hemiptera [**hi-MIP-ter-uh**]

ANSWER: X) HOMOPTERA

### TOSS-UP

3) PHYSICS *Multiple Choice* Which of the following principles of fluid dynamics does an airplane use to create an upward force?

- W) Archimedes'
- X) Pascal's
- Y) Venturi's
- Z) Bernoulli's

ANSWER: Z) BERNOULLI'S

### BONUS

3) PHYSICS *Multiple Choice* If magnetic monopoles exist, which of the following Maxwell's equations would be changed?

- W) Gauss's law for magnetism only
- X) Gauss's law for magnetism and Ampere's law
- Y) Gauss's law for magnetism and Faraday's law
- Z) Gauss's law for magnetism, Ampere's law, and Faraday's law

ANSWER: Y) GAUSS'S LAW FOR MAGNETISM AND FARADAY'S LAW

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### TOSS-UP

4) EARTH AND SPACE *Multiple Choice* Which of the following is the rate at which atmospheric gases and particles are moved across a surface?

- W) Vertical dispersion
- X) Turbulence
- Y) Flux
- Z) Stratospheric transport

ANSWER: Y) FLUX

### BONUS

4) EARTH AND SPACE *Multiple Choice* Which of the following is true of sandstone formed from a long-term paleodesert?

- W) It would exhibit clearly graded bedding
- X) It would have preserved ripples but not dunes
- Y) It would appear black due to the dark iron-rich minerals present
- Z) It would contain well rounded grains and have high quartz content

ANSWER: Z) IT WOULD CONTAIN WELL ROUNDED GRAINS AND HAVE HIGH QUARTZ CONTENT

### TOSS-UP

5) CHEMISTRY *Multiple Choice* Which of the following bonds is the longest in length?

- W) Fluorine-fluorine
- X) Chlorine-chlorine
- Y) Bromine-bromine
- Z) Iodine-iodine

ANSWER: Z) IODINE-IODINE

### BONUS

5) CHEMISTRY *Multiple Choice* Ozonolysis [**oh-zuh-NOL-uh-sis**] cleaves which of the following?

- W) Carbon-carbon double bonds in alkenes [**AL-keens**]
- X) Carbon-carbon bonds in alkanes
- Y) Oxygen-oxygen bonds
- Z) Bonds between carbon and hydrogen

ANSWER: W) CARBON-CARBON DOUBLE BONDS IN ALKENES

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### TOSS-UP

6) MATH *Multiple Choice* Which of the following best represents the conversion of the rectangular coordinates (3, 4) into polar coordinates?

- W) (5, 37°)
- X) (37°, 5)
- Y) (5, 53°)
- Z) (53°, 5)

ANSWER: Y) (5, 53°)

### BONUS

6) MATH *Short Answer* Evaluate  $\int_{\sqrt{2}}^{3\sqrt{2}} (3x^2 + 6) dx$  [**the integral from the square root of 2 to the 3 times the square root of 2 of the quantity 3 x squared plus 6 dx**] in simplest radical form.

ANSWER:  $64\sqrt{2}$

### TOSS-UP

7) BIOLOGY *Short Answer* What modified base in the anticodon's wobble position can base pair with uracil [**YOOR-uh-sil**], cytosine [**SY-tuh-seen**] or adenine [**AD-n-een**] in the third position of an mRNA codon?

ANSWER: INOSINE

### BONUS

7) BIOLOGY *Multiple Choice* Kearns-Sayre Syndrome is caused by a mutation on a gene in the mitochondrial [**my-tuh-KON-dree-uhl**] DNA. Both males and females can have the disease, but the disease can only be transmitted to a child by the mother, never the father. Why is this so?

- W) The gene is on the X chromosome, and females are XX
- X) The sperm that fertilizes the egg contributes only its chromosomes and none of its mitochondria
- Y) The mutant protein is only active in the egg, not the sperm
- Z) The disease is sex-limited

ANSWER: X) THE SPERM THAT FERTILIZES THE EGG ONLY CONTRIBUTES ITS CHROMOSOMES AND NONE OF ITS MITOCHONDRIA

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### TOSS-UP

8) ENERGY *Multiple Choice* Which of the following effects does lowering the temperature have on the decay rate of a sample of radioactive material?

- W) The decay will speed up
- X) The decay will slow down
- Y) There is no change
- Z) There is an inverse relationship between temperature and fission

ANSWER: Y) THERE IS NO CHANGE

### BONUS

8) ENERGY *Multiple Choice* FutureGen 2.0 power plants will reduce carbon dioxide production by burning coal in which of the following ways?

- W) With a mixture of oxygen and carbon dioxide instead of air to produce concentrated carbon dioxide
- X) With an enhanced concentration of oxygen instead of air to produce less carbon dioxide per ton of coal burned
- Y) In a catalytic chamber that scrubs the carbon dioxide out of the emissions
- Z) Using carbon dioxide reduced coal in an 80% nitrogen and 18% oxygen mixture

ANSWER: W) WITH A MIXTURE OF OXYGEN AND CARBON DIOXIDE INSTEAD OF AIR TO

PRODUCE CONCENTRATED CARBON DIOXIDE

### TOSS-UP

9) PHYSICS *Short Answer* Two electromagnetic waves are incident upon a gerbil. They are identical and coherent except for a phase difference of 60 degrees. If the intensity of each wave in isolation is 10 watts per meter squared, what is the intensity of light in watts per square meter experienced by the gerbil?

ANSWER: 30

### BONUS

9) PHYSICS *Short Answer* An ideal gas is enclosed within a container with a movable piston as the lid. The gas is initially at a pressure of 3 atmospheres and occupies a volume of 2 liters. The piston is lowered so that the gas now occupies 1.5 liters at a pressure of  $P$ . If the process was carried out slowly, maintaining constant temperature in contact with a suitable reservoir, what is  $P$  in atmospheres?

ANSWER: 4

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### TOSS-UP

10) EARTH AND SPACE *Multiple Choice* The observation that the mean luminosity of more distant stars tends to be higher than the mean luminosity of nearby stars in a flux-limited sample is an example of which of the following kinds of bias?

- W) Eddington
- X) Selection
- Y) Confirmation
- Z) Hindsight

ANSWER: X) SELECTION

### BONUS

10) EARTH AND SPACE *Multiple Choice* Which of the following features is NOT associated with subduction zone geology?

- W) San Joaquin Valley, California
- X) Accreted terrains of coastal California
- Y) North Carolina barrier islands
- Z) Cascade Mountains in Oregon and Washington

ANSWER: Y) NORTH CAROLINA BARRIER ISLANDS

### TOSS-UP

11) CHEMISTRY *Multiple Choice* Which of the following is true for an adiabatic process?

- W) Temperature remains constant
- X) Pressure remains constant
- Y) Net heat transfer to the surroundings is zero
- Z) Work done on the surroundings is zero

ANSWER: Y) NET HEAT TRANSFER TO THE SURROUNDINGS IS ZERO

### BONUS

11) CHEMISTRY *Short Answer* A reaction between two solutions A and B has a rate constant  $k$  of 1. If A increases from 2.0 molar to 4.0 molar and B is held constant, the reaction rate is doubled. If B goes from 2.0 molar to 4.0 molar and A is held constant, the reaction rate is quadrupled. What is the overall reaction order?

ANSWER: 3 (ACCEPT: THIRD)

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### TOSS-UP

12) BIOLOGY *Multiple Choice* In active meiosis, new genetic combinations can arise in two different ways. Which of the following is the first stage in which there could be genetic recombination?

- W) Anaphase I
- X) Anaphase II
- Y) Prophase I
- Z) Prophase II

ANSWER: Y) PROPHASE I

### BONUS

12) BIOLOGY *Short Answer* What is the term for an inanimate object that is capable of transmitting infectious disease from one individual to another?

ANSWER: FOMITE

### TOSS-UP

13) EARTH AND SPACE *Multiple Choice* Which of the following classes of stars does NOT have radiative zones?

- W) A
- X) G
- Y) M
- Z) O

ANSWER: Y) M

### BONUS

13) EARTH AND SPACE *Multiple Choice* Under which of the following circumstances does ocean depth affect ocean wave motion?

- W) When ocean depth falls below half the wavelength of a wave
- X) When the ocean wave has a period exceeding 20 seconds
- Y) When the ocean waves are impacted by tides
- Z) When the ocean floor has high relief, regardless of the depth

ANSWER: W) WHEN OCEAN DEPTH FALLS BELOW HALF THE WAVELENGTH OF A WAVE

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### TOSS-UP

14) MATH *Short Answer* What is the radius of the circle with equation  $x^2 + 6x + y^2 - 8y - 11 = 0$ ?

ANSWER: 6

### BONUS

14) MATH *Short Answer* Providing your answer as an improper fraction in lowest terms, solve the following equation for  $x$  over the real numbers:  $9^{2x} = 27^{3x-1}$  **[9 to the power of 2x equals 27 to the power of the quantity 3x minus 4].**

ANSWER: 12/5

### TOSS-UP

15) BIOLOGY *Multiple Choice* If a single nucleotide is inserted into the middle of the protein coding sequence of a gene, which of the following is the likely outcome?

- W) A frameshift mutation that leads to multiple missense and/or nonsense mutations
- X) A single codon will have a missense mutation
- Y) One codon will have a missense or nonsense mutation, and the another nucleotide [**NOO-klee-uh-tyd**] will be deleted
- Z) A frameshift mutation that is silent

ANSWER: W) A FRAMESHIFT MUTATION THAT LEADS TO MULTIPLE MISSENSE AND/OR NONSENSE MUTATIONS

### BONUS

15) BIOLOGY *Multiple Choice* Which of the following statements is NOT correct regarding short day plants?

- W) Flowering occurs when night length is less than critical length
- X) Continuity of darkness is crucial; flowering will not occur if darkness is interrupted by a momentary light flash
- Y) Short day plants are synonymous with long night plants
- Z) Photoperiod can be detected via phytochromes

ANSWER: W) FLOWERING OCCURS WHEN NIGHT LENGTH IS LESS THAN CRITICAL LENGTH

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### TOSS-UP

16) ENERGY *Multiple Choice* If you heat a container of gas at a higher temperature than its surroundings to twice its prior absolute temperature without changing the temperature of its environment, you have done which of the following?

- W) Increased the system's enthalpy and decreased its entropy
- X) Increased the system's enthalpy and entropy
- Y) Decreased the system's enthalpy and entropy
- Z) Decreased the system's enthalpy and increased its entropy

ANSWER: X) INCREASED THE SYSTEM'S ENTHALPY AND ENTROPY

### BONUS

16) ENERGY *Short Answer* What is the name of the technique used to enrich gaseous U-235 after it has been combined with fluorine?

ANSWER: CENTRIFUGATION

### TOSS-UP

17) PHYSICS *Short Answer* When an object with a volume of 10 cubic meters is completely submerged in water, given that acceleration due to gravity is 9.8 meters per second squared, what is the buoyant force on the object in newtons if the density of water is 1000 kilograms per cubic meter?

ANSWER: 98,000

### BONUS

17) PHYSICS *Multiple Choice* Stress-strain curves show how real materials respond to forces that are applied to them. Materials such as steel have a region of elasticity where they approximate an ideal spring and a region where they start to deform plastically. Where the materials are acting like an ideal spring, how do we find their Young's modulus?

W) It is the slope of the stress-strain curve

X) It is the integral of the curve in the elastic region

Y) It is the  $y$ -intercept of the stress-strain curve

Z) It is the second derivative of the curve just after transition into the region of plastic deformation

ANSWER: W) IT IS THE SLOPE OF THE STRESS-STRAIN CURVE

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### TOSS-UP

18) EARTH AND SPACE *Short Answer* What is the name for the gravitational equilibrium [**ee-kwuh-LIB-ree-uhm**] points in the orbital plane of two bodies?

ANSWER: LAGRANGIAN POINT (ACCEPT: LAGRANGE POINT)

### BONUS

18) EARTH AND SPACE *Multiple Choice* A galaxy shows a strong bar and very loosely-wound spiral arms. Which of the following would most likely be its class?

W) S0

X) SBa

Y) SBc

Z) Sb

ANSWER: Y) SBc

### TOSS-UP

19) CHEMISTRY *Multiple Choice* In preparing to perform a flame test on a sample, a high molar solution of which of the following chemicals would be best to use to clean your nichrome wire?

- W) Sodium hydroxide
- X) Nitrous acid
- Y) Hydrochloric acid
- Z) Lithium hydroxide

ANSWER: Y) HYDROCHLORIC ACID

### BONUS

19) CHEMISTRY *Short Answer* To heat 0.5 kilograms of water from 20 degrees Celsius to 80 degrees Celsius, providing your answer in kilojoules, how much energy is needed?

ANSWER: 126 (ACCEPT: VALUES FROM 125 TO 126)

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### TOSS-UP

20) MATH *Multiple Choice* Which of the following values for  $a$  and  $b$  provide a counterexample to the statement "If 4 divides  $a + b$ , then 4 divides  $a$  or 4 divides  $b$ ."

- W)  $a = 5$  and  $b = 7$
- X)  $a = 5$  and  $b = 6$
- Y)  $a = 4$  and  $b = 8$
- Z)  $a = 4$  and  $b = 6$

ANSWER: W)  $a = 5$  AND  $b = 7$

### BONUS

20) MATH *Short Answer* Providing your answer as an improper fraction in lowest terms, what is the area under the curve bounded by the  $x$ -axis,  $x = 4$  and  $y = \sqrt{x}$ ?

ANSWER:  $16/3$

### TOSS-UP

21) BIOLOGY *Short Answer* Name the circulatory adaptation found in the legs of ducks and geese that allows them to swim in water that is near freezing and yet not become hypothermic.

ANSWER: COUNTERCURRENT EXCHANGER (ACCEPT: COUNTERCURRENT HEAT EXCHANGE, COUNTERCURRENT)

### BONUS

21) BIOLOGY *Multiple Choice* Muscle fibers can be classified as slow, intermediate, or fast. Which of the following is NOT true regarding fast muscle fibers?

- W) They are found in higher relative abundance in world class sprinters versus world class marathoners
- X) They fatigue most rapidly
- Y) They have the highest mitochondrial density
- Z) The primary pathway for ATP production is fermentation

ANSWER: Y) THEY HAVE THE HIGHEST MITOCHONDRIAL DENSITY

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### TOSS-UP

22) ENERGY *Multiple Choice* Nanticoke Generating Station, located in southern Ontario, Canada, is one of the world's largest coal-burning power plants. However, the Canadian Ministry of Energy announced in 2010 that Nanticoke would convert some of their generators to use which of the following types of fuel instead of coal?

- W) Natural gas
- X) Uranium-238
- Y) Petroleum
- Z) Ethanol

ANSWER: W) NATURAL GAS

### BONUS

22) ENERGY *Multiple Choice* A liquid metal fast reactor (LMFR) is an advanced type of nuclear reactor that uses liquid metal as a primary coolant. Of the following metals, which one is NOT most commonly used as a primary coolant in LMFRs?

- W) Lithium
- X) Mercury
- Y) Lead
- Z) Sodium

ANSWER: W) LITHIUM

### TOSS-UP

23) PHYSICS *Short Answer* What type of antineutrino [*an-tee-noo-**TREE**-noh*] is produced in beta decay?

ANSWER: ELECTRON ANTINEUTRINO

### BONUS

23) PHYSICS *Multiple Choice* There is an electrostatic force of attraction between any two of three metal spheres P, Q, and R. Which of the following is a possible combination for the charges on P, Q, and R?

- W) P: positive, Q: negative, R: positive
- X) P: positive, Q: negative, R: neutral
- Y) P: positive, Q: positive, R: positive
- Z) P: neutral, Q: positive, R: neutral

ANSWER: X) P: POSITIVE, Q: NEGATIVE, R: NEUTRAL

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### TOSS-UP

24) EARTH AND SPACE *Multiple Choice* Consider the track of the 2005 Hurricane Katrina. Alabama's Dauphin Island suffered more extreme damage than other islands exposed to the storm. Based on the nature of hurricanes, what quadrant of the storm pounded Dauphin Island?

- W) Northeast
- X) Northwest
- Y) Southwest
- Z) Southeast

ANSWER: W) NORTHEAST

### BONUS

24) EARTH AND SPACE *Multiple Choice* When the lunar surface is bombarded with solar wind, which of the following resources may be exploited from the Moon's surface?

- W) Helium for nuclear fusion
- X) Iron for steel
- Y) Sulfur for acids
- Z) Silicon for computer technologies

ANSWER: W) HELIUM FOR NUCLEAR FUSION

### TOSS-UP

25) CHEMISTRY *Multiple Choice* For the molecular orbital diagram of H<sub>2</sub>, in which of the following locations are the electrons located?

- W) One electron in each hydrogen's 1s atomic orbital
- X) Both electrons in the sigma 1s orbital
- Y) Both electrons in the sigma\* [***sigma-star***] 1s orbital
- Z) Both electrons in the pi 1s orbital

ANSWER: X) BOTH ELECTRONS IN THE SIGMA 1S ORBITAL

### BONUS

25) CHEMISTRY *Short Answer* Providing your answer to one significant figure, determine the pH of a 5.0 molar solution of acetic acid, given that acetic acid's  $K_a$  is  $2 \times 10^{-5}$ .

ANSWER: 2