

TOSS-UP

1) ENERGY *Multiple Choice* Which of the following statements is incorrect regarding the use of ATP in reactions?

- W) cells use ATP to drive endergonic reactions
- X) reactions with ATP do not proceed spontaneously
- Y) the overall reaction is exergonic if the cleavage of ATP's terminal bond releases more energy than the other reaction consumes
- Z) properties of its phosphate bonds make ATP a good long-term energy storage molecule

ANSWER: Z) PROPERTIES OF ITS PHOSPHATE BONDS MAKE ATP A GOOD LONG-TERM ENERGY STORAGE MOLECULE

BONUS

1) ENERGY *Multiple Choice* Which of the following major events in the evolution of metabolism occurred first in biological life forms?

- W) degradation
- X) oxygen-forming photosynthesis
- Y) anaerobic photosynthesis
- Z) aerobic respiration

ANSWER: Z) AEROBIC RESPIRATION

TOSS-UP

2) MATHEMATICS *Short Answer* You buy a box of dog biscuits for your dog. You give your dog 3 dog biscuits a day. After 10 days, you count 96 dog biscuits left in the box. At this rate, for how many weeks would a full box of dog biscuits feed your dog?

ANSWER: 6 WEEKS

BONUS

2) MATHEMATICS *Short Answer* What value of x satisfies the following equation?

$$2 + 3(4x + 2) = 3x - 4$$

ANSWER: $-4/3$

TOSS-UP

3) EARTH AND SPACE SCIENCE *Multiple Choice* Which of the following best describes the Northern Hemisphere friction-layer wind circulation pattern around a high pressure cell?

- W) convergent and clockwise
- X) convergent and counterclockwise
- Y) divergent and clockwise
- Z) divergent and counterclockwise

ANSWER: Y) DIVERGENT AND CLOCKWISE

BONUS

3) EARTH AND SPACE SCIENCE *Multiple Choice* Which of the following statements is not true about Cepheid variable stars?

- W) they are supergiant or bright giant stars of spectral class F or G
- X) they are brighter and have longer periods than RR Lyrae
- Y) the longer-period Cepheids have luminosities greater than the shorter-period Cepheids
- Z) the Type I Cepheids and RR Lyrae are poor in elements heavier than helium

ANSWER: Z) THE TYPE I CEPHEIDS AND RR LYRAE ARE POOR IN ELEMENTS HEAVIER THAN HELIUM

TOSS-UP

4) PHYSICS *Short Answer* What term is given to the hypothetical level of potential energy for an electron inside a crystalline solid, which if occupied by an electron would give it a potential energy equal to its chemical energy as they both appear in the Fermi-Dirac distribution function?

ANSWER: FERMI ENERGY (ACCEPT: FERMI LEVEL)

BONUS

4) PHYSICS *Short Answer* An 1800-W toaster, a 1200-W electric frying pan, and a 150-W lamp are all connected to the same 20-A, 120-V circuit. What are the current and resistance, respectively, on the toaster?

ANSWER: 15 A, 8 Ω

TOSS-UP

5) BIOLOGY *Multiple Choice* Which of the following is the very first step taken in the construction of a protein microarray?

- W) micromolar quantities of protein are isolated and purified
- X) transcription and translation occur in the prokaryotic host
- Y) cDNAs are constructed and reproduced by cloning them into bacteria or viruses
- Z) the transcriptome of a cell or tissue is isolated

ANSWER: Z) THE TRANSCRIPTOME OF A CELL OR TISSUE IS ISOLATED

BONUS

5) BIOLOGY *Short Answer* Name all of the following 5 processes that are used by plants to achieve morphogenesis:

- 1: cell death
- 2: changes in cell shape
- 3: cell growth and expansion

- 4: cell migration
- 5: the number, timing, and orientation of cell divisions

ANSWER: 1, 2, 3, AND 5

TOSS-UP

6) CHEMISTRY *Multiple Choice* Which of the following salts would produce a basic solution upon being dissolved in pure, distilled water?

- W) NaCl
- X) Na₂CO₃
- Y) Mg(NO₃)₂
- Z) NH₄Cl

ANSWER: X) Na₂CO₃

BONUS

6) CHEMISTRY *Short Answer* Indicate all of the following 4 statements that is/are TRUE regarding the physical properties of alkanes:

- 1: alkanes are soluble in water
- 2: alkanes float on water
- 3: alkanes have lower boiling points compared to other organic compounds of comparable molecular weight
- 4: alkanes are odorless

ANSWER: 2 AND 3

TOSS-UP

7) ENERGY *Multiple Choice* Which of the following first-generation biofuels, also referred to as oxygenated fuel, involves cost-efficient compounds that act as octane rating and engine performance enhancers, while significantly reducing engine wear and toxic exhaust emissions?

- W) biodiesel
- X) green diesel
- Y) bioether
- Z) biogas

ANSWER: Y) BIOETHER

BONUS

7) ENERGY *Short Answer* What devices, implemented by coal companies in order to remove the organic sulfur in coal smoke and eventually eliminate up to 98% of sulfur dioxide emissions, are installed at coal-fired electric and industrial plants where a water and limestone mixture reacts with sulfur dioxide to form sludge?

ANSWER: SCRUBBERS

TOSS-UP

8) MATHEMATICS *Short Answer* Presenting your answer in simplest form, find dy/dx for the function $f(x) = 3 \cdot \ln(\cos(x))$.

ANSWER: $-3 \cdot \tan(x)$

BONUS

8) MATHEMATICS *Short Answer* What is the slope of the tangent line to the graph of $f(x) = \ln(\csc(x))$ at the point $(\pi/3, f(\pi/3))$?

ANSWER: $-\sqrt{3}/3$

TOSS-UP

9) EARTH AND SPACE SCIENCE *Short Answer* What nuclide, which is present in extremely small quantities in the core of a hydrogen-fusing star because of its instability, becomes more abundant during helium fusion because of its role as an intermediate in the triple alpha process, decaying into $^{12}_6\text{C}$?

ANSWER: BERYLLIUM-8

BONUS

9) EARTH AND SPACE SCIENCE *Multiple Choice* Which of the following marine life zones is not dependent upon its distance from the shore?

- W) intertidal
- X) pelagic
- Y) neritic
- Z) oceanic

ANSWER: X) PELAGIC

TOSS-UP

10) PHYSICS *Short Answer* What specific wave equation, formulated in 1928, provides a description of elementary spin-1/2 particles, and is consistent with the principles of quantum mechanics and the theory of special relativity? It was the first of its kind to fully account for relativity in the context of quantum mechanics.

ANSWER: DIRAC EQUATION

BONUS

10) PHYSICS *Multiple Choice* A number of different products can result from the fission of uranium-235. Which of the following choices represents a set of products that is NOT possible with the fission of uranium-235?

- W) iodine-135, yttrium-97, and 4 neutrons
- X) barium-139, krypton-94, and 3 neutrons
- Y) molybdenum-103, tin-132, and 2 neutrons
- Z) xenon-139, strontium-85, and 2 neutrons

ANSWER: Z) XENON-139, STRONTIUM-85, AND 2 NEUTRONS

TOSS-UP

11) BIOLOGY *Short Answer* What is the large, cylindrical cellular organelle that degrades proteins marked with ubiquitin? Proteins enter at one end and exit the other as amino acids or peptide fragments.

ANSWER: PROTEASOME

BONUS

11) BIOLOGY *Multiple Choice* Which of the following DNA-binding motifs has an α -helical segment linked to a β -sheet segment so that the helical segment fits into the major groove of the DNA?

- W) helix-turn-helix motif
- X) homeodomain motif
- Y) zinc finger motif
- Z) leucine zipper motif

ANSWER: Y) ZINC FINGER MOTIF

TOSS-UP

12) CHEMISTRY *Multiple Choice* Which of the following is produced in the hydrogenation reaction of an aldehyde?

- W) ketone
- X) carboxylic acid
- Y) secondary alcohol
- Z) primary alcohol

ANSWER: Z) PRIMARY ALCOHOL

BONUS

12) CHEMISTRY *Short Answer* What is the molarity of a solution made by diluting 0.050 L of 0.10 M HCl solution to a volume of 1.0 L?

ANSWER: 0.0050 M (ACCEPT: 5.0×10^{-3} M HCl)