

Assorted Lightning Round, Medium-Hard Difficulty

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March 24, 2013

TOSS-UP

1. **BIOLOGY** *Multiple Choice* A biochemist wishes to determine the amino acid sequence of insulin, which is composed of two polypeptide chains linked by a disulfide bond. Which of the following is the first step?

(W) Addition of phenylisothiocyanate, which sequentially removes amino acids from the N-terminus

(X) Addition of hydrochloric acid, which slowly degrades the protein into smaller peptides

(Y) Addition of β -mercaptoethanol, which reduces the interchain disulfide bonds

(Z) Addition of salts, which precipitate the protein out of solution

ANSWER: Y

TOSS-UP

2. **CHEMISTRY** *Multiple Choice* Which of the following are not allowed values for the orbital angular momentum quantum number and the magnetic quantum number, respectively, for an electron with a principal quantum number of $n = 3$?

(W) 0, 0

(X) 1, 1

(Y) 2, 2

(Z) 3, 3

ANSWER: Z

TOSS-UP

3. **PHYSICS** *Short Answer* One mole of an ideal gas is trapped within a large cylinder with a plunger at the top. The gas is free to expand as long as the pressure due to the plunger remains constant. If the temperature is raised from 20 Kelvin to 40 Kelvin, in terms of the ideal gas constant R , how much of the heat added is expended in the form of work against the plunger?

ANSWER: 20R

TOSS-UP

4. MATH *Multiple Choice* In group theory, this type of mapping between two algebraic structures is structure-preserving and maps the identity of the first structure to the identity of the second. One example is the length function between lists and the natural numbers. Which of the following mappings is it?

(W) Isomorphism
(X) Homomorphism
(Y) Endomorphism
(Z) Monomorphism

ANSWER: X

TOSS-UP

5. EARTH AND SPACE *Multiple Choice* For which of the following mass numbers are there no stable nuclei?

(W) 3
(X) 5
(Y) 8
(Z) 10

ANSWER: X

TOSS-UP

6. ENERGY *Multiple Choice* In which of the following is the spherical aberration of a lens the greatest?

(W) Around the edges of a lens with a large focal length
(X) Around the edges of a lens with a small focal length
(Y) Near the center of a lens with a large focal length

(Z) Near the center of a lens with a small focal length

ANSWER: X

TOSS-UP

7. BIOLOGY *Short Answer* This coenzyme contains an adenine derivative and can react with carboxylic acids to form thioesters. It is derived from pantothenate and is responsible for the activation and transfer of acetyl groups. It is significant in beta oxidation and the link reaction. Name this coenzyme.

ANSWER: COENZYME A

TOSS-UP

8. CHEMISTRY *Multiple Choice* Which of the following ions is orange in color?

(W) MnO_4^{2-}

(X) CrO_4^{2-}

(Y) $\text{Cr}_2\text{O}_7^{2-}$

(Z) MnO_4^-

ANSWER: Y

TOSS-UP

9. PHYSICS *Short Answer* If two monochromatic sources are emitting light coherently, and a given point is 9 wavelengths away from the first source and 9.5 wavelengths away from the second source, what kind of interference is occurring at the point?

ANSWER: DESTRUCTIVE

TOSS-UP

10. MATH *Short Answer* This statistical test uses a statistic in the form Z/s , where Z is a difference between two the means of two groups and s is the standard error. If the statistic is less than a pre-determined α -value, then the null hypothesis that two groups are equal is rejected. It takes into account both the cases of one group having a smaller and larger mean than the other group. Give the most specific statistical test this could refer to.

ANSWER: UNPAIRED TWO-TAILED T-TEST

TOSS-UP

11. EARTH AND SPACE *Multiple Choice* Which of the following is true?

(W) The Hubble constant remains constant regardless of position and time

(X) The critical density of the universe is around four hydrogen atoms per cubic meter

(Y) Based on redshift studies, the expansion of the universe is slowing down due to gravitational attraction

(Z) If the average density of the universe were greater than the critical density, the universe would be infinite

ANSWER: X

TOSS-UP

12. ENERGY *Short Answer* Calculate the angular magnification of a lens with a focal length of 12 centimeters if an object of height 18 centimeters is placed 15 centimeters away.

ANSWER: 1.25

TOSS-UP

13. BIOLOGY *Multiple Choice* Which of the following is not true of PCR?

(W) DNA primers are used instead of RNA primers

(X) A heat-resistant DNA polymerase is used

(Y) The melting temperature of the primers need not be known to run a PCR

(Z) Complementary primers or primers forming hairpins can lower the efficiency of PCR

ANSWER: Y

TOSS-UP

14. CHEMISTRY *Multiple Choice* Pure corundum is colorless, but ruby, a form of corundum, is red. What additional element in ruby is responsible for this red color?

(W) Chromium

(X) Iron

(Y) Copper

(Z) Manganese

ANSWER: W

TOSS-UP

15. PHYSICS *Short Answer* Identify all of the following three statements that is or are true when the ratio of inertial to viscous forces is less than one:

I. Fluid flow is laminar and the velocity at the boundary layer is zero

II. Volumetric flow rate differs along the pipe

III. This situation may occur when fluid is moving at high velocities

ANSWER: 1 ONLY

TOSS-UP

16. MATH *Short Answer* Using words or numbers, identify all of the following three series which converge:

I. $a_n = n^{-n}$

II. $a_n = (-n)^{-n}$

III. $a_n = \frac{\ln n}{n^2}$

ANSWER: 1, 2, 3

TOSS-UP

17. EARTH AND SPACE *Short Answer* The formation of which nebula was observed by Chinese astronomer's in the 1200's and was said to light up the night sky for 3 consecutive days?

ANSWER: CRAB NEBULA

TOSS-UP

18. ENERGY *Short Answer* The reason why the last step of glycolysis is so energetically favored is due to the instability of which tautomeric form?

ANSWER: ENOL

TOSS-UP

19. BIOLOGY *Multiple Choice* Which of the following types of pumps, used by both bacteria and cancer cells, are important in medicine because they allow the cell to develop resistant to a drug?

(W) Multi-drug resistant pumps

(X) Proton transporters

(Y) Hydrophobicity-specific carriers

(Z) General-drug tolerance transporters

ANSWER: W

TOSS-UP

20. CHEMISTRY *Short Answer* What reduction in organic chemistry uses hydrazine as its primary reagent to reduce a carbonyl group to an alkane?

ANSWER: WOLFF-KISHNER REDUCTION

TOSS-UP

21. PHYSICS *Short Answer* You have a rigid, perfectly cylindrical wheel that contains four balls arranged in a square at its rim. Three of the balls have a positive charge, while the last ball has a negative charge. You then roll this wheel down a rigid, perfectly smooth incline. Using words or numbers, identify all of the following three statements that is or are true:

- I. The normal force does not exert a net torque on the wheel at any point in time
- II. The electrostatic interaction between the balls does not exert a net torque on the wheel at any point in time
- III. Regardless of the curvature of the surface, the wheel will not change direction while rolling

ANSWER: 1, 2, 3

TOSS-UP

22. MATH *Short Answer* Using words or numbers, identify all of the following three functions for which the graph, if rotated about the x-axis, will produce a solid with an infinite surface area but finite volume?

- I. $y = x^{-1/2}$
- II. $y = \frac{x+1}{x^2+8}$
- III. $y = e^{-x}$

ANSWER: 1 AND 2

TOSS-UP

23. EARTH AND SPACE *Short Answer* Which tail of a comet points directly away from the Sun?

ANSWER: ION TAIL

TOSS-UP

24. ENERGY *Multiple Choice* According to Noether's theorem, translation across which quantity corresponds to conservation of energy?

(W) Position

(X) Time

(Y) Parity

(Z) Mass

ANSWER: X

TOSS-UP

25. PHYSICS *Multiple Choice* Which of the following experiments would allow for the direct measurement of time dilation?

(W) Firing a beam of light at a mirror parallel to the axis of motion

(X) Firing a beam of light at a mirror perpendicular to the axis of motion

(Y) Measuring the fringe shift from firing a beam of light perpendicular to the axis of motion

(Z) Measuring the fringe shift from firing a beam of light through multiple mirrors both parallel and perpendicular to the axis of motion

ANSWER: X
