CSBL ROUND 5

TOSS-UP

1) Biology – *Multiple Choice* In a linkage map, which is a genetic map used to determine gene locations, a unit of measurement is a map unit. Map units can describe the distances between gene loci. What is one map unit equivalent to?

W) 1000 base pairs
X) The Length of a Chromosome
Y) A 1% Recombination Rate
Z) 1 cm of electrophoretic migration at 100 V for 30 minutes

ANSWER: Y) A 1% RECOMBINATION RATE

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BONUS

1) Biology – *Short Answer* If a linkage map has three genes: A, B, and C, and A crosses over with C 5% of the time, B crosses over with C 20% of the time, and A crosses over with B 25% of the time, what is the ordering of these genes?

ANSWER: ACB or BCA

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TOSS-UP

2) Chemistry – *Short Answer* In a chemical reaction, equilibrium is reached when the equilibrium constant is EQUAL to what quantity?

ANSWER: REACTION CONSTANT (ACCEPT: Q)

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BONUS

2) Chemistry – *Short Answer* Joy is trying to synthesize ammonia for her farm using the Haber Process: $N_2\,(g) + 3\,H_2(g) \;-->\; 2\,NH_3\,(g)$ Given that the enthalpy change in this reaction is -92 kJ/mol, identify ALL of the following THREE changes that will result in an INCREASE in the formation of ammonia:

I. Addition of Inert Helium
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II. Increasing Pressure
III. Increasing Temperature

ANSWER: II only

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TOSS-UP

3) Physics – *Short Answer* A box with a mass of 1 kg is raised 10 meters upwards. Assuming the box starts and ends at rest, what is the net work done on the box?
ANSWER: 0 J

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BONUS

3) Physics – *Short Answer* A particle travels through a one-dimensional conservative force field, from x = 0 to x = 2 meters. If the force F is defined by the equation $F(x) = x^3 - 1$, what is the change in potential energy of the particle?

ANSWER: -2 J

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TOSS-UP

4) Earth and Space – *Short Answer* In contrast to siliceous ooze, another type of biologic sediment is calcareous ooze, formed from carbonate sediments. However, calcareous ooze does not form at all ocean depths. What is the term for the depth after which calcareous ooze CANNOT form because the rate of supply is less than the rate of solvation?

ANSWER: CARBONATE COMPENSATION DEPTH

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BONUS

4) Earth and Space – *Multiple Choice* A fringing coral reef forms a barrier reef, which in turn forms an atoll. This process was first observed by Charles Darwin, and he thought that volcanic islands sunk, but he couldn't find a plausible mechanism. Which of the following mechanisms BEST explains this phenomenon?

W) Volcanic islands form over MOVING mantle plumes, causing the lithosphere to be lifted, moving these islands AWAY from hot-spot volcanism

X) Volcanic islands form over MOVING mantle plumes, causing the lithosphere to be lifted, moving these islands TOWARDS hot-spot volcanism
Y) Volcanic islands form over STATIONARY mantle plumes, causing the lithosphere to be lifted, moving these islands AWAY from hot-spot volcanism
Z) Volcanic islands form over STATIONARY mantle plumes, causing the lithosphere to be lifted, moving these islands TOWARDS hot-spot volcanism

ANSWER: Y) Volcanic islands form over STATIONARY mantle plumes, causing the lithosphere to be lifted, moving these islands AWAY from hot-spot volcanism

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TOSS-UP

5) Math – *Short Answer* What is $\log_3(7) * \log_7(81)$ (**read as log base 3 of 7, times log base 7 of 81)**?

ANSWER: 4

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BONUS

5) Math – *Short Answer* If $\log_4(32) = \log_x(3125)$ (**read as log base 4 of 32 equals log base x of 3125)**, what is x?

ANSWER: 25

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TOSS-UP

6) Energy – *Short Answer* Scientists at Los Alamos National Lab are studying the existence of ghost particles, also known as neutrinos. During Project Poltergeist, Reines and Cowan detected neutrinos emitted from a reactor by recording their reactions with what type of particle in a liquid scintillator?

ANSWER: PROTON

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BONUS

6) Energy – *Short Answer* Scientists at LANL are also studying how radioisotopes can be used to combat drug-resistant microorganisms. They are testing this by using siderophores, which are

also known as iron carriers, to convey a treatment particle to a pathogen. What radioisotope often replaces iron in the siderophore?

W) Uranium-238
X) Technetium-99
Y) Plutonium-240
Z) Thorium-232

ANSWER: Z) THORIUM-232

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TOSS-UP

7) Biology – *Short Answer* Despite the genetic code consisting of triplet codons, there exist only 50 different types of tRNA molecules. What phenomenon accounts for this disparity?

ANSWER: WOBBLE (ACCEPT: WOBBLE BASE PAIRING)

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BONUS

7) Biology – *Multiple Choice* tRNA molecules are vital for translating mRNAs into polypeptides. Some tRNA molecules may have a modified nitrogenous base in the third position of their anticodon called inosine. Which of the four canonical RNA nitrogenous bases is inosine NOT able to base pair with?

W) A
X) C
Y) G
Z) U

ANSWER: Y) G

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TOSS-UP

8) Chemistry – *Multiple Choice* Kyle is working in the lab and sees that another student is pouring a beaker of warm tap water into an aqueous solution of concentrated sulfuric acid. Which of the following BEST describes why this is a bad decision?
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W) Kyle is not using distilled water, and therefore is adding metal ions to the solution.
X) Adding water to acid is an exothermic process.
Y) The water will neutralize the sulfuric acid, forming hydrogen gas.
Z) Sulfuric acid explodes upon exposure to air.

ANSWER: X) Adding water to acid is an exothermic process

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BONUS

8) Chemistry – *Short Answer* An unnamed acid has a pKa value of 5. What is the ratio of the protonated to deprotonated forms of this acid when the environment's pH is 8.

ANSWER: 1:1000

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TOSS-UP

9) Physics – *Short Answer* John, who has a mass of 50 kg, is stuck on frictionless ice. To get off of it in time, he needs to travel at a speed of 1 m/s, so he plans to throw his jacket in the opposite direction of the shore. Assuming the jacket has a mass of 1 kg, at what speed must the jacket travel for John to be saved?

ANSWER: 50 m/s

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BONUS

9) Physics – *Short Answer* The ice is cracking! John, the 50 kg man traveling at the constant speed of 1 m/s towards the shore, wants to know whether he is about to fall in. If he was able to apply a maximum force of 20 N to the jacket, what is the minimum amount of time his collision with the jacket could have taken?

ANSWER: 2.5 s

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TOSS-UP

10) Earth and Space – *Short Answer* In the Rockies, a strong pressure gradient develops. As winds move down the Eastern slopes, they become heated adiabatically, which causes the descending air to be warmer and dryer. What is the term for this kind of wind?

ANSWER: CHINOOK (DO NOT ACCEPT: SANTA ANA)

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BONUS

(READER NOTE, DO NOT READ THE KOPPEN CLASSIFICATION IN PARENTHESES)

10) Earth and Space – *Short Answer* Now that the pandemic is hopefully getting better, Amy wants to take a trip overseas. She hates tropical areas (**A**) and areas where the temperature can drop below -3 degrees Celsius (**D,E)**. She's also obstinate about NOT visiting an arid region (**B)**. Based on this climate data, which of the following cities would be the best destination for Amy?

W) Singapore (***A)***
X) Moscow, Russia ***(D)***
Y) Lahore, Pakistan (***B***)
Z) Cape Town, South Africa (***C***)
ANSWER: Z) CAPE TOWN, SOUTH AFRICA

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TOSS-UP

11) Math – *Short Answer* An ant wants to walk from the bottom corner of a cube to the corner farthest away. Given that the volume of the cube is sqrt(125) cm^3 (**read as square root of 125 cubic centimeters)**, in centimeters, what is the shortest distance that he can walk?

ANSWER: 5

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BONUS

11) Math – *Short Answer* John has 12 marbles, all indistinguishable from one another. He wants to divide them up amongst 4 friends, but he also wants to make sure that each person gets at least 1. How many ways are there for him to do so?

ANSWER: 165

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TOSS-UP

12) Energy – *Short Answer* Scientists at Argonne National Lab are studying the structure of proteins. They do so by using what technique, which uses the diffraction of low wavelength EMR to resolve structures?

ANSWER: X-RAY CRYSTALLOGRAPHY

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BONUS

12) Energy – *Short Answer* Scientists at Berkeley Lab are studying the usage of polymers against microbial resistance. A common example of polymerization is done through 1-alkenes. What type of catalyst is used to synthesize these polymers while also controlling their stereochemistry?

ANSWER: ZIEGLER-NATTA CATALYST

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TOSS-UP

13) Biology – *Multiple Choice* Bacterial conjugation is a type of genetic recombination between two bacterial cells. Which of the following elements is needed for bacterial conjugation to occur?

W) C-Plasmid
X) F-Plasmid
Y) Capsid
Z) Prion

ANSWER: X) F-PLASMID

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BONUS

13) Biology – *Multiple Choice* Bacterial conjugation also requires the use of cytoplasmic connectors called sex pili. The gene necessary for the production of sex pilus is found on the F-Plasmid. Identify ALL of the following THREE central dogma processes that are NOT needed for bacterial conjugation and the transfer of DNA:

I. DNA Replication
II. Transcription
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III. Translation

ANSWER: NONE

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TOSS-UP

14) Chemistry – *Multiple Choice* Which of the following sets of n, l, m_l (**read as** m sub l), and m_s (**read as** m sub s), respectively, is degenerate?

W) 3, 1, 0, -1
X) 2, 1, 0, -1
Y) 4, 4, 3, 1
Z) 6, 2, -1, -1

ANSWER: Y) 4, 4, 3, 1

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BONUS

14) Chemistry – *Short Answer* Identify ALL of the following THREE molecular orbitals that have THREE angular and radial nodes combined:

I. 4s
II. 5d
III. 6p

ANSWER: I ONLY

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TOSS-UP

15) Physics – *Short Answer* If a 5 kg object is falling through a fluid, with its drag force modeled linearly as $F = -bv$, where b is a positive constant, and reaches a terminal velocity of 10 m/s, what is the value b?

ANSWER: 4.9 kg/s (ACCEPT: 4.9)

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BONUS

15) Physics – *Multiple Choice* The Navier-Stokes equations, which describe the dynamics of fluids, are directly derived from which of the following laws?

W) Hooke's Law
X) Newton's Laws of Motion
Y) Pascal's Law
Z) Bernoulli's Law

ANSWER: NEWTON'S LAWS OF MOTION

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TOSS-UP

16) Earth and Space – *Short Answer* What type of star CANNOT sustain hydrogen fusion but instead fuse deuterium and tritium?

ANSWER: BROWN DWARF

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BONUS

16) Earth and Space – *Short Answer* By name or number, arrange the following 4 stellar spectral classes in order of INCREASING surface temperature:

I. O
II. G
III. A
IV. F

ANSWER: 2,4,3,1 (G, F, A, O)

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TOSS-UP

17) Math – *Multiple Choice* Let R stand for the standard deviation of a set of numbers. If each number is quadrupled, in terms of R, which of the following is the new standard deviation?

W) R/4
X) R
Y) 4R
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Z) 16R

ANSWER: Y) 4R

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BONUS

17) Math – *Short Answer* Suppose that 15 integers between 1 and 16, inclusive, BUT NOT NECESSARILY DISTINCT, are chosen. What is the maximum possible difference between the values of the median and the mean of this set of numbers?

ANSWER: 7

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TOSS-UP

18) Energy – *Short Answer* Scientists at Ames Lab are studying how algorithms enhance the computing power of early-stage quantum computers. Although quantum computers can reduce run time, they are still unable to solve what kind of problem?

ANSWER: UNDECIDABLE (ACCEPT: HALTING PROBLEM)

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BONUS

18) Energy – *Short Answer* Scientists at Ames Lab have also studied Axion antiferromagnets. Axion antiferromagnets are believed to be the first experimental evidence of layering of what Effect, characterized by the production of a voltage difference across an electrical conductor?

ANSWER: HALL EFFECT (ACCEPT: LAYERED HALL EFFECT)

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TOSS-UP

19) Biology – *Multiple Choice* The Loop of Henle is a part of nephrons in the kidneys. Which of the following is the ascending portion of the Loop of Henle permeable to?

W) Potassium Ions
X) Water
Y) Hydrogen Carbonate
Z) Sodium Chloride

ANSWER: Z) SODIUM CHLORIDE

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BONUS

19) Biology – *Short Answer* Animals are required to excrete nitrogenous waste in various forms. Identify ALL of the following FOUR animals that excrete uric acid:

I. Sharks
II. Lizards
III. Geese
IV. Land Snails

ANSWER: II, III, and IV (LIZARDS, GEESE, AND LAND SNAILS)

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TOSS-UP

20) Chemistry – *Short Answer* Identify ALL of the following THREE changes that will result in an INCREASE in vapor pressure:

I. Increase in Atmospheric Pressure
II. Increase in IMF Strength
III. Increase in Temperature

ANSWER: III Only

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BONUS

20) Chemistry – *Short Answer* At a temperature of 100 K, the vapor pressure of an unknown substance is 300 atm. Given that the enthalpy of vaporization is 831.4 kJ/mol, and the universal gas constant is 8.314 J/mol K, if the temperature is decreased to 50 K, what is the ratio of the initial vapor pressure to the final vapor pressure?

ANSWER: e (ACCEPT: 2.72)

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TOSS-UP

21) Physics – *Short Answer* Identify ALL of the THREE following media with GREATER indices of refraction than water:

I. Aqueous Sugar Solution
II. Helium
III. Glass

ANSWER: I and III (AQUEOUS SUGAR SOLUTION AND GLASS)

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BONUS

21) Physics – *Short Answer* If a ray of light travels from air into water at an angle of incidence such that its sin is ⅔, to the nearest degree, what is the angle of refraction?

ANSWER: 30° (DO NOT ACCEPT: PI/6)

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TOSS-UP

22) Earth and Space – *Short Answer* In some cases, charged particles can travel faster than the speed of light in air. These types of particles emit what type of radiation, which is characterized by an eerie blue color?

ANSWER: CHERENKOV RADIATION

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BONUS

22) Earth and Space – *Multiple Choice* Joy the astronomer is back again! She is trying to determine the luminosity of a star that she just discovered. She determined that the radius is 700,000,000 m, and the temperature is 6,000 K. Assuming that the Stefan Boltzmann Constant is 5.67 * 10^-8 Watts per meter squared per Kelvin^4, which of the following is the best estimation of the star's luminosity, in watts?

W) 4 * 10^13
X) 4 * 10^26
Y) 4 * 10^39
Z) 4 * 10^52

ANSWER: X) 4 * 10^26
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TOSS-UP

23) Math – *Short Answer* Convert the number 111 (**read as one one one**) base 8 into base 2.

ANSWER: 1001001

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BONUS

23) Math – *Multiple Choice* The fraction 33/48 can be expressed as 0.45454545… (**read as the 0.45, with 45 repeating**) in some base k. Which of the following is k?

W) 7
X) 11
Y) 13
Z) 17

ANSWER: W) 7