THUMB: SINGLE ELIMINATION 2

1) Biology - *Short Answer* When a B-cell is activated, an enzyme called Activation induced cytidine deaminase triggers both antibody class-switching and what other process, where the variable region of the antibody is repeatedly refined to increase its binding affinity with the antigen?

ANSWER: Somatic Hypermutation OR affinity maturation [SY]

2) Math – *Multiple Choice* A triangle has side lengths of 10, 17, and 21 inches. In inches squared, what is the area of the triangle?

W) 64
X) 72
Y) 84
Z) 96

ANSWER: Y) 84 [AX]

3) Earth and Space – *Short Answer* Identify all of the following three stellar populations that have been observed in the Milky Way galaxy: 1) Population I 2) Population II 3) Population III

ANSWER: 1 and 2 [FJ]

4) Physics – *Short Answer* The magnetism of a ferromagnetic material, like iron, lags behind a changing magnetic field. A graph of the material's magnetism versus the applied field forms a loop, demonstrating that its state depends on its history. What is the name for this effect and the loop itself?

ANSWER: Hysteresis [AX]

5) Chemistry – *Multiple Choice* Sugars with 5 carbons are known as pentose sugars. Which of the following sugars contains exactly 5 carbons?

W) Dextrose
X) Sucrose
Y) Xylulose
Z) Fructose

ANSWER: Y) Xylulose [DS]

6) Biology - *Short Answer* Triple negative breast cancers are characterized by their lack of estrogen receptors, progesterone receptors, and what other characteristic biomarker, an oncogene found in about 30% of all breast cancers, originally named “Human Epidermal Growth Factor Receptor 2”?

ANSWER: HER2, or Receptor tyrosine-protein kinase erbB-2 [SY]

7) Math – Multiple Choice How many ways are there to arrange the letters in the word “HEADED?”

W) 90
X) 120
Y) 180
Z) 240

ANSWER: Y) 180 [AX]

8) Earth and Space – *Multiple Choice* Austin determines the wet and dry adiabatic lapse rates outside his house are approximately 5.5 and 9.8 degrees celsius per kilometer respectively, and that the atmosphere is currently absolutely unstable. Which of the following could be the environmental lapse rate outside Austin’s house in degrees celsius per kilometer?

W) 4
X) 6
Y) 8
Z) 10

ANSWER: Z) 10 [FJ]

9) Physics – *Short Answer* What is the set of linear transformations in special relativity that links the space and time coordinates of two inertial reference frames, and whose derivation depends on the constancy of the speed of light for all observers?

ANSWER: Lorentz Transformation [AX]

10) Chemistry – *Short Answer* What is the oxidation state of germanium in germanium dioxide?

ANSWER: +4 [DS]

11) Biology – *Short Answer* Hemoglobin exists in two states, the relaxed R state and tense T state. When a single oxygen binds to a single subunit of a T-state hemoglobin, the entire molecule begins to shift to the R-state, increasing the oxygen binding affinity in the other hemoglobin subunits. This is a display of the positive form of what phenomenon, where ligand binding to one site in a protein influences binding affinity of another binding site on the same protein?

ANSWER: Cooperativity (ACCEPT positive cooperativity before "positive" is read) [SY]

12) Math - *Short Answer* Order the following three periodic functions by increasing period:

1) f(x) = f(x-2)
2) f(x) = sin^2(x)+cos(x)
3) f(x) = sec^2(x)+cos^2(x)

ANSWER: 1, 3, 2 [OM]

13) Earth and Space – *Multiple Choice* The Mount St. Helens eruption in 1980 laterally blasted away part of the mountain and produced a massive eruption column. This eruption can be best classified as which of the following types?

W) Hawaiian
X) Plinian
Y) Strombolian
Z) Surtseyan

ANSWER: X) Plinian [FJ]

14) Physics – *Multiple Choice* An ideal gas expands, performing work **W** on its surroundings while its internal energy increases by **U**. This expansion is characterized such that the ratio between W and U is always 2 to 5. What type of thermodynamic process must this be?

W) Isobaric
X) Adiabatic
Y) Isothermal
Z) Isochoric

ANSWER: W) Isobaric [AX]

15) Chemistry – *Multiple Choice* Which of the following is the molecular geometry of Sulfur Tetraflouride according to VSEPR theory?

W) Square planar
X) Tetrahedral
Y) Seesaw
Z) Trigonal Bipyramidal

ANSWER: Y) Seesaw [DS]

16) Biology – *Short Answer* In the CRISPR-cas system, the single-guide RNA is composed by joining a segment of crRNA (c-r-R-N-A) with what other RNA segment?

ANSWER: tracrRNA ("tracker" / "tracer") OR trans-activating crRNA [SY]

17) Math – *Short Answer* Ava wants to find the line integral across a closed, counterclockwise 2D region. She wants to use the two-dimensional version of Stoke's theorem, but forgets the name of the theorem. What is the name of this theorem?

ANSWER: Green's Theorem [AX]

18) Earth and Space – *Short Answer* Identify all of the following three elements that can be used to distinguish the spectra of type Ic and II supernovae: 1) Hydrogen 2) Helium 3) Silicon

ANSWER: 1 and 2 [FJ]

19) Physics – *Multiple Choice* Florida throws a ball into the air with an initial velocity at an angle of 45 degrees. Assuming drag is nonnegligible, which of the following correctly identifies the changes in the magnitudes of horizontal velocity and vertical acceleration, respectively?

W) Always decreasing, always increasing
X) Always decreasing, always decreasing
Y) Always increasing, always increasing
Z) Always increasing, always decreasing

ANSWER: X) Always decreasing, always decreasing [AX]

20) Chemistry – *Short Answer* What is the theoretical bond order of the dicarbon molecule, C2, as predicted by molecular orbital theory?

Answer: 2 [SY]

21) Biology - *Short Answer* By name or number, order the following four layers of thin epidermis from most exterior to most interior:

1) Stratum Basale
2) Stratum Corneum
3) Stratum Granulosum
4) Stratum Spinosum

ANSWER: 2 3 4 1 [SY]

22) Math – *Short Answer* What is the measure, in radians, of the smaller angle of a parallelogram with area 120 and side lengths 40 and 20sqrt(3)?

ANSWER: pi/3 [OM]

23) Earth and Space – *Short Answer* Arrange the following three minerals by increasing hardness: 1) Aragonite 2) Selenite 3) Citrine

ANSWER: 2, 1, 3 [FJ]

24) Physics – *Multiple Choice* During beta minus decay, a neutron in an atom's nucleus transforms into a proton. This process involves the creation of an electron and an electron antineutrino, which ensures the conservation of which of the following?

W) Baryon number
X) Lepton number
Y) Charm number
Z) Strangeness number

ANSWER: X) Lepton number [AX]

25) Chemistry – *Multiple Choice* Which of the following types of alcohol is produced in the nucleophilic addition of methylmagnesium chloride to acetone, followed by an acidic workup?

W) Primary
X) Secondary
Y) Tertiary
Z) Quaternary

ANSWER: Y) Tertiary [DS] [AlX] [SY]