# Standard Division Finals 1

**TOSS-UP**

1) BIOLOGY *Multiple Choice* Which of the following changes would increase the affinity of hemoglobin for oxygen?

W) Increased $CO_2$ concentration

X) Increased temperature

Y) Increased pH

Z) Increased 2,3-BPG concentration

ANSWER: Y) INCREASED PH [GKD]

**BONUS**

1) BIOLOGY *Short Answer* Wild-type mice have a brown coat color called agouti **[*a-GOO-tee*]**, while a dominant mutation in this gene produces a yellow coat color. When a yellow mouse is crossed with an agouti mouse, there is always a 1:1 ratio of yellow to agouti offspring. Given this information, when two yellow mice are crossed, what is the expected ratio of yellow to agouti offspring?

ANSWER: 2 TO 1 [GKD]

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**TOSS-UP**

2) CHEMISTRY *Short Answer* For a particle in a one-dimensional box, identify all of the following three factors that, when increased, would increase the energy of the particle:

1) Length of the box
2) Mass of the particle
3) Principle quantum number

ANSWER: 3 ONLY [GKD]

**BONUS**

2) CHEMISTRY *Multiple Choice* While the Rydberg equation is classically applied for energy level transitions in hydrogen, it can be applied to any atoms with a single valence electron. In this case, energy levels are proportional to what power of the charge of the nucleus?

W) -1
X) -2
Y) 1
Z) 2

ANSWER: X) -2 [GKD]

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**TOSS-UP**

3) EARTH AND SPACE *Short Answer* By name or number, identify all of the following three features that are formed by glacial erosion:

1) Roche moutonnee **[*ROASH MOO-toe-nay*]**
2) Horn
3) Kame **[*CAME*]**

ANSWER: 1 AND 2 (ACCEPT: DRUMLIN, HORN) [EB]

**BONUS**

3) EARTH AND SPACE *Multiple Choice* Which of the following types of reflecting telescopes has a hole in its primary mirror for light reflecting by its hyperbolic secondary mirror to reach the observer?

W) Cassegrain **[*KASS-uh-grain*]**
X) Newtonian
Y) Gregorian
Z) Herschellian **[*her-SHELL-ee-in*]**

ANSWER: W) CASSEGRAIN [EB]

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**TOSS-UP**

4) MATH *Short Answer* A license plate is made up of 2 letters followed by 3 digits. How many license plates include at least 1 "A"?

ANSWER: 51000 [MD]

**BONUS**

4) MATH *Short Answer* Alan, Akshansh, and Arvind are in a room practicing for regionals. When Alan leaves the room, Arvind and Akshansh are left alone. Arnesh has added astatine to the buzzer, so when Akshansh buzzes, he has a 1/2 chance of dying a minute after Alan leaves. If Akshansh isn't already dead, he has a 1/5 chance of annoying Arvind until he assassinates Akshansh at the 3 minute mark. Then, assuming Akshansh is alive at the five minute mark, Alex will release arsine gas, which has a 2/5 chance of killing both Akshansh and Arvind. When Alan arrives six minutes later, he is taken aback because Akshansh is dead. What is the probability Arvind is also dead?

ANSWER: 4/19 [MD]

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**TOSS-UP**

5) PHYSICS *Short Answer* A 2000 kg food truck has blown its tires and is now skidding across the road at 14 m/s. If the coefficient of kinetic friction between the road and the food truck is 1/19.6, how far will it take for the food truck to stop, to the nearest meter?

ANSWER: 196 [AC]

**BONUS**

5) PHYSICS *Short Answer* Arvind rides a unicycle with a frictionless around a banked turn at constant speed. He manages to stay on the road when the tangent of the bank angle is equal to omega. He tries this again, except this time going 50% faster on a turn with three times the radius and on a planet with three times as much gravity as Earth. What is the tangent of the new bank angle required for Arvind to stay on the road, in terms of omega?

ANSWER: OMEGA/4 [AC]

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**TOSS-UP**

6) ENERGY *Short Answer* Davidson MS A Team members are studying groundwater and its many usages. In areas where there is significant use of groundwater, the water levels around individual wells drop, leading to the water table sloping inward towards the well. What is the name for this feature?

ANSWER: CONE OF DEPRESSION [EB]

**BONUS**

6) ENERGY *Short Answer* Davidson HS A team members are currently studying tournament question writing-induced cell death. In the intrinsic apoptotic pathway, what electron transport chain protein is released from the mitochondria, which activates cytoplasmic caspases and ultimately causes cell death?

ANSWER: CYTOCHROME C [GKD]

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**TOSS-UP**

7) BIOLOGY *Short Answer* Akshansh discovers a plant where the locations of the primary and secondary xylem are swapped and the locations of the primary and secondary phloem **[*FLOW-um*]** are swapped. Order the following four tissues from outermost to innermost in this plant:

1) Primary xylem
2) Secondary xylem
3) Primary phloem
4) Secondary phloem

ANSWER: 4, 3, 1, 2 (ACCEPT: SECONDARY PHLOEM, PRIMARY PHLOEM, PRIMARY XYLEM, SECONDARY XYLEM) [GKD]

**BONUS**

7) BIOLOGY *Short Answer* Griffin discovers a new organism, *Sciencebowl insularis*, that has a third photosystem he very creatively names photosystem III. He names the reaction center chlorophyll of this photosystem P690. Based on this information, order the reaction center chlorophylls of the following three photosystems in increasing order of wavelength of light maximally absorbed:

1) Photosystem I
2) Photosystem II
3) Photosystem III

ANSWER: 2, 3, 1 (ACCEPT: PHOTOSYSTEM II, PHOTOSYSTEM III, PHOTOSYSTEM I) [GKD]

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**TOSS-UP**

8) CHEMISTRY *Multiple Choice* Which of the following best explains why carboxylic acids tend to be more acidic than simple alcohols?

W) In carboxylic acids, electron density is withdrawn by the oxygen atom in the carbonyl group

X) Once deprotonated, carboxylic acids can spread the negative charge over both oxygen atoms through resonance

Y) Because they are bulkier, carboxylic acids have less area exposed for the solvent to stabilize the conjugate base

Z) The $sp^2$ hybridized oxygen atom in the hydroxyl group of carboxylic acids draw electrons closer to the nucleus than the $sp^3$ hybridized oxygen in alcohols, stabilizing the conjugate base

ANSWER: X) ONCE DEPROTONATED, CARBOXYLIC ACIDS CAN SPREAD THE NEGATIVE CHARGE OVER BOTH OXYGEN ATOMS THROUGH RESONANCE [GKD]

**BONUS**

8) CHEMISTRY *Short Answer* Alan orders a bottle of mercury off of eBay, but when he receives it, he quickly realizes that he received an element other than mercury. Curious as to what he has received, he performs photoelectron spectroscopy and notices that there are 6 distinct peaks. Assuming that the element was in its ground state when he performed spectroscopy, identify all of the following four elements that Alan could have:

1) Calcium
2) Phosphorous
3) Carbon
4) Rubidium

ANSWER: 1 ONLY (ACCEPT: CALCIUM) [GKD]

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**TOSS-UP**

9) EARTH AND SPACE *Short Answer* Order the following four weather systems from highest to lowest wind speed:

1) Tropical storm
2) Category 5 hurricane
3) F4 tornado

ANSWER: 3, 2, 1 (F4 TORNADO, CATEGORY 5 HURRICANE, TROPICAL STORM) [EB]

**BONUS**

9) EARTH AND SPACE *Multiple Choice* Which of the following describes an igneous rock with a porphyritic texture?

W) A piece of diorite with large phenocrysts **[*FEE-no-crists*]** in a fine-grained groundmass

X) A piece of basalt with crystals only visible under a microscope

Y) A piece of scoria filled with air pockets

Z) A piece of obsidian

ANSWER: W) A PIECE OF DIORITE WITH LARGE PHENOCRYSTS IN A FINE-GRAINED GROUNDMASS [EB]

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**TOSS-UP**

10) MATH *Short Answer* An icon for a person is made up of circles and semicircles. Each icon has a white circle of radius 2 above a white semicircle of radius 6 over the background of a purple circle of radius 10. Expressing your answer in terms of pi, what is the area of the purple part of the icon?

ANSWER: 78 pi [MD]

**BONUS**

10) MATH *Short Answer* In triangle ABC, cevians AX, BY, and CZ intersect at point P. 3*BX = CX, and CY = AY. What is BP/PY?

ANSWER: 6 [MD]

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**TOSS-UP**

11) PHYSICS *Multiple Choice* Which of the following is true about Maxwell's equations?

W) They can be thought of as describing the curl, divergence, and gradient of electric and magnetic fields

X) They imply the nonexistence of magnetic dipoles

Y) They only use linear operators

Z) They were written in their modern form by Maxwell

ANSWER: Y) THEY ONLY USE LINEAR OPERATORS [AC]

**BONUS**

11) PHYSICS *Multiple Choice* 4 current carrying wires are placed at the vertices of a square in the plane of the page, and the wires are normal to the page. If the current in diagonally opposite wires points in the same direction, and any two wires on the same side of the square have opposite currents, which of the following best describes the movement of the wires?

W) They all move closer together

X) They all move farther apart

Y) One diagonal pair moves closer, the other pair moves apart

Z) The square appears to rotate

ANSWER: X) THEY ALL MOVE FARTHER APART [AC]

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**TOSS-UP**

12) ENERGY *Short Answer* Davidson MS B team members are studying mixing. Some polymer solutions are less miscible than solutions of smaller molecules, even though the polymer solutions have stronger interactions. This is because mixing is primarily driven by the increase in what quantity?

ANSWER: ENTROPY (ACCEPT: FREE ENERGY) [AC]

**BONUS**

12) ENERGY *Multiple Choice* Davidson MS C Team members are studying the eightfold way. In particle physics, the eightfold way is an organizational scheme for what particles that are color neutral, even though their constituents aren't?

W) Hadrons and Leptons

X) Leptons and Baryons

Y) Baryons and Mesons

Z) Mesons and Bosons

ANSWER: Y) BARYONS AND MESONS [AC]

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**TOSS-UP**

13) BIOLOGY *Multiple Choice* Which of the following best explains how the immune system is able to generate so many unique immunoglobulins?

W) Genes coding for immunoglobulins undergo random recombination during B cell differentiation

X) The pre-mRNA coding for immunoglobulins undergoes alternative splicing when it is transcribed in B cells

Y) There are many different genes coding for different sections of immunoglobulins whose protein products are randomly assembled in unique combinations to form whole antibodies

Z) Immunoglobulins undergo a variety of different post-translational modifications that alter their 3-dimensional shape

ANSWER: W) GENES CODING FOR IMMUNOGLOBULINS UNDERGO RANDOM RECOMBINATION DURING B CELL DIFFERENTIATION [GKD]

**BONUS**

13) BIOLOGY *Multiple Choice* If an actively contracted muscle is treated with drugs that completely block ATP production, which of the following would you expect to happen once muscle cells run out of ATP?

W) The muscle would instantly go flaccid

X) The muscle would remain rigid until calcium is pumped back into the sarcoplasmic reticulum

Y) The muscle would remain rigid until muscle proteins are enzymatically degraded

Z) The muscle would remain rigid until acetylcholinesterase **[*uh-SEE-tull-ko-luh-NESS-ter-ace*]** degrades all the acetylcholine at the neuromuscular junction

ANSWER: Y) THE MUSCLE WOULD REMAIN RIGID UNTIL MUSCLE PROTEINS ARE ENZYMATICALLY DEGRADED [GKD]

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**TOSS-UP**

14) CHEMISTRY *Short Answer* Griffin is using absorption spectroscopy to measure the concentration of a protein he extracted. Unfortunately, he is extraordinarily bad at math, and during his experimental set-up he accidentally doubles the path length and writes down a value of molar absorptivity that is half the correct value. By what factor would this change the absorbance that he measures?

ANSWER: 1 [GKD]

**BONUS**

14) CHEMISTRY *Multiple Choice* Arnesh wants to synthesize an alkene from an aldehyde. Which of the following reactions would be most appropriate?

W) Hydroboration-oxidation

X) Wittig olefination **[*VIH-dig OLE-uh-fin-AY-shun*]**

Y) Grignard **[*GRIN-yurd*]** reaction

Z) Diels-Alder cycloaddition

ANSWER: X) WITTIG OLEFINATION [GKD]

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**TOSS-UP**

15) EARTH AND SPACE *Short Answer* What is the name of the area on the HR diagram that predicts the behavior of pre-main-sequence stars under three solar masses as they contract and develop a radiative zone?

ANSWER: HAYASHI TRACK [EB]

**BONUS**

15) EARTH AND SPACE *Multiple Choice* Which of the following drainage patterns is characterized by streams flowing in less resistant channels around more resistant rock and entering the main stream at near-right angles?

W) Dendritic

X) Rectangular

Y) Deranged

Z) Trellis

ANSWER: Z) TRELLIS [EB]

(SOLUTION: Rectangular drainage is also characterized by right angles, but that particular drainage pattern forms due to water following joints or fault lines)

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**TOSS-UP**

16) MATH *Short Answer* Bill Gates puts 100 billion dollars in a bank account. Each day, Jeff Bezos hacks into that bank account and transfers half of it into a shell company in the Maldives. How many days will it take for Bill to have less than 1 dollar in his bank account?

ANSWER: 37 [AKa]

**BONUS**

16) MATH *Short Answer* A fly and a spider are in one corner of a room with dimensions 9 foot by 12 foot by 20 foot. The fly flies directly to the opposite corner of the room, while the spider crawls across the wall in the shortest path to the opposite corner. How many feet shorter is the fly's path?

ANSWER: 4 [MD]

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**TOSS-UP**

17) PHYSICS *Short Answer* What additional factor do the Navier-Stokes equations take into account that the Euler equations don't?

ANSWER: VISCOSITY [AC]

**BONUS**

17) PHYSICS *Multiple Choice* The Davidson Academy marching band prowls the streets of Reno at 7 pm every Friday. Which of the following best explains why listeners on different streets will hear low instruments like a tuba before high instruments like a piccolo as the marching band approaches?

W) Low frequency sounds travel faster than high frequency sounds

X) Low frequency sounds dissipate slower than high frequency sounds

Y) Human ears are better at detecting low frequencies than high ones

Z) Low frequency sounds diffract around obstacles better than high frequency sounds

ANSWER: Z) LOW FREQUENCY SOUNDS DIFFRACT AROUND OBSTACLES BETTER THAN HIGH FREQUENCY SOUNDS [AC]

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**TOSS-UP**

18) ENERGY *Multiple Choice* Davidson HS B Team members are studying matrices. What is the determinant of the matrix with first row 1, 4, 8, second row 2, 5, 8, third row 0, 4, 2, fourth row 0, 0, 5

W) 21

X) 26

Y) 40

Z) This matrix does not have a determinant

ANSWER: Z) THIS MATRIX DOES NOT HAVE A DETERMINANT [MD]

**BONUS**

18) ENERGY *Short Answer* Davidson MS B team members are studying periodic changes in Earth's climate. By name or number, identify all of the following three parameters of Earth's orbit that variations in which cause cycles of ice ages and interglacials:

1) Eccentricity
2) Obliquity
3) Orientation of rotational axis

ANSWER: ALL (ACCEPT: ECCENTRICITY, OBLIQUITY, ORIENTATION OF ROTATIONAL AXIS) [EB]

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**TOSS-UP**

19) BIOLOGY *Short Answer* Identify all of the following three classifications that apply to the SARS-CoV-2 virus:

1) Enveloped
2) Positive-sense ssRNA
3) Icosahedral capsid

ANSWER: 1 AND 2 (ACCEPT: ENVELOPED, POSITIVE-SENSE SSRNA) [GKD]

**BONUS**

19) BIOLOGY *Short Answer* Fitness functions are graphs with the value of a trait on the x-axis and the expected fitness on the y-axis. Taking directional selection to mean an increase in the value of a trait is favored, identify all the following three types of selection that would have a positive slope for the entire graph:

1) Directional
2) Stabilizing
3) Disruptive

ANSWER: 1 ONLY [GKD]

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**TOSS-UP**

20) CHEMISTRY *Multiple Choice* Which of the following best describes why metals conduct electricity?

W) They have a large band gap

X) They have a small band gap

Y) Their bands are partially filled

Z) They have no bands

ANSWER: Y) THEIR BANDS ARE PARTIALLY FILLED [GKD]

**BONUS**

20) CHEMISTRY *Short Answer* What mesophase of matter is considered to have anisotropic **[*an-EYE-suh-TROE-pick*]** properties?

ANSWER: LIQUID CRYSTAL [GKD]

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**TOSS-UP**

21) EARTH AND SPACE *Multiple Choice* Winston is sailing in the San Francisco Bay and measures the wavelength of the waves he encounters to be about 3.7 meters. Which of the following measurements is closest to the maximum depth affected by these waves?

W) 185 centimeters

X) 190 centimeters

Y) 195 centimeters

Z) 200 centimeters

ANSWER: W) 185 CENTIMETERS [EB]

**BONUS**

21) EARTH AND SPACE *Multiple Choice* At which of the following orbital resonances would you most expect to find a Kirkwood gap?

W) Three to one

X) Five to four

Y) Three to two

Z) Two to three

ANSWER: Y) THREE TO TWO [EB]

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**TOSS-UP**

22) MATH *Short Answer* When fully simplified, what is the value of (-3-sqrt(5))/(1 - sqrt(5))?

ANSWER: 2 + sqrt(5) [MD]

**BONUS**

22) MATH *Short Answer* Isosceles trapezoid ABCD has sides AB = CD = 15, BC = 25, AD = 7. What is the measure of angle BAC in degrees?

ANSWER: 90 DEGREES [MD]

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**TOSS-UP**

23) PHYSICS *Short Answer* The Schrodinger equation depends upon what operator that acts on the wavefunction?

ANSWER: HAMILTONIAN [AC]

**BONUS**

23) PHYSICS *Short Answer* A photon has frequency $10^{23}$ hertz in jelly, where its speed is sqrt(3)/2 that in vacuum. How much energy, in joules and to two sig figs, does this photon have after it exits the jelly and enters vacuum?

ANSWER: $6.6 * 10^{-11}$ [AC]

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