Competitive Division Double Elimination 3

TOSS-UP

1) BIOLOGY *Short Answer* Order the following three stages of embryogenesis in eudicots from first to last:

1) Torpedo
2) Globular
3) Heart

ANSWER: 2, 3, 1 (ACCEPT: GLOBULAR, HEART, TORPEDO)

BONUS

1) BIOLOGY *Short Answer* In what form of competition do plants produce chemicals toxic to other plant species?

ANSWER: ALLELOPATHY

TOSS-UP

2) CHEMISTRY *Multiple Choice* According to Hückel theory, which of the following molecules is *anti-aromatic*?

W) Naphthalene

X) Octatetraene (pronounced octa-tetra-ene)

Y) Cyclodecapentaene (pronounced cyclo-deca-penta-ene)

Z) Cyclobutadiene (cyclo-buta-di-ene)

ANSWER: Z) CYCLOBUTADIENE

BONUS

2) CHEMISTRY *Short Answer* Identify all of the following three factors that are constant in a microcanonical ensemble:

1) Temperature
2) Total energy
3) Chemical potential

ANSWER: 2 ONLY

TOSS-UP

3) EARTH AND SPACE *Short Answer* By name or number, identify all of the following three types of supernovae that are likely produced by larger stars that have undergone mass loss:

1) Type 2
2) Type 1b
3) Type 1c

ANSWER: 2 AND 3 (ACCEPT: TYPE 1B, TYPE 1C)

BONUS

3) EARTH AND SPACE *Short Answer* By name or number, identify all of the following three statements that are true about groundwater and groundwater zones:

1) In the hyporheic zone, there is mixing of groundwater and surface water
2) The water table is the topmost layer of the aeration zone
3) Soil in the capillary fringe layer is not saturated with water

ANSWER: 1 AND 3

TOSS-UP

4) MATH *Short Answer* The sum of the internal angles of polygon B is twice the sum of the internal angles of polygon A. If polygon A is an octagon, then how many sides does polygon B have?

ANSWER: 14

BONUS

4) MATH *Short Answer* Ethan has seen Eratosthenes' [air-uh-TOSS-thin-ees'] sieve, but misunderstands the point. He writes out every number from 1 to 50, and, starting from 2, crosses off every multiple of that number other than itself, and then goes on to the next number - 3, 4, 5, 6, and so on up to 50. He calls every number that has been crossed out exactly 6 times hextuple composite, because he is super sure they're composite. How many hextuple composite numbers are there?

Answer: 4

TOSS-UP

5) PHYSICS Multiple Choice An electron moving at 200 m/s is deflected by a magnetic field. Which of the following types of radiation would it likely emit?

W) Synchotron radiation

X) Cyclotron radiation

Y) Bremmstrahlung

Z) Beamstrahlung

ANSWER: X) Cyclotron radiation

BONUS

5) PHYSICS *Short Answer* In what space are wavefunctions thought to exist?

ANSWER: HILBERT SPACE

TOSS-UP

6) ENERGY *Short Answer* Davidson HS B team members are studying electric fields due to ions. They note that mobile charge carriers, such as the electrons in a metal, can block the electric field from ions in what phenomenon?

ANSWER: SCREENING (ACCEPT: ELECTRIC FIELD SCREENING)

BONUS

ENERGY *Short Answer* Davidson MS B team members are learning about half angle formulas. What is the cotangent of 15 degrees?

Answer: 2 + sqrt(3)

TOSS-UP

7) BIOLOGY *Short Answer* Colloquially, but inaccurately, referred to as "cold-blooded," what term is given to animals who exhibit a range of body temperatures, particularly as environmental temperature changes?

ANSWER: POIKILOTHERMS [***POY-kih-low-therms***] (DO NOT ACCEPT: ECTOTHERMS)

BONUS

7) BIOLOGY *Short Answer* Phoenixes have a colorless pigment in their feathers that can either be converted to a red pigment or a blue pigment, and they have two genes that regulate this. Phoenixes with at least one copy of the dominant W [***big W***] allele produce an enzyme that inhibits the conversion of the colorless pigment precursor to any colored pigment, while phoenixes with the ww [***little w little w***] phenotype do not produce this enzyme, which allows an enzyme naturally in their feathers to convert the colorless pigment to a blue pigment. Phoenixes with at least one copy of the dominant R [***big R***] allele possess an enzyme that converts the colorless pigment to red pigment instead of blue pigment. In a cross between two WwRr [***big W little w big R little r***] phoenixes, what will the ratio of white to red to blue phoenixes be?

ANSWER: 12:3:1

TOSS-UP

8) CHEMISTRY *Short Answer* How many nodal planes and nodal surfaces, respectively, are there for an 8h orbital?

ANSWER: 5, 2

BONUS

8) CHEMISTRY *Short Answer* How many nodal planes are in the highest energy molecular orbital of benzene?

ANSWER: 3

TOSS-UP

9) EARTH AND SPACE *Short Answer* Due to irregular seafloor topography, tides often get refracted. However, this large-scale movement of water is deflected by the Coriolis force, leading to circulation around what points of minimal tidal fluctuation?

ANSWER: AMPHIDROMIC POINT

BONUS

9) EARTH AND SPACE *Short Answer* By name or number, identify all of the following spectral lines in order of highest temperature peak to lowest-temperature peak:

1) Helium I **[*helium one*]**
2) Hydrogen
3) Calcium II **[*calcium two*]**

ANSWER: 1, 2, 3 (ACCEPT: HELIUM I, HYDROGEN, CALCIUM II)

TOSS-UP

10) MATH *Multiple Choice* Which of the following is a hyperbolic function?

W) y=e^(2x)/2

X) 4x^2 - 4y^2 = 25

Y) y= (e^x)/2 + (e^(-x))/2

Z) x^2+4y^2=25

Answer: Y) (e^x)/2 + (e^(-x))/2

BONUS

10) MATH *Short Answer* Given that x^4+1/x^4=98, what is the product of all possible real values of x+1/x?

ANSWER: -12

TOSS-UP

11) PHYSICS *Multiple Choice* Which of the following best explains why magnetization of a ferromagnetic material occurs in short bursts?

W) Spin is quantized, so magnetization must occur discontinuously

X) Eddy currents delay the magnetization at certain points, which spring back quickly

Y) Defects in the crystal lattice cause sudden changes in magnetic domains

Z) The magnetic field performing the magnetization must magnetize the outer layers of the material and progress inward

ANSWER: Y) Defects in the crystal lattice cause sudden changes in magnetic domains

BONUS

11) PHYSICS *Short Answer* A magnetic scalar potential cannot be described in some cases because of free currents. This is because of what law of electromagnetism?

ANSWER: BIOT-SAVART

TOSS-UP

12) ENERGY *Multiple Choice* Davidson MS C team members are studying meiosis. During what substage of prophase I does crossing over occur?

W) Leptotene

X) Diplotene

Y) Pachytene

Z) Zygotene

ANSWER: Y) PACHYTENE

BONUS

12) ENERGY *Short Answer* Davidson HS A team members are studying drug synthesis schemes. What reaction involves hydrazine and an aldehyde or ketone to produce a heterocycle found in tryptophan, serotonin, and many drugs?

ANSWER: FISCHER INDOLE SYNTHESIS

TOSS-UP

13) BIOLOGY *Multiple Choice* Ashley is studying the expression of a protein using western blots. When she adds the detection reagent, she finds that her blot has extremely high background noise. What error did she most likely make?

W) She did not run her gel on the electrophoresis [***electro-for-EE-sis***] machine for long enough

X) After transferring the gel to a membrane, she forgot to block it

Y) She did not incubate the membrane with secondary antibody for long enough

Z) She used too much detection reagent

ANSWER: X) AFTER TRANSFERRING THE GEL TO A MEMBRANE, SHE FORGOT TO BLOCK IT

BONUS

13) BIOLOGY *Multiple Choice* Which of the following statements about cell signaling is false?

W) $G_{\alpha q}$ [***G-alpha q***] activates phospholipase [***foss-foe-LIE-pase***] C

X) The combination of increased intracellular calcium concentration and diacylglycerol [***die-ASS-il-GLIH-sir-all***] activates protein kinase B

Y) Both G protein-coupled receptors and receptor tyrosine kinases can activate phospholipase C

Z) Cyclic AMP activates protein kinase A

ANSWER: X) THE COMBINATION OF INCREASED INTRACELLULAR CALCIUM CONCENTRATION AND DIACYLGLYCEROL ACTIVATES PROTEIN KINASE B

TOSS-UP

14) CHEMISTRY *Short Answer* For atoms with Z greater than 56, a smaller-than-expected ionic radius is observed. This can be partially be explained by poor shielding by partially or fully filled atomic orbitals and partially by relativistic contractions owing to high-speed electrons. What is this phenomenon called?

ANSWER: LANTHANIDE CONTRACTION

BONUS

14) CHEMISTRY *Short Answer* Under what conditions would a disrotatory electrocyclization of 1,3,5-hexatriene be favored?

ANSWER: THERMAL

TOSS-UP

15) EARTH AND SPACE *Short Answer* Jonathan confirms the discovery of the first Thorne-Żytkow **[*ZHIT-kov*]** object, a type of neutron star formed by the merger of the core of a giant star and a neutron star that takes place inside the giant start itself. In order for the merger to not become a black hole, the combined mass of the original neutron star and the giant star's core must not exceed what limit?

ANSWER: TOV LIMIT (ACCEPT: TOLMAN-OPPENHEIMER-VOLKOFF LIMIT)

BONUS

15) EARTH AND SPACE *Multiple Choice* Which of the following best describes the relationship between El Niño Southern Oscillation, Madden-Julian Oscillation, and the climate of South Asia?

W) Enhanced-phase MJO triggers positive-phase ENSO, causing stronger South Asian monsoons

X) Enhanced-phase MJO triggers negative-phase ENSO, causing stronger South Asian monsoons

Y) Positive-phase ENSO weakens MJO, causing weaker South Asian monsoons

Z) Positive-phase ENSO strengthens MJO, causing weaker South Asian monsoons

ANSWER: Y) POSITIVE-PHASE ENSO WEAKENS MJO, CAUSING WEAKER SOUTH ASIAN MONSOONS

TOSS-UP

16) MATH *Short Answer* Griffin and Emmy are adding pronunciation guides to questions. For each word they consider, they have a 90% chance of making the right call to add one or not. 80% of the words they consider need a guide. What is the probability that, if a word has a pronunciation guide, it is necessary?

Answer: 36/37

BONUS

16) MATH *Short Answer* Determine the least prime factor of the quantity two to the 2019th power end quantity minus one.

ANSWER: 7

TOSS-UP

17) PHYSICS *Short Answer* Many physical constants are exactly the required values they need to be for life to develop in this universe. What principle states that this is not a mystery because if fundamental constants were not the value they are, we would not be here to observe them?

ANSWER: Anthropic principle

BONUS

17) PHYSICS *Short Answer* An optic fiber one light-second long is constructed out of material with a refractive index of 1.6, and a photon is sent along the fiber. What is the maximum time, to the nearest tenth of a second, that the photon will take to reach the end of the fiber?

ANSWER: 2.6

TOSS-UP

18) ENERGY *Short Answer* Davidson HS B Team members are studying star-forming regions. Often found in association with bok globules, what is formed when jet of ionized gas from a newborn star interact with nearby dust clouds to produce a nebula-like cloud?

ANSWER: HERBIG-HARO OBJECT

BONUS

18) ENERGY *Short Answer* Davidson HS A Team members are studying dissolved salts, gases, and nutrients in oceans. By name or number, identify all of the following three dissolved substances whose concentration always increases as depth increases, assuming no upwelling:

1) Carbon dioxide
2) Dissolved salt
3) Oxygen

ANSWER: 1 ONLY (ACCEPT: CARBON DIOXIDE)

TOSS-UP

19) BIOLOGY *Multiple Choice* Which of the following best describes the purpose of dihydropyridine [***di-HI-dro-PEER-uh-deen***] receptors in skeletal muscle?

W) Directly release calcium ions from the sarcoplasmic reticulum

X) Propagate action potentials along the sarcolemma [***sar-co-LEH-muh***]

Y) Bind acetylcholine [***uh-SEE-tul-KO-leen***] released by lower motor neurons

Z) Block the ryanodine [***rye-AN-o-deen***] receptors at rest

ANSWER: Z) BLOCK THE RYANODINE RECEPTORS AT REST

BONUS

19) BIOLOGY *Short Answer* Marathon runners often have resting heart rates below 50 beats per minute. Identify all of the following four factors that would be significantly greater in these runners than in the average adult at rest:

1) End systolic volume
2) End diastolic volume
3) Stroke volume
4) Cardiac output

ANSWER: 2 AND 3 (ACCEPT: END DIASTOLIC VOLUME, STROKE VOLUME)

(SOLUTION: Because they have slower heart rates, they have a longer diastolic filling phase, increasing end diastolic volume. The increased stretch on the ventricles increases the length of sarcomeres, allowing for a greater contraction of the ventricles, increasing stroke volume)

TOSS-UP

20) CHEMISTRY *Short Answer* The quantum harmonic oscillator is generally insufficient at modeling the vibrational structure of a chemical bond. Another model, which varies the potential energy of a chemical bond by distance, considers dissociation energy. What is this model called?

ANSWER: MORSE POTENTIAL

BONUS

20) CHEMISTRY *Short Answer* The Bartoli indole synthesis involves the reaction between a nitroarene and 3 equivalents of vinyl Grignard reagents. The first vinyl Grignard converts the nitro- group to a nitroso- group. The second facilitates a certain pericyclic reaction reminiscent of the Cope rearrangement. Including the number of components, the Cope rearrangement is an example of what general class of pericyclic?

ANSWER: [3,3]-SIGMATROPIC REARRANGEMENT

TOSS-UP

21) EARTH AND SPACE *Multiple Choice* Jonathan is on vacation and spots an interesting-looking mineral. He texts a picture of it to Winston, who identifies it as stibnite. What does the presence of this mineral indicate about the geologic history of Jonathan's location?

W) Past hydrothermal activity

X) Past volcanic activity

Y) Past contact metamorphism

Z) Past intermediate-grade regional metamorphism that has since been brought to the surface via uplift and erosion

ANSWER: W) PAST HYDROTHERMAL ACTIVITY

BONUS

21) EARTH AND SPACE *Multiple Choice* Which of the following is not true about weakening of the polar jet stream?

W) Weakening of the polar jet stream leads to splitting of the polar vortex

X) Weakening of the polar jet stream leads to increased temperatures in the Arctic

Y) Weakening of the polar jet stream leads to more severe mid-latitude winters

Z) Weakening of the polar jet stream is closely associated with anomalously cold polar stratospheric temperatures

ANSWER: Z) WEAKENING OF THE POLAR JET STREAM IS CLOSELY ASSOCIATED WITH ANOMALOUSLY COLD POLAR STRATOSPHERIC TEMPERATURES

TOSS-UP

22) MATH *Short Answer* What is the sum from i=0 to i=2021 of 8 to the power of 4i, taken mod 9?

Answer: 6

BONUS

22) MATH *Multiple Choice* Every day, a virus kills 1% of Earth's population. After 100 days, how much of Earth's population remains to the nearest percentage point, assuming that no other people are born or die during that period?

W) 0%

X) 16%

Y) 37%

Z) 63%

Answer: Y) 37%

TOSS-UP

23) PHYSICS *Short Answer* Name all of the following classes of particles that contain members that are their own antiparticle.

1) Leptons
2) Quarks
3) Bosons
4) Mesons

ANSWER: 3 AND 4 (ACCEPT: BOSONS AND MESONS)

BONUS

23) PHYSICS *Multiple Choice* A particle is in a superposition of states A and B, where state A corresponds to measuring a momentum of 20 and B to measuring a momentum of 10. Which of the following is true when the momentum of many such particles are measured?

W) A continuous range of values will result
X) The momenta will inhabit quantized intervals between 10 and 20, inclusive
Y) Only a momentum of 10 or 20 will be observed for every particle and no intermediate values
Z) A momentum of 15 will be measured for every particle

ANSWER: Y) Only a momentum of 10 or 20 will be observed for every particle and no intermediate values