Competitive Division Round Robin 2

TOSS-UP

1) BIOLOGY *Short Answer* When two spatially separated populations diverge while continuing to interbreed, what type of speciation is occurring?

ANSWER: PARAPATRIC (DO NOT ACCEPT: SYMPATRIC, PERIPATRIC)

BONUS

1) BIOLOGY *Short Answer* Identify all of the following three statements that are true about r/K selection:

1) The first species to colonize a new habitat are typically K-strategists
2) Areas with limited resources favor r-strategists
3) Areas with intermediate levels of ecological disturbance favor r-strategists

ANSWER: NONE

TOSS-UP

2) CHEMISTRY *Short Answer* Order the following three compounds in order of increasing shift in an ^{1}H-NMR [***H***-1 ***N-M-R***] spectrum:

1) Methyl iodide
2) Methyl fluoride
3) Methyl bromide

ANSWER: 1, 3, 2 (ACCEPT: METHYL IODIDE, METHYL BROMIDE, METHYL FLUORIDE)

BONUS

2) CHEMISTRY *Multiple Choice* Which of the following best describes the reason that deuterated solvents such as CDCl3 are used when preparing a sample for NMR analysis:

W) Deuterated solvents typically have higher boiling points compared to their protiated counterparts

X) Deuterated solvents are more polar than their protiated counterparts

Y) Deuterated solvents do not show up on an NMR spectrum, while their protiated counterparts do

Z) Deuterated solvents are less viscous than their protiated counterparts, and therefore are easier to use when working with thin NMR tubes

ANSWER: Y) DEUTERATED SOLVENTS DO NOT SHOW UP ON AN NMR SPECTRUM, WHILE THEIR PROTIATED COUNTERPARTS DO

TOSS-UP

3) EARTH AND SPACE *Short Answer* What is the name of the yellow deposits of windblown silt found in areas like the Mississippi River Valley and eastern China's Huangtu ***[hu-áhng tŭ]*** plateau?

ANSWER: LOESS ***[LOW-ess]***

BONUS

3) EARTH AND SPACE *Short Answer* Emmy is in the Davidson Academy courtyard practicing kung fu, and she notices a slight breeze coming from the southwest. If she turns to face the high pressure center, which cardinal direction is she looking towards?

ANSWER: SOUTHEAST

TOSS-UP

4) MATH *Short Answer* Dallin is emailing students at Davidson Academy to help run DASONI. He sends out a clickbait virus to an equal number of middle and high school kids. Middle schoolers have a 65% chance to click, high schoolers have a 15% chance to click. Out of the kids who clicked, what fraction of them are expected to be high schoolers?

Answer: 3/16

BONUS

4) MATH *Short Answer* Alan the tortoise is hopping around the lattice points in the Cartesian plane. He starts at the origin, and has an equal chance of going to any of the four neighboring lattice points. From then on, he has a 25% chance of moving 1 unit in any given direction. What is the probability that, after 13 moves, he is back at the origin?

ANSWER: 0

TOSS-UP

5) PHYSICS *Short Answer* A spring is connected to a mass and allowed to oscillate. The spring is then cut in half and both halves are connected to the same mass in parallel. By what factor is the period of this oscillator multiplied?

ANSWER: 1/2

BONUS

5) PHYSICS *Short Answer* Gwen builds an electric cake in the shape of an insulating sphere of radius 2 meters. The sphere has a charge density of r coulombs per cubic meter at a distance r from the center of the sphere. Assuming coulomb's constant to be 9 * 10^9 in SI units, what is the electric field by the sphere at a distance of 3 * 10^5 meters away from the sphere, in Volts per meter and in terms of pi?

ANSWER: 1.6 pi

TOSS-UP

6) ENERGY *Short Answer* Davidson HS A Team members are studying acid mine drainage, often abbreviated as AMD. AMD forms when water floods into an abandoned mine and reacts with oxygen and minerals such as pyrite and chalcopyrite to form an acid. What acid is AMD composed of?

ANSWER: SULFURIC

BONUS

6) ENERGY *Short Answer* Davidson HS B team members are playing Belgravian roulette. A Belgravian roulette table contains 19 red numbers, 19 black numbers, and 2 green numbers, all of equal probability. On each spin of the wheel, the team places a 3-dollar bet on red, which will secure a 3-dollar payout plus their 3 dollar bet back if they win. How many spins of the wheel can the team play while still, on average, losing less than ten dollars total?

ANSWER: 66

TOSS-UP

7) BIOLOGY *Short Answer* During fertilization in plants, the pollen tube penetrates through what opening in the ovule?

ANSWER: MICROPYLE

BONUS

7) BIOLOGY *Multiple Choice* Which of the following best describes the state of the *lac* [***LACK***] operon when lactose is present and there are high glucose levels in the cell?

W) Repressor is active, CAP is bound to DNA

X) Repressor is inactive, CAP is bound to DNA

Y) Repressor is active, CAP is not bound to DNA

Z) Repressor is inactive, CAP is not bound to DNA

ANSWER: Z) REPRESSOR IS INACTIVE, CAP IS NOT BOUND TO DNA

TOSS-UP

8) CHEMISTRY *Short Answer* Identify all of the following three geometries in which a coordination complex could display *cis-trans* isomerism:

1) Square planar
2) Octahedral
3) Square pyramidal

ANSWER: 1 AND 2 (ACCEPT: SQUARE PLANAR, OCTAHEDRAL)

BONUS

8) CHEMISTRY *Short Answer* Sulfuric acid can dehydrate to create oleum, or $H_2S_2O_7$. Oleum is an extremely strong acid due to $S_2O_7^{2-}$'s high stability. How many stable resonance structures does $S_2O_7^{2-}$ have?

ANSWER: 9

TOSS-UP

9) EARTH AND SPACE *Short Answer* In 1995, Pegasi 51b was the first exoplanet discovered orbiting a sun-like star. However, the first exoplanets were first detected in 1992. What class of star did these planets orbit?

ANSWER: PULSAR (DO NOT ACCEPT: NEUTRON STAR)

BONUS

9) EARTH AND SPACE *Short Answer* Sometimes, when a comet encounters a change in the magnitude and strength of the sun's magnetic field, the tail of the comet breaks off from the nucleus. What is the name for this event?

ANSWER: DISCONNECTION EVENT

TOSS-UP

10) MATH *Short Answer* How many distinct digits are in the base 5 representation of ⅓?

ANSWER: 2

BONUS

10) MATH *Short Answer* What is the positive difference between the arithmetic and geometric mean of the zeros of the polynomial x cubed minus 21 x squared plus 84 x minus 64?

Answer: 3

TOSS-UP

11) PHYSICS *Multiple Choice* During the summer, Akshansh looks out the window and notices that microscopic particles of all the smoke in the air scatter light passing through them. Which of the following types of light will be scattered most?

W) Long wavelength light

X) Short wavelength light

Y) Linearly polarized light

Z) Circularly polarized light

ANSWER: X) SHORT WAVELENGTH LIGHT

BONUS

11) PHYSICS *Short Answer* In General Relativity, gravity is thought of not as a force but as a result of objects following the geodesic through curved spacetime. This curved spacetime results from what tensor?

ANSWER: STRESS-ENERGY

TOSS-UP

12) ENERGY *Short Answer* Davidson HS A team members are studying allotropes of carbon, which can be classified according to hybridization. One class of sp^2-hybridized carbons are planar graphenes and graphite. The other is a 3-dimensional structure resembling a soccer ball. What is this allotrope of carbon called?

ANSWER: BUCKMINSTERFULLERENE (ACCEPT: FULLERENE, BUCKY BALL)

BONUS

12) ENERGY *Short Answer* Davidson MS A team members are studying immunology. Identify all of the following three isotypes of antibodies that can be membrane-bound:

1) IgD
2) IgM
3) IgG

ANSWER: ALL

TOSS-UP

13) BIOLOGY *Short Answer* Arvind is investigating an uncharacterized protein. He performs RT-PCR and sees moderate expression of the mRNA encoding the protein in a cell line, but when he extracts protein and performs a western blot, he doesn't detect any protein in the cells. He hypothesizes that they are targeted for degradation in proteasomes [***PRO-tea-uh-zomes***] by the attachment of what small peptide upon translation?

ANSWER: UBIQUITIN [***you-BICK-wih-tin***]

BONUS

13) BIOLOGY *Short Answer* What waste product is formed from the breakdown of the porphyrin [***POR-fer-in***] ring in hemoglobin?

ANSWER: BILIRUBIN (ACCEPT: BILIVERDIN)

TOSS-UP

14) CHEMISTRY *Short Answer* Natural cholesterol is biosynthesized via an oxidation of squalene, followed by a cascade reaction and a triple demethylation. The overall process yields 8 stereocenters. How many stereoisomers are there of cholesterol, besides natural cholesterol?

ANSWER: 255 (2^8 - 1, from natural cholesterol)

BONUS

14) CHEMISTRY *Short Answer* Identify all of the following three modifications to amino acids that would allow them to form disulfide bonds:

1) Demethylate methionine (meth-EYE-oh-neen)
2) Replacing the hydroxyl group in the side chain of serine with a thiol group
3) Replacing the primary amide side chain in asparagine (uh-SPARE-uh-geen) with a thioester (THIGH-oh-ester)

ANSWER: 1 AND 2

TOSS-UP

15) EARTH AND SPACE *Short Answer* What type of star cluster is made up of similarly-aged stars, formed from the same molecular cloud, that are expected to drift apart over time, an example of which is the Pleiades cluster?

ANSWER: OPEN CLUSTER

BONUS

15) EARTH AND SPACE *Multiple Choice* Which of the following statements is not true of red tides?

W) They can lead to the formation of hypoxic or anoxic zones

X) They lead to buildup of harmful toxins in shellfish

Y) They are generally caused by increased levels of nitrates and sulfates

Z) They generally occur near the coast

ANSWER: Y) THEY ARE GENERALLY CAUSED BY INCREASED LEVELS OF NITRATES AND SULFATES

TOSS-UP

16) MATH *Short Answer* How many zeros are in the base 7 expansion of 60 base 10 factorial?

Answer: 9

BONUS

16) MATH *Short Answer* When writing DASONI, Emmy has 24 blank problem slots that she needs to dish out between 5 writers, giving each writer no more than 6 questions. How many ways can she do this?

Answer: 210

TOSS-UP

17) PHYSICS *Short Answer* Diatomic molecules can be modeled as what systems that can be analyzed using the Schrodinger equation?

ANSWER: QUANTUM HARMONIC OSCILLATOR (DO NOT ACCEPT: SIMPLE HARMONIC OSCILLATOR)

BONUS

17) PHYSICS *Multiple Choice* An n-mutilated spring is constructed as follows. A base spring is cut into n pieces, then these n pieces are attached parallel to each other to make a new spring. Which of the following best describes how k, the spring constant of the new spring, is related to n, the number of pieces the spring is cut into?

W) Proportional to n

X) Proportional to n^2

Y) Exponential in n

Z) Proportional to n^3

ANSWER: X) Proportional to n^2

TOSS-UP

18) ENERGY *Short Answer* Davidson HS B Team members are studying hadrons. They hate free hadrons and love watching them decay. What free hadron is least satisfying to watch, as it does not decay quickly?

ANSWER: PROTON

BONUS

18) ENERGY *Multiple Choice* Davidson HS A Team members are studying the Harvard Computers and their work in completing the Draper catalogue and creating what is now known as the Harvard classification scheme. Which of the following Harvard Computers was the first to classify stars based off their spectral type by grouping them in terms of the strength of their Balmer absorption lines?

W) Annie Jump Cannon

X) Henrietta Swan Leavitt

Y) Williamina Fleming

Z) Florence Cushman

ANSWER: W) ANNIE JUMP CANNON

TOSS-UP

19) BIOLOGY *Short Answer* Excess neurotransmitter is removed from the synaptic cleft by what type of glial **[*GLEE-ul*]** cell?

ANSWER: ASTROCYTES

BONUS

19) BIOLOGY *Multiple Choice* The P wave on an electrocardiogram is most directly due to which of the following?

W) Sodium influx into atrial cardiomyocytes

X) Potassium efflux out of atrial cardiomyocytes

Y) Sodium influx into ventricular cardiomyocytes

Z) Potassium efflux out of ventricular cardiomyocytes

ANSWER: W) SODIUM INFLUX INTO ATRIAL CARDIOMYOCYTES

TOSS-UP

20) CHEMISTRY *Short Answer* The most general formulation of the equilibrium constant expresses reactants and products in terms of what thermodynamic property?

ANSWER: ACTIVITY

BONUS

20) CHEMISTRY *Short Answer* Consider the following gas-phase reaction at 1000 K: $PCl_5 \rightarrow PCl_3 + Cl_2$. To the nearest significant figure, by what factor is K_c multiplied by to yield K_p?

ANSWER: 80

TOSS-UP

21) EARTH AND SPACE *Multiple Choice* Which of the following best describes the active layer in soil science?

W) A layer that contains groundwater due to capillary action

X) A layer with high cation exchange capacity, leading to depletion of ions like potassium and sodium

Y) A layer below which there is not enough water to support plants

Z) A layer that freezes in winter but thaws in summer

ANSWER: Z) A LAYER THAT FREEZES IN WINTER BUT THAWS IN SUMMER

BONUS

21) EARTH AND SPACE *Short Answer* What major type of coral reef is commonly attached to the shore and lacks a backreef?

ANSWER: FRINGING REEF

TOSS-UP

22) MATH *Short Answer* A sphenocorona (sfee-noh-cor-oh-nuh) is a polyhedron with 22 edges and 14 faces. How many vertices does it have?

ANSWER: 10

BONUS

22) MATH *Short Answer* The volume of every conversation follows a sin(t*pi/b)^2 pattern. A moment of awkward silence occurs when all conversations have a volume of zero. A room devolves into 5 side conversations at 8:00 am. The conversations have b values of 2, 3, 4, 6, and 11. When is the first moment of awkward silence?

ANSWER: 10:12 am

TOSS-UP

23) PHYSICS *Short Answer* A machine stores energy by producing a magnetic field inside a spherical glitter bead. If the radius of the glitter bead is quadrupled and the strength of the magnetic field is halved, how many times more energy can this new machine store?

ANSWER: 16

BONUS

23) PHYSICS *Short Answer* A block of frozen carbonite is hung next to the Davidson science bowl coach's desk. The block of carbonite is in the shape of a 2 meter long rectangular prism with a cross section of 1 meter by 0.2 meters. If the coach hangs a 1000 newton weight from the block and it stretches by 2 centimeters, what is the Young's modulus of the block, in Pascals?

ANSWER: 500,000