AVES



DE 6

TOSS-UP

1) MATH *Short Answer* Edwin is trying to approximate the sum from i=1 to 100 of the square root of i. To do this, he computes the sum from i=1 to 100 of the floor of square root of i and then computes the sum from i=1 to 100 of the ceiling of square root of i. He then averages these values to get his final answer. If he computed the sum of the floor of square root of i as 625, what approximation would he get for the sum from i=1 to 100 of square root of i?

ANSWER: 670 [RG]

BONUS

1) MATH *Short Answer* What is the seventh derivative of $x^2 \sin(x)$ evaluated at x = 0?

ANSWER: 42 [RG]

TOSS-UP

2) BIOLOGY *Multiple Choice* Which of the following types of chromosome would lack a p arm?

W) Metacentric

X) Submetacentric

Y) Telocentric

Z) Acrocentric

ANSWER: Y) Telocentric [EH]

BONUS

2) BIOLOGY *Short Answer* Identify all of the following three hormones whose concentration would decrease in a plant undergoing de-etiolation:

1) Auxins;

2) Gibberellins;

3) Brassinosteroids.

ANSWER: All of them [EH]

TOSS-UP

3) PHYSICS *Short Answer* Identify all of the following 3 quantities that could be the change in strangeness during a weak process:

1) -1;

2) 0;

3) 1.

ANSWER: All [RG]

BONUS

3) PHYSICS *Short Answer* Consider a given RLC circuit, containing a resistor of resistance 5 ohms, an inductor of inductance 500 millihenries, and a capacitor of capacitance 5 millifarads. All elements are connected in series to a 10 V power source. When the angular frequency of the system is equal to 20 rad/s, what is the impedance of the circuit in ohms?

ANSWER: 5 [AK]

TOSS-UP

4) EARTH AND SPACE *Short Answer* Identify all of the following four masses that could reasonably be the mass of a neutron star:

1) 1 solar mass;

2) 2 solar masses;

3) 3 solar masses;

4) 4 solar masses.

ANSWER: 2 only [PB]

BONUS

4) EARTH AND SPACE *Short Answer* Order the following three igneous rocks in terms of increasing depth at which they could be found in an ophiolite complex:

1) Diabase;

2) Dunite;

3) Gabbro.

ANSWER: 1, 3, 2 [PB]

TOSS-UP

5) CHEMISTRY *Multiple Choice* Which of the following explains how phosphorescence is able to persist for much longer than fluorescence?

W) It involves heavier elements which fall back to their original state much slower

X) It forms a pair of parallel spins which revert back much slower

Y) An electron is lost in fluorescence which creates instability

Z) It releases a different set of particles which are less effective at luminescence

ANSWER: X) It forms a pair of parallel spins which revert back much slower [RG]

BONUS

5) CHEMISTRY *Multiple Choice* A sample of an ideal gas initially at 1000 Kelvin is cooled to 500 Kelvin at constant volume**.** In kilojoules, what is closest to the amount of kinetic energy per mole lost in the process?

W) 2

X) 4

Y) 6

Z) 8

ANSWER: Y) 6 [AK]

TOSS-UP

6) MATH *Short Answer* Rohan has been playing a game and is wondering if it will ever end**.** He realizes that for a player to make a move, a specific quantity called the score of the game must be a positive integer**.** However, after each move, the score must decrease, so he realizes the game must eventually end**.** What is the name of such a variable, which only changes in one direction and is often useful in proving whether a game is finite?

ANSWER: Monovariant [RG]

BONUS

6) MATH *Short Answer* Consider the polynomial P, which is the product from i = 1 to 6 of (x^i-1) [**read: product from i = 1 to 6 of open parenthesis x to the power of i minus one close parenthesis**]**.** How many distinct roots does P have?

ANSWER: 12 [RG]

TOSS-UP

7) BIOLOGY *Short Answer* Smooth muscle cells lack the specialized motor-end plates found in skeletal muscle fibers, so instead they are stimulated when neurotransmitters are released from what small swollen regions along the axons of passing neurons?

ANSWER: Varicosities [EH]

BONUS

7) BIOLOGY *Multiple Choice* On the inner surface of vesicles formed by endocytosis, Toll-like receptor 3 serves a vital role in the cell's innate defense by binding to fragments from a certain set of pathogens. Which of the following family of viruses would Toll-like receptor 3 most likely defend against?

W) Sedoreoviridae

X) Parvoviridae

Y) Picornaviridae

Z) Filoviridae

ANSWER: W) Sedoreoviridae [RA]

TOSS-UP

8) PHYSICS *Short Answer* Edwin is experimenting with an iron torus by winding a coil of wire around it and running a current through it to generate a magnetic field. He slowly increases the current and notices that the iron torus is exerting a stronger magnetic field. However, when he decreases the current back to the original amount, he observes that the iron torus is still exerting a magnetic field stronger than it was originally. What phenomenon is occurring to the iron torus?

ANSWER: Hysteresis [EH]

BONUS

8) PHYSICS *Short Answer* A particle of charge 2 coulombs traveling in the xy plane with a speed of 10 meters per second is subject to a magnetic field in the xy plane with magnitude 6 teslas and angled 30 degrees with respect to the velocity vector. The particle is also subject to an electric field directed along the z-axis with a magnitude 12 Newtons per coulomb. What is the minimum and maximum possible magnitudes of the overall force on the particle respectively?

ANSWER: 36 and 84 [RG]

TOSS-UP

9) EARTH AND SPACE *Multiple Choice* Which of the following best represents the effect of La Niña on wind shear and tropical cyclone formation in the Atlantic, respectively?

W) Increase, increase

X) Increase, decrease

Y) Decrease, increase

Z) Decrease, decrease

ANSWER: Y) Decrease, increase [PB]

BONUS

9) EARTH AND SPACE *Short Answer* Edward is extraordinarily rich and as a result has decided to recreate the solar system, exactly the same as ours**.** Currently, he is working on his planet Sram, the fourth and final terrestrial planet**.** He finds that on his Mars-like planet Sram, there are no flood basalt plains or outflow channels from deep groundwater escaping present, and there is a high presence of phyllosilicate minerals**.** Edward most likely messed up by forgetting to replicate what period of Mars' development on Sram?

ANSWER: Hesperian period [RA]

TOSS-UP

10) CHEMISTRY Short Answer Consider a hydrogen atom with an electron in the 1s orbital. What is the ratio of the probability of the electron being found in a small region around the nucleus to the probability it is found in the same small region at a distance of 2 Bohr radii away?

ANSWER: $1/e^2$ [RG]

BONUS

10) CHEMISTRY *Short Answer* Order the following 3 ligands by increasing magnitude of the field splitting they produce:

1) Cyanide.

2) Fluoride ion;

3) Water;

ANSWER: 2, 3, 1 [RG]

TOSS-UP

11) MATH *Multiple Choice* Which of the following must be true about a function f over the real numbers that satisfies f of the quantity x+y is equal to f of x plus f of y for all real x and y?

W) f is linear

X) f has an infinite number of roots

Y) f has a root at x=0

Z) f is continuous

ANSWER: Y) f has a root at x=0 [RG]

BONUS

11) MATH *Short Answer* Evaluate the summation from k=1 to infinity of 1/(2k+1)^2 (READ: the fraction with numerator 1 and denominator the quantity 2k+1 squared).

ANSWER: pi^2/8 - 1 [RG]

TOSS-UP

12) BIOLOGY *Short Answer* Identify all of the following three characteristics about mRNA in prokaryotes that are true:

1) A single mRNA can encode for multiple proteins;

2) mRNA lacks UTRs before the reading frame;

3) Prokaryotic mRNA generally has a longer degradation time than eukaryotic mRNA .

ANSWER: 1 only [EH]

BONUS

12) BIOLOGY *Multiple Choice* Gnathosomes are named for their development of jaws, but they also share other derived characteristics. Which of the following is a derived characteristic found in all gnathostomes?

W) The covering of the gills by the operculum

X) A lateral line system to detect vibrations in the surrounding water

Y) Neural crest cells that give rise to the cartilage of the skull

Z) A swim bladder to maintain a buoyancy equal to the surrounding water

ANSWER: X) A lateral line system to detect vibrations in the surrounding water [EH]

TOSS-UP

13) PHYSICS *Short Answer* Rohan the fish uses his superfish abilities to look at a moving proton in the water he lives in as it passes by. He notices that the proton is giving off a blue glow. Assuming the speed of light is 3.0 times 10^8 meters per second, identify all of the following four speeds that the proton could be traveling at:

1) 2 times 10^8 meters per second;

2) 2.5 times 10^8 meters per second;

3) 2.9 times 10^8 meters per second;

4) 3.0 times 10^8 meters per second.

ANSWER: 2 and 3 [RG]

BONUS

13) PHYSICS *Short Answer* A ball is held over a building at a height of 50 meters and dropped. At a unique point during its fall, the Lagrangian is equal to 0, assuming the potential energy at the ground is 0. How long, in seconds and to the nearest tenth, does the ball fall for until reaching this point?

ANSWER: 2.2 [RG]

TOSS-UP

14) EARTH AND SPACE *Short Answer* Ship tracks increase the overall albedo of Earth because of what effect, which describes how an increase in cloud condensation nuclei results in smaller cloud droplets that reflect more radiation?

ANSWER: Twomey effect [PB]

BONUS

14) EARTH AND SPACE *Short Answer* Identify all of the following 3 types of gasses in which a Fraunhofer line would be seen in the continuous spectrum of the gasses's spectral lines:

1) A hot dense gas;

2) A hot diffuse gas;

3) A cool diffuse gas.

ANSWER: 3 only [RG]

TOSS-UP

15) CHEMISTRY *Short Answer* Certain metals like manganese exhibit antiferromagnetism where neighboring spins are locked into an antiparallel arrangement**.** However, this only exists at low temperatures**.** What is the name for the temperature at which a paramagnetic material when cooled becomes an antiferromagnetic material?

ANSWER: Neel temperature [RG]

BONUS

15) CHEMISTRY *Multiple Choice* Atropisomerism occurs mainly due to the effects of what type of strain preventing the rotation of a single bond?

W) Torsional

X) Angle

Y) Steric

Z) Transannular

ANSWER: Y) Steric [EH]

TOSS-UP

16) MATH *Short Answer* Srijon is trying to solve a Gaussian integral**.** What trick in integration should he use, which involves creating a new parameter for the function and then differentiating under the integral?

ANSWER: Feynman's Trick [RG]

BONUS

16) MATH *Multiple Choice* Which of the following is closest to the sum from i=1 to 50 of the number of factors of i?

W) 100

X) 150

Y) 200

Z) 250

ANSWER: Y) 200 [RG]

TOSS-UP

17) BIOLOGY *Short Answer* Identify all of the following four scenarios in which base excision repair could fix the error in the DNA strand:

1) Mismatched base pairing of uracil with guanine

2) Carbon-carbon double bond conversion to carbon-carbon single bond in cytosine

3) Formation of a covalent bond between adjacent thymine bases on the same strand

4) Double strand break during the G2 phase of the cell cycle

ANSWER: 1 and 2 only [EH]

BONUS

17) BIOLOGY *Short Answer* From the progression of N3 sleep to REM sleep, order the following three features from first to last of appearance:

1) K-complex;

2) Delta rhythm;

3) 32 hertz oscillations.

ANSWER: 2, 1, 3 [RA/EH]

TOSS-UP

18) PHYSICS *Multiple Choice* Around which of the following axes would a uniformly dense cube have the largest moment of inertia?

W) An axis through two opposite corners

X) An axis through the center of the cube and the center of face

Y) An axis through the center of the cube and the center of an edge

Z) All of these axes have the same moment of inertia

ANSWER: Z) All of these axes have the same moment of inertia [RG]

BONUS

18) PHYSICS *Multiple Choice* In Minkowski space, which of the following would best describe the cosmological constant?

W) Positive but finite

X) Negative but finite

Y) Zero

Z) Infinite

ANSWER: Y) Zero [EH]

TOSS-UP

19) EARTH AND SPACE *Short Answer* The current leading theory for the structure of grand design spiral galaxies describes spiral arms as what kind of waves, in which misaligned elliptical orbits happen to concentrate stars in a spiral pattern?

ANSWER: Density waves (Accept: spiral density waves) [PB]

BONUS

19) EARTH AND SPACE *Multiple Choice* Which of the following orogenies did NOT contribute to the formation of the Appalachian Mountains?

W) Alleghanian

X) Grenville

Y) Laramide

Z) Taconic

ANSWER: Y) Laramide [PB]

TOSS-UP

20) CHEMISTRY *Short Answer* Grignard's reagents can attack a wide range of electrophiles due to the large electronegativity difference between its constituent carbon and what other element?

ANSWER: Magnesium [RG]

BONUS

20) CHEMISTRY *Multiple Choice* In the reaction between acetone and cyanide, what would be the HOMO of the nucleophile and the LUMO of the electrophile in the reaction respectively?

W) pi, sigma star

X) nonbonding, sigma star

Y) pi, pi star

Z) nonbonding, pi star

ANSWER: Z) nonbonding, pi star [EH]
