AVES



DE 3

TOSS-UP

1) MATH *Short Answer* Aarav is performing a chi-square test. If he rejected the null hypothesis, identify all of the following three errors that he could have made:

1) Type I;

2) Type II;

3) Type III.

ANSWER: 1 and 3 [RG]

BONUS

1) MATH *Short Answer* Ritwik creates a list of the factors of 8. Edwin makes a copy of Ritwik's list, but squares every integer in the list. What is the positive difference between the sum of elements in Edwin's list and the sum of the elements in Ritwik's list?

ANSWER: 70 [RG]

TOSS-UP

2) BIOLOGY *Short Answer* Order the following three diseases by increasing number of Barr bodies a person exhibits in their somatic cells:

1) Klinefelter syndrome;

2) Turner's syndrome;

3) Triple X**.**

ANSWER: 2, 1, 3 [EH]

BONUS

2) BIOLOGY *Short Answer* Aarav the botanist is experimenting with the lemon plants in his garden**.** According to the ABC hypothesis, identify all of the following three genes that he could knockout individually to produce more lemons per flower:

1) A gene;

2) B gene;

3) C gene**.**

ANSWER: 1 and 2 [EH]

TOSS-UP

3) PHYSICS *Short Answer* Identify all of the following three particles that can interact with the strong force:

1) Electron antineutrino;

2) Pion;

3) Neutron.

ANSWER: 2 and 3 [EH]

BONUS

3) PHYSICS *Short Answer* In a certain medium, light travels at a speed of 1.73 times 10^8 meters per second and in a second medium, light travels at a speed of 1 times 10^8 meters per second. At what angle in degrees, to the nearest integer, must light of a particular polarization be incident for it to be perfectly transmitted with no reflection to go from the first medium to the second medium?

ANSWER: 60 [RG]

TOSS-UP

4) EARTH AND SPACE *Multiple Choice* In which of the following geologic periods could trilobite fossils not have been present?

W) Carboniferous

X) Cretaceous

Y) Devonian

Z) Permian

ANSWER: X) Cretaceous [PB]

BONUS

4) EARTH AND SPACE *Short Answer* Order the following four spectral classes by increasing Balmer line strength:

1) O;

2) A;

3) F;

4) M.

ANSWER: 1, 4, 3, 2 [RA]

TOSS-UP

5) CHEMISTRY *Short Answer* Dalton's law states that the partial pressure of an individual gas is proportional to the mole fraction of the gas in the mixture. What law, analogous to Dalton's law, gives a similar statement about vapor pressures?

ANSWER: Raoult's law [RG]

BONUS

5) CHEMISTRY *Short Answer* Consider the reaction H_2O (g) + CO (g) yields H_2 (g) + CO_2 (g) where the equilibrium constant is equal to 1. If the concentration of H_2O is 0.5 molar and the concentration of CO is 0.25 molar at the start, what is the concentration of CO_2 present at equilibrium to two significant figures in molarity?

ANSWER: 0.17 [EH]

TOSS-UP

6) MATH *Multiple Choice* Which of the following explains why a regular pentagon can not tessellate the plane?

W) A polygon with more than 4 sides cannot tessellate the plane

X) The interior angle is not a factor of 360 degrees

Y) A regular pentagon is not rotationally symmetrical

Z) The sine of the interior angle is not rational

ANSWER: X) The interior angle is not a factor of 360 degrees [RG]

BONUS

6) MATH *Short Answer* Rohan considers all pairs of subsets of the first 9 positive integers, call the two subsets A and B, such that the union of A and B is the set of the first 9 positive integers. If he chooses the subsets A and B randomly out of all the possible subsets with the property, what is the expected number of elements in the intersection of A and B?

ANSWER: 3 [RG]

TOSS-UP

7) BIOLOGY *Short Answer* Deamination is the removal of the nitrogen-containing group from an amino acid to form a keto acid and what other compound?

ANSWER: Ammonia [EH]

BONUS

7) BIOLOGY *Short Answer* Identify all of the following three nucleotide substitutions in an mRNA codon that could cause a premature stop codon in translation:

1) Adenine to guanine;

2) Guanine to adenine;

3) Uracil to cytosine.

ANSWER: 2 only [GG]

TOSS-UP

8) PHYSICS *Short Answer* Identify all of the following 3 types of scattering that are considered elastic:

1) Rayleigh scattering;

2) Thomson scattering;

3) Raman scattering.

ANSWER: 1 and 2 [RG]

BONUS

8) PHYSICS *Short Answer* A particle with a mass of 3 kilograms is initially at rest. It splits into 3 particles each of mass 1 kilogram. Two of the particles move at 3 meters per second with an angle of 60 degrees between them. What is the speed of the last particle?

ANSWER: $3\sqrt{3}$ [RG]

TOSS-UP

9) EARTH AND SPACE *Short Answer* The Sloan Great Wall is the largest structure known in the universe. This structure is made up of voids and what long narrow structures constituted by superclusters?

ANSWER: Galactic filaments (Accept: filaments) [RA]

BONUS

9) EARTH AND SPACE *Short Answer* Rohan is playing a game! He is given two minerals and told their identities in random order. He is trying to figure out which mineral is which. However, the only piece of information he gets about the two minerals is whether they can scratch a streak plate. Identify all of the following three pairs of minerals in which Rohan would lose the game because he does not know the identities with certainty:

1) Orthoclase and quartz;

2) Topaz and talc;

3) Calcite and apatite.

ANSWER: 3 only [RG]

TOSS-UP

10) CHEMISTRY *Multiple Choice* The boiling point elevation of a compound is proportional to what power of molality?

W) -1

X) 0

Y) 1

Z) 2

ANSWER: Y) 1 [RG]

BONUS

10) CHEMISTRY *Short Answer* Order the following three spectral series of hydrogen in terms of increasing wavelength:

1) Balmer;

2) Paschen;

3) Lyman.

ANSWER: 3, 1, 2 [RG]

TOSS-UP

11) MATH *Multiple Choice* Aarav has a triangle and for each pair of sides, he computes the ratio of the larger side to the smaller side. He obtains 3 numbers as a result and takes the minimum of these 3. Which of the following is true about the minimum?

W) It can be any positive real number

X) It can be any positive real number less than 3 but greater than or equal to 1

Y) It can be any positive real number less than or equal to 2 but greater than or equal to 1

Z) It can be any positive real number less than 2 but greater than or equal to 1

ANSWER: Z) It can be any positive real number less than 2 but greater than or equal to 1 [RG]

BONUS

11) MATH *Short Answer* In triangle ABC, side BC has length 4 and angle A has measure 60 degrees. What is the area of the circumcircle of the triangle?

ANSWER: 16pi/3 [RG]

TOSS-UP

12) BIOLOGY *Short Answer* Hemoglobin is able to deliver oxygen to oxygen-deprived tissues because its affinity for oxygen drops at these tissues from high carbon dioxide production. This is due to what effect in which low pH at these tissues decreases hemoglobin's affinity for oxygen?

ANSWER: Bohr shift (Accept: Bohr effect) [EH]

BONUS

12) BIOLOGY *Multiple Choice* In cellular respiration, how many electrons are deposited to the electron transport chain from an input of one glucose molecule?

W) 12

X) 20

Y) 22

Z) 24

ANSWER: Z) 24 [EH]

TOSS-UP

13) PHYSICS *Short Answer* Rohan has a 11 meter tall jug which is completely filled with water. A faucet 1 meter above the ground lets water drip out and is initially closed. To the nearest integer, at what speed does the water leave the faucet immediately when he opens the faucet, assuming flow is laminar and the area of the faucet is significantly smaller than the cross sectional area?

ANSWER: 14 [RG]

BONUS

13) PHYSICS *Multiple Choice* Rohan builds a lego tower 10 meters high on the ground such that its mass is uniformly distributed, and calculates the location of the center of mass and the center of gravity. Being lazy, he assumes the Earth is a perfect sphere. Which of the following describes the relative position of the center of mass and the center of gravity?

W) The center of mass is closer to Earth than the center of gravity

X) The center of gravity is closer to Earth than the center of mass

Y) The center of gravity and the center of mass are at the same distance from the Earth

Z) Not enough information is provided

ANSWER: X) The center of gravity is closer to Earth than the center of mass [RG]

TOSS-UP

14) EARTH AND SPACE *Short Answer* Order the following three stages of thunderstorm development from earliest to latest:

1) Water condenses into raindrops in the cloud and starts to fall;

2) A downdraft begins to blow;

3) A strong updraft develops.

ANSWER: 3, 1, 2 [EH]

BONUS

14) EARTH AND SPACE *Short Answer* When a neutron star's degenerate core is compressed further than its degeneracy pressure, it is theorized to become what kind of compact, exotic star, characterized by its behavior as a Fermi liquid?

ANSWER: Quark star (Accept: strange star) [RA]

TOSS-UP

15) CHEMISTRY *Short Answer* Rohan creates a new element that forms a unique unit cubic cell. There is an atom at half of the corners, half of the faces, and one in the center. How many atoms exist inside each unit cell?

ANSWER: 3 [RG]

BONUS

15) CHEMISTRY *Short Answer* Order the following three acids by increasing pH of their equivalence point in a titration with NaOH:

1) $HClO_2$;

2) $HBrO_3$;

3) HIO_2.

ANSWER: 2, 1, 3 [RG]

TOSS-UP

16) MATH *Short Answer* Identify all of the following 3 positive integers that can be expressed as the sum of two perfect squares:

1) 13;

2) 29;

3) 31.

ANSWER: 1 and 2 [RG]

BONUS

16) MATH *Short Answer* Two real numbers a and b satisfy the equations a + (1 over b) = 5 and b + (1 over a) = 7. What is the sum of the possible values of the product of ab?

ANSWER: 33 [RG]

TOSS-UP

17) BIOLOGY *Multiple Choice* Which of the following gases is a product of cellular respiration in the reduced mitochondria of parabasalids?

W) Carbon monoxide

X) Methane

Y) Hydrogen gas

Z) Hydrogen sulfide

ANSWER: Y) Hydrogen gas [EH]

BONUS

17) BIOLOGY *Multiple Choice* Dr. Dalbert is treating a patient with an adenoma in one of his four parathyroid glands. The patient's bloodstream has an abnormally high concentration of parathyroid hormone. Which of the following vitamins would most likely be produced in excess due to this patient's condition?

W) Thiamine

X) Tocopherol

Y) Phylloquinone

Z) Calcitriol

ANSWER: Z) Calcitriol [EH]

TOSS-UP

18) PHYSICS *Multiple Choice* Rohan is finding the number of unstable and stable equilibrium configurations. He has 3 point charges of 1 coulomb, 2 coulombs, and -3 coulombs. He places the 1 coulomb charge at x = 0 and the -3 coulomb charge at x = 3. How many ways can Rohan place the 2 coulomb charge on the x-axis such that the particles are in unstable and stable equilibrium respectively?

W) 0, 0

X) 0, 1

Y) 1, 0

Z) 2, 0

ANSWER: Y) 1, 0 [RG]

BONUS

18) PHYSICS *Short Answer* A torsional pendulum consisting of a suspended thin spherical shell of radius 3 meters and mass 2 kg, is being rotated about an axis 10 centimeters away and parallel to an axis through its center. If the period of the sphere's oscillation is 12.56 seconds, then to one significant figure, what is the torsional constant of the wire suspending the shell?

ANSWER: 3 [AK]

TOSS-UP

19) EARTH AND SPACE *Short Answer* Identify all of the following three celestial objects which may display Herbig Haro objects:

1) Protostars;

2) Super massive black holes;

3) Protoplanets.

ANSWER: 1 only [RA]

BONUS

19) EARTH AND SPACE *Multiple Choice* Between which of the following two plates would a convergent boundary most likely be found?

W) Cocos and Nazca plate

X) Caribbean and South American plate

Y) Juan de Fuca and Pacific plate

Z) Australian-Indian and Antarctic plate

ANSWER: X) Caribbean and South American plate [EH]

TOSS-UP

20) CHEMISTRY *Short Answer* Identify all of the following three orbitals that have exactly 1 radial node:

1) 3p;

2) 3d;

3) 4f.

ANSWER: 1 only [RG]

BONUS

20) CHEMISTRY *Short Answer* Gaurav has an acid with a concentration of 0.9 molar. The pKb of the conjugate base is 9. What is the hydrogen ion concentration of the acid, to one significant figure and in scientific notation?

ANSWER: 3×10^{-3} [RG]
