AVES



DE 4

TOSS-UP

1) MATH *Short Answer* Ritwik plugs 3 into 1/x and gets 1/3. He plugs in 1/3, and gets 3 again. 1/x is what type of function, which when applied twice, yields the identity function?

ANSWER: Involution [RG]

BONUS

1) MATH *Short Answer* Edwin has a number and he squares it. Identify all of the following three values that could be the ratio of the number of factors the number originally had to the number of factors it had after he squared it:

1) 2/5;

2) 2/3;

3) 4/5.

ANSWER: 1 and 2 [RG]

TOSS-UP

2) BIOLOGY *Multiple Choice* A fatty acid chain is completely broken down through beta oxidation to produce 4 ATP in the citric acid cycle**.** How many carbon atoms must the fatty acid chain have initially?

W) 4

X) 8

Y) 16

Z) 20

ANSWER: X) 8 [EH]

BONUS

2) BIOLOGY *Multiple Choice* Which of the following is not a function of the hypothalamus?

W) Produce antidiuretic hormone

X) Control food swallowing

Y) Synchronize circadian rhythms

Z) Regulate body temperature

ANSWER: X) Control food swallowing [EH]

TOSS-UP

3) PHYSICS *Multiple Choice* A straight wire with a constant current running through it is attached to the diameter of a disk spinning counterclockwise. A circular loop of wire is placed directly above the spinning disk with their centers aligned, close enough so that the magnetic field from the current of the straight wire penetrates the loop of wire. In what direction would an induced current flow through the loop of wire?

W) Clockwise

X) Counterclockwise

Y) The current would alternate between clockwise and counterclockwise directions

Z) No current would be induced

ANSWER: Z) No current would be induced [AK/EH]

BONUS

3) PHYSICS *Short Answer* The radius of a planet is triple that of Earth. The ratio of the planet's surface gravity to Earth's surface gravity is equal to the ratio of the planet's escape velocity to Earth's escape velocity. What is the ratio of the planet's mass to Earth's mass?

ANSWER: 27 [RG]

TOSS-UP

4) EARTH AND SPACE *Short Answer* Identify all of the following three lunar features that are more common in maria than in the lunar highlands:

1) Craters;

2) Domes;

3) Rilles.

ANSWER: 2 and 3 [PB]

BONUS

4) EARTH AND SPACE *Short Answer* The formation of the Himalayas, resulted from the collision between the Indian plate and the Eurasian plate. What is the general term for a boundary between two continents where they are now welded together?

ANSWER: Suture [EH]

TOSS-UP

5) CHEMISTRY *Short Answer* Identify all of the following three types of colloids in which the dispersed medium is a liquid.

1) Aerosol;

2) Gel;

3) Emulsion;

ANSWER: 2 and 3 [RG]

BONUS

5) CHEMISTRY *Multiple Choice* Which of the following is true about the transferred heat into a system in a process that keeps volume constant?

W) It is equal to the change in internal energy

X) It is equal to the change in enthalpy

Y) It is equal to the change in work

Z) It varies depending on the type of work done

ANSWER: Z) It varies depending on the type of work done [RG]

TOSS-UP

6) MATH *Multiple Choice* Let A be the expected number of times you have to roll a fair, six-sided dice to get the numbers 1, 2, 3 on three consecutive rolls in that order. Similarly, let B be the expected number of times you have to roll it to get the numbers 1, 1, and 2 on three consecutive rolls in that order. Which of the following describes the relationship between A and B?

W) A is less than B

X) A is greater than B

Y) A is equal to B

Z) One of A or B is infinite and hence not comparable

ANSWER: Y) A is equal to B [RG]

BONUS

6) MATH *Multiple Choice* Five positive integers have a product of 2024. What is the smallest possible sum they could have?

W) 40

X) 41

Y) 42

Z) 43

ANSWER: W) 40 [RG]

TOSS-UP

7) BIOLOGY *Short Answer* Most fungi have hyphae that are divided into cells by cross-walls called septa. What term describes species of fungi that lack septa and thus, consist of a continuous cytoplasmic mass having hundreds or thousands of nuclei?

ANSWER: Coenocytic (Accept: aseptate) [EH]

BONUS

7) BIOLOGY *Short Answer* Rohan is studying a mysterious disease. He notices that a cross between a father from a family without history of the disease and a diseased mother produced a diseased son. He also observes that a cross between a normal phenotype father from a family with history of the disease and a diseased mother produced a diseased child 50% of the time. Identify all of the following three inheritance patterns that the disease could follow:

1) Autosomal dominant;

2) Autosomal recessive;

3) X-linked recessive.

ANSWER: 1 and 3 [EH]

TOSS-UP

8) PHYSICS *Multiple Choice* Rohan has a spherical ball filled with water. He lets the water exit the ball at a constant rate. Which of the following best describes the height of the center of mass of the system containing the water in the ball and the ball as time progresses?

W) Always decreases

X) Always increases

Y) Decreases and then increases

Z) Increases and then decreases

ANSWER: Y) Decreases and then increases [RG]

BONUS

8) PHYSICS *Short Answer* A cylindrical resistor has a cross-sectional area of 5 square meters, length of 6 meters, and resistivity of 20 ohm meters. If 5 of these identical resistors are placed in parallel in a circuit with a current of 10 amperes, what will the voltage of the circuit be in volts?

ANSWER: 48 [GG]

TOSS-UP

9) EARTH AND SPACE *Short Answer* Daniel is observing an absorption nebula in the sky. His inquisitive nature and unrelenting spirit of exploration for the human race leads him to seek out what lays beyond this nebula. Identify all of the following three telescopes with which he could use to analyze the region beyond:

1) James Webb Space Telescope;

2) Chandra Observatory;

3) Fermi Space Telescope.

ANSWER: 1 only [RA]

BONUS

9) EARTH AND SPACE *Short Answer* Unlike Schwarschild and Reissner–Nordström black holes, Kerr and Kerr-Newman black holes are defined to have a nonzero value of what quantity?

ANSWER: Angular momentum [PB]

TOSS-UP

10) CHEMISTRY *Multiple Choice* In which of the following scenarios would increasing the number of moles of electrons per mole of reaction transferred increase the equilibrium constant?

W) The reaction is exothermic

X) The reaction is endothermic

Y) The cell potential is negative

Z) The cell potential is positive

ANSWER: Z) The cell potential is positive [RG]

BONUS

10) CHEMISTRY *Short Answer* Identify all of the following three systems that can accurately be described by the Bohr model:

1) Hydrogen atom;

2) Helium-1+ ion;

3) Beryllium-2+ ion.

ANSWER: 1 and 2 [EH]

TOSS-UP

11) MATH *Short Answer* Rotating or dilating the complex plane around the origin can be done by multiplying every complex number by a fixed complex number. If Gaurav wants to dilate by a factor of 2 and rotate an angle of 60 degrees clockwise, what complex number would he multiply by?

ANSWER: 1- i sqrt3 [RG]

BONUS

11) MATH *Short Answer* The probability a weighted spinner is split into regions labeled 1 through 4 and the probability a region is spun is proportional to the area of the region. If the area of the region numbered i is proportional to 1 over i, what is the probability two consecutive spins are prime?

ANSWER: 4/25 [RG]

TOSS-UP

12) BIOLOGY *Multiple Choice* Krutharth is studying the mechanisms of saltatory conduction and counts there to be nine nodes of Ranvier in the axon of a single neuron**.** Which of the following best predicts the number of Schwann cells that are myelinating this axon?

W) 1

X) 8

Y) 9

Z) 10

ANSWER: Z) 10 [EH]

BONUS

12) BIOLOGY *Short Answer* Identify all of the three statements that are true about phytochromes in plant development and photoperiodism:

1) The conversion of Pfr to Pr is faster than the conversion of Pr to Pfr in daylight;

2) A higher ratio of Pfr to Pr would stimulate plant vertical growth;

3) A short-day plant with a critical night length of 12 hours would flower if exposed to a flash of far-red light followed by a flash of red light 8 hours into darkness in the middle of 14 hours of otherwise continuous darkness**.**

ANSWER: 2 only [RA]

TOSS-UP

13) PHYSICS *Short Answer* Identify all of the following three steps of a Carnot cycle that would decrease temperature:

1) Adiabatic compression;

2) Adiabatic expansion;

3) Isothermal compression.

ANSWER: 2 only [RG]

BONUS

13) PHYSICS *Short Answer* A charged conducting sphere is surrounded by a conducting shell with negligible thickness. The radius of the sphere is 1 meter, and the radius of the shell is 2 meters. The electric field strength at the point halfway between the outer surface of the sphere and the inner surface of the shell is measured to be 8 times 10^9 directed outwards in volts per meter. What is the charge on the inner surface of the shell?

ANSWER: -2 [AK]

TOSS-UP

14) EARTH AND SPACE *Short Answer* Identify all of the following four glacial depositional features that are made of sorted sediments:

1) Drumlins;

2) Kames;

3) Moraines;

4) Eskers.

ANSWER: 2 and 4 [EH]

BONUS

14) EARTH AND SPACE *Multiple Choice* Which of the following is the main limiting factor for phytoplankton growth in the spring bloom?

W) Depletion of nutrients

X) Dwindling sunlight

Y) Decreasing salinity

Z) Increased predation

ANSWER: W) Depletion of nutrients [EH]

TOSS-UP

15) CHEMISTRY Short Answer What is the maximum number of diastereomers a molecule could have if the molecule has 7 chiral centers?

ANSWER: 126 [RG]

BONUS

15) CHEMISTRY Short Answer According to molecular orbital theory, identify all of the following four molecules that have the same bond order as H_2:

1) He_2^{2+};

2) B_2;

3) O_2^{2-};

4) F_2^{2+}.

ANSWER: 1, 2, 3 [RG]

TOSS-UP

16) MATH *Multiple Choice* Consider the function f(x) which is equal to the sum from n = 1 to infinity of x to the power of n divided by n. Which of the following is the value of the derivative of f at x = 1/3?

W) 2/3

X) 3/2

Y) 2

Z) 3

ANSWER: X) 3/2 [RG]

BONUS

16) MATH *Short Answer* Rohan is trying to flip as many heads as possible on 3 fair coins. He flips the 3 coins. After looking at the results, for each coin, he can choose whether or not he wants to flip it again. If he plays optimally, what is the expected number of heads he gets?

ANSWER: 9/4 [RG]

TOSS-UP

17) BIOLOGY *Multiple Choice* Daniel is tending to a plant in his garden when he notices that the older leaves have started to yellow. Chlorosis in older leaves is a symptom of many nutrient deficiencies, but Daniel believes that the plant is deficient in magnesium. Which of the following observations would confirm Daniel's suspicion?

W) The leaves of the plant show uniform yellowing

X) Most of the chlorosis happens between the veins of the leaves

Y) The leaves are curled and have a scorched appearance

Z) The plant also exhibits poor flowering

ANSWER: X) Most of the chlorosis happens between the veins of the leaves [EH]

BONUS

17) BIOLOGY *Short Answer* Identify all of the following three cellular structures that are plastids:

1) Statolith;

2) Kinetoplast;

3) Glyoxysome.

ANSWER: 1 only [EH]

TOSS-UP

18) PHYSICS *Short Answer* Every event in spacetime can influence future events or be influenced by past ones**.** The set of all points in spacetime that can be reached by a light signal emitted from a specific event, or from which a light signal can reach that event, is known as what region?

ANSWER: Light cone [AK/EH/RG]

BONUS

18) PHYSICS *Short Answer* A standing wave has length 2 meters and mass 5 grams with fundamental frequency of 50 hertz**.** What is the tension on the string in newtons?

ANSWER: 100 [RG]

TOSS-UP

19) EARTH AND SPACE *Multiple Choice* The influence of which of the following currents decreases precipitation on continental coastlines?

W) Brazil current

X) Kuroshio current

Y) Agulhas current

Z) Humboldt current

ANSWER: Z) Humboldt current [EH]

BONUS

19) EARTH AND SPACE *Short Answer* Order the following four features of Saturn's rings from innermost to outermost:

1) C ring;

2) Encke gap;

3) Cassini Division;

4) A ring.

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

TOSS-UP

20) CHEMISTRY *Short Answer* Rohan is trying to determine the lattice enthalpy of potassium oxide. Identify all of the following 3 quantities that he must know about potassium to calculate the lattice enthalpy if he is using the Born-Haber cycle:

1) First ionization energy;

2) Second ionization energy;

3) Electron affinity.

ANSWER: 1 only [RG]

BONUS

20) CHEMISTRY *Short Answer* Identify all of the following 3 oxides that are amphoteric:

1) Magnesium oxide;

2) Aluminum oxide;

3) Copper (II) oxide.

ANSWER: 2 and 3 [RG]
