AVES

DE 1

TOSS-UP

1) MATH *Short Answer* Rohan is driving and notices that the time, 10:01, is a palindrome. After driving for 42 miles, he notices that the time is again a palindrome, the first time since he last observed such a time. What was his average speed over this interval, in miles per hour?

ANSWER: 36 [RG]

BONUS

1) MATH *Multiple Choice* How many positive integers that are at most 100 have at least one odd factor greater than 1?

W) 50

X) 90

Y) 92

Z) 93

ANSWER: Z) 93 [RG]

TOSS-UP

2) BIOLOGY *Short Answer* Identify all of the following three organ systems that the heart belongs to:

1) Circulatory;

2) Respiratory;

3) Endocrine.

ANSWER: 1 and 3 [EH]

BONUS

2) BIOLOGY *Multiple Choice* Auxin triggers cell elongation in plants primarily by stimulating which of the following ATPases?

W) Proton pump

X) Sodium-potassium pump

Y) Calcium pump

Z) Chloride pump

ANSWER: W) Proton pump [EH]

TOSS-UP

3) PHYSICS *Short Answer* Positronium is a system of two particles that consists of an electron and positron. However, such a system is highly unstable due to the result of what process, in which a particle and antiparticle collide and disappear?

ANSWER: Annihilation [RG]

BONUS

3) PHYSICS *Short Answer* Edwin is looking at the up and down quarks found in the 6 protons of a carbon atom. What is the ratio of the total charge of the up quarks to the total charge of the down quarks among the quarks he is studying?

ANSWER: -4 [RG/EH]

TOSS-UP

4) EARTH AND SPACE *Multiple Choice* A planet starts at perihelion and completes a full revolution. Which of the following describes how the planet's velocity changes throughout its motion?

W) Increases then decreases

X) Decreases then increases

Y) Stays the same

Z) Always increases

ANSWER: X) Decreases then increases [RG]

BONUS

4) EARTH AND SPACE *Short Answer* Identify all of the following three statements that are true of seismic waves:

1) L-waves have a larger amplitude than P-waves;

2) S-waves cause particles of material to move back and forth parallel to the direction of the wave;

3) R-waves cause the ground to ripple up and down.

ANSWER: 1 and 3 [EH]

TOSS-UP

5) CHEMISTRY *Multiple Choice* Which of the following allotropes of phosphorus is the most reactive?

W) Red

X) White

Y) Black

Z) Violet

ANSWER: X) White [EH]

BONUS

5) CHEMISTRY *Short Answer* Identify all of the following 3 statements that are true regarding pH:

1) The pH of a solution is always greater than or equal to 0;

2) The pH of pure water is always 7;

3) Increasing the pOH of a solution always decreases the pH at constant temperature.

ANSWER: 3 only [EH]

TOSS-UP

6) MATH *Short Answer* Two concentric circles have radius 3 and 6. A tangent is drawn to the smaller circle and it intersects the larger circle at two points A and B. What is the length of the segment AB?

ANSWER: $6\sqrt{3}$ [RG]

BONUS

6) MATH *Short Answer* A sphere with radius 3 has the same numerical value of its surface area as the circumference of a circle. What is the ratio of the volume of the sphere to the area of the circle, ignoring units?

ANSWER: 1/9 [RG]

TOSS-UP

7) BIOLOGY *Short Answer* Some plant leaves have specialized epidermal cells that form hair-like outgrowths to prevent water loss and defend against invaders. What are these structures called?

ANSWER: Trichomes [EH]

BONUS

7) BIOLOGY *Short Answer* Identify all of the following three transport pathways that a vesicle could take in a cell:

1) Golgi apparatus to endoplasmic reticulum;
2) Golgi apparatus to peroxisome;
3) Nucleus to endoplasmic reticulum.

ANSWER: 1 only [EH]

TOSS-UP

8) PHYSICS *Multiple Choice* Edwin wakes up one day and decides to test his strength by seeing how much he can stretch different materials**.** He finds some rubber and some nylon, and attempts to stretch both until they rip, but he notices that doing so for the nylon requires more force than for the rubber, due to nylon having a higher value for what property?

W) Bulk modulus

X) Young's modulus

Y) Compressive strength

Z) Tensile strength

ANSWER: Z) Tensile strength [AK]

BONUS

8) PHYSICS *Multiple Choice* The Higgs Boson was discovered recently and was the first known scalar boson**.** Which of the following properties distinguishes a scalar boson?

W) It has zero spin

X) It has nonzero spin

Y) It has zero mass

Z) It has nonzero mass

ANSWER: W) It has zero spin [RG]

TOSS-UP

9) EARTH AND SPACE *Multiple Choice* The atmosphere is conditionally stable**.** Which of the following best describes the stability of unsaturated and saturated air parcels respectively?

W) Unstable; unstable

X) Unstable; stable

Y) Stable; unstable

Z) Stable; stable

ANSWER: Y) Stable; unstable [EH]

BONUS

9) EARTH AND SPACE *Multiple Choice* Which of the following statements about impact cratering on the moon is not true?

W) Darker ejecta rays are older than lighter rays as a result of solar weathering

X) The South Pole–Aitken basin is the largest crater on the moon's surface

Y) Lunar maria formed as a result of lava flooding impact craters

Z) The large impact hypothesis explains why the moon has high levels of iron in its mantle and crust

ANSWER: Z) The large impact hypothesis explains why the moon has high levels of iron in its mantle and crust [RA]

TOSS-UP

10) CHEMISTRY *Short Answer* A reaction can be split into several elementary reactions. Using these, it is possible to determine a precise formula for the rate law. However, this can usually be simplified using what approximation, which assumes that the change in concentrations of intermediates is constant?

ANSWER: Steady-state approximation [RG]

BONUS

10) CHEMISTRY *Short Answer* The solid-liquid boundary in a phase diagram for a compound has a negative slope. Identify all of following three statements that would necessarily be true about this compound:

1) The solid phase is denser than the liquid phase;
2) The melting point of the compound increases with pressure;
3) The liquid phase would have lower entropy than the solid phase.

ANSWER: None of them [EH]

TOSS-UP

11) MATH *Short Answer* Order the following three numbers in terms of increasing number of factors:

1) 48;

2) 49;

3) 50.

ANSWER: 2, 3, 1 [RG]

BONUS

11) MATH *Multiple Choice* Alice, Bob, and Carl are trying to build a house. They each work at a constant rate but two people don't necessarily work at the same rate. If Alice and Bob can build the house in 3 hours, Bob and Carl can build the house in 4 hours, and Alice and Carl can build the house in 5 hours, how long would it take them together to build the house?

W) 12/5

X) 90/37

Y) 120/47

Z) 60/23

ANSWER: Y) 120/47 [RG]

TOSS-UP

12) BIOLOGY *Short Answer* During RNA processing, the pre-mRNA is modified in the 5' to 3' direction. Order the following three enzymes from first to last to modify the pre-mRNA:

1) Poly-A polymerase;

2) Guanine-7 methyltransferase;

3) snRNA.

ANSWER 2, 3, 1 [EH]

BONUS

12) BIOLOGY *Short Answer* Identify all of the following three diseases that result from a gain-of-function mutation:

1) Huntington's disease;

2) Phenylketonuria;

3) Duchenne muscular dystrophy.

ANSWER: 1 only [EH]

TOSS-UP

13) PHYSICS *Multiple Choice* If a uniform solid sphere always has a density of 1 kilogram per meter cubed, the moment of inertia of the sphere varies with what power of its radius?

W) 2

X) 3

Y) 4

Z) 5

ANSWER: Z) 5 [RG]

BONUS

13) PHYSICS *Short Answer* Gaurav exerts a force of 20 newtons for 4 seconds on a box of mass 5 kilograms which was initially at rest. What is the average power exerted on the box over the 4 seconds?

ANSWER: 160 [RG/GG]

TOSS-UP

14) EARTH AND SPACE *Short Answer* Order the following three periods by increasing average atmospheric oxygen content:

1) Carboniferous;

2) Triassic;

3) Ediacaran.

ANSWER: 3, 2, 1 [EH]

BONUS

14) EARTH AND SPACE *Multiple Choice* A theoretical binary system contains Star A, a subgiant star, and Star B, a main sequence star. Which of the following outcomes would be expected to occur over time?

W) Star A will increase in mass while Star B will decrease in mass

X) Star A will decrease in mass while Star B will increase in mass

Y) Star A will decrease in mass while Star B will maintain its mass

Z) Star B will decrease in mass while Star A will maintain its mass

ANSWER: X) Star A will decrease in mass while star B will increase in mass [RA]

TOSS-UP

15) CHEMISTRY *Multiple Choice* Which of the following elements is most likely to form an interstitial alloy with iron?

W) Carbon

X) Copper

Y) Zinc

Z) Aluminum

ANSWER: W) Carbon [EH]

BONUS

15) CHEMISTRY *Short Answer* How many electrons does barium with atomic number 56 possess in its n = 4 shell when it is in its ground state?

ANSWER: 18 [GG]

TOSS-UP

16) MATH *Multiple Choice* Which of the following describes the convergence of the series with Nth term $(-1)^n/n$ **[read: negative 1 to the power of n divided by n]**?

W) Diverges

X) Converges conditionally

Y) Converges absolutely

Z) Partially divergent

ANSWER: X) Converges conditionally [RG]

BONUS

16) MATH *Short Answer* Edwin has a list of 100 integers all initially equal to 1. For each positive integer n between 1 and 100 inclusive, he flips the sign of every Nth integer in the list. For example, after n=1 is completed, the list is filled with negative ones. After he finishes this procedure, what is the sum of the integers in the list?

ANSWER: 80 [RG]

TOSS-UP

17) BIOLOGY *Short Answer* Angiotensin II binds to receptors in the adrenal cortex to stimulate the release of what hormone responsible for maintaining the salt and water balance in the bloodstream?

ANSWER: Aldosterone [EH]

BONUS

17) BIOLOGY *Multiple Choice* Which of the following is true about the electron carrier NADP in photosynthesis?

W) NADP+ is reduced in the Calvin Cycle

X) NADPH is generated in the thylakoid space during the light-dependent reactions

Y) Reducing NADP+ to NADPH involves the addition of one electron

Z) NADPH formation during the light-dependent reactions increases the pH of the stroma

ANSWER: Z) NADPH formation during the light-dependent reactions increases the pH of the stroma [EH]

TOSS-UP

18) PHYSICS *Multiple Choice* Which of the following distributions describes the energy levels of a gluon?

W) Bose-Einstein

X) Planck

Y) Fermi-Dirac

Z) Maxwell

ANSWER: W) Bose-Einstein [RG]

BONUS

18) PHYSICS *Short Answer* If an object in front of a lens has an object distance of 12 cm and an image distance of 30 cm, what is the radius of curvature of the lens in centimeters, rounded to the nearest whole number?

ANSWER: 17 [GG]

TOSS-UP

19) EARTH AND SPACE *Short Answer* What limit is defined as the maximum luminosity a body can achieve under hydrostatic equilibrium before it begins to lose mass by intense solar wind?

ANSWER: Eddington limit [RA]

BONUS

19) EARTH AND SPACE *Short Answer* Identify all of the following three actions that would decrease the melting point of magma:

1) Adding water to the magma;

2) Shifting the composition of the magma to include more mafic minerals;

3) Increasing the pressure exerted on the magma.

ANSWER: 1 only [EH]

TOSS-UP

20) CHEMISTRY *Short Answer* Ritwik is shining a laser through smoke in a glass tube. He notices that he is able to see clearly the path that the light takes through the tube. What effect does this demonstrate in which light is scattered by particles in a colloid?

ANSWER: Tyndall effect [EH]

BONUS

20) CHEMISTRY *Short Answer* Pratham is working with the elementary reaction A + B yields 2C. The rate constant of the forward reaction is 12 liters per mole seconds and the rate constant of the reverse reaction is 3 liters per mole seconds. What is the equilibrium constant of the reaction 4C yields 2A + 2B under the same conditions?

ANSWER: 1/16 [RG]
