AVES

DE 2

TOSS-UP

1) MATH *Multiple Choice* If $\log_3(a) + \log_3(b) = 4$ and $\log_3(a) - \log_3(b) = 2$, what is a – b?

W) 3

X) 24

Y) 27

Z) 30

ANSWER: X) 24 [RG]

BONUS

1) MATH *Short Answer* In how many ways can you choose a subset of the first 6 positive integers such that the subset contains at least one odd number and at least one even number?

ANSWER: 49 [RG]

TOSS-UP

2) BIOLOGY *Multiple Choice* Which of the following parts of a plant cell is not a component of its protoplast?

W) Plasma membrane

X) Cell wall

Y) Endosome

Z) Nucleus

ANSWER: X) Cell wall [RA]

BONUS

2) BIOLOGY *Short Answer* In eukaryotes, order the following three steps of translation initiation from first to last:

1) Small subunit binds to the mRNA at the 5' cap **[read as: 5 prime cap]**;

2) Large subunit of the ribosome binds to the small subunit;

3) Initiator tRNA charged with methionine binds to the small subunit**.**

ANSWER: 3, 1, 2 [EH]

TOSS-UP

3) PHYSICS *Short Answer* Identify all of the following three laws that are a consequence of the conservation of energy:

1) Kirchhoff's junction rule;

2) Bernoulli's principle;

3) First law of thermodynamics.

ANSWER: 2 and 3 [EH]

BONUS

3) PHYSICS *Short Answer* In a spring mass system, the magnitude of the force required to stretch the spring 3 meters is 12 newtons. If the block attached to the spring has mass 1 kilogram, what is the frequency of the system in terms of pi and in hertz?

ANSWER: 1/π [RG]

TOSS-UP

4) EARTH AND SPACE *Short Answer* What term is used to describe a rock with large crystals embedded in a matrix of fine crystals, which is formed by a rapid change in the cooling speed of its parent magma?

ANSWER: Porphyritic [PB]

BONUS

4) EARTH AND SPACE *Multiple Choice* Which of the following best describes the solar nebula hypothesis for the formation of the solar system?

W) The planets moons and asteroids were all formed from a spinning disk of dust and light elements around the sun

X) Large differentiated bodies from different sources slowly entered orbit around our sun, colliding and combining to form the bodies of our solar system

Y) A large body passing nearby our sun created tidal forces that ejected filaments to form a nebula, from which solar system bodies could form

Z) The collision of two nebulae early in the universe's history led to the creation of our sun as well as the bodies surrounding it

ANSWER: W) The planets moons and asteroids were all formed from a spinning disk of dust and light elements around the sun [RA]

TOSS-UP

5) CHEMISTRY *Multiple Choice* When an aqueous solution of lithium fluoride is electrolyzed, which of the following gases is most likely to be detected at the anode?

W) Hydrogen

X) Fluorine

Y) Oxygen

Z) Water vapor

ANSWER: Y) Oxygen [RG]

BONUS

5) CHEMISTRY *Short Answer* By number, rank the following three compounds in order of increasing dipole moment:

1) Xenon dioxide;

2) Boron trifluoride;

3) Ammonia.

ANSWER: 2, 1, 3 [GG]

TOSS-UP

6) MATH *Multiple Choice* What is the first digit of 2^{50}?

W) 1

X) 2

Y) 3

Z) 4

ANSWER: W) 1 [RG]

BONUS

6) MATH *Multiple Choice* When the region bounded by the x-axis, y-axis, x = 4, and $y = x^2$ is rotated around the x-axis, a region is formed. What is the volume of this region?

W) $256\pi/5$

X) $512\pi/5$

Y) $1024\pi/5$

Z) $2048\pi/5$

ANSWER: Y) $1024\pi/5$ [RG]

TOSS-UP

7) BIOLOGY *Multiple Choice* Which of the following plant structures is the first to emerge from a germinating seed?

W) Hypocotyl

X) Epicotyl

Y) Plumule

Z) Radicle

ANSWER: Z) Radicle [RA]

BONUS

7) BIOLOGY *Short Answer* Identify all of the following three types of bonds that could be found between an enzyme and its substrate during a chemical reaction:

1) Covalent;

2) Ionic;

3) Hydrogen.

ANSWER: All of them [EH]

TOSS-UP

8) PHYSICS *Short Answer* Identify all of the following 3 changes that could occur to the magnitude of the charge stored in a parallel plate capacitor when a dielectric is inserted:

1) Increase;

2) Decrease;

3) No change.

ANSWER: 1 and 3 [RG]

BONUS

8) PHYSICS *Short Answer* A block has a potential energy function U of x defined to be $2x^3 - 10x^2 + 5x + 6$. At what position x is the acceleration on the particle maximized?

ANSWER: 5/3 [RG]

TOSS-UP

9) EARTH AND SPACE *Short Answer* Identify all of the following three features that are made from the depositional ability of longshore currents:

1) Spit;

2) Baymouth bar;

3) Tombolo.

ANSWER: All of them [EH]

BONUS

9) EARTH AND SPACE *Multiple Choice* Which of the following is not true about sand dunes?

W) Longitudinal dunes are parallel to the direction of the wind

X) Transverse dunes are perpendicular to the direction of the wind

Y) Barchan dunes form where supplies of sand are plentiful

Z) Parabolic dunes form in areas where vegetation partially covers the sand

ANSWER: Y) Barchan dunes form where supplies of sand are plentiful [EH]

TOSS-UP

10) CHEMISTRY *Short Answer* Identify all of the following three pairs of orbitals that could overlap to create a sigma bond:

1) Two s-orbitals;

2) One s and one p orbital;

3) Two p orbitals.

ANSWER: All of them [RG]

BONUS

10) CHEMISTRY *Short Answer* In phosphorus pentachloride, identify all of the following 4 bond angles that are present between two chlorine atoms:

1) 90°;

2) 109.5°;

3) 120°;

4) 180°.

ANSWER: 1, 3, 4 [RG]

TOSS-UP

11) MATH *Short Answer* If n! [**read: n factorial**] ends with 4 zeroes, what is the maximum number of zeroes (n+1)! [**read: the quantity n plus one factorial**] can end with?

ANSWER: 6 [RG]

BONUS

11) MATH *Multiple Choice* What is the argument, in radians, of the complex number 2 to the power of the quantity i times π?

W) natural log of 2

X) 2 times π over e

Y) π times natural log of 2 over 2

Z) π times natural log of 2

ANSWER: Z) π times natural log of 2 [RG]

TOSS-UP

12) BIOLOGY *Short Answer* The AluI [**read as: aloo one**] restriction enzyme recognizes the DNA sequence AGCT, cutting between guanine and cytosine**.** What type of endings are created by the AluI restriction enzyme?

ANSWER: Blunt ends (Do not accept: sticky ends) [EH]

BONUS

12) BIOLOGY *Multiple Choice* Kian breeds a true breeding fruit fly all-recessive for two traits with a true breeding fruit fly all-dominant for the same two traits**.** How would the frequency of recombinant phenotypes in the F1 generation differ if the two genes encoding for the traits were linked compared to if it was not?

W) If the genes were linked, the frequency of recombinant phenotypes would most likely be greater

X) If the genes were linked, the frequency of recombinant phenotypes would most likely be smaller

Y) The frequency of recombinant phenotypes would be about the same

Z) The frequency of recombinant phenotypes varies unpredictably

ANSWER: Y) The frequency of recombinant phenotypes would be about the same [EH]

TOSS-UP

13) PHYSICS *Short Answer* What quantity for a metal determines the minimum energy a photon must have in order to eject an electron from the metal?

ANSWER: Work function [RG]

BONUS

13) PHYSICS *Multiple Choice* A long metal rod is grounded on one end. A negatively charged metal rod is slowly brought closer to the metal rod at the other end until it touches. Which of the following best describes the overall charge of the metal rod in the period of the negative rubber rod approaching to just after the metal rod makes contact?

W) Positive then negative

X) Positive then neutral

Y) Negative then neutral

Z) Always neutral

ANSWER: X) Positive then neutral [EH]

TOSS-UP

14) EARTH AND SPACE *Short Answer* The Tully-Fisher relation is used to estimate our distance from galaxies by comparing the galaxy's luminosity to what other mechanical quantity of the galaxy?

ANSWER: Rotational velocity [PB]

BONUS

14) EARTH AND SPACE *Multiple Choice* At the beginning of a solar cycle, sunspots typically occur in which of the following locations?

W) In the photosphere near the poles

X) In the photosphere near the equator

Y) In the chromosphere near the poles

Z) In the chromosphere near the equator

ANSWER: W) In the photosphere near the poles [PB]

TOSS-UP

15) CHEMISTRY *Short Answer* In an atom, two electrons reside in the 3p orbital. Identify all of the following 3 quantum numbers that must be the same for these two electrons:

1) Principal;

2) Azimuthal;

3) Orbital magnetic.

ANSWER: 1 and 2 [RG]

BONUS

15) CHEMISTRY *Short Answer* At an unknown temperature, the ion-product constant for water Kw equals 1.0 x 10^{-15}. What is the neutral pH value at this temperature to one decimal point?

ANSWER: 7.5 [EH]

TOSS-UP

16) MATH *Short Answer* Rohan is particularly fond of the number 1729, since it is the first positive integer that can be expressed as the sum of two cubes in two different ways, as 1729 is both $12^3 + 1^3$ and $10^3 + 9^3$. Identify all of the 3 primes which are factors of 1729:

1) 3;

2) 13;

3) 19.

ANSWER: 2 and 3 [RG]

BONUS

16) MATH *Short Answer* When the polar curve given by r = sqrt(1/cos(2theta)) [**read: r equals square root open parenthesis 1 over cosine of the quantity 2 theta close parenthesis**] is graphed, it resembles what conic?

ANSWER: Hyperbola [RG]

TOSS-UP

17) BIOLOGY *Short Answer* Helaina is observing populations of finches and notices that two populations that were allopatrically separated have more similar beak morphologies than two populations that separated sympatrically. What term best describes this phenomenon?

ANSWER: Character displacement [EH]

BONUS

17) BIOLOGY *Short Answer* Identify all of the following three cells that would display MHC class I proteins on their plasma membrane:

1) Macrophages;

2) Dendritic cells;

3) B cells.

ANSWER: All of them [EH]

TOSS-UP

18) PHYSICS *Short Answer* Assuming they are all at the same velocity, order the following 3 particles in terms of increasing de-Broglie wavelength:

1) Electron;

2) Neutron;

3) Proton.

ANSWER: 2, 3, 1 [RG]

BONUS

18) PHYSICS *Short Answer* A large ball with mass 10,000 kilograms and speed 10 meters per second collides with a ball of mass 1 kilogram at rest perfectly elastically. To the nearest integer, what is the speed of the smaller ball after the collision in meters per second?

ANSWER: 20 [RG]

TOSS-UP

19) EARTH AND SPACE *Multiple Choice* After passing through the asymptotic giant branch, dying main sequence stars typically move in which direction on the H-R diagram?

W) Up

X) Down

Y) Left

Z) Right

ANSWER: Y) Left [PB]

BONUS

19) EARTH AND SPACE *Multiple Choice* Which of the following types of volcanoes when erupting would typically result in the largest pyroclastic flows?

W) Stratovolcano

X) Shield

Y) Cinder cone

Z) Fissure

ANSWER: W) Stratovolcano [EH]

TOSS-UP

20) CHEMISTRY *Short Answer* Rohan has a sample of uranium 238. The sample goes through an unknown number of alpha decays and beta decays with the possibility of zero for either. Identify all of the following 3 isotopes of lead that could be the identity of the final compound:

1) Lead 204;

2) Lead 206;

3) Lead 207.

ANSWER: 2 only [RG]

BONUS

20) CHEMISTRY *Multiple Choice* Which of the following would best explain what would happen to the van't Hoff factor of calcium chloride if its concentration in a solution increased from 2M to 4M at 25 degrees Celsius?

W) The van't Hoff factor would increase because there is a greater number of particles in solution

X) The van't Hoff factor would increase because the solution becomes more conductive increasing dissociation

Y) The van't Hoff factor would decrease because of increasing electrostatic interactions between ions

Z) The van't Hoff factor would decrease because small amounts of precipitate would form at high concentrations

ANSWER: Y) The van't Hoff factor would decrease because of increasing electrostatic interactions between ions [EH]
