ROUND 7

TOSS-UP

1) Biology – *Multiple Choice* A scientist crosses a pea plant that is true breeding for the dominant traits of round and yellow seeds with a plant that is true breeding for wrinkled and green seeds. What percent of the offspring will have round, yellow seeds?

W) 0%
X) 25%
Y) 50%
Z) 100%

ANSWER: Z) 100%

BONUS

1) Biology – *Short Answer* Sieve cells are long, conducting cells in the phloem that do not form sieve tubes. Similar to how sieve tube members are associated with companion cells, sieve cells are flanked with what type of nourishing cell?

ANSWER: ALBUMINOUS CELLS

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TOSS-UP

2) Physics – *Multiple Choice* At sufficiently high temperatures, when vibrational modes are excited, what fraction of the thermal energy of a diatomic gas molecule is translational kinetic energy?

W) 2/3
X) 3/5
Y) 3/7
Z) 5/7

ANSWER: Y) 3/7

BONUS

2) Physics – *Short Answer* A pipe has water flowing at 10 m/s through a section with a radius of 14 centimeters. Farther down, the pipe narrows to a radius of 2 centimeters. In pascals, what is the difference in pressure to two significant figures and in scientific notation, between the two pipe sections, given that the density of water is 1000 kg/m^3?

ANSWER: 1.2 TIMES 10^8
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TOSS-UP

3) Chemistry – *Multiple Choice* Which of the following molecules can undergo keto-enol tautomerization?

W) Formaldehyde
X) 3-pentanone
Y) Formic acid
Z) Dimethyl ether

ANSWER: X) 3-PENTANONE

BONUS

3) Chemistry – *Multiple Choice* Which of the following cyclic hydrocarbons experiences the least strain?

W) Cyclobutane
X) Cyclopentane
Y) Chair cyclohexane
Z) Boat cyclohexane

ANSWER: Y) CHAIR CYCLOHEXANE

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TOSS-UP

4) Earth and Space – *Multiple Choice* Which of the following minerals does NOT have a chemical formula of SiO_2?

W) Sillimanite
X) Coesite ***[KOH-site]***
Y) Tridymite
Z) Quartz

ANSWER: W) SILLIMANITE

BONUS

4) Earth and Space – *Short Answer* Type Ia supernovae are distinguished from other Type I supernovae by the presence of a spectral line of what element?

ANSWER: SILICON (ACCEPT: SINGLY IONIZED SILICON, SI I)
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TOSS-UP

5) Energy – *Short Answer* Scientists at Pacific Northwest National Lab are studying secondary organic aerosols, which form from photochemical reactions involving volatile organic compounds, or VOCs. Identify all of the following four pollutants that are considered VOCs: 1) Benzene; 2) Carbon monoxide; 3) Polyethylene; 4) Formaldehyde.

ANSWER: 1 AND 4

BONUS

5) Energy – *Short Answer* In 1964, scientists at Brookhaven National Laboratory decided to test theoretical predictions for the number of solar neutrinos that would convert chlorine atoms into argon atoms. When the experiment was conducted, it was found that only a third as many of the argon atoms were found compared to the theoretical figure. This discrepancy is due to what phenomenon, which was later confirmed by the Sudbury Neutrino Observatory?

ANSWER: NEUTRINO OSCILLATION (DO NOT ACCEPT: FLAVOR OSCILLATION)

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TOSS-UP

6) Math – *Multiple Choice* A triangle has side lengths of 5, 7, and 8. Which of the following statements is true?

W) The circumcenter and orthocenter are both inside the triangle
X) The circumcenter is inside the triangle, while the orthocenter is outside the triangle
Y) The circumcenter is outside the triangle, while the orthocenter is inside the triangle
Z) The circumcenter and orthocenter are both outside the triangle

ANSWER: W) THE CIRCUMCENTER AND ORTHOCENTER ARE BOTH INSIDE THE TRIANGLE

BONUS

6) Math – *Short Answer* Convex quadrilateral ABCD has an inscribed circle. If AB = 12, BC = 15, and CD = 23, what is DA?

ANSWER: 20
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TOSS-UP

7) Biology – *Multiple Choice* Primary xylem and secondary xylem are formed from what meristematic tissue types, respectively?

W) Procambium, vascular cambium
X) Vascular cambium, procambium
Y) Procambium, cork cambium
Z) Vascular cambium, cork cambium

ANSWER: W) PROCAMBIUM, VASCULAR CAMBIUM

BONUS

7) Biology – *Short Answer* Giving your answer as a fraction, and assuming no incest, what is the coefficient of relatedness between a human and her second cousin?

ANSWER: 1/32

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TOSS-UP

8) Physics – *Multiple Choice* A student measures the periods of a pendulum of fixed length at sea level to calculate the acceleration due to gravity. Which of the following changes would make her measured period of the pendulum swing smaller in magnitude?

W) The same experiment is conducted in a sealed chamber 20 miles below ground
X) The same experiment is conducted on the top of a 5 mile high mountain
Y) The pendulum's center of mass is shifted closer to the point of rotation
Z) There is more friction between the point of rotation and the pendulum

ANSWER: Y) THE PENDULUM'S CENTER OF MASS IS SHIFTED CLOSER TO THE POINT OF ROTATION

BONUS

8) Physics – *Short Answer* A bouncy ball is dropped from a height of 3 meters. Each time it bounces, it loses a third of its kinetic energy. What total distance, in meters, will it travel before it comes to rest?

ANSWER: 15
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TOSS-UP

9) Math – *Multiple Choice* A sequence has first term 1 and second term 2, with all following terms equal to the sum of all of the terms before it. What is the tenth term?

W) 89
X) 144
Y) 192
Z) 384

ANSWER: Z) 384

BONUS

9) Math – *Short Answer* What is the largest prime factor of the quantity $5^6 + 5^8 + 5^{10}$?

ANSWER: 31

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TOSS-UP

10) Earth and Space – *Multiple Choice* Which of the following is not true regarding roche moutonnées ***[ROH-sh moo-tun-AYS]***?

W) Plucking occurs on the lee side
X) Abrasion occurs on the stoss side
Y) The less steep side of roche moutonnées dips towards the direction of glacial movement
Z) Roche moutonnées are strictly erosional structures

ANSWER: Y) THE LESS STEEP SIDE OF ROCHE MOUTONNEES DIPS TOWARDS THE DIRECTION OF GLACIAL MOVEMENT

BONUS

10) Earth and Space – *Short Answer* Rank the following three layers of the solar atmosphere in terms of increasing temperature: 1) Corona; 2) Chromosphere; 3) Photosphere.

ANSWER: 3, 2, 1
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TOSS-UP

11) Energy – *Short Answer* Scientists at Pacific Northwest National Lab are using metal-organic frameworks, or MOFs, to adsorb refrigerants. After the ban of CFCs, these MOFs are being used to adsorb what organofluorine compounds?

ANSWER: HYDROFLUOROCARBONS (ACCEPT: HFCs)

BONUS

11) Energy – *Short Answer* Scientists at Lawrence Livermore National Lab are studying the release of carbonyl sulfide, or OCS, from forest fires. Identify all of the following three statements about carbonyl sulfide that are true: 1) It is bent; 2) The carbon-oxygen bond is longer than the carbon-sulfur bond; 3) The formal charge on the carbon is +1.

ANSWER: NONE

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TOSS-UP

12) Math – *Short Answer* What is the cross product of the two vectors $4\boldsymbol{i} + 6\boldsymbol{j}$ and $\boldsymbol{i} - 3\boldsymbol{j}$?

ANSWER: $-18\boldsymbol{k}$

BONUS

12) Math – *Short Answer* A convex quadrilateral ABCD has AB = 1, BC = 2, CD = 3, and angles ABC and BCD equal to 120 degrees. What is the length of AD?

ANSWER: SQUARE ROOT OF 19
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TOSS-UP

13) Biology – *Short Answer* What buffer system maintains the internal pH of the fluids of all cells?

ANSWER: PHOSPHATE BUFFER SYSTEM (ACCEPT: PHOSPHATE)

BONUS

13) Biology – *Short Answer* Inside the human mouth, starch can be split into maltose by what enzyme?

ANSWER: AMYLASE (ACCEPT: SALIVARY AMYLASE)

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TOSS-UP

14) Physics – *Multiple Choice* Two reflective objects are placed in front of a uniform beam of light, normal to the rays. One is a disk, and the other is a sphere with the same diameter. Which of the following best describes the net radiation force?

W) Greater on the disk
X) Greater on the sphere
Y) The same on both
Z) Zero

ANSWER: W) GREATER ON THE DISK

BONUS

14) Physics – *Multiple Choice* Which of the following quarks is most massive?

W) Strange
X) Charm
Y) Up
Z) Down

ANSWER: X) CHARM
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TOSS-UP

15) Chemistry – *Short Answer* Rank the following three species in terms of increasing acid dissociation constant in water: 1) NH_4Cl; 2) HCl; 3) Fe^{3+}.

ANSWER: 1, 3, 2

BONUS

15) Chemistry – *Short Answer* Rank the following three degrees of substitution in terms of increasing likelihood of attack in acid-catalyzed epoxide ring opening: 1) Primary; 2) Secondary; 3) Tertiary.

ANSWER: 2, 1, 3

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TOSS-UP

16) Earth and Space – *Multiple Choice* Two planets orbit the same star. One planet has orbital period *T* and semimajor axis *a*, while the other planet has orbital period 2*T*. In terms of *a*, what is its semimajor axis?

W) *a* times the cube root of 4
X) Two *a* times the square root of 2
Y) 2*a*
Z) 4*a*

ANSWER: W) A TIMES THE CUBE ROOT OF 4

BONUS

16) Earth and Space – *Short Answer* Rank the following three clastic rock types in terms of increasing quartz to clay ratio: 1) Quartz arenite; 2) Greywacke; 3) Siltstone.

ANSWER: 3, 2, 1
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TOSS-UP

17) Energy – *Short Answer* Scientists at Lawrence Livermore National Lab are using beryllium-10 to date moraines left by tropical glaciers during the Last Glacial Maximum. Beryllium-10 undergoes beta-minus decay to boron-10, which is stable. If a sample contains beryllium-10 and there is no other source of boron-10, how many half-lives have gone by if there is 15 times more boron-10 than beryllium-10?

ANSWER: 4

BONUS

17) Energy – *Multiple Choice* By using the ChemCam instrument on the Curiosity rover, scientists at Los Alamos National Lab have found evidence of evaporite deposits in Gale crater. They observed high concentrations of dry calcium sulfate, which is also present on Earth as what common evaporite mineral?

W) Halite
X) Gypsum
Y) Anhydrite
Z) Calcite

ANSWER: Y) ANHYDRITE

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TOSS-UP

18) Biology – *Short Answer* What cranial nerve innervates the sinoatrial node of the heart?

ANSWER: VAGUS NERVE (ACCEPT: X, 10)

BONUS

18) Biology – *Short Answer* What structures receive impulses from the Atrioventricular node and branch out into Purkinje ***[PER-kin-jee]*** fibers?

ANSWER: BUNDLES OF HIS
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TOSS-UP

19) Physics – *Multiple Choice* Which of the following combinations of resistance and capacitance in series will discharge with the shortest time constant?

W) 20 ohms and 5 microfarads
X) 50 ohms and 2 microfarads
Y) 100 ohms and 4 microfarads
Z) 30 ohms and 3 microfarads

ANSWER: Z) 30 OHMS AND 3 MICROFARADS

BONUS

19) Physics – *Short Answer* Name all of the following four quantities that change sign upon time reversal: 1) Poynting vector, 2) Electric field, 3) Magnetic field, 4) Force.

ANSWER: 1 AND 3

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TOSS-UP

20) Chemistry – *Short Answer* The Daniell cell makes use of the oxidation of what metal?

ANSWER: ZINC

BONUS

20) Chemistry – *Multiple Choice* A student is tasked with deciphering the identity of an unknown white solid. When added to water, only a small amount of the solid dissolves, but after an excess of ammonia is bubbled through the solution, the solid turns gray. Which of the following is the likely identity of the solid?

W) Mercury I chloride
X) Lead II chloride
Y) Silver chloride
Z) Lithium carbonate

ANSWER: W) MERCURY I CHLORIDE
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TOSS-UP

21) Earth and Space – *Short Answer* Responsible for generating almost all nuclei heavier than iron-56, the s-process and r-process function via the capture of what subatomic particle?

ANSWER: NEUTRON

BONUS

21) Earth and Space – *Short Answer* Lunar highlands are primarily composed of what rock?

ANSWER: ANORTHOSITE

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TOSS-UP

22) Math – *Short Answer* What is the partial derivative with respect to y of $4x^6y^4$?

ANSWER: $16x^6y^3$

BONUS

22) Math – *Short Answer* An ant is at the origin. Every second, he picks one of four directions (positive x, positive y, negative x, or negative y) and travels 1 unit in that direction. After 6 seconds, the ant is at the point P = (x, y). What is the probability that the sum of the absolute values of x and y equals 6?

ANSWER: 63 OVER 1024
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TOSS-UP

23) Chemistry – *Multiple Choice* When acetone is dissolved in chloroform in a certain ratio, the two compounds cannot be separated by fractional distillation. Which of the following best explains this phenomenon?

W) Acetone and chloroform experience more favorable interactions and form a minimum-boiling azeotrope
X) Acetone and chloroform experience more favorable interactions and form a maximum-boiling azeotrope
Y) Acetone and chloroform experience less favorable interactions and form a minimum-boiling azeotrope
Z) Acetone and chloroform experience less favorable interactions and form a maximum-boiling azeotrope

ANSWER: X) ACETONE AND CHLOROFORM EXPERIENCE MORE FAVORABLE INTERACTIONS AND FORM A MAXIMUM-BOILING AZEOTROPE

BONUS

23) Chemistry – *Multiple Choice* 2,3-dichlorobutane is reacted with excess potassium tert-butoxide. Which of the following functional groups will form?

W) Disubstituted alkene
X) Cumulated diene
Y) Conjugated diene
Z) Unconjugated diene

ANSWER: Y) CONJUGATED DIENE