ROUND 14

TOSS-UP

1) Physics – *Short Answer* By name or number, identify all of the following that are polytropic processes when the ideal gas law does not apply 1) Isothermal, 2) Isobaric, 3) Isochoric?

ANSWER: 2 AND 3 (ACCEPT: ISOBARIC AND ISOCHORIC)

BONUS

1) Physics – *Short Answer* For an isentropic process, the value of gamma, the ratio of specific heat at constant pressure to specific heat at constant volume is 4/3. If the isentropic process takes place at an initial pressure and volume of 50 Pascals and 8 Liters respectively, then find the final volume in simplest radical form given that the final pressure was 160

ANSWER: $\sqrt[4]{125}$ (Solution: $50 \cdot 8^{4/3} = 160 \cdot x^{4/3}$, $x = (50*16/160)^{3/4}$)

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TOSS-UP

2) Energy – *Multiple Choice* Scientists at Brookhaven National Laboratory have found that the effect of constituent antiquark spin has different effects on the overall spin of a proton based on the flavor of the antiquark. To the nearest order of 10, how many times heavier is the heaviest quark, the top quark, than the lightest quark, the up quark

W) 100
X) 1,000
Y) 10,000
Z) 100,000

ANSWER: Z) 100,000

BONUS

2) Energy – *Short Answer* In beta minus decay, a neutron decays into a proton, electron and electron antineutrino. What conservation law governs the formation of an electron - electron antineutrino pair

ANSWER: CONSERVATION OF LEPTON NUMBER
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ROUND 14

TOSS-UP

3) Chemistry – *Multiple Choice* Which of the following molecules is not aromatic?

W) Bromobenzene
X) Benzoic Acid
Y) Styrene
Z) 4-Vinylcyclohexene

ANSWER: Z) 4-VINYLCYCLOHEXENE

BONUS

3) Chemistry – *Short Answer* What element has an atomic number 2 greater than that of the element refined by the Miller Process?

ANSWER: THALLIUM (The Miller Process purifies gold)

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TOSS-UP

4) Biology – *Multiple Choice* What type of connective tissue is found in the lymph nodes, spleen, and bone marrow?

W) Reticular
X) Adipose
Y) Dense Regular
Z) Dense Irregular

ANSWER: W) RETICULAR

BONUS

4) Biology – *Short Answer* What type of connective tissue is formed from nearby undamaged blood vessels to replace clots?

ANSWER: GRANULATION TISSUE
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ROUND 14

TOSS-UP

5) Math – *Short Answer* Let the period of sine of 3x be A and let the period of cosine of 1/15x be B. What is 15A + 10B in terms of pi.

ANSWER: 310π

BONUS

5) Math – *Short Answer* For a point P inside a square ABCD, the distance to each of the vertices is 3, 4, 5, and x, starting from A and going clockwise. In simplest radical form what is x?

ANSWER: 3√2

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TOSS-UP

6) Earth and Space – *Short Answer* Rocks that contain large crystals as well as small crystals are said to have porphyritic texture. What is the name of the matrix of smaller crystals that surrounds a large phenocryst in these types of rocks?

ANSWER: GROUND MASS

BONUS

6) Earth and Space – *Short Answer* Plagioclase feldspars are differentiated from potassium feldspars due to the presence of sodium and calcium. By name or number, Order the following 3 minerals from the lowest to highest temperature at which they would crystallize: 1) calcium-rich plagioclase feldspar, 2) sodium-rich plagioclase feldspar, 3) potassium feldspar?

ANSWER: 3, 2, 1 (ACCEPT POTASSIUM FELDSPAR, SODIUM-RICH PLAGIOCLASE FELDSPAR, CALCIUM-RICH PLAGIOCLASE FELDSPAR)
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ROUND 14

TOSS-UP

7) Energy – *Multiple Choice* Recent research at Lawrence Berkeley National Laboratory may help explain why chronic diseases tend to develop as we age. The research team has found that a chain reaction can be started by hydroxyl molecules working with what other type of molecule defined as containing the oxide of a carbonyl group?

W) Criegee Intermediate
X) Molozonide
Y) Hemiketal
Z) Orthropendum Diester

ANSWER: W) CRIEGEE INTERMEDIATE

BONUS

7) Energy – *Short Answer* The researchers are focusing on a new mechanism that can cause the building blocks of cell membranes to deteriorate. The reaction results from a reaction between oxygen and free radicals of hydroxyl. By name or number, which of the following atoms of molecules is a free radical: 1) Arsenic, 2) Lead, 3) Nitric Oxide?

ANSWER: 1 AND 3 (ACCEPT: ARSENIC AND NITRIC OXIDE)

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TOSS-UP

8) Biology – *Short Answer* What is the name of the special type of cilia in cells that are not motile, but instead serve as receptors for some signaling pathways?

ANSWER: PRIMARY CILIUM (ACCEPT PRIMARY CILIA)

BONUS

8) Biology – *Multiple Choice* Herring gulls have a special ritual when it's time for the parent to feed the chick. The parent taps its beak on the ground, followed by the chicks tapping their beaks in the same spot in the ground, even without any prior training. Which of the following best fits this type of behavior.

W) Kinesis
X) Imprinting
Y) Innate Behavior
Z) Habituation

ANSWER: Y) INNATE BEHAVIOR
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(Solution: The chicks are hardwired to respond to the parent's pecking by pecking in the same spot)

ROUND 14

TOSS-UP

9) Physics – *Short Answer* Let the gravitational field at a point of the surface of a spherical Planet A be X. What will be the resultant gravitational field at the same point in terms of X after the following two changes occur one after the other: 1) The planet, while maintaining an equal mass increases to twice the radius and 2) The density of the planet triples?

ANSWER: 3X/8

BONUS

9) Physics – *Short Answer* By number, order the following 3 planet-star systems from most to least gravitational potential energy: 1) A planet with a mass m orbits the Sun at a radius r, 2) A planet with a mass 2m orbits a star with 5 times the mass of the Sun at a radius 4r, 3) A planet with a mass of 0.5 m orbits the Sun at a radius of 2/3 r

ANSWER: 3, 1, 2

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TOSS-UP

10) Chemistry – *Short Answer* What is the standard potential, in volts, of a Daniell Cell at 25C to the nearest tenth?

ANSWER: 1.1V

BONUS

10) Chemistry – *Short Answer* Balance the following equation in an acidic solution:
$Cr_2O_7^{2-} + HNO_2 \longrightarrow Cr^{3+} + NO_3^-$

ANSWER: $3\ HNO_2 + 5\ H^+ + Cr_2O_2^{-7}(aq) \rightarrow 3\ NO_3^- + 2\ Cr^{3+} + 4\ H_2O$

TOSS-UP

11) Math – *Short Answer* Given a dodecahedron has 20 vertices, how many edges does it have?

ANSWER: 30
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ROUND 14

BONUS

11) Math – *Short Answer* How many ways are there to tessellate a plane with 1 or more types of regular polygons if the same array of polygons must surround each vertex?

ANSWER: 11

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TOSS-UP

12) Earth and Space – *Short Answer* What is the name for the rare lens-shaped clouds typically found on the leeward side of mountains, which people commonly mistake for UFOs?

ANSWER: LENTICULAR

BONUS

12) Earth and Space – *Short Answer* By name or number, identify all of the following 5 statements that are true about lenticular clouds: 1) They appear to be stationary clouds, 2) They can be caused by man-made structures, such as buildings, 3) They are very damaging to the ozone layer, 4) They generally have very weak updrafts, 5) They are formed when a stable air mass flows over an obstruction, usually a mountain, creating a series of oscillating waves

ANSWER: 1, 2, 5 IN ANY ORDER
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ROUND 14

TOSS-UP

13) Biology – *Multiple Choice* What is the name of the anatomical position for the heel?

W) Olecranal
X) Calcaneal
Y) Plantar
Z) Tarsal

ANSWER: X) CALCANEAL

BONUS

13) Biology – *Short Answer* What is the name of the anatomical plane that divides the body into two equal halves along the vertical axis, the left half and right half?

ANSWER: MIDSAGITTAL **(**ACCEPT: SAGITTAL**)**

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TOSS-UP

14) Energy – *Multiple Choice* Scientists at Lawrence Berkeley National Laboratory are studying how a process called autoxidation breaks down organic molecules, specifically unsaturated lipids. Which of the following is an example of why unsaturated lipids are important in cells?

W) Kinks in unsaturated phospholipid tails allow for the cell membrane to maintain fluidity at lower temperatures.
X) The absence of kinks in unsaturated phospholipid tails allow for the cell membrane to maintain fluidity at higher temperatures.
Y) Unsaturated lipids are readily broken down to provide short-term energy for the cell.
Z) Unsaturated lipids lower the pH of the cell's interior.

ANSWER: W) KINKS IN UNSATURATED PHOSPHOLIPID TAILS ALLOW FOR THE CELL MEMBRANE TO MAINTAIN FLUIDITY AT LOWER TEMPERATURES.

BONUS

14) Energy – *Short Answer* To understand how autoxidation works, the researchers did experiments involving mass spectrometry, which measures the charge to mass ratio of ions. The 1989 Nobel Prize in Physics was awarded for what specific technique, known for its uses in mass spectrometry, characterized by the use of both electric magnetic fields to capture charged particles?
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ANSWER: ION TRAP TECHNIQUE (ACCEPT: ION TRAP)

ROUND 14

TOSS-UP

15) Physics – *Multiple Choice* Two rockets are traveling through space in the same 1 dimension. The first rocket is moving at 50% c as measured by the second rocket moving behind it. The second rocket is measured as moving at 40% c by a stationary observer in the same dimension as both rockets. In the reference frame of the stationary observer, what is the exact speed of the first rocket moving in terms of c?

ANSWER: 0.75 c (ACCEPT: 75% OF THE SPEED OF LIGHT)

BONUS

15) Physics – *Short Answer* A ball moving at v meters per second collides with another ball at rest in an elastic collision. After the collision, one ball travels at 9 meters per second at an angle 30° below the horizontal, and the other ball travels at 12 meters per second 30° above the horizontal. What is the initial velocity of the ball, v?

W) 15 meters per second
X) $\sqrt{117}$
Y) $12 + 15\sqrt{3}/4$
Z) $\sqrt{333}$

ANSWER: X) $\sqrt{117}$

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TOSS-UP

16) Earth and Space – *Short Answer* Assume a star has an apparent magnitude of 5. Given that log(2) is .30, how far away is an observer from the star, in parsecs, if the absolute magnitude is 3.6?

ANSWER: 250
(Solution: $m = M + \log(d/10)$; $5 - 3.6 = 1.4 = 2 - .6 = \log(100) - \log(4) = \log(25) = \log(d/10)$; $d=250$)

BONUS

16) Earth and Space – *Short Answer* The Stefan-Boltzman law explains the relationship between the luminosity of a star and its radius and temperature. If the surface temperature of a star is decreased by 33%, and the radius is 9 times as large as it was originally, how many times brighter is the luminosity of the star than it was originally to the nearest integer?

ANSWER: 16
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(Solution: $L = 4\pi R^2 \sigma T^4$; R is multiplied by 9; T is multiplied by ⅔; $9^2(⅔)^4 = 16$)

ROUND 14

TOSS-UP

17) Chemistry – *Multiple Choice* Compounds of uranium-235 and uranium-238 can be separated from one another by
W) distillation
X) gaseous diffusion
Y) fractional crystallization
Z) paper chromatography

ANSWER: X) GASEOUS DIFFUSION

BONUS

17) Chemistry – *Short Answer* By name or number, identify all of the following that are true for ideal gases at an equal temperature moving through a small hole: 1) Hydrogen effuses twice as fast as helium, 2) Helium effuses twice as fast as oxygen, 3) Argon effuses twice as fast as bromine

ANSWER: NONE OF THEM

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TOSS-UP

18) Math – *Short Answer* Pascal's theorem describes hexagons inscribed within types of these figures, while Brainchon's theorem describes hexagons circumscribed about these figures. One type of these figures are the locus of points such that the sum of the distances from two points is constant. What are these curves, whose definition is the intersection of a plane with a double napped cone?

ANSWER: CONIC

BONUS

18) Math – *Short Answer* What type of conic is described by $r = 6/(3+2\sin\Theta)$ (READ: r equals 6 over the quantity three plus two times sine of theta)?

ANSWER: ELLIPSE
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ROUND 14

TOSS-UP

19) Chemistry – *Short Answer* Hydrogens are assigned the lowest priority when determining chirality in what nomenclature system, named after three organic chemists?

ANSWER: CAHN-INGOLD-PRELOG PRIORITY RULES (ACCEPT: CIP)

BONUS

19) Chemistry – *Short Answer* A single hydrogen atom makes up the side chain of what non-essential amino acid?

ANSWER: GLYCINE

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TOSS-UP

20) Physics – *Short Answer* A force of 4 + 4 sine of t is applied to a block of mass 4 kg. This force acts on the block from t = 0 to t = π. Ignoring friction and air resistance, find the instantaneous speed of the block after the time interval.

W) 1 + π
X) 2 + π
Y) 2 + 2π
Z) 4 + 2π

ANSWER: X) 2 + π

BONUS

20) Physics – *Multiple Choice* Blocks A, B, C, and D are at positions x = 0, x = 5, and x = 20 respectively. Block D has double the mass of Block C, which has the double the mass of Block B, which has double the mass of block A. The velocities of Blocks A, B, C, and D are 2 m/s to the right, 7 m/s to the right, 26 m/s to the left, and 5 m/s to the left. The blocks suffer one of more collisions, all of which are elastic. After the collisions, what is the velocity of the center of mass of the system?

ANSWER: 13/15 M/S TO THE LEFT (DO NOT ACCEPT: 13/15 M/S) (Solution: 8*2 + 4*7 - 2*26 - 1*5 = -13. -13/(8 + 4 + 2 + 1) = 13/15 meters per second to the left)

TOSS-UP

21) Earth and Space – *Multiple Choice* Which celestial body is the coldest known place in the entire universe with a temperature of -458 degrees Kelvin?
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W) Helix Nebula
X) Butterfly Nebula
Y) Alpha Centauri
Z) Boomerang Nebula

ANSWER: Z) BOOMERANG NEBULA

BONUS

21) Earth and Space – *Multiple Choice* Which of the following best explains why the Boomerang Nebula is believed to be so cold?
W) There is a large amount of endothermic reactions occurring inside the Boomerang Nebula.
X) The gas inside the Boomerang Nebula is rapidly expanding.
Y) Most of the energy within the planetary nebula was lost to the surrounding gas through radiation.
Z) The Boomerang Nebula is the farthest away from any stars than any other point in the universe, so it receives very little energy from the radiation of stars, allowing it to be so cold.

ANSWER: X) THE GAS INSIDE THE BOOMERANG NEBULA IS RAPIDLY EXPANDING

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TOSS-UP

22) Biology – *Multiple Choice* α(alpha) and β(beta) glucose ring structures are defined by the placement of which group?

W) Amino
X) Hydroxyl
Y) Carboxyl
Z) Carbonyl

ANSWER: X) HYDROXYL

BONUS

22) Biology – *Multiple Choice* Microtubules have two different ends called the plus end and the minus end. Which of the following best explains the cause of these different ends?

W) There is a higher concentration of beta-tubulin than alpha-tubulin at the plus end.
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X) There is a higher concentration of alpha-tubulin than beta-tubulin at the plus end.
Y) The special orientation of the tubulin dimers allows for the plus end to add and remove tubulin proteins at a much higher rate.
Z) The special orientation of the tubulin dimers allows for the minus end to remove tubulin proteins at a much higher rate.

ANSWER: Y) THE SPECIAL ORIENTATION OF THE TUBULIN DIMERS ALLOWS FOR THE PLUS END TO ADD AND REMOVE TUBULIN PROTEINS AT A MUCH HIGHER RATE

ROUND 14

TOSS-UP

23) Math – *Short Answer* How many ways are there to get from the origin to (4, 4) if (2, 2) is impassable?

ANSWER: 34

BONUS

23) Math – *Multiple Choice* Formally, fields are sets with two operations called addition and multiplication that satisfy certain basic properties, called field axioms. Which of the following is not a field axiom?

W) Associative Property
X) Distributive Property
Y) Commutative Property
Z) Transitive Property

ANSWER: Z) TRANSITIVE PROPERTY