

ROUND ROBIN 5

TOSS-UP

1) Chemistry - *Multiple Choice* Which of the following elements has a very high ionization energy but a very low electron affinity?

- W) Hydrogen
- X) Helium
- Y) Lithium
- Z) Fluorine

ANSWER: X) Helium

BONUS

1) Chemistry - *Multiple Choice* Solid CaCO_3 decomposes to solid CaO and gaseous CO_2 at 800 kelvin. In a rigid, closed container containing excess CaCO_3 but no CaO , how does the equilibrium shift if there is a CO_2 pressure greater than the value of K_p ?

- W) Reactants increase
- X) Products increase
- Y) The system is already at equilibrium
- Z) No change

ANSWER: Z) No change

TOSS-UP

2) Math - *Short Answer* The weights of three students on the football team are 171, 176, and 178 pounds. What is the mean weight of the three students?

ANSWER: 175

BONUS

2) Math - *Short Answer* Identify all of the following three statements that are true of cyclic quadrilaterals: 1) Opposite angles must sum to 180° ; 2) Any diagonal divides the quadrilateral into two similar triangles; 3) The circumradius must be smaller than all four sides.

ANSWER: 1 only

TOSS-UP

3) Earth and Space - *Multiple Choice* Which of the following quantities describing a river does not typically increase as one moves farther downstream?

- W) Depth
- X) Slope
- Y) Velocity
- Z) Sediment capacity

ANSWER: X) Slope

BONUS

3) Earth and Space - *Short Answer* Identify all of the following three igneous rocks that are phaneritic: 1) Basalt; 2) Andesite; 3) Granite.

ANSWER: 3 only

TOSS-UP

4) Physics - *Multiple Choice* A block is attached to the end of an ideal spring and moved from coordinate x_1 [**x one**] to coordinate x_2 [**x two**]. If the relaxed position of the spring is at $x = 0$ centimeters, which of the following values for x_1 and x_2 , in centimeters, would result in the total work done by the spring being positive?

W) $x_1 = -2, x_2 = 4$

X) $x_1 = -2, x_2 = -4$

Y) $x_1 = -2, x_2 = 2$

Z) $x_1 = -4, x_2 = -2$

ANSWER: Z) $x_1 = -4, x_2 = -2$

BONUS

4) Physics - *Short Answer* Patrick is adding resistance to a circuit using 10 identical 10-ohm resistors. In ohms, what is the numerical difference between the lowest and highest equivalent resistances he can create in the circuit?

ANSWER: 99

TOSS-UP

5) Biology - *Short Answer* Identify all of the following three proteins which are components of the thin filaments in muscle fibers: 1) Myosin [**MY-uh-sin**]; 2) Troponin [**TROH-poh-nin**]; 3) Tropomyosin [**troh-poh-MY-uh-sin**].

ANSWER: 2 and 3

BONUS

5) Biology - *Multiple Choice* Beta-linkages create long, straight chains of sugar units that can compact rigidly through hydrogen bonds. Which of the following polysaccharides possess beta one-four glycosidic [**gly-koh-SY-dic**] linkages?

W) Chitin [**KAI-tin**]

X) Amylopectin

Y) Glycogen

Z) Starch

ANSWER: W) Chitin

TOSS-UP

6) Energy - *Short Answer* Researchers at SLAC are studying the emission of electromagnetic radiation that occurs as charged particles move along curved paths at relativistic speeds. What name is given to this type of radiation?

ANSWER: Synchrotron [**SINK-roh-tron**] radiation

BONUS

6) Energy - *Multiple Choice* Scientists at Stanford's Precourt Institute for Energy are investigating the use of sodium manganese hexacyanomanganate in large-scale batteries. If this compound has chemical formula $\text{Na}_2\text{Mn}[\text{Mn}(\text{CN})_6]$ [**Na2, Mn, open bracket, Mn, open parentheses, CN, close parentheses, 6, close bracket**], which of the following most likely represents the oxidation states of the two manganese ions in this compound, respectively?

W) +2 and +2

X) +2 and +3

Y) +3 and +3

Z) +3 and +4

ANSWER: W) +2 and +2

TOSS-UP

7) Math - *Short Answer* Let f be a differentiable function on real numbers such that $|f'| \leq 5$ [**the absolute value of f prime is less than or equal to 5**]. If $f(0) = 7$, what is the difference between the maximum and minimum possible values of $f(11)$?

ANSWER: 110

BONUS

7) Math - *Short Answer* The perimeter of parallelogram $ABCD$ is 20. Given that the altitude from AB to CD is 3 and the altitude from BC to DA is 7, what is the area of $ABCD$?

ANSWER: 21

TOSS-UP

8) Physics - *Multiple Choice* Which of the following mechanical quantities is considered a scalar?

- W) Energy
- X) Force
- Y) Momentum
- Z) Velocity

ANSWER: W) Energy

BONUS

8) Physics - *Multiple Choice* Which of the following can NEVER characterize the image of an object through a thin converging lens, as compared to the original object?

- W) Real, inverted, and smaller
- X) Real, inverted, and larger
- Y) Virtual, upright, and smaller
- Z) Virtual, upright, and larger

ANSWER: Y) Virtual, upright, and smaller

TOSS-UP

9) Biology - *Short Answer* Harmless king snakes' resemblance to venomous coral snakes is an example of what type of mimicry, in which a prey species is protected by its resemblance to a harmful one?

ANSWER: Batesian mimicry

BONUS

9) Biology - *Multiple Choice* Which of the following best explains why the central vacuole is so important in plant cell growth?

W) Provides a membrane-bound compartment to support metabolic functions

X) Ensures the ratio of plasma membrane surface to cytosolic volume is sufficient

Y) Stores starch, which is an important food source in cell growth

Z) Acts as a site of vesicular formation for sugar transport between organelles

ANSWER: X) Ensures the ratio of plasma membrane surface to cytosolic volume is sufficient

TOSS-UP

10) Chemistry - *Short Answer* A solution of 0.1 molar formic acid is titrated with NaOH. Given that the pK_a of formic acid is 3.75, what will be the pH of the solution at the half-equivalence point of the titration?

ANSWER: 3.75

BONUS

10) Chemistry - *Short Answer* Identify all of the following three ions that experience resonance: 1) Carbonate; 2) Sulfate; 3) Nitrate.

ANSWER: All

TOSS-UP

11) Earth and Space - *Multiple Choice* Jerry the cosmologist is analyzing the Cosmic Microwave Background Radiation, or CMBR. Which of the following statements best describes the origin of CMBR?

- W) It consists of radiation emitted by cooling after the Big Bang
- X) It consists of radiation emitted by black holes at the center of galaxies
- Y) It consists of radiation emitted by the first stars that formed in the universe
- Z) It consists of radiation emitted by dark energy interacting with dark matter

ANSWER: W) It consists of radiation emitted by cooling after the Big Bang

BONUS

11) Earth and Space - *Multiple Choice* Which of the following types of stars is typically the densest?

- W) Red dwarf
- X) Blue giant
- Y) White dwarf
- Z) Neutron star

ANSWER: Z) Neutron star

TOSS-UP

12) Energy - *Multiple Choice* Researchers at Stanford's Hoover Institution are analyzing energy sources that adapt to grid stressors. Which of the following energy sources is most commonly used for providing power to match peak demand?

- W) Coal
- X) Hydropower
- Y) Nuclear
- Z) Wind

ANSWER: X) Hydropower

BONUS

12) Energy - *Multiple Choice* Scientists at SLAC recently worked with the National Ignition Facility to produce the first-ever fusion test with a positive energy yield. Given that the test produced one megajoule of energy, which of the following is closest to the total change in mass, in kilograms, of the target nuclei during the test?

- W) 10^{-5}
- X) 10^{-7}
- Y) 10^{-9}
- Z) 10^{-11}

ANSWER: Z) 10^{-11}

TOSS-UP

13) Physics - *Short Answer* Two balls of mass 5 kilograms and 7 kilograms are traveling at 10 meter per second to the right and 10 meters per second to the left, respectively, when they collide elastically. What is the change in velocity of the center of mass during the collision?

ANSWER: 0

BONUS

13) Physics - *Short Answer* Identify all of the following three vectors that the angular momentum vector is always perpendicular to: 1) Radius vector; 2) Linear momentum vector; 3) Torque vector.

ANSWER: 1 and 2

TOSS-UP

14) Math - *Short Answer* Stewie and Brian both randomly pick an integer from 1 to 10 inclusive. What is the probability that Stewie's number is greater than Brian's?

ANSWER: $\frac{9}{20}$ (ACCEPT: 45%, 0.45)

BONUS

14) Math - *Short Answer* In radians, find the smallest positive value of x such that $\ln(\cos^2 x - \frac{3}{4})$ **[natural log of quantity cosine squared of x minus three over four]** is not defined.

ANSWER: $\frac{\pi}{6}$

TOSS-UP

15) Energy - *Multiple Choice* Researchers in the Hodgson lab at Stanford are using light to determine the structure of different molecules. Which of the following techniques is most useful for determining molecular structure?

- W) IR spectroscopy
- X) Mass spectrometry
- Y) NMR spectroscopy
- Z) X-ray crystallography

ANSWER: Z) X-ray crystallography

BONUS

15) Energy - *Short Answer* Researchers at Stanford's Beckman Center are exploring the molecular mechanisms of the antibiotic erythromycin [**uh-ree-throh-MY-sin**]. Identify all of the following three statements regarding antibiotics that are true: 1) Antibiotics fight viral infections; 2) Antibiotics can target prokaryotic ribosomes separately from eukaryotic ribosomes; 3) Over successive generations, a higher proportion of bacteria in a population will possess antimicrobial resistance.

ANSWER: 2 and 3

TOSS-UP

16) Earth and Space - *Short Answer* What name is given to the type of igneous rock that is almost entirely composed of solidified tephra?

ANSWER: Tuff (ACCEPT: Welded tuff, ignimbrite)

BONUS

16) Earth and Space - *Multiple Choice* The Intertropical Convergence Zone is located between which of the following pairs of atmospheric circulation cells?

- W) Ferrel and polar
- X) Polar and Hadley
- Y) Hadley and Ferrel
- Z) Hadley and Hadley

ANSWER: Z) Hadley and Hadley

TOSS-UP

17) Biology - *Multiple Choice* Which of the following cells would be found in the epidermal layer of a leaf?

W) Bundle sheath cells

X) Spongy mesophyll [**MEH-soh-fill**] cells

Y) Guard cells

Z) Palisade mesophyll cells

ANSWER: Y) Guard cells

BONUS

17) Biology - *Short Answer* Identify all of the following three actions that commonly contribute to DNA deactivation: 1) Acetylation [**uh-SET-uh-lay-shun**] of histone tails; 2) Loosening of chromatin strands; 3) CRP protein binding to cyclic AMP.

ANSWER: None

TOSS-UP

18) Chemistry - *Multiple Choice* Which of the following reactions must be performed to turn an alkene [**al-KEEN**] to an alkane?

- W) Hydration
- X) Oxidation
- Y) Combustion
- Z) Hydrogenation

ANSWER: Z) Hydrogenation

BONUS

18) Chemistry - *Multiple Choice* What does the word "critical" imply when referring to the critical mass of a nuclear fission?

- W) The minimum amount of fissile material needed to self-sustain a nuclear chain reaction
- X) The amount of radioactive waste that is produced after the reaction
- Y) The catalyst to start a nuclear fission event
- Z) The maximum mass of radioactive material before nuclear fission takes place

ANSWER: W) The minimum amount of fissile material needed to self-sustain a nuclear chain reaction

TOSS-UP

19) Physics - *Short Answer* Which law of thermodynamics states that if two systems are in thermal equilibrium with a third, they are also in thermal equilibrium with each other?

ANSWER: Zeroth law

BONUS

19) Physics - *Multiple Choice* Which of the following conservation laws is not exact?

- W) Conservation of mass
- X) Conservation of linear momentum
- Y) Conservation of angular momentum
- Z) Conservation of charge

ANSWER: W) Conservation of mass

TOSS-UP

20) Math - *Short Answer* Navia is building a fence of length 220 feet. If she wants the fence to have a total of 11 evenly spaced fence posts, how far, in feet, should the distance be between each pair of adjacent posts?

ANSWER: 22

BONUS

20) Math - *Short Answer* Compute $4! \cdot 3! \cdot 2! \cdot 1!$ [**four factorial times three factorial times two factorial times one factorial**].

ANSWER: 288

TOSS-UP

21) Biology - *Short Answer* Mitochondria and chloroplasts both possess many characteristics similar to bacteria. What theory proposes that these organelles were once free-living prokaryotes engulfed by an ancestral eukaryotic cell in a mutually beneficial relationship?

ANSWER: Theory of endosymbiosis (ACCEPT: Endosymbiosis, endosymbiont theory)

BONUS

21) Biology - *Short Answer* A plasmid and a gene of interest are cut by the same restriction enzyme. When introduced to each other, the gene of interest binds to the plasmid at complementary sticky ends. What enzyme is then needed to seal together the strands to form a cloning vector?

ANSWER: Ligase (ACCEPT: DNA ligase)

TOSS-UP

22) Earth and Space - *Multiple Choice* The brightness of a star as observed from Earth is proportional to its distance from Earth raised to what power?

W) -1

X) -2

Y) -3

Z) -4

ANSWER: X) -2

BONUS

22) Earth and Space - *Short Answer* Order the following three planets from most to least spherical: 1) Earth; 2) Jupiter; 3) Saturn.

ANSWER: 1, 2, 3

TOSS-UP

23) Chemistry - *Multiple Choice* Which of the following reaction types does NOT occur when vinegar is combined with baking soda?

- W) Acid-base
- X) Double replacement
- Y) Metathesis
- Z) Redox

ANSWER: Z) Redox

BONUS

23) Chemistry - *Short Answer* Two identical containers, each consisting of two chambers, have one empty chamber and one chamber filled with a gas. If the identities of the gases in the two containers are helium and sulfur dioxide, then to the nearest whole number, what is the ratio of their respective rates of effusion once a pinhole opening is made between the chambers?

ANSWER: 4 (ACCEPT: 4 to 1)