BSB ROUND 14

TOSS-UP

1) Chemistry – *Short Answer* 1-propanol is treated with PBr_3 to form phosphorous ***[phos-FOR-ous]*** acid and what other compound?

ANSWER: 1-BROMOPROPANE

BONUS

1) Chemistry – *Short Answer* What theory places polymer segments and solvent molecules on a lattice to describe the thermodynamics of polymer solutions?

ANSWER: FLORY–HUGGINS SOLUTION THEORY

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TOSS-UP

2) Math – *Short Answer* What is the derivative with respect to t of $3t^3e^t$ at $t = 1$?

ANSWER: $12e$

BONUS

2) Math – *Short Answer* If vector A is $3\boldsymbol{i} + 14\boldsymbol{j} + 5\boldsymbol{k}$ and vector B is $4\boldsymbol{i} + 7\boldsymbol{j} + 13\boldsymbol{k}$, then what is A cross B?

ANSWER: $147\boldsymbol{i} - 19\boldsymbol{j} - 35\boldsymbol{k}$
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TOSS-UP

3) Biology – *Multiple Choice* Which of the following correctly summarizes the pathway of insulin through a pancreatic cell?

W) Ribosome to golgi body to rough ER to plasma membrane
X) Smooth ER to nucleus to vesicle to plasma membrane
Y) Rough ER to golgi body to vesicle to plasma membrane
Z) Nucleus to vesicle to rough ER to plasma membrane

ANSWER: Y) ROUGH ER TO GOLGI BODY TO VESICLE TO PLASMA MEMBRANE

BONUS

3) Biology – *Multiple Choice* Which of the following methods for target identification of a small molecule relies on generating a covalent bond between the molecule of interest and its target?

W) Thermal proteome profiling
X) Photoaffinity labeling
Y) Affinity purification
Z) Antibody labeling

ANSWER: X) PHOTOAFFINITY LABELING

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TOSS-UP

4) Energy – *Short Answer* Scientists in the Tilley Group at UC Berkeley are trying to create electrocatalysts that are able to split water into hydrogen and oxygen. These catalysts reduce the difference between the theoretical and actual cell potential, which is also known as what quantity?

ANSWER: OVERPOTENTIAL

BONUS

4) Energy – *Short Answer* Researchers in the Limmer Group at UC Berkeley are developing theories for photoinduced phase separation in lead halide perovskites. These theories involve a change in the surrounding electronic structure caused when charge carriers deform their lattice neighbors. This phenomenon is mediated by what quasiparticles?

ANSWER: POLARONS
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TOSS-UP

5) Physics – *Short Answer* Rank the following three isotopes of hydrogen in terms of increasing neutron scattering cross section: 1) Protium; 2) Deuterium; 3) Tritium.

ANSWER: 3, 2, 1

BONUS

5) Physics – *Short Answer* Identify all of the following three thermodynamic variables that remain constant during a Joule–Thomson expansion: 1) Entropy; 2) Internal energy; 3) Enthalpy.

ANSWER: 3 ONLY

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TOSS-UP

6) Earth and Space – *Multiple Choice* Which of the following is a type of bright nebula that is often produced in active star forming regions of galaxies and is known for its radiation of Energy?

W) Reflection nebula
X) Planetary nebula
Y) Dark nebula
Z) Emission nebula

ANSWER: Z) EMISSION NEBULA

BONUS

6) Earth and Space – *Short Answer* Arkose is a type of sandstone whose composition is at least 25% of what mineral?

ANSWER: FELDSPAR
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TOSS-UP

7) Math – *Short Answer* What are the new coordinates of the point (6, 0) when it is reflected diagonally across the line $y = x + 10$?

ANSWER: (−10, 16)

BONUS

7) Math – *Short Answer* What are the first three terms of the McLaurin series for x times e^{-x}?

ANSWER: $x - x^2 + x^3/2$

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TOSS-UP

8) Physics – *Short Answer* Identify all of the following three properties of the Maxwell-Boltzmann distribution of speeds that increase upon increasing temperature: 1) Average speed; 2) Width of distribution; 3) Area under curve.

ANSWER: 1 AND 2

BONUS

8) Physics – *Multiple Choice* The curvature of a potential well near the equilibrium position of a quantum harmonic oscillator is most directly related to which of the following quantities?

W) Reduced mass
X) Force constant
Y) Angular frequency
Z) Wavenumber

ANSWER: X) FORCE CONSTANT
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TOSS-UP

9) Chemistry – *Short Answer* Phenol is an industrially important chemical. In the first step of its production, benzene is treated with propene and phosphoric acid to form what intermediate?

ANSWER: CUMENE (ACCEPT: ISOPROPYLBENZENE; DO NOT ACCEPT: PROPYLBENZENE)

BONUS

9) Chemistry – *Short Answer* In order to synthesize a small-molecule drug precursor, scientists combine phenylhydrazine, an aldehyde, and acetic acid while heating. This results in the formation of what heterocycle?

ANSWER: INDOLE

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TOSS-UP

10) Biology – *Multiple Choice* A failure in what stage of spermatogenesis produces nondisjunction that results in a male having a XXY karyotype?

W) Prophase 1
X) Metaphase 1
Y) Anaphase 1
Z) Telophase 1

ANSWER: Y) ANAPHASE 1

BONUS

10) Biology – *Multiple Choice* Which of the following is true regarding the interaction between myosin and actin during muscle fiber contraction?

W) Myosin and actin bind in a weak and reversible manner, allowing for quick muscle relaxation
X) Myosin filaments slide past actin filaments without any binding during muscle contraction
Y) Myosin heads attach to the actin filament and pull it towards the center of the sarcomere during contraction
Z) Actin filaments bind to myosin heads and push them towards the Z-disc during muscle relaxation

ANSWER: Y) MYOSIN HEADS ATTACH TO THE ACTIN FILAMENT AND PULL IT TOWARDS THE CENTER OF THE SARCOMERE DURING CONTRACTION
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TOSS-UP

11) Energy – *Multiple Choice* Researchers at Berkeley's Molecular Foundry have been expanding synthetic capabilities on the surfaces of quantum dots. One of their target reactions is the azide-alkyne click reaction, which won the Nobel Prize in Chemistry in 2022. Which of the following metals is most commonly used as a catalyst for this reaction?

W) Iron
X) Nickel
Y) Platinum
Z) Copper

ANSWER: Z) COPPER

BONUS

11) Energy – *Short Answer* UC Berkeley's Benjamin Safdi is working on finding axions, which are hypothetical particles expected to solve the strong-CP problem arising in what theory of the strong interaction?

ANSWER: QUANTUM CHROMODYNAMICS (ACCEPT: QCD)

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TOSS-UP

12) Earth and Space – *Multiple Choice* Geologists examining sedimentary rocks can often deduce many factors of their surrounding environments in which they were accumulated. Which of the following rock-environment pairings cannot be true?

W) Conglomerate may indicate a high-energy environment such as a rushing stream
X) Breccia may indicate a low-energy environment such as a lake
Y) Arkose may indicate a dry climate
Z) Carbonaceous shale may indicate an organic-rich environment such as a swamp

ANSWER: X) BRECCIA MAY INDICATE A LOW-ENERGY ENVIRONMENT SUCH AS A LAKE

BONUS

12) Earth and Space – *Short Answer* What type of variable star is classified as a red dwarf and shows rapid and irregular changes in light?

ANSWER: FLARE STAR
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TOSS-UP

13) Chemistry – *Short Answer* Identify all of the following three functional groups that may be reduced by lithium aluminum hydride: 1) Ketone; 2) Aldehyde; 3) Carboxylic acid.

ANSWER: ALL

BONUS

13) Chemistry – *Short Answer* Ethyl iodide is treated with tert-butyllithium and then reacted with acetone followed by an acid workup. What functional group is formed by this reaction?

ANSWER: ALCOHOL (ACCEPT: TERTIARY ALCOHOL)

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TOSS-UP

14) Earth and Space – *Short Answer* Regions abundant with limestone and sinkholes such as areas of Florida and Kentucky are said to have what type of topography?

ANSWER: KARST

BONUS

14) Earth and Space – *Short Answer* Throughout the course of Earth's history, several supercontinents have existed. Order the following three supercontinents from the most recent to the oldest: 1) Vaalbara; 2) Pangaea; 3) Rodinia.

ANSWER: 2, 3, 1
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TOSS-UP

15) Biology – *Multiple Choice* Which of the following statements is NOT true regarding blood groups and agglutination?

W) Agglutination is caused by antibodies
X) Type O blood does not undergo agglutination
Y) Type B blood contains antibodies for Type A antigens
Z) The Rh factor is found in human blood

ANSWER: X) TYPE O BLOOD DOES NOT UNDERGO AGGLUTINATION

BONUS

15) Biology – *Short Answer* Identify all of the following three statements that are true regarding bile: 1) Bile is both an excretory product and a digestive secretion; 2) Bile is stored in the liver; 3) Bilirubin is formed from the breakdown of heme.

ANSWER: 1 AND 3

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TOSS-UP

16) Physics – *Short Answer* What is the name given to solids that have zero disorder but lack a repeating unit cell?

ANSWER: QUASICRYSTALS

BONUS

16) Physics – *Short Answer* An infinite sheet of charge produces an electric field of 12 newtons per coulomb at a distance of 10 meters from its surface. What is the charge density of this infinite sheet in terms of the permittivity of free space?

ANSWER: 24 TIMES THE PERMITTIVITY OF FREE SPACE (ACCEPT: 24 TIMES EPSILON NAUGHT)
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TOSS-UP

17) Energy – *Short Answer* Scientists in the Bilder Lab at UC Berkeley are using *Drosophila* cancer models to understand how epithelial organization prevents tumor formation. What epithelial tissue consists of a single layer of cells varying in height and the position of their nuclei?

ANSWER: PSEUDOSTRATIFIED COLUMNAR EPITHELIUM

BONUS

17) Energy – *Short Answer* Scientists at Lawrence Berkeley National Laboratory are working on creating enantiopure products from a racemic mixture of reactants using asymmetric catalysts. What is the name of this general type of chemical reaction?

ANSWER: KINETIC RESOLUTION (ACCEPT: DYNAMIC KINETIC RESOLUTION)

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TOSS-UP

18) Math – *Short Answer* What is the product of all the distinct prime factors of 135?

ANSWER: 15

BONUS

18) Math – *Short Answer* How many different intersections occur between the following two equations: $y = 2x^4 - 6x^2 - 1$ and $y = 3x - 1$?

ANSWER: 4
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TOSS-UP

19) Biology – *Multiple Choice* Which of the following is the correct order of events in a typical neuromuscular reflex arc, such as the knee-jerk reflex?

W) Effector muscle, motor neuron, sensory neuron
X) Sensory receptor, motor neuron, sensory neuron
Y) Sensory receptor, spinal cord interneuron, motor neuron
Z) Sensory neuron, effector neuron, interneuron

ANSWER: Y) SENSORY RECEPTOR, SPINAL CORD INTERNEURON, MOTOR NEURON

BONUS

19) Biology – *Multiple Choice* Which of the following proteins is most likely to be involved in the determination of muscle cell fate during embryonic development?

W) MyoD
X) Myosin
Y) MyoR
Z) Troponin

ANSWER: W) MyoD

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TOSS-UP

20) Earth and Space – *Short Answer* The Ring of Fire predominantly contains what type of volcano that is large, nearly symmetrical, and consists of alternating layers of pyroclastic material?

ANSWER: COMPOSITE CONE (ACCEPT: STRATOVOLCANO; COMPOSITE VOLCANO)

BONUS

20) Earth and Space – *Multiple Choice* Which of the following statements best explains why below the size of 0.1 millimeters, smaller sediment size is correlated with a greater critical erosion velocity?

W) Smaller sediments have stronger cohesive forces
X) As sediment size becomes smaller its settling velocity decreases
Y) Smaller sediments are more likely to be transported than eroded
Z) Flow acceleration is the primary cause of erosion

ANSWER: W) SMALLER SEDIMENTS HAVE STRONGER COHESIVE FORCES
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TOSS-UP

21) Chemistry – *Short Answer* Rank the following molecules in terms of increasing nucleophilicity in acetone solvent: 1) Methanol; 2) Methoxide; 3) Methylamine ***[METH-ul-uha-meen]***.

ANSWER: 1, 3, 2

BONUS

21) Chemistry – *Short Answer* The difference in potential energy between the eclipsed conformation and the staggered conformation of a given molecule is due to what phenomenon?

ANSWER: TORSIONAL STRAIN

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TOSS-UP

22) Math – *Short Answer* Convert polar coordinate (10, 150 degrees) to rectangular coordinates.

ANSWER: $(-5\sqrt{3}, 5)$

BONUS

22) Math – *Short Answer* Let $f(x)$ denote the *floor function*, which returns the greatest integer less than or equal to x. What is the smallest positive number x such that f of the quantity x squared, f of the quantity x times f of x, and the quantity f of x squared are all different integers?

ANSWER: 2.5
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TOSS-UP

23) Physics – *Short Answer* A wave is traveling on a string with a uniform mass density, at a velocity of 10 meters per second. If the tension in the string is doubled, by what factor does the velocity of the wave change?

ANSWER: SQUARE ROOT OF 2

BONUS

23) Physics – *Short Answer* A square loop of wire with area 1 meter-squared and 1 ampere of current is placed in a 10 tesla magnetic field such that two of its edges lie parallel to the field. If the wire has a linear mass density of 1 kilogram per meter, what is the wire's initial rotational acceleration in radians per second squared?

ANSWER: 15