SBST ROUND 7

TOSS-UP

1) Chemistry – *Short Answer* What is the maximum number of spin-up electrons that can be found in a single atomic orbital?

ANSWER: ONE

BONUS

1) Chemistry – *Multiple Choice* A hydrogen electron transitions from the n = 2 to n = 4 energy level, and then to the n = 3 energy level. Which of the following describes the net amount of energy change during this process?

W) 5/36 rydbergs absorbed
X) 3/16 rydbergs absorbed
Y) 5/36 rydbergs released
Z)5/36 rydbergs released

ANSWER: W) 5/36 RYDBERGS ABSORBED

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TOSS-UP

2) Math – *Short Answer* Using the first 3 terms of the Maclaurin series of *e* to the *x*, what is the approximate value of *e* squared?

ANSWER: 5

BONUS

2) Math – *Multiple Choice* For the function *f* of *x* equals $x^3 + 3x^2 - 24x + 12$ on the domain of the closed interval from –3 to 4, at which of the following *x* values is the function at its global maximum?

W) –3
X) –4
Y) 2
Z) 4

ANSWER: X) –4
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TOSS-UP

3) Biology – *Short Answer* Identify all of the following three ions that have a higher concentration inside the cell than outside the cell: 1) Sodium; 2) Chloride; 3) Potassium.

ANSWER: 3 ONLY

BONUS

3) Biology – *Short Answer* The classic form of phenylketonuria is caused by the defective nature of what enzyme?

ANSWER: PHENYLALANINE HYDROXYLASE

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TOSS-UP

4) Energy – *Short Answer* Scientists at SLAC National Accelerator Lab probed the electron spin properties of nickel oxide ceramics to study their superconductivity. They found it exhibited a similar response to classic cuprate superdoncutorors which possess electron spins aligned in opposite directions in a checkerboard like pattern. What form of magnetism does this pattern produce?

ANSWER: ANTIFERROMAGNETISM

BONUS

4) Energy – *Short Answer* Scientists at Pacific Northwest National Lab have used mass spectrometry to analyze the lipid content of symbiotic leafcutter ant fungi, a new innovative field of study known as lipidomics. In eukaryotes, by what process are fatty acids in the cell broken down into acetyl-coA?

ANSWER: BETA OXIDATION
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TOSS-UP

5) Physics – *Short Answer* The Rayleigh-Jeans law of blackbody radiation produced the ultraviolet catastrophe, which was resolved by what other law?

ANSWER: PLANCK'S LAW

BONUS

5) Physics – *Multiple Choice* A spaceship is travelling at 0.8c with respect to a stationary observer. Which of the following quantities are equal for a person in the spaceship and the observer?

W) Length of the spaceship
X) Speed of light
Y) Width of the earth
Z) Time taken by the spaceship

ANSWER: X) SPEED OF LIGHT

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TOSS-UP

6) Earth and Space – *Multiple Choice* Which of the following minerals does not contain sulfur?

W) Gypsum
X) Anhydrite
Y) Pyrite
Z) Fluorite

ANSWER: Z) FLUORITE

BONUS

6) Earth and Space – *Short Answer* Identify all of the following 3 rocks that are aphanitic: 1) Basalt; 2) Rhyolite; 3) Diorite.

ANSWER: 1 AND 2
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TOSS-UP

7) Math – *Short Answer* In terms of pi, what is the volume of a frustum with a height of 5 and radii of length 3 and 6?

ANSWER: 105π

BONUS

7) Math – *Short Answer* What are the coordinates of the image of the point (2, 6) when it is rotated 90 degrees clockwise about the point (–4, 2)?

ANSWER: (0, –4)

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TOSS-UP

8) Physics – *Short Answer* Snell's law can be derived by applying what principle, which states that light always takes the path of least time?

ANSWER: FERMAT'S PRINCIPLE

BONUS

8) Physics – *Short Answer* Identify all of the following three types of materials that generally have a positive band gap. 1) Insulators; 2) Semiconductors; 3) Superconductors.

ANSWER: 1 AND 2
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TOSS-UP

9) Chemistry – *Multiple Choice* Using spectroscopic methods, chemists are able to track the 3D structure of acyl chlorides as they perform nucleophilic substitution. If the bond angle of the substrate is tracked over time, which of the following trends would be observed?

W) An increase
X) A decrease
Y) An increase, then a decrease
Z) A decrease, then an increase

ANSWER: Z) A DECREASE, THEN AN INCREASE

BONUS

9) Chemistry – *Short Answer* Identify all of the following three factors that affect the collision frequency of two gaseous molecules X and Y in a constant-volume container:
1) Collision cross section; 2) Partial pressure of X; 3) Temperature of container.

ANSWER: ALL

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TOSS-UP

10) Biology – *Multiple Choice* In a resting human, which of the following is the main stimulus for glucagon secretion?

W) Increased amino acid concentration
X) Sympathetic stimulation of the pancreatic islets
Y) Decreased plasma glucose concentration
Z) Increased epinephrine

ANSWER: Y) DECREASED PLASMA GLUCOSE CONCENTRATION

BONUS

10) Biology – *Short Answer* Three species of frogs are found in a jungle in an undiscovered archipelago. Two species of frogs that live in similar niches are observed to be very morphologically different. The third species of frog lives on another island and is very morphically similar to one of the species of frog. This tendency for the allopatric species to be more similar than sympatric species is an example of which phenomena?

ANSWER: CHARACTER DISPLACEMENT
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TOSS-UP

11) Energy – *Multiple Choice* Scientists at Argonne National Lab have been studying new and effective ways to detect HIV infection before it develops into acquired immunodeficiency syndrome. Which of the following methods would be most effective at detecting HIV-like viruses?

W) Sanger sequencing
X) Restriction fragment analysis
Y) RT-PCR
Z) RNAi

ANSWER: Y) RT-PCR

BONUS

11) Energy – *Short Answer* Scientists at SLAC National Accelerator Lab have been studying the properties of high energy electrons and how they can strengthen magnetic fields. The continuous stream of high energy particles in the solar wind originate from which regions of the sun where its magnetic field does not loop back into the photosphere?

ANSWER: CORONAL HOLES

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TOSS-UP

12) Earth and Space – *Short Answer* Rank the following three objects in terms of increasing strength of their magnetic fields: 1) Ganymede; 2) Venus; 3) Earth

ANSWER: 2, 1, 3

BONUS

12) Earth and Space – *Short Answer* To one significant figure, how many times more energy does a magnitude 9.8 earthquake on the Richter scale release than a magnitude 6.8?

ANSWER: 30000
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TOSS-UP

13) Chemistry – *Short Answer* A sample of water is held initially at a temperature of 100 degrees Celsius and a pressure of 0.5 atmospheres. The sample is then pressurized to 2 atmospheres, and subsequently cooled to –30 degrees Celsius. Identify all of the following three phases through which the sample has been in at least once: 1) Solid; 2) Liquid; 3) Gas.

ANSWER: ALL

BONUS

13) Chemistry – *Multiple Choice* The molecular orbitals of carbon monoxide are created by superimposing atomic orbitals from carbon and oxygen with each other, using the coefficients *a* and *b* as weights for C and O, respectively. Which of the following best approximates the respective values of *a* and *b* in a particular bonding orbital?

W) 0 and 1
X) 0.3 and 0.9
Y) 0.9 and 0.3
Z) 1 and 0

ANSWER: X) 0.3 and 0.9

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TOSS-UP

14) Earth and Space – *Short Answer* Identify all of the following three objects that are indicative of star formation. 1) Bok globules 2) Planetary nebulae; 3) Herbig-Haro objects.

ANSWER: 1 AND 3

BONUS

14) Earth and Space – *Short Answer* Rank the following three objects in order of increasing brightness when viewed from Earth: 1) Jupiter; 2) Moon; 3) Venus.

ANSWER: 1, 3, 2
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TOSS-UP

15) Biology – *Short Answer* Human chorionic gonadotropin serves to maintain secretion of progesterone and estrogens by the corpus luteum to maintain the fetus. Therefore, it serves an analogous function to which pituitary hormone?

ANSWER: LUTEINIZING HORMONE

BONUS

15) Biology – *Short Answer* In a virally infected cell, viral proteins may be target for destruction by what structure?

ANSWER: PROTEASOME

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TOSS-UP

16) Physics – *Multiple Choice* Which of the following laws can best be used to calculate the magnetic field due to current flowing through a 4 meter long wire?

W) Ampere's law
X) Biot-Savart law
Y) Gauss' law
Z) Faraday's law

ANSWER: X) BIOT-SAVART LAW

BONUS

16) Physics – *Short Answer* A particle with a mass of 5 kilograms is acted on by a time dependent force given by the function $F(t) = 3t^2 + 2$. Over the interval from $t = 0$ to $t = 3$, in meters per second, what is the magnitude of the change in velocity of the particle?

ANSWER: 6.6 (ACCEPT: 33/5)
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TOSS-UP

17) Energy – *Multiple Choice* Researchers at Oak Ridge National Lab have been investigating quasiparticle excitations in lattices. Which of the following is NOT a quasiparticle?

W) Phonon
X) Magnon
Y) Plasmon
Z) Hyperon

ANSWER: Z) HYPERON

BONUS

17) Energy – *Short Answer* Researchers at Brookhaven National Lab are working with Fermilab scientists to construct the Deep Underground Neutrino Experiment, or DUNE. Their neutrino research is centered around investigating what phenomenon?

ANSWER: NEUTRINO OSCILLATIONS

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TOSS-UP

18) Math – *Multiple Choice* Which of the following functions, when integrated over its entire domain, produces a positive, finite value?

W) Tangent of x
X) Hyperbolic sine of x
Y) 1 over the quantity $9 + x^2$
Z) The square root of the quantity 1 minus x

ANSWER: Y) 1 OVER THE QUANTITY $9 + x^2$

BONUS

18) Math – *Short Answer* Two circles with centers of O and P of radius 10 and 8, respectively, intersect at two points A and B. If the distance AB is equal to 6, what is the length of OP?

ANSWER: SQUARE ROOT OF 91 + SQUARE ROOT OF 55
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TOSS-UP

19) Biology – *Short Answer* Identify all of the following three animal phyla that lack hox genes: 1) Porifera; 2) Cnidaria; 3) Echinodermata.

ANSWER: 1 ONLY

BONUS

19) Biology – *Short Answer* Identify all of the following three characteristics that are shared between prokaryotic and eukaryotic DNA replication: 1) Multiple origins of replication; 2) Unidirectional DNA polymerase; 3) Okazaki fragments.

ANSWER: 1 AND 3

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TOSS-UP

20) Earth and Space – *Short Answer* What is the only planet in the solar system whose barycenter with the sun lies outside the volume of the sun?

ANSWER: JUPITER

BONUS

20) Earth and Space – *Short Answer* Identify all of the following three features that are found on erosional shores: 1) Spits; 2) Tombolos; 3) Barrier islands.

ANSWER: NONE
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TOSS-UP

21) Chemistry – *Short Answer* How many different S—O bond lengths exist in one molecule of H_2SO_4?

ANSWER: 2

BONUS

21) Chemistry – *Short Answer* In acetylene, each carbon has a total of how many unhybridized p-orbitals involved in bonding?

ANSWER: 2

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TOSS-UP

22) Math – *Short Answer* Identify all of the following three centers that must lie inside a triangle: 1) Orthocenter; 2) Circumcenter; 3) Centroid.

ANSWER: 3 ONLY

BONUS

22) Math – *Multiple Choice* Which of the following numbers cannot be a remainder when n^3 is divided by 13, given that n is a positive integer?

W) 1
X) 5
Y) 7
Z) 12

ANSWER: Y) 7
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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 charged particle is given an initial velocity, and is placed in a uniform magnetic field that makes a 45 degree angle with the particle's initial velocity. What is the shape of the particle's trajectory?

ANSWER: HELICAL (ACCEPT: HELIX)