SBST ROUND 4

TOSS-UP

1) Biology – *Short Answer* What extraembryonic membrane is responsible for the formation of blood cells?

ANSWER: YOLK SAC

BONUS

1) Biology – *Short Answer* Which group of local regulators is secreted to contract the uterus during fertilization and prepare the muscles of the uterus for childbirth?

ANSWER: PROSTAGLANDINS

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TOSS-UP

2) Chemistry – *Multiple Choice* Given that the oxidation of iron to iron(III) oxide is exothermic, under which of the following conditions is the reaction spontaneous?

W) High temperatures
X) Low temperatures
Y) All temperatures
Z) It is never spontaneous

ANSWER: X) LOW TEMPERATURES

BONUS

2) Chemistry – *Multiple Choice* A molecular orbital diagram is constructed for the HF molecule using a linear combination of atomic orbitals. Which of the following statements is true regarding this diagram?

W) The HOMO is the same energy as that of atomic fluorine
X) The HOMO is net bonding
Y) The LUMO is the same energy as that of atomic fluorine
Z) The LUMO is net bonding

ANSWER: W) THE HOMO IS THE SAME ENERGY AS THAT OF ATOMIC FLUORINE
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TOSS-UP

3) Math – *Multiple Choice* Which of the following vectors is orthogonal to the vector $2\boldsymbol{i} - 4\boldsymbol{k}$?

W) $6\boldsymbol{i} + 2\boldsymbol{j} + \boldsymbol{k}$
X) $-4\boldsymbol{i} - 3\boldsymbol{j} + 3\boldsymbol{k}$
Y) $5\boldsymbol{i} + 6\boldsymbol{j} + 2\boldsymbol{k}$
Z) $-2\boldsymbol{i} + 7\boldsymbol{j} - \boldsymbol{k}$

ANSWER: Z) $-2\boldsymbol{i} + 7\boldsymbol{j} - \boldsymbol{k}$

BONUS

3) Math – *Short Answer* A sequence is defined such that the first term is 5, and each subsequent term is equivalent to 3 times the previous term plus 7. What is the 5th term of this sequence?

ANSWER: 685

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TOSS-UP

4) Earth and Space – *Short Answer* Identify all of the following three regions of the electromagnetic spectrum that can be effectively detected by telescopes on earth: 1) X-ray; 2) Microwave; 3) Radio.

ANSWER: 3 ONLY

BONUS

4) Earth and Space – *Multiple Choice* A white dwarf can be found in which of the following locations of the HR-diagram?

W) Top-left
X) Top-right
Y) Bottom-left
Z) Bottom-right

ANSWER: Y) BOTTOM-LEFT
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TOSS-UP

5) Physics – *Multiple Choice* A plane has an initial velocity of 100 meters per second and accelerates to 200 meters per second over 5 seconds. If the plane has a positive acceleration for the five seconds, in meters, which of the following best describes the range of the distance the plane travels over the interval?

W) Greater than or equal to 500 and less than or equal to 1000
X) Greater than or equal to 500 and less than 1000
Y) Greater than 500 and less than or equal to 1000
Z) Greater than 500 and less than 1000

ANSWER: Z) GREATER THAN 500 AND LESS THAN 1000

BONUS

5) Physics – *Short Answer* A uniform rope of mass 2 kilograms and length 5 meters hangs from a bridge. In newtons, what is the tension at the bottom of the rope?

ANSWER: 0

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TOSS-UP

6) Energy – *Short Answer* Researchers at Argonne National Lab have been working on emulating biological pathways to split water into its component elements using sunlight. What is the scientific term for the decomposition of molecules by light?

ANSWER: PHOTOLYSIS (ACCEPT: PHOTODISSOCIATION; PHOTODECOMPOSITION)

BONUS

6) Energy – *Short Answer* Researchers at Oak Ridge National Lab are working on creating nanomaterials such as fullerenes for applications in tumor research. Fullerenes are allotropes of what element?

ANSWER: CARBON
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TOSS-UP

7) Math – *Short Answer* Identify all of the following three functions that have no local maxima: 1) The square root of *x*; 2) *x* minus *e* to the *x*; 3) Tangent of *x*.

ANSWER: 1 AND 3

BONUS

7) Math – *Short Answer* What is the average value of the function $f(x) = x^4$ over the interval $x = 2$ to $x = 3$?

ANSWER: 211/5

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TOSS-UP

8) Earth and Space – *Short Answer* The Gulf of Mexico experiences what type of tidal pattern that has one high tide and one low tide each day?

ANSWER: DIURNAL

BONUS

8) Earth and Space – *Short Answer* Baily's beads are a feature of what astronomical event?

ANSWER: SOLAR ECLIPSES (DO NOT ACCEPT: ECLIPSES)
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TOSS-UP

9) Chemistry – *Short Answer* Haworth projections are visualization tools that organic chemists use to represent sugars that have what property?

ANSWER: CYCLIC (ACCEPT: RINGS)

BONUS

9) Chemistry – *Short Answer* Identify all of the following three compounds that are constitutional isomers of butane: 1) 2-methylpropane; 2) 2,2-dimethylpropane; 3) 2-butene.

ANSWER: 1 ONLY

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TOSS-UP

10) Biology – *Short Answer* Saltatory conduction occurs only at which densely populated regions of ion channels between successive myelin sheaths?

ANSWER: NODES OF RANVIER

BONUS

10) Biology – *Multiple Choice* During which of the following steps of glycolysis is glucose prevented from leaving the cell?

W) Glucose is phosphorylated to glucose-6-phosphate
X) Fructose-1,6-bisphosphate is split into glyceraldehyde-3-phosphate and dihydroxyacetone phosphate
Y) 3-phosphoglycerate is isomerized into 2-phosphoglycerate
Z) Phosphoenolpyruvate is dephosphorylated into pyruvate

ANSWER: W) GLUCOSE IS PHOSPHORYLATED TO GLUCOSE-6-PHOSPHATE
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TOSS-UP

11) Physics – *Short Answer* Order the following three processes from least to most work done on an ideal gas: 1) Adiabatic compression; 2) Isothermal compression; 3) Isobaric compression.

ANSWER: 1, 2, 3

BONUS

11) Physics – *Short Answer* On a certain planet with an acceleration due to gravity of 0.8 meters per second squared, a ball of mass 10 kilograms is attached to a string that is being swung around horizontally. If the ball has a tangential velocity of 3 meters per second and the radius of the string is 6 meters, then in newtons to the nearest whole number, what is the force of tension acting on the ball?

ANSWER: 17

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TOSS-UP

12) Energy – *Short Answer* Scientists at Pacific Northwest National Lab have been studying the use of Argon-39 to date groundwater as alternatives to carbon-14 and tritium. Rank the following three radioactive isotopes in order of increasing half-life: 1) Argon-39; 2) Carbon-14; 3) Hydrogen-3.

ANSWER: 3, 1, 2

BONUS

12) Energy – *Short Answer* Researchers at Argonne National Lab are studying the dynamics of different subatomic particles in quantum dots through the use of transient absorption spectroscopy. In particular, they are studying the dynamics of the electron along with what quasiparticle?

ANSWER: ELECTRON HOLE
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TOSS-UP

13) Biology – *Short Answer* The organism paramecium caudatum usually lives in a hypotonic environment, but does not burst because it is equipped with what organelle?

ANSWER: CONTRACTILE VACUOLE

BONUS

13) Biology – *Short Answer* A certain plant is noticed to open its stomata at night and perform photosynthesis in the morning. Identify all of the following three statements that are also likely true about this plant: 1) It fixes carbon into malic acid; 2) It is a xerophyte; 3) It has waxy leaves.

ANSWER: ALL

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TOSS-UP

14) Math – *Short Answer* A triangle has two sides of length 5 and 8. How many possible integer side lengths exist for the third side?

ANSWER: 9

BONUS

14) Math – *Short Answer* What is the slope of the line tangent to the curve $x^3y + 3y^2 = 11$ at the point (2, 1)?

ANSWER: –6/7
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TOSS-UP

15) Chemistry – *Short Answer* What term is given to the number of nuclear disintegrations a radioactive sample exhibits over a period of time?

ANSWER: ACTIVITY

BONUS

15) Chemistry – *Short Answer* According to molecular orbital theory, what is the bond order of a single boron-hydrogen bridging bond in B_2H_6?

ANSWER: 1/2 (ACCEPT: 0.5)

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TOSS-UP

16) Earth and Space – *Short Answer* Rank the following three gases in terms of increasing concentration in Venus's atmosphere: 1) CO_2; 2) N_2; 3) H_2O

ANSWER: 3, 2, 1

BONUS

16) Earth and Space – *Short Answer* Identify all of the following three planets that are astronomically inferior to Earth: 1) Mars; 2) Neptune; 3) Uranus.

ANSWER: NONE
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TOSS-UP

17) Physics – *Short Answer* How many times greater is the magnitude of the energy of an electron in the ground state of a hydrogen atom than the energy of an electron in the second excited state?

ANSWER: 9

BONUS

17) Physics – *Short Answer* Order the following three objects from first to last to roll down a ramp of equal length, given that their mass and radius are the same: 1) Uniform cylinder; 2) Uniform sphere; 3) Uniform spherical shell.

ANSWER: 2, 1, 3

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TOSS-UP

18) Energy – *Short Answer* SLAC National Accelerator Lab have been studying the prospect of using exoplanets to discover hot dark matter scattering off of planets due to anomalous temperature disparities. The heating of exoplanets by regions that are highly dense in dark matter likely occurs via what process that produces gamma rays?

ANSWER: ANNIHILATION

BONUS

18) Energy – *Short Answer* Scientists at Argonne National Lab discovered a new mineral called santabarbaraite in ancient chiton fossils. It was contained within a structure known as a stylus which is present in the mollusk to help mechanically digest its food before chemical digestion. The stylus is part of what feeding structure in mollusks?

ANSWER: RADULA
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TOSS-UP

19) Physics – *Short Answer* What quantum mechanical principle states that at high quantum numbers, quantum physics reproduces classical physics?

ANSWER: CORRESPONDENCE PRINCIPLE

BONUS

19) Physics – *Short Answer* A particle has a displacement given by the parametric equations $x(t) = 4t^2 + 8$ and $y(t) = 2.5t^3$. In meters per second squared, what is the magnitude of the particle's acceleration at $t = 1$?

ANSWER: 17

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TOSS-UP

20) Biology – *Short Answer* The peripheral nervous system possesses specialized glial cells called Schwann cells that help maintain the myelin sheath. What is its functional analog in the central nervous system?

ANSWER: OLIGODENDROCYTES

BONUS

20) Biology – *Short Answer* Somatostatin is manufactured in the delta cells of what organ?

ANSWER: PANCREAS
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TOSS-UP

21) Chemistry – *Short Answer* A sample of phosphorus pentachloride is injected into an evacuated container. The partial pressure of phosphorus pentachloride begins at 1 atmosphere and drops to 0.8 atmospheres as it is converted into phosphorus trichloride and chlorine gas. To one significant figure, what is the equilibrium constant for this reaction?

ANSWER: 0.05

BONUS

21) Chemistry – *Short Answer* The dipole-dipole interaction between two acetone molecules has an associated force magnitude that varies as the distance between molecules *r* to what power?

ANSWER: –4

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TOSS-UP

22) Math – *Short Answer* How many subsets of the set {2, 4, 7, 9, 12} contain at least 2 elements?

ANSWER: 26

BONUS

22) Math – *Short Answer* What is the cosine of the angle between the two vectors $3\boldsymbol{i} - 2\boldsymbol{j} + \boldsymbol{k}$ and $3\boldsymbol{j} + 4\boldsymbol{k}$?

ANSWER: NEGATIVE SQUARE ROOT OF 14 OVER 35
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TOSS-UP

23) Earth and Space – *Short Answer* Order the following three layers of the sun from innermost to outermost: 1) Radiative zone; 2) Tachocline; 3) Convective zone.

ANSWER: 1, 2, 3

BONUS

23) Earth and Space – *Short Answer* Usually, the magnetic axis of a planet is not perfectly aligned with its axis of rotation. Which planet is the exception to this rule?

ANSWER: SATURN