SBL FALL ROUND 7

TOSS-UP

1) Earth and Space – *Multiple Choice* Which of the following best describes the movement of a 0.8-solar mass stellar remnant contracting to become a white dwarf on the HR diagram?

W) Left, then top right
X) Left, then bottom right
Y) Right, then bottom left
Z) Right, then top left

ANSWER: X) LEFT, THEN BOTTOM RIGHT

BONUS

1) Earth and Space – *Short Answer* Identify all of the following three statements regarding stream flow that are true: 1) The Reynolds number of the flow generally decreases further away from the source; 2) Glacial river channels are generally braided due to high sediment load; 3) Assuming no uplift or changes in total river discharge, there exists a longitudinal profile after which being reached, the river cannot downcut further.

ANSWER: ALL

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TOSS-UP

2) Math – *Short Answer* What is the sine of 15 degrees times the cosine of 15 degrees?

ANSWER: 1/4

BONUS

2) Math – *Short Answer* A quadratic in x passes through the points (0, 4), (1, 5), and (2, 8). What is the y-coordinate of the intersection of the quadratic and the line $x = 10$?

ANSWER: 104
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TOSS-UP

3) Chemistry – *Short Answer* Indicating proper charge, what is the oxidation state of the phosphorus atom in phosphorous acid?

ANSWER: +3 (DO NOT ACCEPT: 3)

BONUS

3) Chemistry – *Multiple Choice* How many distinct carbon-oxygen bond lengths exist in an iron(III) complex coordinated by three oxalate ions?

W) 1
X) 2
Y) 3
Z) 6

ANSWER: X) 2

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TOSS-UP

4) Physics – *Short Answer* A fire hydrant can supply 1.5 cubic meters of water per minute at a pressure of 400 kilopascals. In kilowatts, how much power is carried by the water?

ANSWER: 10

BONUS

4) Physics – *Short Answer* A volleyball on Earth is dropped from rest at the same height as a golf ball on the moon, which has only 1/6 of Earth's gravity. Right before they reach the ground, they have the same kinetic energy. What is the ratio of the momentum of the golf ball to that of the volleyball?

ANSWER: SQUARE ROOT OF 6
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TOSS-UP

5) Biology – *Short Answer* What model describes the change in the active site of an enzyme following the binding of a substrate?

ANSWER: INDUCED FIT

BONUS

5) Biology – *Short Answer* Identify all of the following three viruses that use reverse transcriptase in their reproductive cycles: 1) Ebolavirus; 2) HIV; 3) Togavirus.

ANSWER: 2 ONLY

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TOSS-UP

6) Energy – *Short Answer* Researchers at Lawrence Berkeley National Lab have been studying hundreds of secondary metabolite compounds within plant species all over the world to better understand their production. Many of these compounds have been found to permanently inhibit the germination of nearby seeds. What family of plant hormone is likely inhibited by these metabolites?

ANSWER: GIBBERELLINS

BONUS

6) Energy – *Short Answer* Scientists at Pacific Northwest National Lab are studying diatoms and their role in nitrogen fixation in the oceans. As they decompose, diatoms form what type of biogenous sediment?

ANSWER: SILICEOUS OOZE
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TOSS-UP

7) Chemistry – *Short Answer* In the presence of a metal catalyst, hydrogen peroxide decomposes spontaneously into oxygen gas and what other product?

ANSWER: WATER

BONUS

7) Chemistry – *Short Answer* Identify all of the following three compounds that readily dimerize in the gaseous phase: 1) Acetic acid; 2) Methane; 3) Aluminum chloride.

ANSWER: 1 AND 3

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TOSS-UP

8) Biology – *Short Answer* What is the only genus of bacteria that contains no cell walls?

ANSWER: MYCOPLASMA (DO NOT ACCEPT: MYCOBACTERIUM)

BONUS

8) Biology – *Short Answer* The leptin hormone is released by what class of connective tissue cells?

ANSWER: ADIPOSE CELLS (ACCEPT: ADIPOCYTES)
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TOSS-UP

9) Energy – *Short Answer* Researchers at Pacific Northwest National Lab are studying the difference in reaction rates between molecules of gamma-lithium aluminate based on whether the lithium atom has 3 or 4 neutrons. What is the term for this effect?

ANSWER: KINETIC ISOTOPE EFFECT

BONUS

9) Energy – *Short Answer* Researchers at Argonne National Lab are researching efficient iron based hydrogenases that are resistant to oxygen gas poisoning. These biological catalysts may be modeled using steady state kinetics described by what equation?

ANSWER: MICHAELIS–MENTEN EQUATION

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TOSS-UP

10) Math – *Multiple Choice* A continuous function passes through the points (0, –2) and (9, 5). Which of the following horizontal lines does the function NOT have to intersect?

W) $y = -2$
X) $y = 0$
Y) $y = 4$
Z) $y = 8$

ANSWER: Z) $y = 8$

BONUS

10) Math – *Short Answer* If a rhombus has a side length of 10 and one of its angles is 30 degrees, what is the radius of the circle inscribed in the rhombus?

ANSWER: 2.5
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TOSS-UP

11) Earth and Space – *Multiple Choice* Oceans at which of the following latitudes, in degrees North, have weak pycnoclines year-round?

W) 0
X) 30
Y) 40
Z) 75

ANSWER: Z) 75

BONUS

11) Earth and Space – *Multiple Choice* The Earth's atmosphere has undergone evolution within the past 4.6 billion years. The secondary atmosphere was characterized by an abundance in what two gases?

W) Hydrogen and helium
X) Water vapor and carbon dioxide
Y) Oxygen and carbon dioxide
Z) Nitrogen and oxygen

ANSWER: X) WATER VAPOR AND CARBON DIOXIDE

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TOSS-UP

12) Physics – *Short Answer* A nonconducting sphere of radius 2 meters has a uniform charge density of 1 coulomb per cubic meter. Two points, one inside the sphere and one outside the sphere, experience the same magnitude of electric field. If the distance between the center of the sphere and one of the points is 3 meters, what is the distance in meters between the center of the sphere and the other point?

ANSWER: 8/9

BONUS

12) Physics – *Short Answer* An oscillating LC circuit consists of a 6-millihenry inductor and a 4.5-microfarad capacitor. If the maximum charge on the capacitor is 3 microcoulombs, then, in scientific notation to one significant figure, what is the total energy in the circuit in joules?

ANSWER: 1×10^{-6}
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TOSS-UP

13) Biology – *Multiple Choice* Which of the following cells within the digestive tract serves mainly to secrete mucus?

W) D cells
X) Chief cells
Y) Parietal cells
Z) Goblet cells

ANSWER: Z) GOBLET CELLS

BONUS

13) Biology – *Short Answer* Identify all of the following three statements that are true regarding photoperiodism: 1) Day neutral plants do not display photoperiodism; 2) Photoperiodism is mediated by cryptochromes only; 3) A short day plant with a critical period of 6 hours will flower if subjected to 24 hours of light interrupted by darkness every five minutes.

ANSWER: 1 ONLY

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TOSS-UP

14) Math – *Short Answer* What is log base 2 of 8 + log base 8 of 2?

ANSWER: 10/3

BONUS

14) Math – *Short Answer* What is the units digit of the product of the first 100 odd numbers?

ANSWER: 5
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TOSS-UP

15) Earth and Space – *Short Answer* Assuming no change in the ultimate base level, identify all of the following three changes that will not result in an altered longitudinal profile of a stream: 1) Greater downcutting; 2) Headward erosion; 3) Tectonic uplift.

ANSWER: NONE

BONUS

15) Earth and Space – *Multiple Choice* Which of the following best approximates the mass percent of silica in an anhydrous mafic melt?

W) 20%
X) 50%
Y) 70%
Z) 90%

ANSWER: X) 50%

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TOSS-UP

16) Physics – *Short Answer* Rounded to the nearest meter, what is the maximum possible horizontal range of a projectile fired from the ground at an initial velocity of 10 meters per second?

ANSWER: 10

BONUS

16) Physics – *Multiple Choice* A dipole is a system of point charges of equal magnitude and opposite sign fixed at a close distance from each other. If r is a distance far from the dipole, which of the following relations describes the dependence of the electric potential on r?

W) $1/r$
X) $1/r^2$
Y) $1/r^3$
Z) $1/r^4$

ANSWER: X) $1/r^2$
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TOSS-UP

17) Energy – *Short Answer* Researchers at Pacific Northwest National Lab are studying the trans-Pacific propagation of aerosols. What is the dominant global wind circulation at 45 degrees North that carries aerosols across the Pacific?

ANSWER: WESTERLIES (ACCEPT: ANTI-TRADE WINDS; PREVAILING WESTERLIES)

BONUS

17) Energy – *Short Answer* Researchers at Lawrence Berkeley National Lab have been researching new methods to reduce the atmospheric concentration of carbon dioxide, one of which involves injecting carbon dioxide into subsurface aquifers. What term describes this general process?

ANSWER: CARBON SEQUESTRATION (ACCEPT: CARBON DIOXIDE REMOVAL, CDR)

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TOSS-UP

18) Chemistry – *Multiple Choice* The heating curve of a substance plots heat absorbed on the *x* axis and temperature on the *y* axis. Which of the following quantities is represented by the slope of this curve?

W) Heat capacity
X) One over heat capacity
Y) Enthalpy of vaporization
Z) Enthalpy of sublimation

ANSWER: X) ONE OVER HEAT CAPACITY

BONUS

Moderator Note: Read Slowly
18) Chemistry – *Multiple Choice* In one reaction vessel, propene is treated with boron trihydride and tetrahydrofuran, followed by hydrogen peroxide and sodium hydroxide. In another reaction vessel, acetone is treated with lithium aluminum hydride. What is the relationship between the major products formed in each reaction?

W) Structural isomers
X) Diastereomers
Y) Enantiomers
Z) Identical

ANSWER: W) STRUCTURAL ISOMERS
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TOSS-UP

19) Biology – *Short Answer* Turner syndrome results from the monosomy of what chromosome?

ANSWER: X CHROMOSOME (DO NOT ACCEPT: CHROMOSOME 23)

BONUS

19) Biology – *Short Answer* Which glycoprotein does thrombin cleave to cause the formation of platelet plugs?

ANSWER: FIBRINOGEN (DO NOT ACCEPT: FIBRIN)

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TOSS-UP

20) Math – *Short Answer* An infinite geometric series has first term 128 and second term 96. How many terms in this series are integers?

ANSWER: 4

BONUS

20) Math – *Short Answer* Regular octagon ABCDEFGH has side length 1. What is the area of the trapezoid ACDF?

ANSWER: 3/2 PLUS ROOT 2 (ACCEPT: 3 PLUS 2 ROOT 2 ALL OVER 2)
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TOSS-UP

21) Earth and Space – *Short Answer* Identify all of the following 3 depositional environments in which cross-bedding may develop: 1) Aeolian sand dunes; 2) Side bank of a meandering river; 3) Tidal flat.

ANSWER: ALL

BONUS

21) Earth and Space – *Multiple Choice* Which of the following are likely the origin of long gamma ray bursts?

W) Kilonovae
X) Magnetars
Y) Type 1a supernovae
Z) Hypernovae

ANSWER: Z) HYPERNOVAE

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TOSS-UP

22) Physics – *Multiple Choice* Which of the following particles does not obey Fermi-Dirac statistics?

W) Muon
X) Top quark
Y) Neutron
Z) Higgs boson

ANSWER: Z) HIGGS BOSON

BONUS

22) Physics – *Short Answer* Minkowski diagrams are used to qualitatively explain what theory?

ANSWER: SPECIAL RELATIVITY
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TOSS-UP

23) Chemistry – *Short Answer* Identify all of the following three compounds that can deprotonate acetylene: 1) Sodium hydroxide; 2) Sodium methoxide; 3) Sodium hydride.

ANSWER: 3 ONLY

BONUS

23) Chemistry – *Multiple Choice* Which of the following substances has the lowest standard molar entropy?

W) Graphite
X) Water
Y) Benzene
Z) Calcium carbonate

ANSWER: W) GRAPHITE