SSBT Playoffs Finals

TOSSUP

1) Physics – *Short Answer* To two significant figures, what is the strength of the magnetic field around a 0.5 meter solenoid given that the solenoid has 200 turns and the current through the solenoid is 4 amperes?

ANSWER: $2.0 * 10^{-3}$ T

BONUS

1) Physics – *Short Answer* A magnet pushed through a square coil and induces an emf E. If the magnet is pushed through a square coil with double the dimensions at a 60 degree angle, what is the induced emf?

ANSWER: 2E

TOSS-UP

2) Earth and Space – *Multiple Choice* Which of the following types of faults would lead to the exhumation of deep crust below it?

W) Normal

X) Reverse

Y) Strike-slip

Z) Oblique-slip

ANSWER: W) NORMAL

BONUS

2) Earth and Space – *Short Answer* Identify all of the following three events that could produce breccias: 1) Rockfall; 2) Asteroid impact; 3) Volcanic eruption.

ANSWER: ALL

TOSS-UP

3) Biology – *Multiple Choice* Which of the following hormones causes increased atrial pressure and decreases sodium reabsorption in the kidneys?

W) Atrial Natriuretic (nay-tree-ur-etic) Peptide

X) PTH (Parathyroid Hormone)

Y) Aldosterone

Z) Vasopressin

Answer: (W: Atrial Natriuretic (nay-tree-ur-etic) Peptide)

BONUS

3) Biology – *Short Answer* Peter has discovered that the nitrogenous bases of nucleotides do engage in non-Watson-Crick base pairing. Such an example is hydrogen bonding between 3 nitrogenous bases in triple stranded DNA. Peter's evil twin Patrick has also discovered the Guanosine Tetraplex, a structure in which 4 different guanine bases interact with one another via hydrogen bonding. What is the term which defines this type of non-canonical base pairing?

ANSWER: Hoogsten Base Pairing

TOSS-UP

4) Chemistry - *Short Answer* What is the oxidation state of Chromium in the compound sodium chromate?

ANSWER: 6+ (DO NOT ACCEPT: 6)

BONUS

4) Chemistry - *Multiple Choice* What reagent, produced from magnesium and an alkyl halide, can be used to prepare an alcohol from esters, ketones, and aldehydes?

W) Wittig Reagent

X) Grignard Reagent

Y) Collins Reagent

Z) Baeyer's Reagent

ANSWER: X) Grignard Reagent

TOSSUP

5) Energy- *Multiple Choice* Researchers at Osaka Metropolitan University are currently studying efficient means of producing biodegradable plastics using the monomer, fumarate. A current method of producing this biodegradable plastic relies upon combining carbon dioxide and pyruvate via what enzyme, known to directly catalyze the regeneration of oxaloacetate in the Citric Acid Cycle?

W) Malate Dehydrogenase

X) Pyruvate Dehydrogenase

Y) Isocitrate Dehydrogenase

Z) NADH Dehydrogenase

ANSWER: W) Malate Dehydrogenase

BONUS

5) Energy – *Short Answer* In modern science, nanopatterning is an essential technique for the fabrication of compact devices for electronic, optical, photonic, and biological applications. What technique is based on creating nanopatterns using UV light on a light-sensitive material called “resist” that is deposited on a substrate?

Answer: (UV-NIL) Ultraviolet Nanoimprint Lithography

TOSS-UP

6) Math – *Short Answer* A circle loses 30% of its area when a smaller circle of radius 3 is cut from its middle. What is the radius of the circle?

ANSWER: sqrt30

BONUS

6) Math – *Short Answer* Two fair three-sided dice with sides numbered 1, 2, and 3 are rolled. What is the expected value of the maximum value of the two die?

ANSWER: 22/9

TOSS-UP

7) Physics - *Short Answer* What law is the more general version of Ampere's Law that solves for the total magnetic field at some distance from the wire?

ANSWER: BIOT-SAVART LAW

BONUS

7) Physics - *Short Answer* How far away must a point be to have a magnetic field of $2.0 * 10^{-3}$ T given that the wire carries 5 amps?

ANSWER: 50 mm (accept equivalent distances)

TOSS-UP

8) Earth and Space – *Short Answer* Identify all of the following three things that would most likely cause an increase in ocean salinity: 1) Formation of sea ice; 2) Evaporation; 3) Increased runoff.

ANSWER: 1 AND 2

BONUS

8) Earth and Space – *Short Answer* Identify by name or number all of the following 3 bodies that are in orbital resonance with each other: 1) Pluto and Neptune, 2) Ganymede and Io, 3) Hyperion and Titan

ANSWER: ALL

TOSS-UP

9) Biology – *Short Answer* What hormone directly controls erythrocyte production by acting on bone marrow cells, leading to the proliferation of erythrocyte progenitor cells?

ANSWER: Erythropoietin

BONUS

9) Biology – *Short Answer* A population of imaginary diploid mice living in Antarctica have one gene with which determines their fur color. In this population of mice, white fur is dominant to brown fur. At the same time, this population is undergoing natural selection, as there are falcons which are hunting brown mice as they can be easily spotted. Therefore, the dominant allele frequency is 0.80 while the recessive allele frequency is 0.20. If the fitness factor for white mice is 1 and is .25 for brown mice, calculate the mean fitness of this population.

ANSWER: 0.85 (ACCEPT: An equivalent fraction)

TOSS-UP

10) Chemistry - *Short Answer* Identify the following compounds that have the same electron and molecular geometry?

I) Boron Trifluoride

II) Formaldehyde

III) Ammonia

ANSWER: 1 and 2 only

BONUS

10) Chemistry -*Short Answer* Identify the following are TRUE regarding interactions between strictly alcohols and a hydrogen halide.

1) A primary alcohol and a hydrogen halide will undergo an SN1 reaction
2) A secondary alcohol and a hydrogen halide will undergo an SN2 reaction
3) A tertiary alcohol and a hydrogen halide will undergo an E1 reaction

ANSWER: 2 only

TOSS-UP

11) Energy – *Short Answer* Scientists are studying the cause of the 2015 Gorkha earthquake in Nepal with a moment magnitude of 7.8, formed by the convergence of which two plates?

ANSWER: EURASIAN AND INDIAN (IN ANY ORDER)

BONUS

11) Energy – Researchers in the U.S. Department of Energy's Fermi National Accelerator Laboratory have announced the first successful demonstration of a new technique that improves particle beams. Future particle accelerators could potentially use the method to create better, denser particle beams. Which of the following is a benefit of denser particle beams?

W) Reduced velocity of the particles within the beams

X) Increased velocity of the particles within the beams

Y) Reduced number of collisions within the beam

Z) Increased number of collisions within the beam

ANSWER Z) Increased number of collisions within the beam

TOSS-UP

12) Math – *Short Answer* What is the cosine of the angle between two vectors 2i+j and i+2j?

ANSWER: 4/5

BONUS

12) Math – *Short Answer* What is the volume of a regular tetrahedron with surface area 36sqrt3

ANSWER: 18 sqrt 2

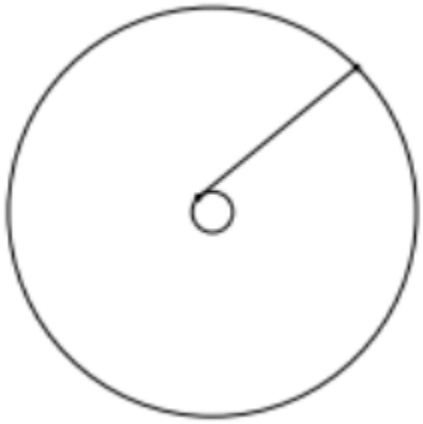
TOSS-UP

13) Physics – *Short Answer* The period of oscillation of a given simple pendulum is 2 seconds. What would be the period in seconds of the same pendulum on another planet where the gravitational acceleration is 1/9 that of the earth?

ANSWER: 6

Visual BONUS

13) Physics – *Short Answer* A mass of 100 g is attached to the end of a 4m long string. A person swings the mass overhead such that it traverses a circle of radius 2cm at an angular velocity of 5 rad/s ahead of the mass by a quarter circle. To the nearest integer, what is the power exerted by the hand on the mass?



ANSWER: 1

TOSS-UP

14) Earth and Space – *Multiple Choice* Which of the following upper-atmosphere phenomena is most commonly associated with cyclonic activity?

W) Ridge

X) Trough

Y) Convergence

Z) Divergence

ANSWER: Z) DIVERGENCE

BONUS

14) Earth and Space – *Short Answer* Order the following three water masses in the Atlantic in terms of increasing salinity: 1) North Atlantic Surface Water; 2) Antarctic Intermediate Water; 3) North Atlantic Deep Water.

ANSWER: 2, 3, 1

TOSS-UP

15) Biology – *Multiple Choice* Which of the following structures, found in the brain stem and is a loose association of neurons and their axons, is crucial to survival as it is involved in cardiopulmonary activity, sleep, along with motor functions, and vital when it comes to receiving and processing information from the rest of the Central Nervous System?

W) Corpus Callosum

X) Basal nuclei

Y) Hippocampus

Z) Reticular Formation

ANSWER: Z) RETICULAR FORMATION

BONUS

15) Biology – *Short Answer* To control metabolism and other key processes in the human body, the hypothalamus releases hormones such as dopamine into the hypothalamo–hypophyseal portal

vessel to regulate the activity of the anterior pituitary gland. What is the collective term for these regulatory hormones?

ANSWER: Hypophysiotropic Hormones

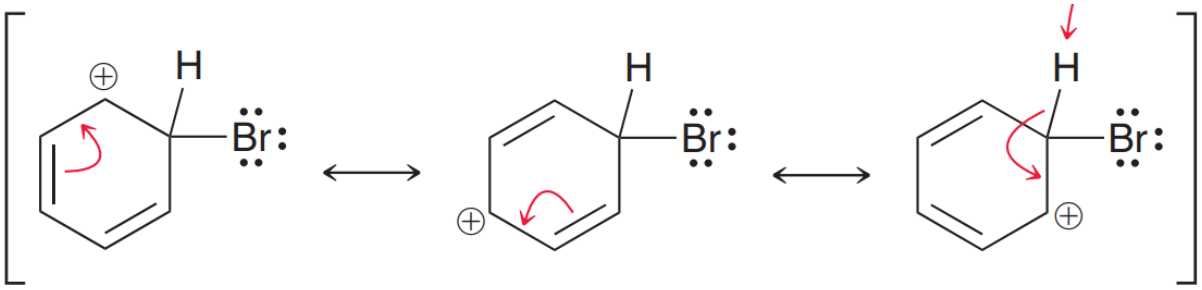
TOSS-UP

16) Chemistry - *Short Answer* What is the hybridization of the carbon atoms in pentane?

ANSWER: sp^3

BONUS

16) Chemistry - *Short Answer* Identify the following complex, a resonance stabilized intermediate formed during a nucleophilic attack by an aromatic ring.



ANSWER: Sigma Complex (ACCEPT: Arenium Ion)

TOSS-UP

17) Energy – *Short Answer* The shock felt from static electricity occurs because of charge build-up resulting from two dissimilar objects coming in contact with each other. In 2012, scientists from the USA and China used this phenomenon to build a generator known as TENG that converts unused mechanical energy into useful electrical energy. What is the name of this phenomenon?

Answer: Triboelectric effect

BONUS

17) Energy – *Short Answer* Scientists are currently studying effective means of developing inefficient catalysts to decrease the carbon dioxide concentration in the atmosphere. Many of these include enzymes from simple organisms such as bacteria and archaea. Specifically, researchers are studying the inexpensive lead-sulfur catalyst known as KGF-9, which has a selectivity of over 99% to reduce CO2 into what highly energetic organic compound?

ANSWER: Formate (ACCEPT: Formate Ion or HCOO-)

TOSS-UP

18) Math – *Short Answer* Five guys who can have at least 1 bean have an average of 20 beans per person. If two guys leave, the average increases to 30 beans per person. What is the average number of beans for the two guys who left?

ANSWER: 5

BONUS

18) Math – *Short Answer* In how many ways can 12 ba--nanas be distributed to 6 children if exactly two children will have 1 banana and each child must have at least 1 banana?

ANSWER: 150

TOSS-UP

19) Physics – *Short Answer* What two particles are produced from beta minus decay?

ANSWER: ELECTRONS AND ANTINEUTRINOS

BONUS

19) Physics – *Short Answer* A top is spinning at a rate of 5π radians per second when it slows uniformly to a stop in 14 seconds. Through how many revolutions did the top turn before stopping?

ANSWER: 17.5

TOSS-UP

20) Earth and Space – *Short Answer* Which of the following spectral classes typically contains stars with a radiative core?

W) W

X) B

Y) G

Z) M

ANSWER: Y) G

BONUS

20) Earth and Space - *Short Answer* H II *[H two]* regions often disperse to form open clusters due to the effects of what force?

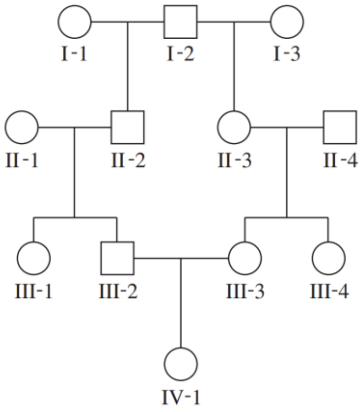
ANSWER: RADIATION PRESSURE

TOSS-UP

21) Biology – *Short Answer* What disease, characterized by the accumulation of cerebrospinal fluid in the ventricles of the brain, can lead to elevated pressure on the brain's blood vessels and cause neuronal damage?

ANSWER: Hydrocephalus

VISUAL BONUS



21) Biology - *Short Answer* Using the diagram above, calculate the inbreeding coefficient of Individual IV-1, assuming that the common ancestor has an inbreeding coefficient of 0.

ANSWER: 1/32 (ACCEPT: 3.125% exactly)

TOSS-UP

22) Chemistry - *Short Answer* Identify the following which would be soluble in water.

1) Hexane

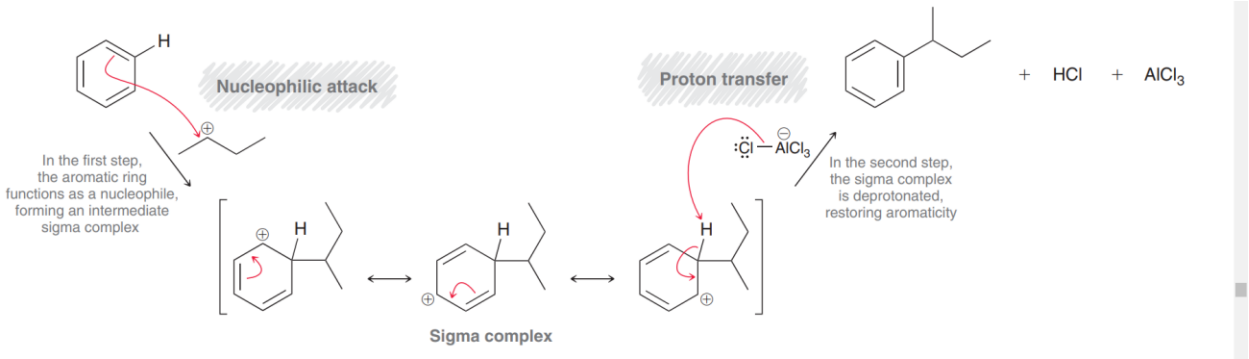
2) Dimethyl ether

3) Benzene

ANSWER: 2 only

BONUS

22) Chemistry - *Short Answer* Identify the following reaction below, which can be used to add an alkyl group on an aromatic ring via the use of a Lewis Acid such as Aluminum Trichloride.



ANSWER: Friedel-Craft Alkylation

TOSS-UP

23) Math – *Short Answer* Find the determinant of the 3 by 3 matrix [top row 3, 1, 2, middle row 5, 8, 7, bottom row 9, 4, 7]

|3 1 2|
|5 8 7|
|9 4 7|

ANSWER: 8

BONUS

23) Math – *Short Answer* An airplane travels at a speed of 500 mph with a bearing of 330° at a fixed altitude. The airplane encounters wind with a velocity of 70 mph in the direction N 45° E (read as North 45 degrees East). What is the velocity of the airplane in the wind in vector notation?

ANSWER: $\langle -250+35\sqrt{2}, 250\sqrt{3}+35\sqrt{2} \rangle$