

DE3

TOSSUP

1) Physics - *Multiple Choice* A steel ball of mass m is dropped from a height h and falls onto the table. It rebounds to almost exactly the same height. Which of the following best describes the force exerted on the ball?

W) Less than mg
X) Exactly mg
Y) between mg and 2 mg
Z) Greater than 2 mg

ANSWER: Z) Greater than 2 mg

BONUS

1) Physics - *Short Answer* A special gas has a heat capacity c(T) = alpha * T. The change in entropy of the gas when heating it from 100 K to 200 K is delta S. In terms of delta S, what is the change in entropy of the gas when heating it from 200 K to 600 K?

ANSWER: 4*DELTA S

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TOSSUP

2) Chemistry - *Short Answer* For a reaction split into its elementary steps, the rate of change of the intermediates can often be treated as 0. What is the term for this method, used in chemical kinetics, to derive the rate law for a reaction?

ANSWER: Steady state approximation [SO]

BONUS

2) Chemistry - *Short Answer* If the time needed for the concentration of species A to decrease from 1.0 M to 0.50 M is 10 minutes, and the time needed for the concentration to decrease from 0.50 M to 0.25 M is 5 minutes, what is the overall reaction order for the process?

ANSWER: Zeroth [SO]

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TOSSUP

3) Biology - *Short Answer* What water soluble plant pigments conferring a purple or red color to a plant are crucial for photoprotective and antioxidant processes?

ANSWER: Anthocyanins [HL]

BONUS

3) Biology - *Short Answer* Two birds are sitting on a tree branch. Unfortunately, a predator is approaching the second bird. The first bird can save the second bird, but this carries a 50% chance of getting eaten itself. If the second bird is not saved, its chance of death is 100%. The first bird would have 4 more offspring if it lives, while the second would have 6. Identify all of the following three relations between the two birds that would make an altruistic act by the first bird evolutionarily advantageous:

1) Cousins
2) Siblings
3) Twins

ANSWER: 2 and 3 (ACCEPT: Siblings and Twins) [HL]

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TOSSUP

4) Math - *Short Answer* Abstract algebra is the study of sets and operations. Order the following three constructs in terms of increasing scope:

1) Groups
2) Rings
3) Fields

ANSWER: 3 2 1

BONUS

4) Math - *Short Answer* Find the sum of all values of x for which 4^x - 2^(x+2) = -4 (read: 4 to the x … minus 2 to the quantity x + 2 is equal to -4)

ANSWER: 1

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TOSSUP

5) Earth and Space - *Short Answer* Ekman pumping is a phenomenon that occurs in oceans where converging surface Ekman transport results in what phenomenon?

ANSWER: Downwelling [JY]

BONUS

5) Earth and Space - *Short Answer* Identify all of the following that are depositional in origin:

1) Tombolo
2) Double spit
3) Sea stack

ANSWER: 1 and 2 [JY]

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TOSSUP

6) Chemistry - *Multiple Choice* Which of the following diagrams is most appropriate to use when portraying a molecule with multiple chirality centers, such as a sugar or peptide?

W) Line diagram
X) Newman projection
Y) Fischer projection
Z) Strecker projection

ANSWER: Y) Fischer Projection [SO]

BONUS

6) Chemistry - *Multiple Choice* Which of the following products will be formed at the cathode and anode respectively during the electrolysis of aqueous hydrobromic acid?

W) H_2, Br_2
X) Br_2, H_2
Y) H_2, O_2
Z) O_2, H_2

ANSWER: W) H_2, Br_2 [SO]

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TOSSUP

7) Earth and Space - *Multiple Choice* Which of the following best describes the luminosity of a red dwarf over very long time scales?

W) Increases
X) Decreases
Y) Increases then decreases
Z) Decreases then Increases

ANSWER: Y) Increases then decreases

BONUS

7) Earth and Space - *Short Answer* When a standard 20 solar mass star undergoes a supernova and forms a black hole, this black hole would be most likely described by what metric?

ANSWER: Kerr Metric (DO NOT ACCEPT: Kerr Neumann)

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TOSSUP

8) Physics - *Multiple Choice* 2 stars are orbiting each other, with masses M1 and M2. If M2 starts accreting mass from M1, which of the following is true? Assume they are accreting relatively slowly.

W) The semi major axis of the orbit always increases
X) The semi major axis of the orbit always decreases
Y) Angular momentum is conserved.
Z) Total mechanical energy is conserved

ANSWER: Y) Angular momentum is conserved

BONUS

8) Physics - *Multiple Choice* Sanjay is swimming through the Titanic and Oceangate Wreckage, at about 4 km below the surface of the ocean and records a pressure of P. Joel is swimming through the Challenger deep which is about 12 km deep. Which of the following is true about the pressure Joel records?

W) P
X) Between P and 3P
Y) 3P
Z) Greater than 3P
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ANSWER: Z

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TOSSUP

9) Math - *Short Answer* How many of the 36'th roots of unity satisfy the equation x^18 = -1?

ANSWER: 18

BONUS

9) Math - *Multiple Choice* Let p, q, and r be the roots of the cubic equation x^3 - 3x^2 + 5x - 7 = 0. What is p^2 + q^2 + r^2.

W) -1
X) 0
Y) 1
Z) 2

ANSWER: W) -1

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TOSSUP

10) Biology - *Short Answer*: By name or number, identify all of the following three germ layers that can be found in cnidarians:

1) Ectoderm
2) Mesoderm
3) Endoderm

ANSWER: 1 and 3 (ACCEPT: Ectoderm and Endoderm) [HL]

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BONUS

10) Biology - *Multiple Choice*: Which of the following correctly describes a difference between dyneins and kinesins?

W) Dyneins move along microtubules, while kinesins move along microfilaments
X) Dyneins function in retrograde transport, while kinesins function in anterograde transport
Y) Dyneins prevent microtubule catastrophe, while kinesins do not
Z) Dyneins bind to alpha-tubulin, while kinesins bind to beta-tubulin

ANSWER: X) Dyneins function in retrograde transport, while kinesins function in anterograde transport [HL]
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TOSSUP

11) Earth and Space - *Short Answer* The unconfirmed Hercules Corona Borealis Great Wall is theorized to be a massive structure of galactic filaments almost 10 billion light years long. This violates what principle, which states that the Universe is homogenous on large scales?

ANSWER: Cosmological Principle

BONUS

11) Earth and Space - *Short Answer* Which of the following correctly explains what will happen to the Laniakea Supercluster over a few trillion years?

W) All the individual galaxies will be torn apart from each other due to Dark Energy.
X) All the individual galaxies will race towards the center of the Laniakea Supercluster
Y) All the individual galaxies will coalesce within their own galaxy groups before gradually merging together at the center of the Laniakea Supercluster
Z) All the individual galaxies will coalesce within their own galaxy groups before these groups are torn apart from each other due to Dark Energy.

ANSWER: Z) All the individual galaxies will coalesce within their own galaxy groups before these groups are torn apart from each other due to Dark Energy.

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TOSSUP

12) Math - *Short Answer* Which of the following triples of integers do not form an obtuse triangle? (read answer choices slowly)

W) 8, 14, 17
X) 7, 10, 13
Y) 20, 20, 28
Z) 9, 12, 16

ANSWER: Y) 20, 20, 28

BONUS

12) Math - *Short Answer* In a certain population of rabbits, the growth of the population is proportional to both the current population of rabbits and N minus the current population of rabbits, where N is often referred to as the carrying capacity. When graphing the population vs time for this population of rabbits, what curve is plotted?

ANSWER: Sigmoid (ACCEPT: S) (everyone and their mother said logistic on this but monish didnt accept it so)

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TOSSUP

13) Chemistry - *Short Answer* Rhombic sulfur, characterized by its atoms arranged in a puckered ring, is the most stable polymorph of Sulfur at room temperature. What is the chemical formula of rhombic sulfur?

ANSWER: S_8 [SO]

BONUS

13) Chemistry - *Short Answer* When calcium oxalate is heated to 500 degrees celsius, a white solid residue is formed. Upon vigorous heating at 750 degrees celsius, the new compound further decomposes to another white solid precipitate. What is the identity of the two unknown compounds respectively?

ANSWER: Calcium carbonate, calcium oxide (ACCEPT: $CaCO_3$, CaO) [SO]

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TOSSUP

14) Biology - *Multiple Choice* Arjun is studying microtubule arrangements with the axonemes of motile cilia and flagella in eukaryotic cells. Which of the following best describes the microtubule arrangements found in the axonemes of motile cilia and flagella respectively?

W) 9+0, 9+0
X) 9+0, 9+2
Y) 9+2, 9+2
Z) 9+2, 9+0

ANSWER: Y) 9+2, 9+2 [AD]

BONUS

14) Biology - *Multiple Choice* Which of the following enzymes are secreted by the pancreas and are not part of the duodenal brush border?

W) carboxypeptidases
X) enterokinases
Y) lactases
Z) dextrinases

ANSWER: W) carboxypeptidases [AD]

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TOSSUP

15) Earth and Space - *Multiple Choice* Which of the following metamorphic facies would be LEAST likely found in a stable continent?

W) Zeolite
X) Greenschist
Y) Sanidinite
Z) Granulite

ANSWER: Y) Sanidinite [JY]

BONUS

15) Earth and Space - *Short Answer* Every western boundary current of every major ocean gyre on Earth is typically stronger, narrower, warmer, and faster than its eastern counterpart. What phenomenon, driven by the Coriolis force, conservation of angular momentum, and the beta effect, describes this behavior?

ANSWER: Western intensification [JY]

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TOSSUP

16) Physics - *Multiple Choice* The electric field energy density of a point charge is dependent on distance to which of the following?

W) -4
X) -3
Y) -2
Z) -1

ANSWER: W) -4

BONUS

16) Physics - *Short Answer* A ball is dropped from a height h = 10 m above an inclined plane which is angled 30 degrees above the horizontal. The ball then bounces down the ramp. Calculate the time between successive collisions.

ANSWER: 2sqrt(2) seconds

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TOSSUP

17) Math - *Short Answer* Identify all of the following three actions that will increase the power of a significance test:

1) Increasing alpha
2) Increasing the number of samples
3) Using a larger degree of t.

ANSWER: ALL

BONUS

17) Math - *Short Answer* In a certain game, the contestant has to guess a random card from a standard 52 card deck. The contestant is rewarded 10 points if they guess the suit correctly, 14 points if they guess the value correctly, and 52 points if they guess both the suit and the value of the card. What is the expected earning from one round of this game?

ANSWER: 163/52

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TOSSUP

18) Chemistry - *Multiple Choice* Which of the following statements best explains why the dissolution of solid Calcium Sulfate has a negative change in entropy?

W) Calcium Sulfate dissolves exothermically, thus the loss in heat causes a decrease in microstates of the system
X) Solid Calcium Sulfate is an ionic compound, thus the atoms can be far more spread out over a larger surface area
Y) Aqueous Ca2+ and SO42- ions are tightly hydrated, thus decreasing the number of ways the ions can be arranged in water
Z) Ca2+ and SO42- are held together by restrictive strong electrostatic forces in solid Calcium Sulfate, thus there are more ways of arranging the Ca2+ and SO42- ions in aqueous solution.

ANSWER: Y) Aqueous Ca2+ and SO42- ions are tightly hydrated, thus decreasing the number of ways the ions can be arranged in water [SO]

BONUS

18) Chemistry - *Short Answer* Identify all of the following four orbitals which contain 2 angular nodes:

1) 3s
2) 4p
3) 4d
4) 5f

ANSWER: 3 ONLY [SO]

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TOSSUP

19) Biology - *Short Answer* Order the following three structures as they are passed through by lipids that are absorbed by the small intestine as chylomicrons.

1) liver
2) left ventricle
3) pulmonary artery

ANSWER: 3, 2, 1 [AD]

BONUS

19) Biology - *Multiple Choice* Virologists at the National Emerging Infectious Disease Laboratories (NEIDL) are studying the replicative cycle of the Ebola virus. Which of the following best describes the replication of Ebola?

W) Capsid proteins are produced by the direct translation of viral RNA
X) Capsid proteins are produced by the translation of RNA complementary to the viral RNA.
Y) Capsid proteins are produced by the transcription and translation of viral DNA.
Z) Capsid proteins are produced by the translation and transcription of DNA that is produced from viral RNA.

ANSWER: X) Capsid proteins are produced by the translation of RNA complementary to the viral RNA. [AD]

TOSSUP

20) Physics - *Short Answer* A medium has a relative electric permittivity of 16 and a relative magnetic permeability of 25. What is the speed of light in the medium?

ANSWER: $1.5 * 10^7$ m/s ACCEPT 0.05 C or c/20
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BONUS

20) Physics - *Short Answer* Sanjay is studying electrons and wants to excite an electron in a hydrogen atom. What is the energy required if the electron is transitioning from the n=1 to n=3, to 2 significant figures assuming that the ground state energy of the hydrogen atom is -14 eV?

ANSWER: 12 eV