Tab 1



DE4

TOSSUP

1) Chemistry - *Short Answer* In nonmetallic compounds, the difference in energies between the HOMO and LUMO can be used to predict the chemical reactivity and stability of a compound. What quantity in metals, analogous to the HOMO-LUMO difference for nonmetals, represents the range where no electrons can exist, and is measured as the difference between the conduction band and valence band?

ANSWER: Band gap [SO]

BONUS

1) Chemistry - *Short Answer* Identify all of the following four reactions which are expected to be exothermic:

1) The attraction of Mg^{2+} and O^{2-} ions to form solid magnesium oxide
2) The dissociation of solid magnesium oxide to Mg^{2+} and O^{2-} ions
3) The formation of the O^{2-} ion through the addition of electrons to monoatomic oxygen
4) The formation of the Mg^{2+} ion through the release of electrons from magnesium

ANSWER: 1 ONLY [SO]

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TOSSUP

2) Earth and Space - *Multiple Choice* Which of the following spectral classes tends to have the highest methane concentration in its atmosphere?

W) L
X) M
Y) T
Z) Y

ANSWER: Y) T

BONUS

2) Earth and Space - *Short Answer* Rank the following four stages of an initally 85 solar mass star in chronological order:

1) Of Star
2) O Star
3) Wolf Rayet Star
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4) Luminous Blue Variable

ANSWER: 2143

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TOSSUP

3) Physics - *Short Answer* The Hall Effect occurs when a magnetic field is applied to a wire, and an emf is created across the wire perpendicular to the current. The hall voltage is the magnitude of this emf. Consider a wire with current I in a magnetic field B. To what power of the wire's radius is the hall voltage proportional to?

ANSWER: -1

BONUS

3) Physics - *Short Answer* A bungee cord with a spring constant k is attached to a jumper of mass 50 kg who is standing on a platform a height h above the ground. If he is stationary at 5 meters below the platform, what is the minimum value of h where he doesn't touch the ground? Assume g = 10 m/s^2.

ANSWER: 10 m

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TOSSUP

4) Math *Multiple Choice* Monish rolls a standard 8 sided dice. What is the minimum number of rolls he could roll in order for the product of the numbers to end with 13 zeros?

W) 18
X) 19
Y) 20
Z) 21

ANSWER: W) 18

BONUS

4) Math *Short Answer* Two concentric similar ellipses have Major Axes (Axe-ees) of 10 and 5 respectively. What is the difference between the upper bound and lower bound of the area that lies inside the larger ellipse but outside the smaller ellipse?

ANSWER: 75pi

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TOSSUP

5) Biology - *Multiple Choice:* Sanjay is searching for crystals of calcium oxalate in plants. Which cell type, known to contain sharp calcium oxalate crystals called raphides, should he look for?

W) Lactifers
X) Tracheids
Y) Idioblasts
Z) Albuminous Cells

ANSWER: Y) Idioblasts [AD]

BONUS

5) Biology - *Short Answer:* Aspirin is an effective treatment for strokes and myocardial infarctions because it inhibits the production of what eicosanoid that is produced by platelets and is involved in clotting?

ANSWER: thromboxane A2 [AD] (ACCEPT: thromboxanes)

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TOSSUP

6) Math *Multiple Choice* If the list of numbers 1, 7, 7, 9, and x have a mean of x. What is the value of x?

W) 4
X) 5
Y) 6
Z) 7

ANSWER: 6

BONUS

6) Math *Short Answer* How many integers x and y satisfy the inequality, |x| + |y| <= 4. (read: absolute value of x plus absolute value of y is less than or equal to 4)

ANSWER: 41

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TOSSUP

7) Earth and Space - *Multiple Choice* Which of the following best explains the difference between metasomatism and contact metamorphism?

W) Metasomatism involves changes in chemical composition from fluid percolation while contact metamorphism involves the conduction of heat from magma
X) Contact metamorphism involves changes in chemical composition from fluid percolation while metasomatism involves the conduction of heat from magma
Y) Metasomatism alters rocks primarily through directed pressure while contact metamorphism is driven by circulating hydrothermal fluids
Z) Contact metamorphism alters rocks primarily through directed pressure while metasomatism is driven by circulating hydrothermal fluids

ANSWER: W) Metasomatism involves changes chemical composition change from fluid percolation while contact metamorphism involves the conduction of heat from magma [JY]

BONUS

7) Earth and Space - *Short Answer* Sanjay is walking on top of a glacier, notices an unstratified and unsorted ridge of sediment ON the glacier's SURFACE. What is the name for this type of moraine?

ANSWER: Supraglacial moraine (DO NOT ACCEPT: any other types of moraines) [JY]

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TOSSUP

8) Chemistry - *Multiple Choice* DMSO is a polar, aprotic solvent which dissolves both polar and nonpolar molecules. In DMSO, which of the following reactions mechanisms is the most favored?

W) E1
X) E2
Y) SN1
Z) SN2

ANSWER: Z) SN2 [SO]

BONUS

8) Chemistry- *Multiple Choice* A concentration cell is set up using 2 different containers A and B containing Cu^{2+} ions and copper electrodes. If the concentration of Cu^{2+} ions in container A is 0.6 molar, and the concentration of Cu^{2+} ions in container B is 0.2 molar, then which of the following statements regarding the flow of electrons in the cell is true?

W) Electrons will flow from A to B
X) Electrons will flow from B to A
Y) Electrons will not flow
Z) The reduction potentials must be known to determine

ANSWER: X) Electrons will flow from container B to A

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TOSSUP

9) Physics - *Short Answer* Quantum mechanical behaviors such as the uncertainty principle and superposition are not shown in macroscopic objects. The transition of quantum behaviors to those that are governed by classical mechanics is described by what phenomenon?

ANSWER: Quantum Decoherence

BONUS

9) Physics - *Short Answer* A mass m is moving to the right at velocity v. Another mass of 4m is moving to the left at velocity 2v. If the 2 masses collide, what will be the final speed and direction of the lighter mass?

ANSWER: 19v/5 to the left

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TOSSUP

10) Math *Short Answer* Identify all of the following three numbers which are congruent to 9 mod 13:

1) -17
2) 31
3) 95

ANSWER: 1 and 2 only

BONUS

10) Math *Short Answer* The point (3, -2) is rotated 60 degrees counter-clockwise about the origin. What is the resulting point?

ANSWER: (3/2 + sqrt(3), 3sqrt(3)/2 -1)

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TOSSUP

11) Physics - *Multiple Choice* Which of the following are not conjugate physical pairs of a quantum system?

W) Position and momentum
X) Energy and time
Y) Number of particles and phase
Z) Angular momentum and angular displacement

ANSWER: Z) Angular momentum and angular displacement

BONUS

11) Physics - *Short Answer* A sample of an ideal diatomic gas undergoes a reversible adiabatic expansion. The initial pressure is 40 kilopascals and the initial volume is 64 liters. The gas is compressed adiabatically to a volume of 2.0 liters. What is the new pressure in kilopascals?

ANSWER: 5120 kilopascals

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TOSSUP

12) Biology - *Multiple Choice:* Which of the following classes of immunoglobulins is responsible for recognizing the A, B and H antigens on blood cells and occurs as a pentamer in the plasma?

W) IgA
X) IgG
Y) IgM
Z) IgD

ANSWER: Y) IgM

BONUS

12) Biology - *Short Answer* A population of mosquitoes is in Hardy-Weinberg Equilibrium for a single gene that controls resistance to DDT, with the recessive allele being responsible for DDT resistance and the dominant allele being responsible for DDT susceptibility. If the frequency of the DDT resistance allele is 0.2 before Arjun applies DDT to the population, and mosquitoes without the resistance phenotype have half the fitness of resistant mosquitoes, what proportion of mosquitoes will be resistant one generation after Arjun applies the pesticide?

ANSWER: 1/13 [AD]

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ANSWER: Y) Stable for both unsaturated and saturated parcels [JY]

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TOSSUP

14) Chemistry - *Short Answer* Identify all of the following 3 molecules that contain both covalent and ionic bonds:

1) Potassium Bicarbonate
2) Vanadyl Sulfate
3) Phosphorus Oxychloride

ANSWER: 1 and 2 [SO]

BONUS

14) Chemistry - *Multiple Choice* How many total valence electrons are in the thiosulfate ion, $S_2O_3^{2-}$?

W) 28
X) 30
Y) 32
Z) 34

ANSWER: Y) 32 [SO]

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TOSSUP

15) Physics - *Short Answer* Identify all of the following 3 options that are newton's third law pairs:

1) The Earth pulls downward on an apple and the apple pulls upward on the Earth.
2) The gravitational force of the Earth on the Moon and the centripetal force that keeps the Moon in orbit.
3) The gravitational force of the Earth on an object and the normal force on the object

ANSWER: 1 only

BONUS

15) Physics - *Short Answer* 2 metal plates are at a temperature of 300 K and 200 K and the temperature between them follows the relation T(x) = 5x^3 - 70x + 300. Assuming that there is

air between the 2 metal plates and its thermal conductivity is 0.025, find the magnitude of the heat flux at x=1 meters.

ANSWER: 1.375 W/m^2

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TOSSUP

16) Biology- *Short Answer:* The phragmoplast, a plant cell element formed during late cell division, is composed of microtubules and serves as a scaffold for the creation of what structure?

ANSWER: Cell plate (ACCEPT: Cell division plate) [HL]

BONUS

16) Biology- *Short Answer:* What term refers to the process by which DNA strands are pulled into loops by cohesins until CTCF binding sites block them, and is the most common mechanism by which topologically associated domains are formed?

ANSWER: Loop Extrusion [HL]

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TOSSUP

17) Earth and Space - *Short Answer* When observing a moon of Saturn, you only see it on the West side of Saturn rather than both sides. What is the most likely moon you are observing?

ANSWER: Iapetus

BONUS

17) Earth and Space - *Multiple Choice* Which of the following describes a galaxy where there would be the highest star formation?

W) A galaxy with a very strong AGN
X) A galaxy with a high metallicity
Y) A galaxy with relatively low dust concentration in the ISM
Z) A galaxy with a lower supernova rate

ANSWER: Z) A galaxy with a lower supernova rate

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TOSSUP

18) Chemistry - *Short Answer* Identify all of the following three molecules which have a nonzero dipole moment:

1) CO
2) XeF_4
3) SF_4

ANSWER: 1 and 3 [SO]

BONUS

18) Chemistry - *Multiple Choice* Which of the following is the electron configuration for the transition metal in the complex $[Ag(NH_3)_2]Cl$?

W) [Kr] $5s^1$ $4d^{10}$
X) [Kr] $5s^1$ $4d^9$
Y) [Kr] $4d^{10}$
Z) [Kr] $4d^9$

ANSWER: Y) [Kr] $4d^{10}$ [SO]

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TOSSUP

19) Math *Short Answer* In what octant is the point (-1, 2, 3) found?

ANSWER: Second (ACCEPT: 2)

BONUS

19) Math *Short Answer* Two identical jugs, are filled with juice and water. Jug A is 80% Juice while Jug B is 30% juice. If 25% of Jug A and 50% of Jug B is poured into a third empty Jug. How much of the new Jug's contents are juice?

ANSWER: 7/15

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TOSSUP

20) Biology- *Short Answer:* What term refers to a peptide sequence found on the N-terminus of proteins bound for the nucleus that is bound by importin proteins to facilitate translocation through nuclear pores?

ANSWER: Nuclear Localization Signal (ACCEPT: NLS) [HL]

BONUS

20) Biology - *Short Answer:* A plant growing in your garden demonstrates an abnormal super-complex leaf phyllotaxy in which the leaf contains branching sub-leaflets off of the sub-leaflets. A wild-type plant next to it lacks this same pattern and instead only exhibits compound leaves. A mutation in what gene is most likely to cause this pattern?

ANSWER: KNOTTED-1 [HL]