

DE7

TOSSUP

1) Math - *Multiple Choice* In triangle SCB with integer sidelengths, SC = 10 and CB = 15, what is the sum of all possible values of the length of SB?

W) 285
X) 290
Y) 309
Z) 315

ANSWER: W) 285

BONUS

1) Math - *Short Answer* Given that sine of alpha = 5/13 and sine of beta = 8/17 what is tangent of alpha plus beta.

ANSWER: 6

~~~~~~

TOSSUP

2) Physics - *Short Answer* In solid-state physics, lattice vibrations in a crystalline material can be quantized into quasiparticles that mediate heat conduction and play a major role in superconductivity. What is the name of these quantized vibrational excitations?

ANSWER: Phonons

BONUS

2) Physics - *Short Answer* A regular tetrahedron is set up with 6 7 ohm resistors. What is the equivalent resistance between 2 vertices?

ANSWER: 3.5 ohms

~~~~~~

TOSSUP

3) Biology - *Multiple Choice* According to the opponent-process theory of color vision, which of the following types of color blindness is least likely to occur?

W) Black-White Colorblindness
X) Green-Yellow Colorblindness
Y) Blue-Yellow Colorblindness
Z) Red-Green Colorblindness

ANSWER: X) Green-Yellow Colorblindness [HL]

BONUS

3) Biology - *Multiple Choice* The Delta-Notch pathway is a cell signalling pathway crucial in development. Specifically, it is involved in the process of lateral inhibition. If an embryo has a mutation in the gene encoding for the notch protein, which of the following would be a result of this?

W) The development of situs inversus
X) Abnormal melanation patterns
Y) The development of neurons without the accompanying development of glia and progenitor cells
Z) Unusually evenly distributed goblet cell distribution

ANSWER: Y) The development of neurons without the accompanying development of glia and progenitor cells [HL]

~~~~~~

TOSSUP

4) Math - *Short Answer* When rowing a boat downstream, Arjun takes 10 minutes to cross 2 miles. When rowing the same boat upstream he takes 10 minutes to cross 1 mile. What is the speed of the current of the river in miles per minute?

ANSWER: 1/20

BONUS

4) Math - *Short Answer* What is the sum of the digits of the base 8 version of the hexa-decimal number 3B7.

ANSWER: 20

~~~~~~

TOSSUP

5) Chemistry- *Short Answer* Order the following 3 species in order of increasing length of the carbon-oxygen bond:

1) Na_2CO_3
2) $NaOCH_3$
3) $NaHCO_2$

ANSWER: 312 [SO]

BONUS

5) Chemistry- *Multiple Choice* Typically, the molar solubility X of an ionic compound in pure water and its K_{sp} are related by a simple formula, such as $K_{sp} = 4x^3$. Which formula is not expected for the K_{sp} of an ionic compound in terms of its molar solubility?

W) $27x^5$
X) $4x^4$
Y) $16x^5$
Z) $8x^4$

ANSWER: Z) $8x^4$ [SO]

~~~~~~

TOSSUP

6) Earth and Space - *Short Answer* Rank the following 3 events in the history of Mars in chronological order:

1) The Formation of the Tharsis Bulge
2) Late Heavy Bombardment
3) The Loss of Martian Oceans

ANSWER: 213

BONUS

6) Earth and Space - *Multiple Choice* Gabe is modeling the universe and proposes 2 universes: Universe A and Universe B. If Universe A has a greater equation of state parameter omega compared to Universe B, then which of the following is always true?

W) Universe A expands faster than Universe B
X) Universe A expands slower than Universe B
Y) Universe A's rate of expansion accelerates faster than Universe B's
Z) Universe A's rate of expansion accelerates slower than Universe B's

ANSWER: Z) Universe A’s rate of expansion accelerates slower than Universe B’s

~~~~~~

TOSSUP

7) Earth and Space - *Short Answer* Identify all of the following three classes of elements that are typically absent in a D-MORB:

1) Large-Ion Lithophile Elements
2) Light Rare Earth Elements
3) Volatile elements

ANSWER: All [JY]

BONUS

7) Earth and Space - *Multiple Choice* Which of the following criteria must be met for the formation of chevron folds?

W) Passive-flow folding with strong competence contrast
X) Fault-propagation folding with weak competence contrast
Y) Flexural-shear folding with strong competence contrast
Z) Buckling with weak competence contrast

ANSWER: Y) Flexural-shear folding with strong competence contrast [JY]

~~~~~~

TOSSUP

8) Physics - *Multiple Choice* In conventional superconductors, which of the following best describes how Cooper pairs form?

W) Electrons form pairs by aligning their wavefunctions in the same quantum state without interaction with the lattice
X) Two electrons directly overcome their Coulomb repulsion and bind through magnetic dipole alignment
Y) Electrons lower their energy by exchanging virtual phonons, effectively attracting each other
Z) An electron moving through the lattice slightly displaces nuclei, creating a region of higher positive charge that attracts another electron with opposite spin and momentum

ANSWER**:** Z) An electron moving through the lattice slightly displaces nuclei, creating a region of higher positive charge that attracts another electron with opposite spin and momentum

BONUS

8) Physics - *Short Answer* An electric field is given by the equation E = 4x i + 6j and a magnetic field is given by B = 2i - yj. Calculate the Poynting vector in terms of the magnetic permeability of free space at 1,1.
~~~~~~

ANSWER: -16 k /mu_0,

~~~~~~

TOSSUP

9) Biology - *Multiple Choice:* Joel's cardiac pressure volume loop is vertically stretched and horizontally compressed. Which of the following valvular disorders is this most consistent with?

W) mitral stenosis
X) mitral regurgitation
Y) aortic stenosis
Z) aortic regurgitation

ANSWER: Y) aortic stenosis [AD]

BONUS

9) Biology - *Short Answer:* A patient presents with an electric shock sensation at the back of the neck, an upgoing plantar reflex, and intermittent periods of muscle weakness, spasticity and paresthesia. Identify the cell type whose death is most likely to cause the patient's symptoms.

ANSWER: oligodendrocytes [AD]

~~~~~~

TOSSUP

10) Chemistry - *Multiple Choice* In the dimerization of borane to diborane, two borane molecules react to form a single diborane molecule. Which of the following statements regarding the spontaneity of this reaction is true?

W) Spontaneous only at low temperatures
X) Spontaneous only at high temperatures
Y) Spontaneous at all temperatures
Z) Nonspontaneous at all temperatures

ANSWER: W) Spontaneous only at low temperatures [SO]

BONUS

10) Chemistry- *Short Answer* Compound A decomposes according to two parallel reactions to form compounds B and C with rate constants k_b = 0.6 s^{-1} and k_c= 0.8 s^{-1} respectively. To one significant figure and in seconds, what is the half-life of the overall decomposition of compound A?

ANSWER: 0.5 seconds [SO]

~~~~~~

TOSSUP

11) Math *Short Answer* What is the sum of all the positive divisors of 40?

ANSWER: 90

BONUS

11) Math *Short Answer* Sanjay has a strange plant. At first, it's 4 inches tall. At the end of every day, it has a 25% chance of tripling its height. In inches, what is the expected value of its height after 3 days?

ANSWER: 27/2

~~~~~~

TOSSUP

12) Earth and Space - *Multiple Choice* Which of the following sediment conditions would most likely result in the formation of well-developed, hexagonal mud cracks?

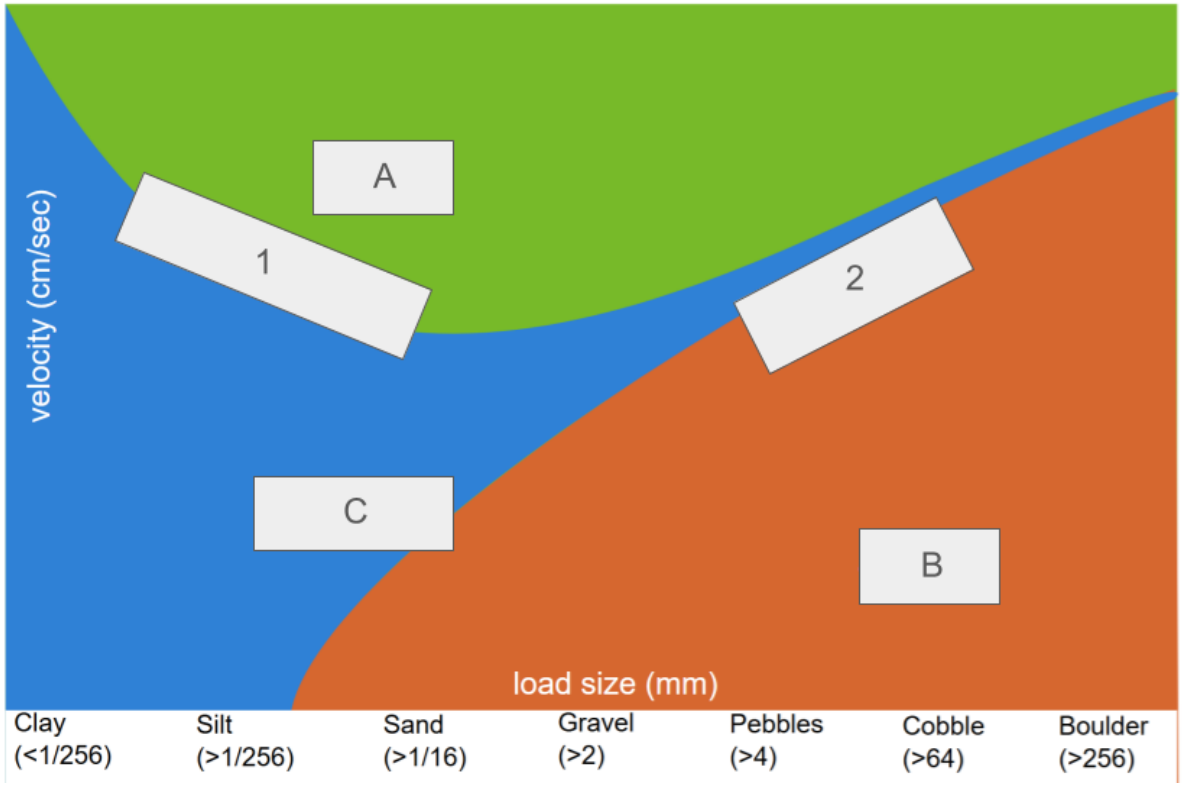
W) Heterogenous, clay-rich sediment
X) Homogenous, carbonate-rich sediment
Y) Heterogenous, carbonate-rich sediment
Z) Homogenous, clay-rich sediment

ANSWER: Z) Homogenous, clay-rich sediment [JY]

VISUAL BONUS

12) Earth and Space - *Short Answer* The image below is a Hjulstrom curve, a graph used to determine the behavior of certain sediments in a stream with variable velocity. Answer the following two questions about the image below:

1. Two curves divide this graph into three regions, labeled A, B, and C. Identify the name of each region, A, B, and C, respectively, that characterizes the sediment behavior in that region.
2. This graph is divided into three regions by two curves, labeled 1 and 2. Identify the names of these curves, 1 and 2, respectively.



ANSWER: A erosion, B deposition, C transportation; 1 is erosion velocity curve, 2 is settling velocity curve (ACCEPT: “deposition” in place of settling) [JY]

~~~~~~
~~~~~~

TOSSUP

13) Physics - *Short Answer* The eightfold way is used to organize what class of subatomic particles?

ANSWER: Hadrons

BONUS

13) Physics - A particle is moving according to the equation r(t) = (t^2 +2)i + (t+6) j + (t^3+3)z. Calculate the centripetal acceleration of the particle at t=1. Give your answer in radical form, rational denominator is not necessary.

ANSWER: sqrt(38/7) ACCEPT: sqrt(266)/7

~~~
~~~

TOSSUP

15) Physics - *Short Answer* Identify all of the following 3 particles that are their own antiparticle:

1) Gluon
2) W^+ Bosons
3) Omega Meson

ANSWER: 1, 3

BONUS

15) Physics - *Short Answer* According to Noether's theorem, a symmetry of the universe leads to a conservation law. What symmetry leads to the conservation of electric charge?

ANSWER: U1 Gauge Symmetry

~~~~~~

TOSSUP

16) Chemistry - *Short Answer* In the decomposition of ammonium nitrate, NH_4NO_3, nitrous oxide, N_2O, is produced. This reaction is an example of what type of special redox reaction, in which an element with two different oxidation states in the reactants forms a single intermediate oxidation state in the products?

ANSWER: Comproportionation [SO]

BONUS

16) Chemistry- *Short Answer* Order the following three diatomic molecules in terms of increasing ionization energy:

1) N_2
2) O_2
3) F_2

ANSWER: 231 [SO]

~~~~~~

TOSSUP

17) Earth and Space- *Short Answer* What metric in general relativity describes a homogeneous, isotropic expanding or contracting universe, and forms the mathematical basis for the standard Big Bang cosmological model?

ANSWER: FLRW Metric

BONUS

17) Earth and Space - *Short Answer* Rank the following 3 types of stars by increasing optical depth of their atmospheres:

1) White Dwarf
2) Neutron Star
3) O Type Main Sequence Star

ANSWER: 213

~~~~~~

TOSSUP

18) Biology - *Short Answer* What equation uses the mean phenotypic values of two pure-breeding parental strains of quantitative characters and the genetic variance of the F2 population to estimate the number of gene pairs contributing to an additive inheritance pattern?

ANSWER: Castle-Wright Estimator [HL]

BONUS

18) Biology - *Short Answer* Species A outcompetes and eliminates Species B, which is also a competitor of Species C. Due to this, the positive effect on Species C due to Species A's effect is larger than the negative effect due to their competition with each other. What phenomenon does this illustrate?

ANSWER: Indirect Facilitation [HL]

~~~~~~

TOSSUP

19) Math - *Short Answer* How many ways are there to pick 3 students from a class of 16 students where the order in which they are picked does not matter?

ANSWER: 560

BONUS

19) Math - *Short Answer* What is 37^85 mod 100?

ANSWER: 57

~~~~~~

TOSSUP

20) Chemistry - *Short Answer* The tert-butyl carbocation is highly stable, whereas the methyl carbocation is highly unstable. This difference in stability is attributed to what effect, in which electrons from a sigma bond are partially delocalized over an adjacent empty p orbital?

ANSWER: Hyperconjugation [SO]

BONUS

20) Chemistry- *Multiple Choice* Which of the following is NOT a reason why tetramethylsilane, TMS, is the most widely used standard in proton NMR spectroscopy?

W) It is unreactive to most compounds
X) It is soluble in both nonpolar and polar solutions
Y) It has a sharp, distinct peak
Z) It has a chemical shift lower than most compounds

ANSWER: X) It is soluble in both nonpolar and polar solutions [SO]
~~~~~~