ESBOT

2023

DE7

Tossup

1) *Biology– Multiple Choice:* Which of the following energy carriers is involved with moving TRNA from one site on a ribosome to another?

W) ATP
X) FADH
Y) NADH
Z) GTP

ANSWER: Z) GTP

Bonus

1) *Biology – Short Answer:* In the immune system, antigen receptors on T and B cells are specific to certain antigens. When detected, these antigens promote proliferation for those specific T or B cells. What is this process called?

ANSWER: Clonal selection

Tossup

2) *Energy– Multiple Choice:* Researchers at Pacific Northwest National Laboratory are studying the ways in which muscle contraction is affected by different types of toxins. One of the toxins they are studying is known to bind to calcium, and prevent it from binding on to what troponin subunit?

W) Troponin C
X) Troponin T
Y) Troponin I
Z) Troponin S

ANSWER: W) Troponin C

Bonus

2) *Energy – Short Answer:* Scientists at Lawrence Livermore National Lab are studying the properties of plasmas in stellar bodies. In Cepheid variables, the opacity of these plasmas varies periodically which drives an oscillation in radius of the star. What is the name of this pulsation mechanism?

ANSWER: Eddington Valve (Accept: Kappa Mechanism)

Tossup

3) *Chemistry – Short Answer:* What effect, often seen in octahedral complexes, stabilizes nonlinear molecules through geometrical distortion that forces nondegeneracy?

ANSWER: Jahn-Teller Effect

Bonus

3) *Chemistry – Short Answer:* Identify all of the following 3 changes that would increase the Van't Hoff number of the given compound in aqueous solution:

I) Increasing the concentration of acetic acid
II) Increasing the temperature of NaOH
III) Encouraging dimerization in propanoic acid

ANSWER: None

Tossup

4) *Physics – Short Answer:* Due to the neutrino's lack of charge and peculiar preference for handedness, it is possible that they are what kind of particle, which is its own antiparticle?

ANSWER: Majorana Particle

Bonus

4) *Physics - Short Answer:* A coil of wire carrying a current is fixed in a magnetic field parallel to the axis of the coil. Which of the following statements are true of this situation?

I) The coil feels a force radially, squeezing it together or pulling it apart.
II) An opposing EMF is generated in the wire.
III) The coil feels a force parallel to the field.

ANSWER: I, III

Tossup

5) *Math – Multiple Choice:* Consider the equation $x^2 - by^2 = 25$. Which of the following values of b will create the graph of an ellipse with a vertical major axis?

W) 1
X) -0.5
Y) -1
Z) -1.5

ANSWER: X) -0.5

Bonus

5) *Math – Short Answer:* How many positive integers x exist such that $\frac{1080}{6^x}$ is an integer?

ANSWER: 3

Tossup

6) *Biology – Short Answer:* Identify all of the following 3 cells that are haploid:

I) Megasporocyte
II) Synergid cells
III) Antipodal cells

ANSWER: II, III

Bonus

6) *Biology – Short Answer:* What is the term for the circuit in amphibians that sends blood to both the lungs and the skin at the same time?

ANSWER: Pulmocutaneous Circuit

Tossup

7) *Earth and Space – Multiple Choice:* Which of the following accurately describes warm core rings in the North Atlantic Ocean?

W) They derive their warm insides from the Gulf stream
X) They are regions of low biological productivity
Y) They form south of the Gulf stream
Z) They are regions of upwelling

ANSWER: X) They are regions of low biological productivity

Bonus

7) *Earth and Space – Short Answer:* Which two major soil horizons are not present in aridisols?

ANSWER: O and E

Tossup

8) *Math – Short Answer:* Green Hope, Panther Creek, and Green Level each scrimmaged each other four times in Science Bowl this year. Enloe played each of those teams twice. How many total games were played among those four teams?

ANSWER: 18

Bonus

8) *Math – Short Answer:* What is the integral from -3π to 4π of $2x - sin(x)\ dx$?

ANSWER: $7\pi^2 + 2$

Tossup

9) *Energy – Multiple Choice:* Researchers at SLAC are using the LINAC coherent light source to study the geometry of molecules. Which of the following best explains why VSEPR **[vesper]** hybridization can be inadequate in describing molecules such as SF_6?

W) SF_6 electrons do not have enough energy to fit into d orbitals
X) SF_6 does not have an octahedral geometry like predicted
Y) VSEPR **[vesper]** theory does not accurately predict electron spins in SF_6
Z) VSEPR **[vesper]** theory does not accurately predict resonance in SF_6

ANSWER: W) SF_6 electrons do not have enough energy to fit into d orbitals

Bonus

9) *Energy – Short Answer:* Researchers at Argonne National Lab are studying ways to increase the efficiency of large energy storage systems. Diodes and transistors are some of the most important components used to control the flow of electricity. What phenomenon, which leads to losses and unintentional discharge of electricity, occurs when charge slowly travels across a diode or transistor in reverse bias?

ANSWER: Leakage current

Tossup

10) *Physics - Short Answer:* In classical mechanics, Lagrangian mechanics can be used to predict how a system will evolve over time. What 2 terms make up the Lagrangian for mechanical systems?

ANSWER: Kinetic Energy, Potential Energy

Bonus

10) *Physics – Short Answer:* Thanush is messing with Nikhil again, this time trying to freeze him to death. He uses a Carnot refrigerator with a coefficient of performance of 1.5 to cool the room Nikhil is in. If the heat transferred to the hot reservoir is 12 Joules during a cycle, what is the total work transferred into the engine in one cycle?

ANSWER: 4 Joules

Tossup

11) *Earth and Space – Short Answer:* Brian is observing a binary star system of two stars, A and B. Over a long period of time, Brian can see star A oscillating back and forth over 12 arcseconds in his telescope, and he sees star B oscillating back and forth over 2 arcseconds in his telescope. What is the ratio of the mass of star A to the mass of star B?

ANSWER: 1/6

Bonus

11) *Earth and Space – Short Answer:* Order the following 3 Martian surfaces from oldest to youngest:

1) Amazonis Planitia
2) Hesperia Planum
3) Noachis Terra **[No-ack-is Tay-ra]**

ANSWER: 3, 2, 1

Tossup

12) *Chemistry – Multiple Choice:* The electron configuration of nickel is often used as both $[Ar]4s^2 3d^8$ **[A R 4 s 2 3 d 8]** and $[Ar]4s^1 3d^9$ **[A R 4 s 1 3 d 9]**. Which of the following best explains why both of these configurations can be considered valid?

W) Nickel is commonly found in an excited state
X) Different isotopes of nickel have different ground state configurations
Y) The excited state of the nickel nucleus affects which electron configuration has the lowest energy
Z) Fine structure splitting causes overlap between the two configurations' orbitals

ANSWER: Z) Fine structure splitting causes overlap between the two configurations' orbitals

Bonus

12) *Chemistry – Short Answer:* Order the following 3 molecules in order of increasing ring strain per carbon:

1) Cubane
2) Tetrahedrane
3) Cyclobutadiene

ANSWER: 3, 1, 2

Tossup

13) *Biology – Multiple Choice:* Which of the following best describes the structure of collagen?

W) Coiled-coil protein
X) Double helix
Y) Triple helix
Z) Globular

ANSWER: Y) Triple helix

Bonus

13) *Biology – Short Answer:* Edwards syndrome is a trisomy of what chromosome?

ANSWER: 18

Tossup

14) *Earth and Space – Multiple Choice:* Which of the following is not a polymorph of quartz?

W) Cristobalite **[cris-to-ba-lite]**
X) Beta-Quartz
Y) Coesite **[co-site]**
Z) Cassiterite **[kuh-set-er-ite]**

ANSWER: Z) Cassiterite

Bonus

14) *Earth and Space – Short Answer:* Order the following ore minerals in increasing density.

1) Wolframite
2) Hematite
3) Pyrolusite

ANSWER: 3,2,1

Tossup

15) *Math – Short Answer:* What is the number of 8 inch by 8 inch tiles needed to cover a floor measuring 8 feet by 6 feet?

ANSWER: 108

Bonus

15) *Math – Short Answer:* Brian has a rod of length 16 meters. He splits the rod into n equal pieces and multiplies the length of each piece together to obtain a new number, k. What value of n should Brian choose so that k is maximized?

ANSWER: 6

Tossup

16) *Physics – Short Answer:* In NMR spectroscopy, magnetic nuclei are perturbed out of alignment with a magnetic field and undergo precession as they come back into alignment, emitting radiation in the process. What property of a nucleus explains why it precesses as it realigns with the field?

ANSWER: Spin (ACCEPT: Angular momentum)

Bonus

16) *Physics – Short Answer:* Brian has decided to create a new unit system called the BBB system from the following base units: Bohr radius, BTU, and Boltzmann constant. Identify all of the following 3 quantities that can be represented in the BBB system:

I) Temperature
II) Time
III) Volume

ANSWER: I and III

Tossup

17) *Chemistry – Multiple Choice:* When conducting chromatography, which of the following mobile phases would be most commonly used alongside a silica gel stationary phase?

W) Acetone
X) DMSO
Y) Acetaldehyde
Z) Toluene

ANSWER: Z) Toluene

Bonus

17) *Chemistry – Multiple Choice:* In the backbonding of a conjugated alkene ligand to a central metal atom in a complex, the HOMO d orbital of the metal donates into the LUMO pi star orbital of the conjugated system. How do the bond angle and bond length of the alkene change during backbonding, respectively?

W) Increase, Increase
X) Increase, Decrease
Y) Decrease, Increase
Z) Decrease, Decrease

ANSWER: Y) Decrease, Increase

Tossup

18) *Biology – Short Answer:* What process, commonly used by environmental scientists in wildlife conservation efforts, uses organisms to add essential materials to a degraded ecosystem?

ANSWER: Biological Augmentation

Bonus

18) *Biology – Short Answer:* Identify all of the following 3 intermediates in the C4 cycle that are a 3 carbon molecule:

I) Oxaloacetate
II) Malate
III) PEP

ANSWER: III only

Tossup

19) *Energy – Multiple Choice:* Brian, who is your average NCD enthusiast, decides that he wants to manufacture a bioweapon in Kaiwen's garage, and realizes that he needs to introduce plasmids to bacteria. Which of the following is not a type of transfection that he could use to introduce the plasmids?

W) Magnetofection
X) Chemofection
Y) Electroporation
Z) Sonopronation

ANSWER: X) Chemofection

Bonus

19) *Energy – Short Answer:* Researchers at Brookhaven National Lab are studying black holes. The entropy of a black hole is directly proportional to what physical property of the black hole?

ANSWER: Area

Tossup

20) *Earth and Space – Short Answer:* The characteristic absorption line for a type 1a supernova at 615 nanometers is produced by what specific chemical species?

ANSWER: Silicon II (DO NOT ACCEPT: Silicon, ACCEPT: Singly ionized silicon, Si^{+})

Bonus

20) *Earth and Space – Multiple Choice:* Which of the following is true of Jupiter's great red spot?

W) Its color is derived from hematite
X) It is a persistent cyclone
Y) It moves westward along the surface of Jupiter
Z) It is in Jupiter's northern hemisphere

ANSWER: Y) It moves westward along the surface of Jupiter

Tossup - Nikhil

21) *Chemistry – Short Answer:* What type of isomerism occurs in two compounds where the atom of a ligand bonded to the central metal atom is different?

ANSWER: Linkage isomerism

Bonus

21) *Chemistry – Multiple Choice:* As temperature increases, which of the following best describes how the vapor pressure of a solid changes?

W) Linearly
X) Quadratically
Y) Exponentially
Z) Logistically

ANSWER: Y) Exponentially

Tossup

22) *Physics – Multiple Choice:* A spring mass oscillator is immersed in a viscous liquid. Which of the following happens to the resonant frequency when the viscosity of the liquid increases?

W) Increases
X) Stays the same
Y) Decreases
Z) It depends on the viscosity

ANSWER: Y) Decreases

Bonus

22) *Physics – Short Answer:* Identify all of the following 3 changes that would increase the amount of energy dissipated as Cherenkov radiation from a charged particle at some given wavelength of radiation:

I) Increasing particle charge
II) Increasing magnetic permeability
III) Increasing electric permittivity

ANSWER: All

Tossup

23) *Math – Short Answer:* Triangle PQR has side lengths PQ = 6 and PR = 10. Point S lies on side QR such that line segment PS bisects angle QPR. If QS = 3, what is the length of SR?

ANSWER: 5

Bonus

23) *Math – Short Answer:* What is $\lim_{x \to 0^+} x \ln x$ **[the limit as x approaches 0 from the right of x times the natural log of x]**?

ANSWER: 0