ESBOT

2023

RR1

Tossup

1) *Physics – Short Answer:* A lightbulb glows brightly when it is connected across a certain ideal battery. Two more identical bulbs are then connected across the same battery, so that all three bulbs are in parallel. By what factor will the brightness of each of the three bulbs increase compared to the original bulb?

ANSWER: 1

Bonus

1) *Physics – Short Answer:* Kaiwen is repairing a brake system on a car. To prevent overheating of the brake pads, he attaches a heat sink to them with a contact area of 0.05 square meters. If the wheel of the car is spinning at 60 radians per second and the brakes apply a torque of 150 Newton-meters, how much power in Watts must the heat sink absorb to avoid overheating?

ANSWER: 9000

Tossup

2) *Energy – Multiple Choice:* Researchers at Sandia National Laboratory are finding ways to combat the cellular processes involved in the destruction of the substantia nigra. What disease are they aiming to find a solution for?

    W) Hypothyroidism
    X) Parkinson's
    Y) Huntington's
    Z) Lou Gherig's **[Loo-Geh-Rigs]**

ANSWER: X) Parkinsons

Bonus

2) *Energy – Multiple Choice:* Researchers at North Carolina State University are studying ways to improve the efficiency of combustion engines. Which of the following thermodynamic cycles are used inside airbreathing jet engines?

    W) Otto
    X) Stirling
    Y) Brayton
    Z) Rankine

ANSWER: Y) Brayton

Tossup

3) *Math – Multiple Choice:* Brian writes all of the integers from 1 to 100 inclusive on a whiteboard. How many times does he write the number 1?

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

ANSWER: Z) 21

Bonus

3) *Math – Multiple Choice:* Which of the following is logically equivalent to the saying, "If a student attends Enloe High School, then they are a nerd"?

W) If a student does not attend Enloe High School, then they are not a nerd
X) If a student is not a nerd, then they attend Enloe High School
Y) If a student is a nerd, then they attend Enloe High School
Z) If a student is not a nerd, then they do not attend Enloe High School

ANSWER: Z

Tossup

4) *Earth and Space – Multiple Choice:* Which of the following minerals displays the highest hardness?

    W) Beryl **[Beh-Ril]**
    X) Hematite
    Y) Fluorite
    Z) Plagioclase [**Play-jee-oh-claise**]

ANSWER: W) Beryl

Bonus

4) *Earth and Space – Multiple Choice:* What is the name of the structure that is formed from sediments accreted onto the non-subducting tectonic plate at a convergent plate boundary?

    W) Shock diamond
    X) Accretionary wedge
    Y) Triple junction
    Z) Subduction triangle

ANSWER: X) Accretionary wedge

Tossup

5) *Chemistry – Short Answer:* Order the following 3 compounds in order of increasing boiling point:

    1) HF
    2) H_2O
    3) NH_3

ANSWER: 3, 1, 2

Bonus

5) *Chemistry – Short Answer:* What term describes the tendency of a reaction to favor one constitutional isomer over others?

ANSWER: Regioselectivity

Tossup

6) *Energy – Multiple Choice:* Kaiwen is investigating the use of ionic substances as insulators for his high-voltage electronics. The breakdown voltage of ionic solids is roughly proportional to the lattice energy of that compound. Which of the following compounds would be best for him to use as an insulator?

    W) $CaCl_2$
    X) $AlCl_3$
    Y) MgO
    Z) RbCl

ANSWER: Y) MgO

Bonus

6) *Energy – Short Answer:* Kaiwen is studying the effectiveness of different radioactive isotopes in nuclear bombs. He acquires a sample of Uranium-238 and begins to examine one atom of the sample. The atom undergoes alpha decay 3 times, beta minus decay 2 times, and gamma decay once. What is the atomic number and atomic mass, respectively, of the resulting atom?

ANSWER: 88, 226 (ACCEPT: Atomic number 88 and Atomic mass 226)

Tossup

7) *Biology – Multiple Choice:* Which of the following groups of protists are multicellular?

       W) Parabasalids **[pair-a-bay-suh-lids]**
       X) Euglenids **[you-glee-nids]**
       Y) Diatoms
       Z) Brown Algae

ANSWER: Z) Brown Algae

Bonus

7) *Biology – Short Answer:* Identify all of the following 4 types of RNA that are involved in post-transcriptional RNA interference:

       I) tRNA
       II) miRNA
       III) siRNA
       IV) snRNA

ANSWER: II, III

Tossup

8) *Chemistry – Short Answer:* Colin, after driving to school on a cold day, gets out of his warm car and turns it off. The air inside the car begins to cool from being in contact with the cold outside air. Identify all of the following 3 statements that are true about the process:

       I) The entropy of the car's air increases
       II) The entropy of the outside air increases
       III) The entropy of the universe increases

ANSWER: II and III

Bonus

8) *Chemistry – Short Answer:* What is the formal charge on the nitrogen atom in nitrile oxide, which has a structural formula CNO?

ANSWER: +1

Tossup

9) *Earth and Space – Short Answer:* Order the following 4 planets in order of increasing density:

    1) Mercury
    2) Earth
    3) Saturn
    4) Neptune

ANSWER: 3, 4, 1, 2

Bonus

9) *Earth and Space – Short Answer:* What is the term that refers to the rotating circumstellar disk of dense gas surrounding a young newly formed star?

ANSWER: Protoplanetary Disk

Tossup

10) *Physics – Short Answer:* Identify all of the following 3 forces that are conservative:

    I) Gravitational force
    II) Electrostatic force
    III) Tension

ANSWER: I and II

Bonus

10) *Physics – Short Answer:* Brian places a 8 centimeter tall Genshin Impact figurine 20 centimeters from a lens with a focal length of 5 centimeters. How tall will the image of the figurine appear in centimeters?

ANSWER: 8/3

Tossup

11) *Biology – Multiple Choice:* Which of the following enzymes is the "rate limiter" of glycolysis?

    W) Hexokinase
    X) Aldolase
    Y) Phosphofructokinase
    Z) Phosphoglycerokinase **[phospho-glycero-kinase]**

ANSWER: Y) Phosphofructokinase

Bonus

11) *Biology – Short Answer:* Select all of the following three amino acids that have aromatic side chains:

    I) Tyrosine
    II) Proline
    III) Phenylalanine **[feen-ill-al-an-een]**

ANSWER: I and III

Tossup

12) *Math – Short Answer:* There are two faucets in the bathroom. One drips every 6 seconds, and the other drips every 13 seconds. If the two faucets just dripped at the same time, how many seconds will pass before they both drip at the same time again?

ANSWER: 78

Bonus

12) *Math – Short Answer:* Kaiwen has 10 nuclear warheads labeled from 1 to 10. How many ways can Kaiwen choose 3 warheads to put on a MIRV such that no two labels of two chosen warheads are consecutive numbers?

ANSWER: 56

Tossup

13) *Physics – Short Answer:* The fine structure constant is the coupling constant for what fundamental force?

ANSWER: Electromagnetic Force (ACCEPT: Electromagnetic Interaction)

Bonus

13) *Physics – Short Answer:* Order the following 3 objects from smallest to largest moment of inertia about their perpendicular central axis:

    1) 1 kilogram hoop with radius 2 meters
    2) 4 kilogram disk with radius 1 meter
    3) 2 kilogram rod with length 3 meters

ANSWER: 3, 2, 1

Tossup

14) *Chemistry – Short Answer:* What is the name of a common reagent used to distinguish between aldehydes and ketones, also used for silver mirroring?

ANSWER: Tollens reagent

Bonus

14) *Chemistry – Short Answer:* Which two decay mechanisms are most likely to occur in nuclei that are neutron deficient?

ANSWER: Beta plus and electron capture

Tossup

15) *Math – Short Answer:* What is the sum of the coefficients of the expanded form of $(x + y)^{10}$ **[the quantity x plus y to the tenth power]**?

ANSWER: 1024

Bonus

15) *Math – Short Answer:* Siddharth leaves home to go to school, driving at a constant speed of 60 miles per hour. When he is halfway there, he realizes that he is going to be late and drives the second half at a constant speed of 90 miles per hour. What was his average speed for the entire trip, in miles per hour?

ANSWER: 72

Tossup

16) *Energy – Short Answer:* Scientists at Sandia National Lab are studying electron transitions in molecules. What process occurs when electrons are energized by incoming light and slowly transition back to the ground state through forbidden transitions?

ANSWER: Phosphorescence

Bonus

16) *Energy – Short Answer:* Scientists at NASA are using the James Webb Space telescope to create more detailed maps of the universe. Identify all of the following 3 methods which can be used to map spiral arms in galaxies:

    I) O and B associations
    II) Carbon monoxide absorption lines
    III) Emission nebulae

ANSWER: All

Tossup

17) *Biology – Short Answer:* List the following 3 parts of the heart electric system in order of activation during a regular heartbeat:

    1) AV Node
    2) Bundle of His
    3) SA Node

ANSWER: 3, 1, 2

Bonus

17) *Biology – Short Answer:* Identify all of the following 3 organisms that are triploblastic **[trip-lo-blast-ic]**:

    I) Frogs
    II) Jellyfish
    III) Sponges

ANSWER: I only

Tossup

18) *Physics – Short Answer:* Identify all of the following 3 scenarios that would produce an electric field with a nonzero curl:

    I) A stationary point charge
    II) A wire with a constant current flowing through it
    III) A point charge moving with a constant nonzero acceleration

ANSWER: III only

Bonus

18) *Physics – Short Answer:* Two common units for size measurements are pounds and kilograms, which are related by a numeric factor of approximately 2.2 pounds per kilogram. In SI base units, what must be the units of this numeric factor?

ANSWER: m/s^2 (meter per second squared)

Tossup

19) *Earth and Space – Short Answer:* What is the name for the valley formed between two horsts?

ANSWER: Graben

Bonus

19) *Earth and Space – Short Answer:* Order the following 3 noble gases in order of increasing abundance in the Earth's atmosphere:

    1) Neon
    2) Argon
    3) Xenon

ANSWER: 3, 1, 2

Tossup

20) *Math – Multiple Choice:* Serena is making a poster in the shape of a rhombus. What is the area of her poster in square inches if the side length of it is 5 inches and shorter diagonal length is 6 inches?

    W) 15
    X) 24
    Y) 30
    Z) 48

ANSWER: X) 24

Bonus

20) *Math – Multiple Choice:* Andy is broke and decides to start saving money in his empty piggy bank. He inserts one dollar on Mondays, two dollars on Tuesdays, three dollars on Wednesdays, four dollars on Thursdays, five dollars on Fridays, six dollars on Saturdays, and seven dollars on Sundays. After 17 days of saving, he counts 71 dollars in his piggy bank. On what day of the week did he start saving money?

    W) Thursday
    X) Friday
    Y) Saturday
    Z) Sunday

ANSWER: W) Thursday

Tossup

21) *Biology – Short Answer:* According to the ABC hypothesis, identify all of the following 3 genes that are expressed during the development of stamens:

    I) A
    II) B
    III) C

ANSWER: II and III

Bonus

21) *Biology – Short Answer:* Sieve tube elements are known to not have nuclei or any functioning organelles as their primary function is to transport sugars. Sieve tube elements receive resources from *what other cells* as a result

ANSWER: Companion cells

Tossup

22) *Chemistry – Short Answer:* How many radial and angular nodes, respectively, are in a 4p orbital?

ANSWER: 2, 1

Bonus

22) *Chemistry – Multiple Choice:* Serena is trying to make a buffer solution at pH 5.2 using her stock solutions of various bases and their conjugate acids. Which of the following K_b values should she use for her base to make the best buffer solution?

    W) 3×10^{-12}
    X) 2×10^{-9}
    Y) 8×10^{-6}
    Z) 4×10^{-3}

ANSWER: X) 2×10^{-9}

Tossup

23) *Earth and Space – Short Answer:* Astronomers have discovered an alien civilization in the Trisolaris system, which has a parallax of 750 milliarcseconds. How many parsecs away is Trisolaris, to three significant figures?

ANSWER: 1.33 parsecs

Bonus

23) *Earth and Space – Multiple Choice:* The two moons of Kerbin, Mun and Minmus, have an apparent magnitude of –20.0 and –12.0, respectively. Which of the following is closest to the ratio of the brightness of Mun to the brightness of Minmus?

W) 50
X) 100
Y) 500
Z) 1000

ANSWER: Z) 1000