

ESBOT

2023

RR2

Tossup

1) *Earth and Space – Short Answer:* Identify all of the following 3 minerals which form primarily by precipitation from a solvent:

- I) Sulfur
- II) Gypsum
- III) Orthoclase

ANSWER: I and II

Bonus

1) *Earth and Space – Multiple Choice:* The late heavy bombardment had which of the following effects on the geologic record from 4 to 3.8 billion years ago?

- W) It erased the geologic record
- X) It added increased amounts of carbon to rocks produced
- Y) It added large amounts of iron to the rocks produced
- Z) It brought evidence of large scale shock metamorphism

ANSWER: W) It erased the geologic record

Tossup

2) *Chemistry – Short Answer:* Order the following 3 types of intermolecular forces from weakest to strongest:

- 1) Ion - induced dipole
- 2) Dipole - induced dipole
- 3) Dipole - dipole

ANSWER: 2, 1, 3

Bonus

2) *Chemistry – Short Answer:* The standard reduction potentials of Cr^{3+} and Cr^{2+} are -0.74 and -0.9 , respectively. What is the standard reduction potential of the reaction $\text{Cr}^{2+} \rightarrow \text{Cr}^{3+} + \text{e}^-$?

ANSWER: -0.42

Tossup

3) *Biology – Multiple Choice:* Wobble base pairing is most likely to occur in which of the following cellular processes:

- W) DNA replication
- X) Transcription
- Y) Translation
- Z) Homologous recombination

ANSWER: Y) Translation

Bonus

3) *Biology – Short Answer:* Identify all of the following 3 stages of cellular respiration that use substrate level phosphorylation:

- I) Glycolysis
- II) Krebs Cycle
- III) Electron Transport Chain

ANSWER: I and II

Tossup

4) *Math – Short Answer:* How many lattice points does the equation $x^2 + y^2 = 169$ pass through?

ANSWER: 12

Bonus

4) *Math – Short Answer:* A triangle is formed by connecting the points (0, 0), (3, 4), and (2, -1). Rounded to the nearest tenth, what is the area of this triangle?

ANSWER: 5.5

Tossup

5) *Energy – Multiple Choice:* Scientists at the Joint Genomics Institute are studying the phylogeny of life. Which of the following life forms is not correctly paired with the period it formed in?

- W) Eukaryotes; Cambrian
- X) Land Plants; Ordovician
- Y) Vascular Plants; Silurian
- Z) Amphibians; Devonian

ANSWER: W) Eukaryotes; Cambrian

Bonus

5) *Energy – Multiple Choice:* Researchers at Savannah River National Lab are studying the various different types of crustaceans that are found in the Savannah River. Which of the following statements about crustaceans is correct?

- W) Large crustaceans are called copepods
- X) Many small crustaceans are classified as decapods
- Y) The cuticles of decapods are hardened by calcium carbonate
- Z) Barnacles have a cuticle which is hardened by silica

ANSWER: Y) The cuticles of decapods are hardened by calcium carbonate

Tossup

6) *Physics – Multiple Choice:* Which of the following thermodynamic cycles has the highest possible efficiency for a given temperature difference?

- W) Brayton Cycle
- X) Otto Cycle
- Y) Diesel Cycle
- Z) Carnot Cycle

ANSWER: Z) Carnot Cycle

Bonus

6) *Physics – Multiple Choice:* A positively charged particle is slowly lowered into a neutral conducting soda can until it touches the bottom of the can. Which of the following best describes the charge on the outer surface of the can before and after the particle touches it?

- W) Positive, then negative
- X) Negative, then positive
- Y) Always positive
- Z) Always negative

ANSWER: Y) Always positive

Tossup

7) *Earth and Space – Short Answer:* Along what track would a star of 2 solar masses evolve towards the main sequence?

ANSWER: Hayashi track (ACCEPT: Henyey track)

Bonus

7) *Earth and Space – Short Answer:* Order the following three objects from least to greatest abundance in the universe:

- 1) Active Galactic Nuclei
- 2) Blazar
- 3) Quasar

ANSWER: 2, 3, 1

Tossup

- 8) *Math – Short Answer:* The function $f(x) = ax^2 + bx + c$ with $b \neq 0$ has at least one real root for all values of c . What is the value of a ?

ANSWER: 0

Bonus

- 8) *Math – Short Answer:* What is the integral from 0 to $16/3$ of x minus the floor of $x dx$?

ANSWER: 23/9

Tossup

- 9) *Energy – Multiple Choice:* Researchers at Fermilab National Accelerator Facility are studying neutrinos. If A, B, and C are the mass states of the electron neutrino, muon neutrino, and tau neutrino respectively, which of the following statements is true?

- W) A less than B approximately equal to C
- X) A approximately equal to B less than C
- Y) A less than B less than C
- Z) Each neutrino flavor does not have a single defined mass

ANSWER: Z) Each neutrino flavor does not have a single defined mass

Bonus

- 9) *Energy – Multiple Choice:* Researchers at Lawrence Berkeley National Lab are studying advanced computing methods and how they can solve real world problems. In the system of formal mathematics and logic commonly used today, there does not always exist an algorithm that can analyze another algorithm and correctly answer any yes-or-no question about it. What is the term for this property of a mathematical system?

- W) Incompleteness
- X) Inconsistency
- Y) Incomputability
- Z) Undecidability

ANSWER: Z) Undecidability

Tossup

10) *Chemistry – Short Answer:* How many sigma and pi bonds exist in one molecule of S₈?

ANSWER: 8, 0

Bonus

10) *Chemistry – Short Answer:* Identify all of the following crystal structures which have a coordination number of 12:

- I) HCP
- II) FCC
- III) BCC
- IV) Simple cubic

ANSWER: I, II, III

Tossup

11) *Biology – Multiple Choice:* Which of the following locations relative to a gene would be the most likely location of an enhancer?

- W) 10,000 base pairs downstream of a gene
- X) 100 base pairs downstream of a gene
- Y) 10 base pairs downstream of a gene
- Z) 10 base pairs upstream of a gene

ANSWER: W) 10,000 base pairs downstream of a gene

Bonus

11) *Biology – Short Answer:* Select all of the following 3 statements that are true of osmoregulation in fish:

- I) Sharks consume large amounts of seawater to offset osmotic water loss
- II) Freshwater fish produce large quantities of dilute urine to remove excess water
- III) When salmon move from freshwater to marine environments, a physiological change is induced where they produce more cells specialized to excrete salts

ANSWER: II, III

Tossup

12) *Math – Multiple Choice:* Which of the following is not a possible value for the remainder when n^2 is divided by 6 for an integer n ?

- W) 0
- X) 1
- Y) 2
- Z) 4

ANSWER: Y) 2

Bonus

12) *Math – Multiple Choice:* The acceleration of a particle traveling along the x-axis is modeled by the equation $a(t) = 6t + 4$. If the initial velocity of the particle is 3 and the initial position is 4, which equation could model the position $x(t)$ of the particle?

- W) $2t^3 + 4t^2 + 3t + 4$
- X) $2t^3 + 4t^2 + 4t + 3$
- Y) $t^3 + 2t^2 + 3t + 4$
- Z) $t^3 + 2t^2 + 4t + 3$

ANSWER: Y) $t^3 + 2t^2 + 3t + 4$

Tossup

13) *Physics – Multiple Choice:* A galvanometer is used to measure which of the following quantities?

- W) Voltage
- X) Current
- Y) Electric field
- Z) Magnetic field

ANSWER: X) Current

Bonus

13) *Physics – Short Answer:* In the collision and annihilation of an electron and a positron, identify all of the following 3 quantities that are conserved:

- I) Momentum
- II) Energy
- III) Lepton number

ANSWER: All

Tossup

14) *Chemistry – Short Answer:* Identify all of the following 3 traits that would increase the acidity of an organic hydrogen atom:

- I) C-H bond with high S character
- II) Resonance in the acid molecule
- III) Halogenation of the primary carbon

ANSWER: I, II, III

Bonus

14) *Chemistry – Short Answer:* Order the following 3 ions in terms of increasing size:

- 1) H⁻
- 2) F⁻
- 3) Cl⁻

ANSWER: 2, 1, 3

Tossup

15) *Earth and Space – Short Answer:* Order the following 3 earthquake waves in order of increasing amplitude:

- 1) Love waves
- 2) P waves
- 3) S waves

ANSWER: 2, 3, 1

Bonus

15) *Earth and Space – Short Answer:* Order the following 4 extrusive igneous rocks by increasing density:

- 1) Pumice
- 2) Obsidian
- 3) Scoria
- 4) Tachylite

ANSWER: 1, 3, 2, 4

Tossup

16) *Energy – Short Answer:* Researchers at Argonne National Lab are researching ways to make paper recycling more energy efficient. One of the first steps of paper recycling is chemical pulping, where basic solvents are used to cleave the bonds between what two carbohydrate polymers?

ANSWER: Lignin and cellulose

Bonus

16) *Energy – Multiple Choice:* Researchers at Pacific Northwest National Lab are studying ways to improve the efficiency of electroplating processes. After electroplating, extra metal in solution is often precipitated out to be reused in later batches. Which of the following solutes would be best to precipitate silver ions out of solution?

- W) Ba(NO₃)₂
- X) Al₂(SO₄)₃
- Y) NH₄F
- Z) CrBr₂

ANSWER: Z) CrBr₂

Tossup

17) *Physics – Multiple Choice:* The force exerted by a spring on some block as a function of displacement follows the relation $F = 5x^2$. If a block is attached to the end of the spring and the spring is compressed 1 meter, how much work is done by the spring on the block?

- W) $-4/3$ Joules
- X) $-5/3$ Joules
- Y) -2 Joules
- Z) $-7/3$ Joules

ANSWER: X) $-5/3$ Joules

Bonus

17) *Physics – Short Answer:* Rohit connects two balls with mass 4 kilograms and 1 kilogram with a string and hangs them over a pulley. When he releases the balls and lets the pulley spin, what is the acceleration of the balls to the nearest meter per second squared?

ANSWER: 6

Tossup

18) *Earth and Space – Short Answer:* Radio emission from active galactic nuclei results from what parts of the celestial object?

ANSWER: Jets

Bonus

18) *Earth and Space – Short Answer:* Identify all of the following 3 statements that are true of quasars:

- I) They only formed in the early universe
- II) Quasars are a type of Seyfert galaxy
- III) Quasars contain a Black hole at their center

ANSWER: III only

Tossup

19) *Biology – Multiple Choice:* Parenchyma tissue provides which of the following functions in a plant?

- W) Provides mechanical support
- X) Conducts photosynthesis
- Y) Forms bark
- Z) Forms xylem

ANSWER: X) Conducts photosynthesis

Bonus

19) *Biology – Multiple Choice:* Which of the following sequences correctly describes the changes in osmolarity of filtrate as it passes through the nephron from the descending limb of the loop of Henle to the ascending limb of the loop of Henle?

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

ANSWER: X) Increases then decreases

Tossup

20) *Math – Short Answer:* Point C is chosen at random on a square table with side length 8 feet. Point C will then become the center of a circle with radius 1.5 feet. What is the probability that the circle is entirely on the table and no part of the circle is hanging over any edge?

ANSWER: 25/64

Bonus

20) *Math – Multiple Choice:* Given that March 26, 2023 falls on a Sunday, what day of the week does March 26, 2050 fall on?

- W) Monday
- X) Wednesday
- Y) Friday
- Z) Saturday

ANSWER: Z) Saturday

Tossup

21) *Chemistry – Multiple Choice:* Which of the following best describes how the density of metals changes moving left to right across a period?

- W) Increases
- X) Decreases
- Y) Increases, then decreases
- Z) Decreases, then increases

ANSWER: Y) Increases, then decreases

Bonus

21) *Chemistry – Multiple Choice:* Which of the following analysis techniques is most useful to determine the concentration of a compound with a wide endpoint range?

- W) Back titration
- X) Iodometry
- Y) Conductometric titration
- Z) Liquid chromatography

ANSWER: W) Back titration

Tossup

22) *Physics – Short Answer:* Identify all of the following 3 changes that would increase the spacing between fringes projected on a wall by passing light through a double slit:

- I) Increase slit spacing
- II) Increase wavelength of light
- III) Increase distance to wall

ANSWER: II and III

Bonus

22) *Physics – Multiple Choice:* A newly discovered planet is found in the solar system. If the orbital period of the planet is 10 Earth years, then in astronomical units, what is the length of its major axis?

- W) 2.4
- X) 9.3
- Y) 20.0
- Z) 31.6

ANSWER: X) 9.3

Tossup

23) *Biology – Short Answer:* Identify all of the following 3 characteristics that are derived traits of plants:

- I) Apical meristems
- II) Walled spores
- III) Alternation of generations

ANSWER: All

Bonus

23) *Biology – Short Answer:* Identify all of the following 3 organisms that follow a Type III survivorship curve

- I) Humans
- II) Birds
- III) Lizards

ANSWER: None