



## ROUND ROBIN 4

---

### TOSS-UP

1) X-Risk - *Multiple Choice* Which of the following best explains why H<sub>2</sub>O absorbs infrared light but O<sub>2</sub> does not?

- W) H<sub>2</sub>O has no net dipole moment while O<sub>2</sub> does
- X) H<sub>2</sub>O exhibits hydrogen bonding while O<sub>2</sub> does not
- Y) H<sub>2</sub>O can vibrate asymmetrically while O<sub>2</sub> cannot
- Z) H<sub>2</sub>O has single bonds while O<sub>2</sub> has double bonds

ANSWER: Y) H<sub>2</sub>O can vibrate asymmetrically while O<sub>2</sub> cannot

### BONUS

1) X-Risk - *Multiple Choice* Many biological weapons utilize gram positive bacteria and their spores to cause damage to large populations. Which of the following examples of such dangerous bacteria is NOT gram positive?

- W) Clostridium botulinum
- X) Bacillus anthrax
- Y) Staphylococcus Aureus
- Z) Mycobacterium tuberculosis

ANSWER: Z) Mycobacterium tuberculosis

## TOSS-UP

2) Math - *Short Answer* What is the area of the largest inscribed circle in a semi-circle with radius 1?

ANSWER:  $\frac{\pi}{4}$

## BONUS

2) Math - *Short Answer* What is the sum of the squares of the roots of the quadratic  $y = x^2 - 7x - 9$ ?

ANSWER: 67

### TOSS-UP

3) Chemistry - *Short Answer* What simple alcohol is formed by the catalytic [cat-uh-LIT-ic] hydrogenation [hy-draw-juh-NAY-shin] of carbon dioxide?

ANSWER: Methanol

### BONUS

3) Chemistry - *Short Answer* Order the following three ions by increasing  $K_b$  [k-b]: 1) Acetate; 2) Sulfate; 3) Iodide.

ANSWER: 3, 2, 1

## TOSS-UP

4) Earth and Space - *Short Answer* What isotope of hydrogen may be used to track the ages of water masses in the oceans due to its recent increase in abundance as a result of nuclear weapons testing?

ANSWER: Tritium

## BONUS

4) Earth and Space - *Short Answer* Identify all of the following three climate proxies that could be suitable as temperature proxies for the Mesozoic era: 1) Oxygen isotope data from siliceous [suh-LISH-is] oozes; 2) Oxygen isotope data from ice cores; 3) Oxygen isotope data from calcareous [cal-KAIR-ee-is] oozes.

ANSWER: 1 and 3

## TOSS-UP

5) Biology - *Multiple Choice* A plant produces flowers that are white and have a sweet fragrance. Which of the following organisms would most likely pollinate this flower?

- W) Bird
- X) Fly
- Y) Moth
- Z) Bee

ANSWER: Y) Moth

## BONUS

5) Biology - *Short Answer* Identify all of the following three features that are never found in eudicots [YOO-dih-kots]: 1) Coleoptile [koh-lee-OP-tuhl]; 2) Two cotyledons; 3) Parallel venation.

ANSWER: 1 and 3

### TOSS-UP

6) Physics - *Short Answer* Which of Maxwell's equations is fundamental to how transformers and many types of electric motors, generators, and solenoids work?

ANSWER: Faraday's law of induction (ACCEPT: Faraday's law)

### BONUS

6) Physics - *Short Answer* What capacitance, in farads, is required to store an energy of 10 kilowatt-hours at a potential difference of 1000 volts?

ANSWER: 72

## TOSS-UP

7) X-Risk - *Multiple Choice* Asteroid mining may become useful as Earth's natural resources become increasingly depleted. Which of the following processes best explains why valuable heavy metals common in asteroids are not common on Earth's surface?

W) Subduction

X) Differentiation

Y) Radioactive decay

Z) Oxidation

ANSWER: X) Differentiation

## BONUS

7) X-Risk - *Short Answer* The lab leak theory of the origins of COVID-19 speculates that the virus originated from what type of research, concerned with giving new properties to pathogens?

ANSWER: Gain-of-function research

## TOSS-UP

8) Math - *Multiple Choice* Which of the following values of  $x$  satisfies the equation  $3^x = 2$ ?

W)  $\frac{\ln(2)}{\ln(3)}$

X)  $\frac{\ln(3)}{\ln(2)}$

Y)  $\ln(3)$

Z)  $\ln(2)$

ANSWER: W)  $\frac{\ln(2)}{\ln(3)}$

## BONUS

8) Math - *Short Answer* In a simplified football game, players score 3 points from a field goal or 6 points by scoring a touchdown, then potentially 0 or 1 points directly following a touchdown. What is the highest number of points that is impossible for a team to score?

ANSWER: 11

### TOSS-UP

9) Chemistry - *Multiple Choice* According to kinetic molecular theory, which of the following is true about a particle in an ideal gas?

W) The particle's energy only changes following collisions

X) The particle's volume only changes after collisions

Y) The particle's speed only changes following collisions

Z) The direction of the particle's motion only changes following collisions

ANSWER: Z) The direction of the particle's motion only changes following collisions

### BONUS

9) Chemistry - *Short Answer* When potassium is combusted in the ambient atmosphere, what compound is predominantly formed?

ANSWER: Potassium superoxide (Accept:  $\text{KO}_2$ )

## TOSS-UP

10) Earth and Space - *Multiple Choice* Millisecond pulsars spin extremely fast, at rates of up to around 600 times a second. What process is thought to be responsible for the fast rotation of millisecond pulsars, as opposed to other types of pulsars?

- W) Gravitational collapse of the star during supernova
- X) Radioactive decay of nickel on the surface
- Y) Fluid outer core
- Z) Accretion from a binary companion

ANSWER: Z) Accretion from a binary companion

## BONUS

10) Earth and Space - *Multiple Choice* How does a star's metallicity change as it evolves along the main sequence, neglecting any addition or emission from solar wind or interstellar particles?

- W) Increases
- X) Decreases
- Y) Stays the same
- Z) Variable based on the mass of the star

ANSWER: Y) Stays the same

### **TOSS-UP**

11) Biology - *Short Answer* Neurofibrillary [nuhr-oh-FY-bruh-lair-ee] tangles present in the brains of Alzheimer's patients are composed of what protein?

ANSWER: Tau protein

### **BONUS**

11) Biology - *Short Answer* During SDS-PAGE, dithiothreitol [die-thy-oh-THREE-uh-to] or beta-mercaptoethanol [muhr-cap-tow-ETH-uh-nahl] is used to destroy what type of tertiary interactions in proteins?

ANSWER: Disulfide bonds

## TOSS-UP

12) Physics - *Multiple Choice* The formula for the Heisenberg uncertainty principle states that the uncertainty of a given particle's position times the uncertainty of that particle's momentum has to be greater than or equal to Planck's constant over which of the following?

- W)  $\pi$
- X)  $2\pi$
- Y)  $4\pi$
- Z)  $4\pi^2$

ANSWER: Y)  $4\pi$

## BONUS

12) Physics - *Short Answer* The de Broglie wavelength of a particle is dependent on what power of the energy of the particle's motion?

ANSWER:  $-\frac{1}{2}$

## TOSS-UP

13) X-Risk - *Short Answer* Freeway widening projects usually do not alleviate traffic congestion in the long run because residents are encouraged to drive more. What concept is this phenomenon an example of?

ANSWER: Induced demand (ACCEPT: Induced utilization)

## BONUS

13) X-Risk - *Multiple Choice* A greedy algorithm is an example of what type of approach that gives approximate solutions to a problem in a relatively short time?

- W) Heuristic [hyur-IS-tic]
- X) Algorithm
- Y) Protocol
- Z) Optimization

ANSWER: W) Heuristic

### TOSS-UP

14) Math - *Multiple Choice* The equation  $x^2 + y^2 = r^2$  is the general equation for describing a circle in a plane. What would be the resulting shape if the circle was projected onto all planes parallel to the original plane?

- W) Cone
- X) Cylinder
- Y) Ellipse
- Z) Sphere

ANSWER: X) Cylinder

### BONUS

14) Math - *Short Answer* Express  $\frac{1}{\sqrt{5}-1}$  in simplified radical form.

ANSWER:  $\frac{\sqrt{5}+1}{4}$

### TOSS-UP

15) Chemistry - *Short Answer* What is the hybridization of carbon in  $\text{CHCl}_3$ ?

ANSWER:  $sp^3$

### BONUS

15) Chemistry - *Short Answer* Identify all of the following three metals that violate the Aufbau [OF-bow] principle in their ground state: 1) Copper; 2) Technetium [tec-NEE-shee-um]; 3) Gold.

ANSWER: 1 and 3

## TOSS-UP

16) Earth and Space - *Multiple Choice* What type of soils would be expected in areas with permafrost?

W) Aridisol [uh-RID-uh-sol]

X) Gelisol

Y) Ultisol

Z) Oxisol

ANSWER: X) Gelisol

## BONUS

16) Earth and Space - *Short Answer* Most sulfur in the ocean is found as part of what sulfur-containing ion?

ANSWER: Sulfate (ACCEPT: Inorganic sulfate)

### TOSS-UP

17) Biology - *Short Answer* The Islets [EYE-lits] of Langerhans [LAN-gur-hanz] are found within what gland of the body?

ANSWER: Pancreas

### BONUS

17) Biology - *Short Answer* David is crossing two pea plants that show Mendelian inheritance for height and pea color. Green peas are dominant to yellow peas, and tall plants are dominant to short plants. However, all plants that are both yellow and tall die. If a true breeding yellow and short plant is crossed with a true breeding green and tall plant, what proportion of the surviving offspring will be green?

ANSWER: 100%

### TOSS-UP

18) Physics - *Short Answer* What force mediates the decay of a proton into a neutron while simultaneously forming a positron and electron neutrino?

ANSWER: Weak nuclear (ACCEPT: Weak)

### BONUS

18) Physics - *Multiple Choice* An aircraft goes supersonic, forming a shockwave. What shape does the shockwave form as it approaches flat ground?

- W) Circle
- X) Ellipse
- Y) Hyperbola
- Z) Parabola

ANSWER: Y) Hyperbola

## TOSS-UP

19) X-Risk - *Multiple Choice* Why are graphics processing units commonly used for machine learning instead of CPUs?

- W) They can perform sequential operations faster than CPUs
- X) They have a longer history of use in high-performance computing than CPUs
- Y) They can perform more operations in parallel than CPUs
- Z) They can carry out more types of operations than CPUs

ANSWER: Y) They can perform many operations in parallel

## BONUS

19) X-Risk - *Multiple Choice* The Novavax vaccine was the first COVID-19 vaccine based on protein subunit technology. Which of the following is NOT true about protein subunit vaccines when compared to other types of vaccines?

- W) They are more less than live attenuated vaccines
- X) They are less likely to elicit an immune response than inactivated vaccines
- Y) They often do not require booster shots in the future to increase immunization
- Z) They usually do not use viral capsid proteins

ANSWER: Y) They often do not require booster shots in the future to increase immunization

### TOSS-UP

20) Math - *Short Answer* How many trees are there with 5 indistinguishable nodes?

ANSWER: 3

### BONUS

20) Math - *Multiple Choice* The normal distribution is equivalent to a  $t$ -distribution with how many degrees of freedom?

W) 0

X) 1

Y) 2

Z) Infinite

ANSWER: Z) Infinite

### TOSS-UP

21) Chemistry - *Multiple Choice* Which of the following substrates will be alkylated at the heteroatom most quickly under basic conditions?

- W) Primary alcohol
- X) Primary thiol [THY-all]
- Y) Tertiary alcohol
- Z) Tertiary thiol

ANSWER: X) Primary thiol

### BONUS

21) Chemistry - *Short Answer* Order the following three molecules in terms of increasing bond angle: 1)  $\text{NH}_3$ ; 2)  $\text{PH}_3$ ; 3)  $\text{AsH}_3$ .

ANSWER: 3, 2, 1

## TOSS-UP

22) Earth and Space - *Multiple Choice* According to Einstein's theory of general relativity, what shape would a universe with a density less than the critical density assume?

- W) Spherical
- X) Flat
- Y) Hyperbolic
- Z) Parabolic

ANSWER: Y) Hyperbolic

## BONUS

22) Earth and Space - *Multiple Choice* What type of supernovae do Wolf-Rayet stars generally produce?

- W) Type Ia [one-A]
- X) Type Ib [one-B]
- Y) Type II-L [two-L]
- Z) Type II-P [two-P]

ANSWER: X) Type Ib

## TOSS-UP

23) Biology - *Multiple Choice* Metanephridia [meh-tuh-nuh-FRID-ee-uh] are possessed by members of which of the following phyla?

W) Arthropoda [arr-thruh-POD-ah]

X) Nematoda [NEE-mah-toh-duh]

Y) Annelida [ann-uh-LID-uh]

Z) Cnidaria [nid-AIR-ee-uh]

ANSWER: Y) Annelida

## BONUS

23) Biology - *Short Answer* Identify all of the following three statements that are true regarding stomata: 1) Transport of potassium into guard cells causes stomatal opening; 2) CAM plants close their stomata during the day; 3) Guard cells decrease in width while stomata open.

ANSWER: 1 and 2

### TOSS-UP

24) Physics - *Short Answer* What type of radiation results when a charged particle, most commonly an electron, travels through a dielectric medium with a speed greater than light's speed in that medium?

ANSWER: Cherenkov radiation

### BONUS

24) Physics - *Short Answer* A current of 4 amperes is present in a circular wire loop of radius 0.5 meters. If a magnetic field of 0.5 teslas was placed such that it intersects the loop at an angle of 30 degrees at every point, what is the magnitude of the magnetic force felt by the wire loop, in newtons?

ANSWER:  $\pi$