ROUND ROBIN 3

TOSS-UP

1) Math - *Short Answer* A water bottle weighs 400 grams when 75% full and 240 grams when 25% full. In grams, how much does the water bottle weigh when empty?

ANSWER: 160

BONUS

1) Math - *Short Answer* Let a and b be real numbers. Identify all of the following three shapes that could possibly describe the region of the xy-plane satisfying the two inequalities $x+y \leq a$ and $x^2+y^2 \leq b^2$: 1) Circle; 2) Semicircle; 3) Line.

ANSWER: 1 and 2

TOSS-UP

2) Physics - *Multiple Choice* Which of the following particles is NOT correctly matched to the force that it mediates?

W) Gluon, strong force
X) W^+ boson, weak force
Y) Z boson, gravity
Z) Photon, electromagnetic force

ANSWER: Y) Z boson, gravity

BONUS

2) Physics - *Short Answer* A satellite is initially at rest in space around a spherical planet with mass much greater than the mass of the satellite. Identify all of the following three factors on which the time for the satellite to land on the planet depends: 1) Mass of the planet; 2) Mass of the satellite; 3) Distance from the planet's surface.

ANSWER: 1 and 3

TOSS-UP

3) Biology - *Multiple Choice* Pollination involves the transfer of pollen grains between which of the following structures?

W) The carpel **[CAR-pull]** of one flower to the carpel of another flower
X) The carpel of one flower to the stamen **[STAY-min]** of another flower
Y) The stamen of one flower to the carpel of another flower
Z) The stamen of one flower to the stamen of another flower

ANSWER: Y) The stamen of one flower to the carpel of another flower

BONUS

3) Biology - *Multiple Choice* Which of the following vitamins plays an important role in calcium homeostasis **[hoh-mee-oh-STAY-sis]**?

W) Vitamin A
X) Vitamin C
Y) Vitamin D
Z) Vitamin E

ANSWER: Y) Vitamin D

TOSS-UP

4) Chemistry - *Multiple Choice* In a flame test, the peak emitted wavelength of which of the following metals is typically the shortest?

W) Lithium
X) Sodium
Y) Potassium
Z) Barium

ANSWER: Y) Potassium

BONUS

4) Chemistry - *Multiple Choice* Which of the following correctly describes the predicted result of Rutherford's gold foil experiment given the nuclear model of the atom?

W) All alpha particles pass through the foil with only small deflections
X) Most alpha particles pass through the foil with some very large deflections
Y) Most alpha particles are deflected by the foil with some passing directly through
Z) All alpha particles are deflected by very large amounts

ANSWER: X) Most alpha particles pass through the foil with some very large deflections

TOSS-UP

5) Energy - *Multiple Choice* Researchers at SLAC are using models to predict the formation of Cooper pairs at high temperatures. Cooper pairs are responsible for the unique properties of which of the following phenomena?

W) Photoelectric effect
X) Piezoelectricity
Y) Superconductivity
Z) Superfluidity

ANSWER: Y) Superconductivity

BONUS

5) Energy - *Short Answer* Scientists at Stanford's Doerr School of Sustainability are studying the evolution of Jurassic ichthyosaurs **[ICK-thee-oh-saurs]** and modern-day sharks, focusing on how their streamlined bodies allow for efficient swimming. This similarity in body shape despite their distant evolutionary relationship is an example of which type of evolution?

ANSWER: Convergent evolution (ACCEPT: Convergent)

TOSS-UP

6) Biology - *Short Answer* Minerals traveling in the apoplast of the endodermis encounter a dead end that prevents their passage into the vascular cylinder. What structure, made of suberin **[SOO-ber-in]**, is responsible for preventing water and minerals from entering the center of the root?

ANSWER: Casparian **[cas-PAIR-ee-in]** strip

BONUS

6) Biology - *Short Answer* At the site of inflammation, what type of phagocytic cell are the primary responders and migrate from dilated blood vessels into the infected tissue?

ANSWER: Neutrophils **[NEW-troh-fills]**

TOSS-UP

7) Earth and Space - *Multiple Choice* Pāhoehoe **[pah-HOY-hoy]** and ʻaʻā **[AH-ah]** lava flows are most commonly formed by lavas with which of the following compositions?

W) Ultramafic
X) Mafic
Y) Intermediate
Z) Felsic

ANSWER: X) Mafic

BONUS

7) Earth and Space - *Multiple Choice* Which of the following most accurately characterizes the summer phase of the Indian Summer Monsoon?

W) A thermal high results in sinking air and fair weather
X) A thermal high results in sinking air and precipitation
Y) A thermal low results in rising air and fair weather
Z) A thermal low results in rising air and precipitation

ANSWER: Z) A thermal low results in rising air and precipitation

TOSS-UP

8) Physics - *Short Answer* In the classic double slit experiment, what principle is responsible for the generation of new wavefronts that propagate outwards from each slit?

ANSWER: Huygens' **[HOY-gins]** principle

BONUS

8) Physics - *Short Answer* Suppose there are two thermal reservoirs with temperatures 300 and 400 kelvin. Identify all of the following three situations that would violate the second law of thermodynamics: 1) A 100% efficient heat engine operating between the reservoirs; 2) An engine transferring heat from the hot reservoir to the cold reservoir with zero work done; 3) An engine transferring heat from the cold reservoir to the hot reservoir with zero work done.

ANSWER: 1 and 3

TOSS-UP

9) Chemistry - *Short Answer* What is the name of the measurement analogous to concentration that is used to calculate colligative **[cuh-LIG-uh-tiv]** properties and typically has units of moles of solute per kilogram of solvent?

ANSWER: Molality

BONUS

9) Chemistry - *Multiple Choice* Two identical containers are filled with equal moles of two different gases, A and B, at the same temperature. Which of the following statements is true about the properties of the gases?

W) The average molecular speed of A and B are the same
X) The average kinetic energy of the molecules in A and B are the same
Y) The number of molecular collisions per second with the container's walls for A and B are the same
Z) The root-mean-square speed of A and B are the same

ANSWER: X) The average kinetic energy of the molecules in A and B are the same

TOSS-UP

10) Earth and Space - *Short Answer* What term describes the point on the celestial sphere located directly above the viewer?

ANSWER: Zenith

BONUS

10) Earth and Space - *Multiple Choice* Which of the following statements best describes why few Population III **[three]** stars are observed in the universe today?

W) They formed with very low masses and burn fuel too slowly to be detectable
X) They are hidden in distant galaxies and obscured by interstellar dust
Y) They were the first generation of stars and most have already died out
Z) They exist in regions of the universe that are too far away to observe with current technology

ANSWER: Y) They were the first generation of stars and most have already died out

TOSS-UP

11) Math - *Short Answer* What is the smallest positive integer that is both a perfect square and a perfect cube?

ANSWER: 1

BONUS

11) Math - *Short Answer* There are 6 girls and 4 boys in a class. What is the probability that a randomly chosen group of 3 students are all girls?

ANSWER: $\frac{1}{6}$

TOSS-UP

12) Energy - *Multiple Choice* Scientists at Stanford's Bio-X Institute are developing macroporous hydrogels with oxygen-releasing nanoparticles for bone matrix secretion. Which of the following cells involved in bone generation do these hydrogels most likely target?

W) Osteoblasts **[OS-tee-oh-blasts]**
X) Osteoclasts **[OS-tee-oh-clasts]**
Y) Osteocytes **[OS-tee-oh-sites]**
Z) Bone-lining cells

ANSWER: W) Osteoblasts

BONUS

12) Energy - *Multiple Choice* Researchers in the Gratta group at Stanford are experimenting with neutrino oscillation. The oscillation between different flavors of neutrinos was originally used to prove that which of the following properties of neutrinos is nonzero?

W) Charge
X) Mass
Y) Spin
Z) Velocity

ANSWER: X) Mass

TOSS-UP

13) Physics - *Multiple Choice* If both the plate area and the plate separation of a parallel-plate capacitor are doubled, by which of the following values is its capacitance multiplied?

W) 0.5
X) 1
Y) 2
Z) 4

ANSWER: X) 1

BONUS

13) Physics - *Short Answer* If a particle has position $x(t) = 3\sin t - 12\cos t$, then what is its instantaneous acceleration at time $t = \frac{\pi}{2}$?

ANSWER: -3

TOSS-UP

14) Biology - *Short Answer* In high pH conditions or high temperatures, the weak bonds and interactions within a protein may be destroyed, causing it to lose its shape. What term describes this mis-shapening of the protein that can lead to biological inactivation?

ANSWER: Denaturation

BONUS

14) Biology - *Short Answer* Identify all of the following three terms that can describe $NADP^+$ during the light reactions of photosynthesis: 1) Reducing agent; 2) Phosphorylated **[fos-FOUR-uh-lay-tid]** intermediate; 3) Final electron acceptor.

ANSWER: 3 only

TOSS-UP

15) Chemistry - *Multiple Choice* Which of the following elements has the largest atomic radius?

W) Barium
X) Cesium
Y) Oxygen
Z) Selenium

ANSWER: X) Cesium

BONUS

15) Chemistry - *Multiple Choice* Which of the following best describes Henry's law and how it predicts the solubility of a gas in a liquid?

W) Solubility is directly proportional to the temperature of the liquid
X) Solubility is directly proportional to the partial pressure of the gas above the liquid
Y) Solubility is inversely proportional to the molar mass of the gas
Z) Solubility depends solely on a constant specific to the molecule

ANSWER: X) Solubility is directly proportional to the partial pressure of the gas above the liquid

TOSS-UP

16) Math - *Short Answer* How many inches are in one-sixth of a mile?

ANSWER: 10560

BONUS

16) Math - *Short Answer* How many ways are there to split 6 socks into 3 pairs of socks?

ANSWER: 15

TOSS-UP

17) Earth and Space - *Multiple Choice* Which of the following best describes how a spit is created?

W) Sediment deposition between an island and a coast
X) Sediment deposition at the mouth of a river
Y) Sediment transport horizontally along a beach
Z) Erosion of rock at a coastal headland

ANSWER: Y) Sediment transport horizontally along a beach

BONUS

17) Earth and Space - *Short Answer* Karst topography forms when acidic rain-water dissolves the bedrock in a region. This dissolution is primarily caused by what acid, which is produced naturally by reactions between water droplets and the atmosphere?

ANSWER: Carbonic acid

TOSS-UP

18) Energy - *Short Answer* Scientists at the Center for Turbulence Research at Stanford are using supercomputers to simulate high-turbulence flow. This type of flow has a high value for what dimensionless quantity, which is commonly used to identify how turbulent or laminar fluid flow is?

ANSWER: Reynolds number

BONUS

18) Energy - *Short Answer* Researchers at the Precourt Institute for Energy at Stanford recently developed a type of insulating paint that reduces heat loss and increases energy efficiency. This paint works by reflecting light in what region of the electromagnetic spectrum?

ANSWER: Infrared (ACCEPT: Far infrared, longwave infrared)

TOSS-UP

19) Math - *Short Answer* Two different vertices of a regular polygon are randomly chosen and a line is drawn between them. If the probability that this line is a diagonal is $\frac{4}{5}$, how many sides does the polygon have?

ANSWER: 11

BONUS

19) Math - *Short Answer* Derek rolls four standard six-sided dice. What is the probability they roll four distinct numbers?

ANSWER: $\frac{5}{18}$

TOSS-UP

20) Chemistry - *Multiple Choice* Which of the following best describes a Lewis base?

W) Proton donor
X) Proton acceptor
Y) Electron pair donor
Z) Electron pair acceptor

ANSWER: Y) Electron pair donor

BONUS

20) Chemistry - *Multiple Choice* For a reaction A yields B + C, the rate law is experimentally determined to be $Rate = k[A]^2$ **[rate equals k times the concentration of A squared]**. If the reaction occurs in a closed container, what happens to the half-life of the concentration of A as the reaction proceeds?

W) Increases
X) Decreases
Y) Oscillates
Z) Remains constant

ANSWER: W) Increases

TOSS-UP

21) Physics - *Short Answer* An ideal spherical blackbody of radius R and temperature T emits radiation of power P. In terms of P, what is the power radiated by another ideal spherical blackbody of radius $4R$ and temperature $\frac{T}{2}$?

ANSWER: P

BONUS

21) Physics - *Short Answer* A 10-meter long copper wire of resistivity 1.72×10^{-8} ohm-meters has cross-sectional area of 0.43 square centimeters. In ohms to one significant figure and in scientific notation, what is the resistance of the wire?

ANSWER: 4×10^{-3}

TOSS-UP

22) Biology - *Multiple Choice* Which of the following scenarios would not be possible for a disease with an X-linked recessive inheritance?

W) Affected mother and normal father producing an affected son
X) Affected mother and normal father producing an affected daughter
Y) Normal mother and affected father producing an affected son
Z) Normal mother and affected father producing an affected daughter

ANSWER: X) Affected mother and normal father producing an affected daughter

BONUS

22) Biology - *Short Answer* In a population of 1,000 rabbits, the brown phenotype is dominant. Brown rabbits have the genotype big B big B or big B small B, while white rabbits have the genotype small B small B. If the frequency of the big B big B genotype is 0.64, how many rabbits in the population are heterozygous?

ANSWER: 320

TOSS-UP

23) Earth and Space - *Multiple Choice* The James Webb Space Telescope is designed to conduct observations in which of the following ranges of the electromagnetic spectrum?

W) Radio
X) Infrared
Y) Ultraviolet
Z) X-ray

ANSWER: X) Infrared

BONUS

23) Earth and Space - *Short Answer* A planet is defined to have an induced magnetic field if interactions with solar wind are the primary driving force for magnetism. Identify all of the following three planets that have an induced magnetic field: 1) Mercury; 2) Venus; 3) Earth.

ANSWER: 2 only