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## **TOSS-UP**

1) Earth and Space - *Multiple Choice* Which of the following igneous rocks is likely the least resistant to weathering?

- W) Diorite
- X) Gabbro
- Y) Komatiite
- Z) Rhyolite

ANSWER: Y) KOMATIITE

## **BONUS**

1) Earth and Space - *Short Answer* What process allows ice formation at sites like polynyas to increase the salinity of water, creating deep water?

ANSWER: BRINE REJECTION

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## **TOSS-UP**

2) Biology - *Multiple Choice* Which of the following is closest to the average size of an animal cell?

- W) 5 nanometers
- X) 500 nanometers
- Y) 5 micrometers
- Z) 500 micrometers

ANSWER: Y) 5 MICROMETERS

## **BONUS**

2) Biology - *Short Answer* Which face of the Golgi apparatus creates vesicles which travel to other sites?

ANSWER: TRANS FACE

## TOSS-UP

3) Energy - *Short Answer* Scientists at Pacific Northwest National Lab have developed a method for creating self-assembling multimeric proteins. What level of protein structure are they trying to create?

ANSWER: QUATERNARY

## BONUS

3) Energy - *Multiple Choice* Researchers at the Advanced Photon Source are using X-rays to illuminate the structure of SARS-CoV-2 proteins to better understand how antibodies bind to them. Which of the following types of antibodies would this be most useful for?

- W) IgA
- X) IgD
- Y) IgE
- Z) IgG

ANSWER: Z) IGG

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## TOSS-UP

4) Chemistry - *Multiple Choice* In the reaction  $2NO + O_2 \rightarrow 2NO_2$ , doubling the amount of  $NO$  quadruples the reaction rate and doubling the amount of  $O_2$  doubles the reaction rate. Which of the following would be the units of this reaction's rate constant?

- W)  $\frac{L}{s}$
- X)  $L/mol \cdot s$
- Y)  $L^2/mol^2 \cdot s$
- Z)  $L^3/mol^3 \cdot s$

ANSWER: Z)  $L^3/MOL^3 \cdot S$

## BONUS

4) Chemistry - *Multiple Choice* Combustion occurs in a container containing 500 g of ethane and 500 g of oxygen gas. Which of the following is closest to the mass of ethane left over, in grams, after all the oxygen is used up?

- W) 167
- X) 250
- Y) 357
- Z) 366

ANSWER: Z) 366

## TOSS-UP

5) Physics - *Multiple Choice* A white dwarf grows from 1 to 1.4 solar masses, causing its radius to increase by a factor of about 1.1. If its original angular velocity is  $\omega$ , which of the following is closest to its new angular velocity?

- W)  $0.9\omega$
- X)  $0.8\omega$
- Y)  $0.6\omega$
- Z)  $0.5\omega$

 ANSWER: Y)  $0.6\omega$

## BONUS

5) Physics - *Short Answer* A machine accelerates a 150 g baseball from rest by applying a varying force, starting at 30 N and lowering it to 0 N over the course of 1 second. In meters, how far does the ball travel during this time period?

ANSWER: 200/3

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## TOSS-UP

6) Math - *Multiple Choice* Which of the following numbers is not a multiple of 7?

- W) 6112
- X) 8204
- Y) 22981
- Z) 40481

ANSWER: Y) 6112

## BONUS

6) Math - *Short Answer* Assuming that September 17th in a particular year falls on a Tuesday, what day of the week would February 12th be in the next year?

ANSWER: WEDNESDAY

## **TOSS-UP**

7) Earth and Space - *Multiple Choice* An astronomer observes a star that appears to vary in brightness when observed on different days. At which of the following locations on the H-R diagram could this star likely be found?

- W) Asymptotic giant branch
- X) Red giant branch
- Y) Main sequence
- Z) Instability strip

ANSWER: Z) INSTABILITY STRIP

## **BONUS**

7) Earth and Space - *Multiple Choice* Which of the following gases is least common in Venus's atmosphere?

- W) Sulfur dioxide
- X) Oxygen
- Y) Carbon dioxide
- Z) Water vapor

ANSWER: X) OXYGEN

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## **TOSS-UP**

8) Biology - *Short Answer* What is the name of an instrument used to measure the ability of pigments to absorb given wavelengths of light?

ANSWER: SPECTROPHOTOMETER

## **BONUS**

8) Biology - *Short Answer* In which organ are cells that reactivate Barr-body chromosomes?

ANSWER: OVARIES

## **TOSS-UP**

9) Energy - *Short Answer* Researchers in the MicroBooNE experiment at Fermi National Accelerator Lab recently tried and failed to detect what theoretical particle, which is thought to interact with matter only via gravity?

ANSWER: STERILE NEUTRINO

## **BONUS**

9) Energy - *Short Answer* Researchers at Brookhaven National Lab are studying the effects of aerosols like sulfur dioxide on clouds. A major natural source of this gas is the oxidation of what compound released by algae, which can also be oxidized to produce DMSO?

ANSWER: DIMETHYL SULFIDE (ACCEPT: DMS)

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## **TOSS-UP**

10) Chemistry - *Short Answer* Two molecules of oxygen gas exhibit an intermolecular force with potential energy E. If the distance between these molecules is halved, then in terms of E, what is the new potential energy of their interaction?

ANSWER: 64E

## **BONUS**

10) Chemistry - *Multiple Choice* Which of the following types of bonds is not found in formaldehyde?

- W) C-H sigma bond
- X) C-H pi bond
- Y) C-O sigma bond
- Z) C-O pi bond

ANSWER: X) C-H PI BOND

## **TOSS-UP**

11) Physics - *Short Answer* An air parcel containing one mole of oxygen is brought to a height of 12 km, where the atmospheric pressure is about 20% that of sea level. To three significant digits, how much volume in liters will this air parcel take up?

ANSWER: 112

## **BONUS**

11) Physics - *Short Answer* A certain capacitor has square plates with side lengths 6 cm that are a distance of 6 mm away from each other. A second capacitor is placed in series with the first that has the same plates, but they are twice as far from each other as in the first capacitor. In farads, what is the total capacitance of this circuit?

ANSWER: 0.2

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## **TOSS-UP**

12) Math - *Short Answer* What is the sum of the zeroes of the inverse of the following function:  $\sqrt{0.5(x+8)} + 1$

ANSWER: 3

## **BONUS**

12) Math - *Short Answer* Find the derivative with respect to x of the product of the two polynomials  $3x^2 + 7$  and  $x^2 + 3x - 1$

ANSWER:  $12X^3 + 27X^2 + 8X + 21$

## **TOSS-UP**

13) Earth and Space - *Short Answer* What specific type of earthquake waves generally does the most damage due to its rolling motion?

ANSWER: RAYLEIGH

## **BONUS**

13) Earth and Space - *Short Answer* Wolf-Rayet stars are very large, bright stars that have blown away most of their outer layers. These stars can be identified through spectroscopy because they lack spectral lines of what element?

ANSWER: HYDROGEN

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## **TOSS-UP**

14) Biology - *Short Answer* During which phase of mitosis do nonkinetochore microtubules lengthen?

ANSWER: ANAPHASE

## **BONUS**

14) Biology - *Multiple Choice* Which of the following intermediates within the citric acid cycle contains the most carbon atoms?

- W) Citrate
- X) Succinate
- Y) Malate
- Z) Oxaloacetate

ANSWER: W) CITRATE

## **TOSS-UP**

15) Energy - *Short Answer* Scientists at the National Ignition Facility recently recreated the spontaneous generation of a magnetic field that occurs in astronomical bodies, which is then maintained via what effect?

ANSWER: DYNAMO EFFECT

## **BONUS**

15) Energy - *Multiple Choice* Researchers at Pacific Northwest National Lab are studying the role of the Sonic hedgehog protein in the branching of alveoli in the lungs. This branching is important because it increases the surface area of which of the following types of epithelial tissue?

- W) Simple squamous
- X) Simple cuboidal
- Y) Stratified squamous
- Z) Stratified cuboidal

ANSWER: W) SIMPLE SQUAMOUS

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## **TOSS-UP**

16) Chemistry - *Multiple Choice* In the reaction  $N_2 + 3H_2 \rightarrow 2NH_3$ ,  $\Delta H = -92$  kJ/mol. Assuming all other properties remain the same, which of the following changes would shift equilibrium towards the products?

- W) Decreasing pressure
- X) Removing heat
- Y) Adding helium to the container
- Z) Increasing volume

ANSWER: X) REMOVING HEAT

## **BONUS**

16) Chemistry - *Short Answer* TNT is an abbreviation for the compound 2,4,6-trinitrotoluene. What is the chemical formula of this compound?

ANSWER:  $C_7H_5N_3O_6$

## TOSS-UP

17) Physics - *Short Answer* A 1 kg ball moving at 10 m/s hits a 2 kg ball of the same size and stops completely. If momentum is conserved, how much energy, in joules, is lost during the collision?

ANSWER: 50

## BONUS

17) Physics - *Multiple Choice* In the book Ender's Game, a character perceives a 40-year journey in a spaceship as about 2 years long. Which of the following is closest to the speed they were traveling in terms of  $c$ , the speed of light?

- W) 0.95c
- X) 0.975c
- Y) 0.99c
- Z) 0.999c

ANSWER: Z) 0.999C

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## TOSS-UP

18) Math - *Multiple Choice* If  $x$  is equal to 16, solve the following expression for  $y$ :  $8\log(0.5y) = \sqrt{x}$

ANSWER: Y = 210

## BONUS

18) Math - *Short Answer* A certain cancer has a 1% prevalence within the population. A test for this cancer returns results with 70% sensitivity and 90% specificity. A random person tests positive. To two significant figures, what is the percent probability they have the disease?

ANSWER: 6.6%

## TOSS-UP

19) Earth and Space - *Short Answer* What phenomenon explains why the edge of the sun appears darker and slightly redder than its center?

 ANSWER: LIMB DARKENING

## BONUS

19) Earth and Space - *Multiple Choice* Which of the following general cloud types typically accompanies sun dogs?

- W) Cirrus
- X) Cumulus
- Y) Stratus
- Z) Nimbus

ANSWER: W) CIRRUS

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## TOSS-UP

20) Biology - *Multiple Choice* Which of the following "checkpoints" in the cell cycle is generally the most important for animal cells?

- W) G1 checkpoint
- X) G2 checkpoint
- Y) S checkpoint
- Z) M checkpoint

ANSWER: W) G1 CHECKPOINT

## BONUS

20) Biology - *Short Answer* What is the scientific name of the clade of animals which have "true tissues"?

ANSWER: EUMETAZOA

## **TOSS-UP**

21) Chemistry - *Short Answer* Order the following 3 functional groups from most to least electrophilic: 1) Amide; 2) Carboxylate; 3) Ketone

ANSWER: 3, 1, 2

## **BONUS**

21) Chemistry - *Short Answer* What are the coordination number and ligand denticity, respectively, of the ferri-cyanide anion  $[Fe(CN)_6]^{3-}$ ?

ANSWER: 6 AND 1

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## **TOSS-UP**

22) Physics - *Multiple Choice* You hold the end of a 1 meter rod pointing downward at an angle of 45 degrees. If the rod weighs 3.5 kg, which of the following is closest to the torque in newton-meters your hand must produce to keep the rod in place?

- W) 12.5
- X) 17.5
- Y) 25
- Z) 35

ANSWER: W) 12.5

## **BONUS**

22) Physics - *Short Answer* What particle is proposed as a building block of cold dark matter and, if real, would resolve the charge-parity problem within quantum chromodynamics?

ANSWER: AXION

## **TOSS-UP**

23) Math - *Multiple Choice* A ball bounces  $\frac{2}{3}$  of the distance between its peak and the ground each time it bounces. If it begins at a height of 10000 meters above the ground, which of the following is closest to its maximum distance above the ground in terms of  $r$  after 5 bounces?

- W) 1100 meters
- X) 1200 meters
- Y) 1300 meters
- Z) 1400 meters

ANSWER: Y) 1300 METERS

## **BONUS**

23) Math - *Short Answer* A semicircle with a radius  $r$  has chord CD parallel to diameter AB. If the length of CD is  $\frac{2}{3}$  the length of AB, what is the distance between CD and AB in terms of  $r$ ?

ANSWER:  $\frac{r\sqrt{5}}{3}$