TOSS-UP

1) EARTH AND SPACE – *Multiple Choice* S0 ***[S-Zero]*** designates which of the following types of galaxies?

W) Spiral
X) Lenticular
Y) Irregular
Z) Elliptical

ANSWER: X) LENTICULAR

BONUS

1) EARTH AND SPACE – *Short Answer* The ancient Farallon plate split into what three plates when it partially subducted under the North American plate?

ANSWER: JUAN DE FUCA, COCOS, AND NAZCA

TOSS-UP

2) CHEMISTRY – *Short Answer* What is the angular momentum of an electron in a 4s orbital?

ANSWER: 0

BONUS

2) CHEMISTRY – *Multiple Choice* Which of the following is the most stable conformation for trans 1-chloro-3-tert butyl cyclohexane?

W) Chlorine equatorial, tert-butyl equatorial
X) Chlorine equatorial, tert-butyl axial
Y) Chlorine axial, tert-butyl equatorial
Z) Chlorine axial, tert-butyl axial

ANSWER: Y) CHLORINE AXIAL, TERT-BUTYL EQUATORIAL

TOSS-UP

3) ENERGY – *Short Answer* Researchers at Lawrence Berkeley National Laboratory are trying to find new oxide materials to replace silicon in computer chips. The researchers are trying to increase the packing efficiency of what semiconductor based circuit component?

ANSWER: TRANSISTORS

BONUS

3) ENERGY – *Multiple Choice* Scientists at the Pacific Northwest National Laboratory are currently studying the effects of ocean currents on nutrient levels along coast lines. Which of the following best explains why downwelling increases along the Oregon coast during the winter?

W) Northerly winds strengthen, leading to increased movement of water onshore
X) Southerly winds strengthen, leading to increased movement of water onshore
Y) Northerly winds weaken, leading to increased movement of water offshore
Z) Southerly winds weaken, leading to increased movement of water offshore

ANSWER: X) SOUTHERN WINDS STRENGTHEN, LEADING TO INCREASED MOVEMENT OF WATER ONSHORE

TOSS-UP

4) PHYSICS – *Short Answer* What is the ratio of the work done when accelerating a mass from 1 m/s to 3 m/s to the work done when accelerating it from 3 m/s to 5 m/s?

ANSWER: 1:2

BONUS

4) PHYSICS – *Short Answer* A pipe filled with water decreases in elevation by 10 meters, but does not change in the velocity of water in the pipe. If the initial pressure inside the pipe is 3 times 10^5 pascals, what is the pressure of the pipe at the decreased elevation in pascals? The density of water is 1000 kilograms per cubic meter and g equals 10 meters per second squared.

ANSWER: $4*10^5$

TOSS-UP

5) MATH – *Short Answer* A rectangle has dimensions of 6 by 12. What is the area of the largest triangle that can be entirely contained within the rectangle?

ANSWER: 36

BONUS

5) MATH – *Short Answer* How many real numbers must be selected on the open interval from 0 to 5 to guarantee that a pair of them differ by less than 1?

ANSWER: 6

TOSS-UP

6) BIOLOGY – *Short Answer* During neurulation, what group of cells bordering where the neural tube pinches off from the ectoderm migrate off to form teeth, cranial bones, and peripheral nerves?

ANSWER: NEURAL CREST

BONUS

6) BIOLOGY – *Multiple Choice* Which of the following groups of animals is not a lepidosaur ***[lep-E-do-saur]***?

W) Tuataras
X) Lizards
Y) Snakes
Z) Crocodilians

ANSWER: Z) CROCODILIANS

TOSS-UP

7) EARTH AND SPACE – *Multiple Choice* Which of the following types of magma flow would most likely be present at a mid-ocean ridge?

W) Aa flow ***[Ah-Ah]***
X) Pahoehoe flow ***[Pa-hoy-hoy]***
Y) Block flow
Z) Pillow flow

Answer: Z) PILLOW FLOW

BONUS

7) EARTH AND SPACE – *Short Answer* By name or number, identify all the following three geological features that are caused by normal faults: 1) Scarps; 2) Horsts; 3) Hogbacks

Answer: 1 AND 2 (ACCEPT: SCARPS AND HORSTS)

TOSS-UP

8) CHEMISTRY – *Short Answer* For a first order reaction, if the half life is 1 second, what is the rate constant of the reaction to 1 significant figure and in inverse seconds?

ANSWER: 0.7

BONUS

8) CHEMISTRY – *Short Answer* Identify all of the following three statements that are true about diboron: 1) It is diamagnetic; 2) It has a bond order of 1; 3) The highest filled orbital is a σ_{2p} ***[sigma 2p]*** orbital

ANSWER: 2 ONLY

TOSS-UP

9) ENERGY – *Short Answer* Scientists at Lawrence Berkeley National Laboratory are using x-ray crystallography to image the molecular structure of Ddn, a tuberculosis bacterium enzyme. One of the reasons why tuberculosis is so deadly is that it blocks the fusion of phagosomes and lysosomes within macrophages from fusing into what structure?

ANSWER: PHAGOLYSOSOME

BONUS

9) ENERGY – *Multiple Choice* Scientists at the National Renewable Energy Lab are leading efforts to commercialize perovskite solar cells. Which of the following is NOT one of the most important qualities in commercial solar cells?

W) Low toxicity
X) Low cost
Y) High efficiency

Z) High stability

ANSWER: W) LOW TOXICITY

TOSS-UP

10) PHYSICS – *Short Answer* A ball is dropped from a tall building and falls d meters in the first 3 seconds of free fall. In terms of d, how many meters will the ball fall in the next 6 seconds?

ANSWER: 8*d*

BONUS

10) PHYSICS – *Short Answer* Identify all of the following three types of magnetism which would display negative magnetic susceptibility: 1) Ferromagnetism; 2) Paramagnetism; 3) Diamagnetism.

ANSWER: 3 ONLY

TOSS-UP

11) MATH – *Multiple Choice* A sample of 200 voters are surveyed to estimate the proportion voting for a certain candidate in the upcoming election. If the polling company wishes to cut the margin of error of their estimated proportion in half in a second poll, how many voters should the company aim to sample?

W) 50
X) 100
Y) 400
Z) 800

ANSWER: Z) 800

BONUS

11) MATH – *Short Answer* For what value of k is the polynomial $x^4 - kx^2 - 2x - 1$ evenly divisible by $x + 1$?

ANSWER: 2

TOSS-UP

12) BIOLOGY – *Multiple Choice* Which of the following quantities are the two main determinants of island species diversity according to the island equilibrium model?

W) Island succession level and disturbance level
X) Island climate and topography
Y) Island size and distance from the mainland
Z) Island net primary productivity and number of realized niches

ANSWER: Y) ISLAND SIZE AND DISTANCE FROM THE MAINLAND

BONUS

12) BIOLOGY – *Short Answer* During protein folding, the hydrophobic core forms to minimize the size of the solvation shell. What thermodynamic quantity is maximized by this process?

ANSWER: ENTROPY

TOSS-UP

13) EARTH AND SPACE – *Multiple Choice* Which of the following planets has a retrograde rotation?

W) Mercury
X) Mars
Y) Uranus
Z) Neptune

ANSWER: Y) URANUS

BONUS

13) EARTH AND SPACE – *Short Answer* What is the zig-zag transport of beach sediment due to angled wave-refracted swash and backwash called?

ANSWER: BEACH DRIFT (DO NOT ACCEPT: LONGSHORE DRIFT)

TOSS-UP

14) CHEMISTRY – *Multiple Choice* Which of the following acids has the lowest pKa [***p-k-a***]?

W) Acetic acid
X) Fluoroacetic acid
Y) Chloroacetic acid
Z) Bromoacetic acid

ANSWER: X) FLUOROACETIC ACID

BONUS

14) CHEMISTRY – *Short Answer* What stabilizing effect explains the increased stability of more substituted alkenes by accounting for the donation of electron density from alkyl groups to the alkene pi star orbital?

ANSWER: HYPERCONJUGATION

TOSS-UP

15) ENERGY – *Short Answer* Scientists at Lawrence Berkeley National Laboratory are using computers to model the interactions among river water and groundwater. One part they are trying to model is the vadose ***[VAY-dose]*** and phreatic zone. What is the boundary between the vadose and phreatic zone called?

ANSWER: WATER TABLE

BONUS

15) ENERGY – *Short Answer* Researchers at Ames National Laboratory have been studying the effects of cholinesterase on histidine negative Salmonella mutants to discover the carcinogenicity of cholinesterase. To perform this, they used which namesake test to detect mutations in the Salmonella mutants?

ANSWER: AMES TEST

TOSS-UP

16) PHYSICS – *Multiple Choice* Identify all of the following three dopants that can be used for silicon to create an n type semiconductor: 1) Germanium; 2) Gallium; 3) Arsenic.

ANSWER: 3 ONLY

BONUS

16) PHYSICS – *Multiple Choice* The hydrogen 21 cm line arises from a change in what quantum number of an electron?

W) Principal quantum number
X) Orbital quantum number
Y) Magnetic quantum number
Z) Spin quantum number

ANSWER: Z) SPIN QUANTUM NUMBER

TOSS-UP

17) MATH – *Short Answer* Determine the number of factors of 2020^2 that are multiples of 2020.

ANSWER: 12

BONUS

17) MATH – *Short Answer* Three sides of a quadrilateral have lengths 1, 5, and 7. How many possible integer lengths are there for the fourth side?

ANSWER: 11

TOSS-UP

18) BIOLOGY – *Multiple Choice* Which of the following is a characteristic of deuterostomes?

W) Indeterminate cleavage
X) Blastopore forms mouth
Y) Spiral cleavage
Z) Radial symmetry

ANSWER: W) INDETERMINATE CLEAVAGE

BONUS

18) BIOLOGY – *Short Answer* Which lobe of the brain is responsible for somatosensory processing?

ANSWER: PARIETAL

TOSS-UP

19) EARTH AND SPACE – *Short Answer* What is the area from 104 to 140 degrees from an earthquake that receives little to no P-waves called?

ANSWER: P-WAVE SHADOW ZONE (ACCEPT: SHADOW ZONE)

BONUS

19) EARTH AND SPACE – *Short Answer* During what geologic period did angiosperms first appear and proceed to dominate the floral landscape?

ANSWER: CRETACEOUS

TOSS-UP

20) CHEMISTRY – *Short Answer* Identify all of the following three phases of matter that have an activity of 1: 1) Solid; 2) Liquid; 3) Gas.

ANSWER: 1 AND 2

BONUS

20) CHEMISTRY – *Short Answer* Identify all of the following three statements that are true about iodometric titrations: 1) They are an example of a redox titration; 2) Thiosulfate can be employed to reduce triiodide to iodide; 3) Silver ions are used to form a yellow precipitate that determines the endpoint.

ANSWER: 1 AND 2

TOSS-UP

21) ENERGY – *Multiple Choice* Scientists at Los Alamos National Laboratory are studying the use of aerogels for space missions. Aerogels are gels in which the liquid component for the gel has been replaced with a gas. Which of the following is NOT true about aerogels?

W) They are desiccants
X) They have high surface area

Y) They are good thermal insulators
Z) They are hydrophobic

ANSWER: Z) THEY ARE HYDROPHOBIC

BONUS

21) ENERGY – *Short Answer* Scientists at Brookhaven National Laboratory are using 2D silicate frameworks to trap noble gases. These porous sheets can assemble to form 3D silicate nanocages, such as what group of microporous aluminosilicate minerals?

ANSWER: ZEOLITES

TOSS-UP

22) PHYSICS – *Short Answer* A pipe closed at one end and open at the other end has a fundamental frequency of 50 Hz. Identify all of the following three frequencies at which the pipe resonates: 1) 100 Hz; 2) 150 Hz; 3) 200 Hz

ANSWER: 2 ONLY

BONUS

22) PHYSICS – *Multiple Choice* A monatomic ideal gas is expanded adiabatically such that its pressure decreases by a factor of 2. Which of the following describes the change in temperature of the gas?

W) Decreases by a factor of between 1 and 2
X) Decreases by a factor of greater than 2
Y) Increases by a factor of between 1 and 2
Z) Increases by a factor of greater than 2

ANSWER: W) DECREASES BY A FACTOR OF BETWEEN 1 AND 2

TOSS-UP

23) MATH – *Short Answer* Determine the product of the complex numbers $1 - i$ and $2 + 2i$.

ANSWER: 4

BONUS

23) MATH – *Short Answer* Evaluate $\int_{-1}^{0} x\sqrt{x+1}\,dx$ ***[the integral from -1 to 0 of x times the square root of the quantity x plus 1, dx]***.

ANSWER: –4/15

TOSS-UP

24) BIOLOGY – *Multiple Choice* Which of the following diseases occurs when antibodies bind to receptors for TSH, perpetually activating them, leading to excessive hunger, heat sensitivity, and tachycardia?

W) Graves' disease
X) Hashimoto's disease
Y) Addison's disease
Z) Cushing's disease

ANSWER: W) GRAVES' DISEASE

BONUS

24) BIOLOGY – *Short Answer* During DNA replication in *E. coli*, what group of proteins is responsible for maintaining the separation between the two strands after helicase cleaves the helix?

ANSWER: SINGLE STRAND BINDING PROTEINS (ACCEPT: SSBP)

TOSS-UP

25) EARTH AND SPACE – *Multiple Choice* Which of the following ores is correctly paired with its respective metal?

W) Galena, germanium
X) Sphalerite, titanium
Y) Cinnabar, mercury
Z) Chalcopyrite, iron

ANSWER: Y) CINNABAR, MERCURY

BONUS

25) EARTH AND SPACE – *Short Answer* What nearly vertical portion of the HR diagram contains different groups of variable stars as they move rightward and leftward on the diagram?

ANSWER: INSTABILITY STRIP