

High School
Set 7

TOSS-UP

1) Earth and Space – *Multiple Choice* Which layer of the Sun is thickest?

- W) Photosphere
- X) Convection zone
- Y) Core
- Z) Radiation zone

ANSWER: Z) RADIATION ZONE

BONUS

1) Earth and Space – *Short Answer* Identify all of the following three planets that can be at quadrature relative to Earth: 1) Mars; 2) Jupiter; 3) Saturn.

ANSWER: ALL

TOSS-UP

2) Energy – *Multiple Choice* Scientists at Oak Ridge National Lab are developing methods to deuterate [**DOO-tur-ate**] benzene. One of their reactions adds four deuterium [**doo-TEER-ee-um**] atoms to benzene, resulting in what molecule?

- W) Hexane
- X) Cyclohexane [**sigh-kloh-HEX-ane**]
- Y) Cyclohexene [**sigh-kloh-HEX-een**]
- Z) Cyclohexa-1,3-diene [**sigh-kloh-hexa-one-three-DYE-een**]

ANSWER: Y) CYCLOHEXENE

BONUS

2) Energy – *Multiple Choice* Scientists supported by the Department of Energy are studying penicillin-binding proteins. These proteins are what class of enzyme?

- W) Glycosidase [**glye-koh-SIGH-dase**]
- X) Transpeptidase [**trans-PEP-tih-dase**]
- Y) Reductase [**ree-DUCK-tase**]
- Z) Peroxidase

ANSWER: X) TRANSPEPTIDASE

TOSS-UP

3) Math – *Short Answer* The altitude to the hypotenuse of a right triangle divides the hypotenuse into segments of length 7 and 8. What is the length of the altitude?

ANSWER: $2\sqrt{14}$

BONUS

3) Math – *Short Answer* How many zeroes occur at the right of the number of permutations of 90 objects taken 40 at a time?

ANSWER: 9

TOSS-UP

4) Physics – *Short Answer* A particle has a position function given by x of t equals 1 over t squared. What is the particle's instantaneous speed at $t = 2$?

ANSWER: ONE-FOURTH (ACCEPT: 0.25)

BONUS

4) Physics – *Multiple Choice* A dam is holding back a lake that has a water level of 80 meters. A large crack forms at the base of the dam. In meters per second, which of the following is closest to the water speed through the crack?

- W) 60
- X) 40
- Y) 30
- Z) 10

ANSWER: X) 40

TOSS-UP

5) Biology – *Short Answer* The dikaryon is a result of the fusion of two cells without the fusion of their nuclei. This feature is unique to what kingdom of life?

ANSWER: FUNGI (ACCEPT: FUNGUS)

BONUS

5) Biology – *Multiple Choice* The antiviral drug remdesivir [*rem-DES-ih-veer*] is metabolized within cells into a nucleotide analog that inhibits RNA-dependent RNA polymerases [*pah-LIM-er-aces*]. Which of the following viruses would be LEAST likely to be susceptible to remdesivir?

- W) Poliovirus
- X) Ebola virus
- Y) Influenza virus
- Z) Human immunodeficiency virus

ANSWER: Z) HUMAN IMMUNODEFICIENCY VIRUS

TOSS-UP

6) Chemistry – *Short Answer* The half-reaction for substance A is a five-electron reduction with a standard cell potential of +1.5 volts, while the half-reaction for substance B is a two-electron reduction with a standard cell potential of +1.6 volts. In volts, what would be the electrode potential of a galvanic cell containing these two substances?

ANSWER: 0.1 (ACCEPT: 1/10)

BONUS

6) Chemistry – *Short Answer* Rank the following three molecules in terms of increasing volatility: 1) Butanoic *[byoo-tan-OH-ik]* acid; 2) Butanal *[byoo-ta-NAL]*; 3) Butane.

ANSWER: 1, 2, 3

TOSS-UP

7) Earth and Space – *Short Answer* For a seismometer placed 100 miles from the focus of an earthquake, place the following three wave types in chronological order of their detection: 1) Surface waves; 2) P waves; 3) S waves.

ANSWER: 2, 3, 1

BONUS

7) Earth and Space – *Short Answer* Identify all of the following three changes that occur as a result of El Niño: 1) Trade winds slacken; 2) Western Pacific upwelling declines; 3) The tropical Pacific Ocean cools.

ANSWER: 1, 2



TOSS-UP

8) Energy – *Short Answer* Materials researchers at Los Alamos National Lab have developed a new method for making quantum dots for solar cells without using toxic metals. What toxic, group 12 metal, bonded to sulfur or selenium, is commonly used in most commercially-made quantum dots today?

ANSWER: CADMIUM (ACCEPT: Cd)

BONUS

8) Energy – *Short Answer* Scientists at Pacific Northwest National Lab are studying point defects in crystal structures that resemble adamantane [*ad-ah-MAN-tayn*]. What material is this crystal structure named after?

ANSWER: DIAMOND CUBIC (ACCEPT: DIAMOND)

TOSS-UP

9) Math – *Short Answer* Counting itself, what is the 4th-largest integer factor of 1600?

ANSWER: 320

BONUS

9) Math – *Short Answer* What is the y -coordinate of the y -intercept of the line tangent to the circle $x^2 + y^2 = 25$ at the point $(4, 3)$?

ANSWER: $25/3$ (ACCEPT: $8 \frac{1}{3}$)

TOSS-UP

10) Physics – *Short Answer* A planet is orbiting its star in a circular orbit with an orbital speed of 10 kilometers per second. To the nearest kilometer per second, what is the escape velocity from the star at the radius of the planet's orbit?

ANSWER: 14

BONUS

10) Physics – *Short Answer* Linda has a container of gas at 400 kelvins, which has 20 kilo-joules of thermal energy. If she has access to a reservoir that is maintained at 100 kelvins, then in kilo-joules, what is the maximum amount of work she can extract from the gas?

ANSWER: 15



TOSS-UP

11) Biology – *Multiple Choice* Melissa synthesizes a DNA plasmid in which expression of green fluorescent protein is under the *lac [lack]* promoter and *lacI [lack-EYE]* is upstream of the promoter. Which of the following small molecules can she add to bacteria expressing this plasmid to induce expression of green fluorescent protein?

- W) Cyclic AMP
- X) CAP
- Y) Allolactose
- Z) X-gal

ANSWER: Y) ALLOLACTOSE

BONUS

11) Biology – *Short Answer* Nitrification by soil bacteria results in the oxidation of ammonia. What ion is the final product of this process?

ANSWER: NITRATE (ACCEPT: NO_3^-)

TOSS-UP

12) Chemistry – *Short Answer* What IUPAC [*EYE-you-pack*] stem indicates that a molecule has four carbons?

ANSWER: BUT (ACCEPT: BUT-)

BONUS

12) Chemistry – *Short Answer* When cobalt (III) ions react with ammonia, they form an octahedral coordination compound. What is the chemical formula and charge of this compound?

ANSWER: $[\text{Co}(\text{NH}_3)_6]^{3+}$

TOSS-UP

13) Earth and Space – *Multiple Choice* Triton's retrograde orbit provides the strongest evidence for which of the following hypotheses?

- W) It has a deep subsurface ocean
- X) It generates an intrinsic magnetic field
- Y) It was a captured moon
- Z) It formed from a collision with another planet

ANSWER: Y) IT WAS A CAPTURED MOON

BONUS

13) Earth and Space – *Multiple Choice* Which of the following extends farthest from the Sun?

- W) Oort [*ort*] cloud
- X) Kuiper [*KYE-pur*] belt
- Y) Heliopause
- Z) Termination shock

ANSWER: W) OORT CLOUD

TOSS-UP

14) Energy – *Short Answer* Scientists at Pacific Northwest National Lab are analyzing radar reflectivity measurements of squall line systems. Much of the reflectivity that originates from raindrops is due to what type of scattering, where the scattering particles are much smaller than the wavelength of light?

ANSWER: RAYLEIGH

BONUS

14) Energy – *Short Answer* Scientists at Lawrence Berkeley National Lab are developing materials to detect the presence of anthrax toxin, which is secreted by virulent [*VEER-yoo-lent*] strains of what bacterial genus?

ANSWER: *BACILLUS*

TOSS-UP

15) Math – *Short Answer* According to the rational root theorem, what are the smallest and the largest possible positive rational roots of the equation $6x^3 - 9x^2 - 10 = 0$?

ANSWER: SMALLEST = $1/6$, LARGEST = 10

BONUS

15) Math – *Short Answer* Given 4 distinct buckets and 7 indistinguishable marbles, in how many different distinguishable ways can the marbles be arranged in the buckets?

ANSWER: 120

TOSS-UP

16) Physics – *Multiple Choice* An electron undergoing a transition between energy levels in an atom releases a photon with an energy of 2 electron volts. To what range of the electromagnetic spectrum does this photon belong?

- W) Microwave
- X) Visible
- Y) Ultraviolet
- Z) X-ray

ANSWER: X) VISIBLE

BONUS

16) Physics – *Short Answer* In watts per meter squared, what is the absolute difference in intensity between a 140-decibel sound and a 120-decibel sound?

ANSWER: 99

TOSS-UP

17) Biology – *Multiple Choice* Which of the following forms of selection is most conducive for sympatric speciation?

- W) Stabilizing
- X) Directional
- Y) Disruptive
- Z) Purifying

ANSWER: Y) DISRUPTIVE

BONUS

17) Biology – *Short Answer* Place the following three events that occur during muscle contraction in chronological order: 1) Calcium binds troponin [*TROH-poh-nin*]; 2) Acetylcholine is released; 3) Action potentials propagate down T-tubules.

ANSWER: 2, 3, 1

TOSS-UP

18) Chemistry – *Multiple Choice* Nick has an unknown compound that he has determined to be soluble in water and produces a solution that is not electrically conductive. Which of the following might the compound be?

- W) Sucrose
- X) Sodium chloride
- Y) Silicon dioxide
- Z) Hexane

ANSWER: W) SUCROSE

BONUS

18) Chemistry – *Short Answer* What is the chemical formula of ethanamine [*eth-AN-ah-meen*]?

ANSWER: C_2H_7N (accept formula in any order of elements, including $CH_3CH_2NH_2$ and $C_2H_5NH_2$)