

High School
Set 6

TOSS-UP

1) Chemistry – *Multiple Choice* Which of the following functional groups is created by the addition of an alkyne [*AL-kine*] to Lindlar's catalyst and hydrogen gas?

W) Alkane

X) Cis-alkene [*sis-al-KEEN*]

Y) Trans-alkene

Z) Alkyl [*AL-kul*] halide [*HAY-lide*]

ANSWER: X) CIS-ALKENE

BONUS

1) Chemistry – *Short Answer* Identify all of the following three types of orbitals that can form sigma bonds: 1) 1s; 2) 2s; 3) 2p.

ANSWER: ALL

TOSS-UP

2) Earth and Space – *Multiple Choice* Three hundred-millibar charts are used to visualize the dynamics of jet streams. Lines on these charts correspond to places that are equal in which of the following properties?

- W) Altitude
- X) Air pressure
- Y) Temperature
- Z) Humidity

ANSWER: W) ALTITUDE

BONUS

2) Earth and Space – *Short Answer* Place the following three regions of an unconfined aquifer in order of increasing depth:
1) Zone of saturation; 2) Zone of aeration; 3) Capillary fringe.

ANSWER: 2, 3, 1

TOSS-UP

3) Energy – *Multiple Choice* Researchers at Lawrence Berkeley National Lab are using small angle X-ray scattering to study the structural biology of the protein XPG. XPG repairs DNA damage caused by UV photons. To which of the following DNA motifs would XPG most likely be bound?

- W) CG repeats
- X) DNA double strand breaks
- Y) Adjacent pyrimidines [*pur-RIM-ih-deens*]
- Z) Transcription start sites

ANSWER: Y) ADJACENT PYRIMIDINES

BONUS

3) Energy – *Multiple Choice* Scientists at Argonne National Lab are studying supernova nucleosynthesis. Which of the following elements on Earth primarily originates from supernova nucleosynthesis?

- W) Arsenic
- X) Promethium [*pro-MEE-thee-um*]
- Y) Hydrogen
- Z) Beryllium

ANSWER: W) ARSENIC

TOSS-UP

4) Math – *Short Answer* If k is a positive integer such that the least common multiple of 80 and k is $5k$, what is the greatest common divisor of 80 and k ?

ANSWER: 16

BONUS

4) Math – *Short Answer* A line is represented parametrically by the equations $x = 3t + 5$ and $y = -2t - 7$. What are the slope and the y -intercept of this line?

ANSWER: SLOPE = $-2/3$, y -INTERCEPT = $-11/3$ (ACCEPT: $-3 \frac{2}{3}$ for y -intercept)

TOSS-UP

5) Physics – *Multiple Choice* Gabby has a device capable of pushing objects with an unknown amount of constant force. To determine the magnitude of this force, she makes several measurements by using the device to apply force to objects of varying mass and measuring the resultant acceleration. Which parameters should she choose for her x - and y -axes, respectively, such that the slope of the line of best fit is the force her device applies?

- W) Mass and acceleration
- X) One over mass and acceleration
- Y) Mass and one over acceleration
- Z) One over mass and one over acceleration

ANSWER: X) ONE OVER MASS AND ACCELERATION

BONUS

5) Physics – *Short Answer* Identify all of the following three statements that are true of a skydiver as they approach terminal velocity: 1) Their speed is increasing; 2) Their acceleration magnitude is increasing; 3) The magnitude of the gravitational force on them is decreasing.

ANSWER: 1

TOSS-UP

6) Biology – *Short Answer* Juxtamedullary [*juxta-MED-joo-lair-ee*] and cortical nephrons differ most in the length of what segment of the nephron?

ANSWER: LOOP OF HENLE

BONUS

6) Biology – *Short Answer* Identify all of the following three statements that are true of bacterial chromosomes: 1) They are typically circular; 2) Bacteria only possess one chromosome per cell; 3) They possess telomeres [*TEL-oh-meers*].

ANSWER: 1



TOSS-UP

7) Chemistry – *Short Answer* What is the IUPAC [**EYE-you-pack**] name of the product formed when acetic acid is reacted with lithium aluminum hydride in anhydrous conditions?

ANSWER: ETHANOL

BONUS

7) Chemistry – *Short Answer* Butanone [**BYOO-tah-known**] can be synthesized via the reaction of what molecule with potassium dichromate in the presence of acid?

ANSWER: 2-BUTANOL (ACCEPT: BUTAN-2-OL, 2-BUTYL ALCOHOL, SEC-BUTANOL, SEC-BUTYL ALCOHOL; do not accept: C₄H₁₀O)

TOSS-UP

8) Earth and Space – *Multiple Choice* The universe became transparent to light closest to which of the following temperatures in kelvins?

- W) 300,000
- X) 30,000
- Y) 3,000
- Z) 300

ANSWER: Y) 3,000

BONUS

8) Earth and Space – *Short Answer* Identify all of the following three statements that are true of Callisto *[kah-LIS-toh]*: 1) It is the largest moon of Saturn; 2) It has plate tectonics; 3) It has volcanism.

ANSWER: NONE

TOSS-UP

9) Energy – *Short Answer* Geophysicists at SLAC National Accelerator Lab are studying the core-mantle boundary by imaging liquid silicates under shockwave conditions. What type of seismic body waves cannot cross the core-mantle boundary?

ANSWER: S-WAVES (ACCEPT: SECONDARY WAVES; do not accept: P-WAVES, SHEAR WAVES)

BONUS

9) Energy – *Short Answer* Scientists supported by the Department of Energy are studying a phage ferredoxin [*fair-eh-DOCK-sin*]. What prosthetic group does this protein use for electron transfer?

ANSWER: IRON-SULFUR CLUSTER

TOSS-UP

10) Math – *Short Answer* Find the value of a for which the following vectors are orthogonal: $36\mathbf{i} + 20\mathbf{j}$ and $a\mathbf{i} + 27\mathbf{j}$.

ANSWER: -15

BONUS

10) Math – *Short Answer* What is the units digit of 7 to the 33rd power times 8 to the 55th power?

ANSWER: 4

TOSS-UP

11) Physics – *Multiple Choice* Which of the following describes how the electric potential due to a point charge scales with distance away from the charge?

- W) Linearly
- X) Quadratically
- Y) With the inverse
- Z) With the inverse squared

ANSWER: Y) WITH THE INVERSE

BONUS

11) Physics – *Short Answer* Identify all of the following three properties of an electromagnetic wave that can change when the wave passes from one medium to another: 1) Period; 2) Wavelength; 3) Speed.

ANSWER: 2, 3

TOSS-UP

12) Biology – *Short Answer* Genes can be inserted into plasmids by treating both the gene and the plasmid with a restriction enzyme. The DNA fragments are then mixed and treated with what enzyme to complete the insertion?

ANSWER: DNA LIGASE (ACCEPT: LIGASE)

BONUS

12) Biology – *Short Answer* You are drawing the Punnett square to tally the F₂ generation of a trihybrid cross. How many entries are present within this square?

ANSWER: 64

TOSS-UP

13) Chemistry – *Multiple Choice* M over Z is a measured quantity in which of the following analytical techniques?

- W) Mass spectrometry
- X) Infrared spectroscopy
- Y) NMR spectroscopy
- Z) UV-vis spectroscopy

ANSWER: W) MASS SPECTROMETRY

BONUS

13) Chemistry – *Short Answer* In a typical thin-layer chromatography experiment, what is the stationary phase?

ANSWER: SILICA (ACCEPT: SILICA GEL, ALUMINA)

TOSS-UP

14) Earth and Space – *Short Answer* The prevailing wind is blowing towards the south along the west coast of the United States. In which cardinal direction will the net water movement be?

ANSWER: WEST

BONUS

14) Earth and Space – *Short Answer* Identify all of the following three quantities for which mafic [*MAY-fik*] rocks exceed felsic rocks:
1) Silica content; 2) Specific gravity; 3) Melting temperature.

ANSWER: 2, 3

TOSS-UP

15) Energy – *Short Answer* Pacific Northwest National Lab researchers are studying different processes that can lead to cognitive decline, such as the sclerosis of the region of the brain most associated with learning and memory. What is the term for this C-shaped structure?

ANSWER: HIPPOCAMPUS

BONUS

15) Energy – *Short Answer* Scientists at Brookhaven National Lab are studying a quantum-mechanical phase of matter that is a gas composed of only bosons. What is the term for this type of gas?

ANSWER: BOSE GAS (do not accept: BOSE EINSTEIN CONDENSATE)

TOSS-UP

16) Math – *Short Answer* What is the product of $-\sqrt{7} - 2i$ and its complex conjugate?

ANSWER: 11

BONUS

16) Math – *Short Answer* What is the integral from $x = 2$ to $x = \text{cube root of } 13$ of x^2 times the square root of open parenthesis $x^3 - 4$ close parenthesis dx ?

ANSWER: $38/9$ (ACCEPT: $4 \frac{2}{9}$)

TOSS-UP

17) Physics – *Multiple Choice* If two simple pendulums have the same oscillation [*aw-sih-LAY-shun*] frequency but pendulum A has twice the mass of pendulum B, what is the length of pendulum B?

- W) Half that of pendulum A
- X) The same as pendulum A
- Y) Twice that of pendulum A
- Z) Four times that of pendulum A

ANSWER: X) THE SAME AS PENDULUM A

BONUS

17) Physics – *Short Answer* A boat is sliding down a ramp. The ramp is angled at 30 degrees to the horizontal, and the coefficient of kinetic friction between the boat and the ramp is 0.25. To the nearest meter per second squared, what is the acceleration of the boat down the ramp?

ANSWER: 3

TOSS-UP

18) Biology – *Short Answer* What is the term for the process by which plants grow toward light?

ANSWER: PHOTOTROPISM (ACCEPT: POSITIVE PHOTOTROPISM)

BONUS

18) Biology – *Short Answer* Identify all of the following three proteins that can be found in the extracellular matrix: 1) Elastin; 2) Albumin; 3) Fibronectin.

ANSWER: 1, 3