

## High School Set 3

### TOSS-UP

1) Physics – *Multiple Choice* Which of the following is a direct corollary of the second law of thermodynamics?

- W) Energy cannot be created or destroyed
- X) Real thermodynamic processes are not reversible
- Y) Absolute zero cannot be reached
- Z) Absolute zero is the minimum possible temperature

ANSWER: X) REAL THERMODYNAMIC PROCESSES ARE NOT REVERSIBLE

### BONUS

1) Physics – *Short Answer* Astronaut A is in a circular orbit with an altitude of one Earth radius above the surface of Earth, while Astronaut B is in orbit with an altitude of two Earth radii above the surface of Earth. What is the ratio of the gravitational force from Earth on Astronaut A to that on Astronaut B?

ANSWER: 9/4 (ACCEPT: 9 TO 4, 2.25, 2 1/4)

## TOSS-UP

2) Biology – *Short Answer* In population genetics, what term is used to quantify the ability of an individual to propagate its genes to future generations?

ANSWER: FITNESS

## BONUS

2) Biology – *Multiple Choice* In humans, which of the following blood types would be expected to occur with the highest frequency among the offspring of parents who are both type AB?

- W) A
- X) B
- Y) O
- Z) AB

ANSWER: Z) AB

## TOSS-UP

3) Chemistry – *Short Answer* What is the term for the minimum energy required for a chemical reaction to proceed?

ANSWER: ACTIVATION ENERGY

## BONUS

3) Chemistry – *Short Answer* Identify all of the following three compounds that interact mainly via dipole-dipole forces: 1) Hydrogen sulfide; 2) Fluoro-methane; 3) Carbon tetra-bromide.

ANSWER: 1, 2

## TOSS-UP

4) Earth and Space – *Short answer* Columnar jointing commonly forms as an igneous rock cools and contracts, creating polygon shapes between joints. The most common polygon in columnar joints has how many sides?

ANSWER: SIX

## BONUS

4) Earth and Space – *Short Answer* Identify all of the following three moraine types that form perpendicular to the direction of glacial flow: 1) Lateral moraine [**mah-RAYN**]; 2) End moraine; 3) Medial moraine.

ANSWER: 2

## TOSS-UP

5) Energy – *Multiple Choice* Ames Lab researchers are studying quantum phase transitions in materials where the magnetic moments of each molecule point in the opposite direction as each of their neighbors'. Which of the following terms describes this type of magnetism?

- W) Para-magnetism
- X) Dia-magnetism
- Y) Anti-ferro-magnetism
- Z) Ferro-magnetism

ANSWER: Y) ANTI-FERRO-MAGNETISM

## BONUS

5) Energy – *Short Answer* Oak Ridge National Lab researchers are constructing circuit elements by assembling artificial lipid bilayers in hexadecane. How many hydrogen atoms are in one molecule of hexadecane [*hexa-DEH-cane*]?

ANSWER: 34

## TOSS-UP

- 6) Math – *Short Answer* If angle ABC is inscribed in a circle and measures 35 degrees, what is the degree measure of arc ABC?

ANSWER: 290

## BONUS

- 6) Math – *Short Answer* Solve the following equation for  $x$  over the negative integers:  $x^3 + 7x^2 - 9x - 63 = 0$

ANSWER: -3 AND -7 (must give both answers)

## TOSS-UP

7) Physics – *Short Answer* Consider 1 mole of an ideal gas at STP. If the temperature of this gas were reduced to 0 kelvins, then, in liters, what would its volume become?

ANSWER: 0

## BONUS

7) Physics – *Short Answer* Identify all of the following three properties that are the same for a positron and an electron: 1) Their movement in a uniform electric field; 2) Their movement in a uniform gravitational field; 3) Their behavior upon collision with an electron.

ANSWER: 2

## TOSS-UP

8) Biology – *Short Answer* What type of reproductive isolation is demonstrated by the mule, which is a cross between a horse and a donkey?

ANSWER: HYBRID STERILITY (ACCEPT: STERILITY, do not accept: PRE-ZYGOTIC, POST-ZYGOTIC)

## BONUS

8) Biology – *Multiple Choice* Which of the following statements is TRUE regarding water balance in the mammalian body?

- W) Dehydration increases the osmolality of blood
- X) Vasopressin is produced by the adrenal gland
- Y) Renin inhibits the conversion of angiotensinogen *[an-jee-oh-ten-SIN-oh-jen]* to angiotensin *[an-jee-oh-TEN-sin]* two
- Z) Aldosterone *[al-DOSS-ter-own]* inhibits sodium absorption in the distal tubules

ANSWER: W) DEHYDRATION INCREASES THE OSMOLALITY OF BLOOD

## TOSS-UP

9) Chemistry – *Short Answer* The ionization energy of neon is equivalent to the energy required to move an electron from what subshell to the  $n$  equals infinity energy level?

ANSWER: 2P

## BONUS

9) Chemistry – *Multiple Choice* The dispersity of a polymer would be measured using which of the following techniques?

- W) Gel permeation chromatography
- X) Nuclear magnetic resonance
- Y) Transmission electron microscopy
- Z) X-ray diffraction

ANSWER: W) GEL PERMEATION CHROMATOGRAPHY

## TOSS-UP

10) Earth and Space – *Short Answer* What is the term for a solar eclipse during which, despite perfect alignment, the angular size of the Moon is not large enough to fully cover the Sun?

ANSWER: ANNULAR (ACCEPT: ANNULAR ECLIPSE)

## BONUS

10) Earth and Space – *Short Answer* Identify all of the following three gas giants that are hypothesized to have a layer of liquid metallic hydrogen: 1) Saturn; 2) Uranus; 3) Neptune.

ANSWER: 1

## TOSS-UP

11) Energy – *Short Answer* Oak Ridge National Lab scientists are studying how to bioengineer bacteria with complex immune systems. These systems destroy foreign DNA based on a modification that is also used in genomic imprinting and Barr body formation in mammals. What is this type of DNA modification called?

ANSWER: METHYLATION

## BONUS

11) Energy – *Short Answer* Researchers at SLAC National Lab are studying how gluons scatter off one another. What is the term for a particle composed entirely of gluons?

ANSWER: GLUEBALL (ACCEPT: GLUONIUM, GLUONBALL)

## TOSS-UP

12) Math – *Short Answer* What is 6 factorial divided by 4 factorial?

ANSWER: 30

## BONUS

12) Math – *Short Answer* Express the fraction with numerator  $23 + 11i$  and denominator  $1 + 5i$  in standard  $a + bi$  form.

ANSWER:  $3 - 4i$

## TOSS-UP

13) Physics – *Multiple Choice* An 8-kilogram and a 20-kilogram mass are on opposite sides of a 7-meter-long lever. In meters, how far should the fulcrum be placed from the 8-kilogram mass so that the two masses are balanced?

- W) 3.5
- X) 4
- Y) 4.5
- Z) 5

ANSWER: Z) 5

## BONUS

13) Physics – *Multiple Choice* Which of the following expressions does not have units of energy?

- W) Position times momentum
- X) Velocity squared times mass
- Y) Angular momentum divided by time
- Z) Momentum squared divided by mass

ANSWER: W) POSITION TIMES MOMENTUM

## TOSS-UP

14) Biology – *Multiple Choice* Limited food, decreased water, and loss of available nesting sites are likely to have which of the following impacts on a population?

- W) Decreased carrying capacity
- X) Increased population growth
- Y) Decreased selection pressure
- Z) Decreased per capita death rates

ANSWER: W) DECREASED CARRYING CAPACITY

## BONUS

14) Biology – *Short Answer* Identify all of the following three numbers of petals a flower could have that would suggest that it is a monocot: 1) 6; 2) 8; 3) 12.

ANSWER: 1, 3 (ACCEPT: 6, 12)

## TOSS-UP

15) Chemistry – *Multiple Choice* Which of the following compounds or ions is the best oxidizing agent?

- W) Copper(II) ions
- X) MnO<sub>2</sub>
- Y) NaBH<sub>4</sub>
- Z) Iodine solid

ANSWER: X) MnO<sub>2</sub>

## BONUS

15) Chemistry – *Short Answer* Rank the following three metals in order of increasing strength as a reducing agent: 1) Copper; 2) Zinc; 3) Lead.

ANSWER: 1, 3, 2

## TOSS-UP

16) Earth and Space – *Multiple Choice* Which of the following properties of a telescope determines its resolving power?

- W) Objective focal length
- X) Eyepiece focal length
- Y) Lens index of refraction
- Z) Aperture **[AP-ur-chur]**

ANSWER: Z) APERTURE

## BONUS

16) Earth and Space – *Short Answer* Mineral spherules **[SFEER-ools]**, sometimes called blueberries, present on the Martian surface are thought to be evidence of earlier surface water. Of what mineral are these spherules composed?

ANSWER: HEMATITE

## TOSS-UP

17) Energy – *Short Answer* Researchers at Brookhaven National Lab are studying therapeutic recombinant protein production in plants. A major use of this technology is to create what class of proteins, which are commonly composed of a pair of heavy chains and a pair of light chains?

ANSWER: ANTIBODY (ACCEPT: IMMUNOGLOBULIN, GAMMAGLOBULIN)

## BONUS

17) Energy – *Short Answer* Scientists at Pacific Northwest National Lab are developing NWChem, a software used in computational chemistry. One assumption typically made in computational chemistry is that the motion of nuclei is negligible compared to the motion of electrons. What is the name of this approximation?

ANSWER: BORN-OPPENHEIMER APPROXIMATION (ACCEPT: BO APPROXIMATION)

## TOSS-UP

18) Math – *Multiple Choice* A differentiable function  $f$  of  $x$  has domain the closed interval from 2 to 6 and range the closed interval from 4 to 8. If  $f'$  prime of  $x$  is less than 0 for all  $x$  in the domain, what is  $f$  of 2?

- W) 2
- X) 4
- Y) 6
- Z) 8

ANSWER: Z) 8

## BONUS

18) Math – *Short Answer* To the nearest whole number, what is the slant height of a right circular cone with radius 7 and height 14?

ANSWER: 16