

HIGH SCHOOL - ROUND 10A

TOSS-UP

1) Chemistry – *Multiple Choice* The mass spectrum of a certain diatomic element has an isotope abundance pattern of one to two to one. What would the isotope abundance pattern look like if the sample were triatomic instead of diatomic?

- W) One to one to one to one
- X) One to two to two to one
- Y) One to two to three to one
- Z) One to three to three to one

ANSWER: Z) ONE TO THREE TO THREE TO ONE

BONUS

1) Chemistry – *Multiple Choice* Which of the following compounds is the product of the ozonolysis [*oh-zohn-AW-lih-sis*] of ethylene followed by a reductive workup?

- W) Methanol
- X) Ethanol
- Y) Formaldehyde
- Z) Acetone

ANSWER: Y) FORMALDEHYDE

TOSS-UP

2) Biology – *Short Answer* What is the term for the enlarged end of a stolon that is used for storing food?

ANSWER: TUBER

BONUS

2) Biology – *Short Answer* How many different types of opsins are found in the normal human eye?

ANSWER: 4

TOSS-UP

3) Physics – *Short Answer* When beryllium-8 emits an alpha particle, what isotope is formed?

ANSWER: HELIUM-4

BONUS

3) Physics – *Short Answer* A toaster is composed of 4 compartments connected in parallel to a standard 120-volt RMS wall socket. If each compartment is modeled by a 4-kilo-ohm resistor, what is the peak power, in watts, dissipated by the toaster when 4 waffles are being toasted simultaneously?

ANSWER: 28.8

TOSS-UP

4) Energy – *Multiple Choice* Researchers at SLAC National Accelerator Lab have developed a new electron-gun that produces near-continuous high-energy electron beams. The electron gun uses a chamber of niobium cooled to 4 kelvins, which has what property?

- W) Piezoelectricity [*PEE-zoh-electricity*]
- X) Extremely high magnetic susceptibility
- Y) Superfluidity
- Z) Superconductivity

ANSWER: Z) SUPERCONDUCTIVITY

BONUS

4) Energy – *Short Answer* A team of scientists from Oak Ridge National Laboratory have been studying the enzyme RuBisCO [*roo-BIS-koh*] using neutron scattering and X-ray diffraction techniques. What key atom can neutron-scattering methods directly detect that X-ray methods cannot?

ANSWER: HYDROGEN

TOSS-UP

5) Math – *Multiple Choice* Consider the polynomial equation $6x^3 - 24x + 25 = 0$. According to the rational root theorem, which of the following is NOT a possible rational root of this equation?

- W) -3
- X) 1/3
- Y) 5/6
- Z) 5/3

ANSWER: W) -3

BONUS

5) Math – *Short Answer* If two sides of a right triangle have lengths 15 and 7, then, rounded to the nearest whole numbers, what are the possible lengths of the third side?

ANSWER: 13 and 17

TOSS-UP

6) Earth and Space – *Multiple Choice* Which of the following is closest to the pre-industrial concentration of carbon dioxide in the atmosphere?

- W) 800 parts per billion
- X) 275 parts per billion
- Y) 275 parts per million
- Z) 8 parts per million

ANSWER: Y) 275 PARTS PER MILLION

BONUS

6) Earth and Space – *Short Answer* A subsurface magma chamber cools until fifty percent of its mass has crystallized. Identify all of the following three statements that are true of the magma-rock system: 1) The magma is differentiated; 2) The rock and the magma will be chemically identical; 3) The newly-formed rock will have a glassy texture.

ANSWER: 1

TOSS-UP

7) Physics – *Short Answer* What is the term for frictional forces between adjacent layers within a fluid that prevent them from flowing freely?

ANSWER: VISCOSITY (ACCEPT: VISCOUS FORCES)

BONUS

7) Physics – *Short Answer* What is the maximum possible efficiency for a heat engine whose cold reservoir is at 0 degrees Celsius and whose hot reservoir is at 546 degrees Celsius?

ANSWER: 2/3

TOSS-UP

8) Math – *Short Answer* If f is a continuous function such that the definite integral from 3 to 8 of f of x dx equals 16, what is the average value of f on the closed interval from 3 to 8?

ANSWER: 16/5 (ACCEPT: 3 1/5, 3.2)

BONUS

8) Math – *Short Answer* Consider a pair of “loaded” six-sided dice. In this case, each die is weighted so that each odd number is twice as likely as each even number. What is the probability of rolling the same number on both dice?

ANSWER: 5/27

TOSS-UP

9) Biology – *Short Answer* What type of meristem is primarily responsible for secondary growth?

ANSWER: LATERAL

BONUS

9) Biology – *Short Answer* Identify all of the following three organisms that are known to possess G-protein coupled receptors: 1) *E. coli*; 2) *S. cerevisiae* [*sarah-VIH-see-ay*]; 3) *C. lupus*.

ANSWER: 2, 3

TOSS-UP

10) Energy – *Multiple Choice* Scientists at Pacific Northwest National Lab have constructed the Shallow Underground Laboratory at a depth of 12 meters to reduce background from which of the following sources?

- W) Neutrinos
- X) Cosmic rays
- Y) Top quarks
- Z) Gravitational waves

ANSWER: X) COSMIC RAYS

BONUS

10) Energy – *Short Answer* Researchers at Ames Lab are studying bound electron-hole pairs in photovoltaic [*photo-vawl-TAY-ik*] materials. What is the term for these quasiparticles?

ANSWER: EXCITONS

TOSS-UP

11) Earth and Space – *Multiple Choice* The habitable zone in our solar system ranges from approximately the orbit of Venus to the orbit of Mars. Which of the following best explains why astrobiologists are optimistic about the habitability of Jupiter’s icy moon Europa, which is far outside the habitable zone?

- W) It is rich in organic carbon molecules
- X) It has a magnetic field similar in magnitude to Earth’s magnetic field
- Y) Its interior is heated by tidal friction
- Z) It is believed to have originally formed in the habitable zone

ANSWER: Y) ITS INTERIOR IS HEATED BY TIDAL FRICTION

BONUS

11) Earth and Space – *Multiple Choice* Which of the following best describes how the Sun’s solar luminosity has changed since the formation of Earth?

- W) It has increased
- X) It has decreased
- Y) It has cyclically increased and decreased with a period of 500 million years
- Z) It has increased and decreased sporadically

ANSWER: W) IT HAS INCREASED

TOSS-UP

12) Chemistry – *Short Answer* A chemist notes that when graphing one over the concentration of a reactant in a reaction versus time, she gets a linear fit. This implies that the reaction is what order?

ANSWER: SECOND (ACCEPT: TWO)

BONUS

12) Chemistry – *Multiple Choice* Which of the following ions has a noble gas electron configuration?

- W) Yttrium [*IH-tree-um*] three plus
- X) Chromium three plus
- Y) Palladium [*pah-LAY-dee-um*] two plus
- Z) Titanium two plus

ANSWER: W) YTTRIUM THREE PLUS

TOSS-UP

13) Math – *Short Answer* Consider a triangle with two sides of lengths 5 and 9. How many different integers could be the length of the third side?

ANSWER: 9

BONUS

13) Math – *Short Answer* A custom mixture of nuts is composed of cashews worth \$8 a pound and almonds worth \$6 a pound. Mae purchases 11 pounds of the mixture for \$75. How many of these 11 pounds are cashews?

ANSWER: 4.5 (ACCEPT: 4½, 9/2)

TOSS-UP

14) Earth and Space – *Multiple Choice* Welded tuff is composed primarily of what material?

- W) Marine carbonates
- X) Volcanic ash
- Y) Siliciclastic [*sil-IH-see-KLAS-tik*] sediment
- Z) Evaporite deposits

ANSWER: X) VOLCANIC ASH

BONUS

14) Earth and Space – *Multiple Choice* Which of the following locations in a spiral galaxy possesses the highest rate of star formation?

- W) Halo
- X) Core
- Y) Spiral arm
- Z) Area between spiral arms

ANSWER: Y) SPIRAL ARM

TOSS-UP

15) Physics – *Multiple Choice* The energy potential of a system scales quadratically with respect to distance away from a point. Which of the following could represent this system?

- W) Gravitational orbit
- X) Electrostatic orbit
- Y) Hookean spring
- Z) Double pendulum

ANSWER: Y) HOOKEAN SPRING

BONUS

15) Physics – *Short Answer* In an experiment of the photoelectric effect, a metal is found to emit electrons when exposed to strong blue light, but not to weak yellow light. Identify all of the following four forms of light that will eject electrons from the metal: 1) Weak red light; 2) Strong red light; 3) Weak violet light; 4) Strong violet light.

ANSWER: 3, 4

TOSS-UP

16) Energy – *Multiple Choice* Idaho National Lab researchers are studying rocks that form near rhyolitic [*rye-oh-LIT-ik*] eruptions with x-ray fluorescence. Which of the following statements is true regarding the magma from eruptions?

- W) It contains little silica compared to basaltic magma
- X) It is cooler in temperature than basaltic magma
- Y) It is low-viscosity compared to basaltic magma
- Z) It is high in iron content relative to basaltic magma

ANSWER: X) IT IS COOLER IN TEMPERATURE THAN BASALTIC MAGMA

BONUS

16) Energy – *Short Answer* Scientists at SLAC National Accelerator Lab are developing improvements to scanning tunneling electron microscopy. In this technique, an electron beam interacts with what shell of electrons in the sample?

ANSWER: VALENCE SHELL

TOSS-UP

17) Chemistry – *Multiple Choice* Which of the following is NOT a Lewis acid?

- W) Boron tribromide
- X) Aluminum trichloride
- Y) Carbon tetrachloride
- Z) Sulfur trioxide

ANSWER: Y) CARBON TETRACHLORIDE

BONUS

17) Chemistry – *Short Answer* Rank the following three indicators in terms of increasing pKa:

- 1) Phenolphthalein [*fee-nawlf-THAY-leen*];
- 2) Methyl red;
- 3) Bromothymol [*BROH-mo-THIGH-mawl*] blue.

ANSWER: 2, 3, 1

TOSS-UP

18) Biology – *Multiple Choice* What is the name of the largest family of human cell surface receptors that is characterized by a 7-transmembrane domain motif?

- W) G-protein coupled receptor
- X) Ionotropic receptor
- Y) Receptor tyrosine kinase
- Z) Catalytic receptor

ANSWER: W) G-PROTEIN COUPLED RECEPTOR

BONUS

18) Biology – *Multiple Choice* Which of the following is NOT a seedless, vascular plant?

- W) Ferns
- X) Liverworts
- Y) Horsetails
- Z) Club mosses

ANSWER: X) LIVERWORTS

TOSS-UP

19) Chemistry – *Multiple Choice* Which of the following would cause the electron distribution in a molecule to change the least?

- W) A nearby ion
- X) A far-away dipole
- Y) An external magnetic field
- Z) An external electric field

ANSWER: X) A FAR-AWAY DIPOLE

BONUS

19) Chemistry – *Short Answer* 2-chloropentane is reacted with sodium hydroxide at 45 degrees Celsius to form an alcohol. What is the mechanism of this reaction?

ANSWER: SN₂

TOSS-UP

20) Math – *Short Answer* What is the slope of a line perpendicular to the line with equation $7x - 6y = 21$?

ANSWER: $-6/7$

BONUS

20) Math – *Short Answer* How many positive integer factors does 1584 have?

ANSWER: 30

TOSS-UP

21) Earth and Space – *Short Answer* What letter denotes the spectral type of the Sun?

ANSWER: G (ACCEPT G2, G2V)

BONUS

21) Earth and Space – *Short Answer* Identify all of the following three seismic waves that are surface waves: 1) P-wave; 2) Rayleigh [**RAY-lee**] wave; 3) S-wave.

ANSWER: 2

TOSS-UP

22) Biology – *Short Answer* A pea plant with yellow, round seeds that is heterozygous [**hetero-ZYE-gus**] for both traits is allowed to self-pollinate. What percentage of the offspring plants will be true-breeding for both yellow and wrinkled seeds?

ANSWER: 6.25 (ACCEPT: 6¼, 25/4)

BONUS

22) Biology – *Short Answer* In animals, what is the most important substrate of hexokinase in terms of cellular respiration?

ANSWER: GLUCOSE

TOSS-UP

23) Physics – *Short Answer* In kilometers per second, what is the speed of a ray of light traveling in a medium where the index of refraction is 1.5?

ANSWER: 200,000

BONUS

23) Physics – *Short Answer* A thin copper wire carries a current density of 3 times 10^5 amps per square meter. If the conductivity of copper is 6 times 10^7 siemens per meter, what is the electric field, in millivolts per meter, inside the wire?

ANSWER: 5