

HIGH SCHOOL - ROUND 9A

TOSS-UP

1) Math – *Short Answer* What is the period of the function with equation $y = 3 \sin(\text{open parenthesis } 12\pi x + 4 \text{ close parenthesis} - 7)$?

ANSWER: $1/6$

BONUS

1) Math – *Short Answer* Simplify the following sum of two fractions: $1 \text{ over log base } 3 \text{ of } 6 + 1 \text{ over log base } 12 \text{ of } 6$.

ANSWER: 2

TOSS-UP

2) Energy – *Multiple Choice* Oak Ridge National Lab has demonstrated that 3D-printed magnets made from recycled materials can outperform those created by traditional methods. Permanent magnets made from rare-earth lanthanoid [*LAN-tha-noyd*] elements have partially occupied shells of what type?

- W) S
- X) P
- Y) D
- Z) F

ANSWER: Z) F

BONUS

2) Energy – *Short Answer* Researchers at Argonne National Lab are developing a new understanding of water oxidation via electrocatalysis. Identify all of the following four choices that are products of the water oxidation half-reaction: 1) Protons; 2) Molecular oxygen; 3) Molecular hydrogen; 4) Heavy water.

ANSWER: 1, 2

TOSS-UP

3) Chemistry – *Short Answer* Identify all of the following three acids that are diprotic acids:
1) Hydrochloric acid; 2) Sulfuric acid; 3) Phosphoric acid.

ANSWER: 2

BONUS

3) Chemistry – *Short Answer* What is the product of the reaction of ethylene and hydrogen bromide?

ANSWER: BROMOETHANE (ACCEPT: ETHYL BROMIDE)

TOSS-UP

4) Earth and Space – *Short Answer* When CO₂ from the atmosphere dissolves in ocean water, it quickly reacts with water to create what neutral acidic species?

ANSWER: CARBONIC ACID (ACCEPT H₂CO₃)

BONUS

4) Earth and Space – *Short Answer* Identify all of the following three regions that are typically at low atmospheric pressures due to global atmospheric circulation patterns: 1) ITCZ; 2) Horse latitudes; 3) Polar front.

ANSWER: 1, 3

TOSS-UP

5) Biology – *Short Answer* What is the term for the plant growth response to touch stimuli?

ANSWER: THIGMOTROPISM

BONUS

5) Biology – *Short Answer* Steroid hormones are produced in the gonads as well as what other organ?

ANSWER: ADRENAL GLANDS (ACCEPT: SUPRARENAL GLANDS)

TOSS-UP

6) Physics – *Short Answer* Truth, beauty, and charm are flavors of what type of particle?

ANSWER: QUARK (ACCEPT: ANTI-QUARK)

BONUS

6) Physics – *Short Answer* A 1-ohm resistor and a 2-ohm resistor are connected in parallel to an 8-volt battery with internal resistance of 2 ohms. In amperes, how much current flows through the 1-ohm resistor?

ANSWER: 2

TOSS-UP

7) Earth and Space – *Short Answer* With an apparent magnitude of 3.4, what is the most distant celestial object that is reliably visible with the naked eye?

ANSWER: ANDROMEDA GALAXY

BONUS

7) Earth and Space – *Short Answer* The Little Ice Age in the 17th century coincided with the Maunder minimum, a period of time defined by the observation of very few of what astronomical phenomena?

ANSWER: SUNSPOTS

TOSS-UP

8) Biology – *Short Answer* What gaseous hormone promotes ripening of fruit in many plants?

ANSWER: ETHYLENE (ACCEPT: ETHENE, C_2H_4)

BONUS

8) Biology – *Short Answer* Identify all of the following four cell types that are considered white blood cells: 1) T cells; 2) Erythrocytes; 3) Thrombocytes; 4) Neutrophils.

ANSWER: 1, 4

TOSS-UP

9) Chemistry – *Short Answer* Identify all of the following three forces that play a role in the interparticle interactions for hydrogen chloride: 1) Hydrogen bonding; 2) London dispersion; 3) Dipole-dipole.

ANSWER: 2, 3

BONUS

9) Chemistry – *Short Answer* Rank the following three atoms in terms of increasing magnitude of their electron affinities: 1) Lithium; 2) Boron; 3) Carbon.

ANSWER: 2, 1, 3

TOSS-UP

10) Physics – *Short Answer* Birefringence [*bye-ree-FRIN-jents*] is a phenomenon seen in materials whose index of refraction is dependent on the direction of travel and what other property of light?

ANSWER: POLARIZATION

BONUS

10) Physics – *Multiple Choice* An asteroid with linear momentum is gravitationally captured by a planet. Which of the following best explains where the linear momentum of the asteroid went?

- W) Converted into angular momentum
- X) Conserved in the asteroid's orbital velocity
- Y) Dissipated by frictional forces
- Z) Translating the planet-asteroid system

ANSWER: Z) TRANSLATING THE PLANET-ASTEROID SYSTEM

TOSS-UP

11) Math – *Short Answer* What is the partial derivative with respect to y of the expression x^3y^7 ?

ANSWER: $7x^3y^6$

BONUS

11) Math – *Short Answer* Other than 5, what is the smallest positive integer that, when divided by 6, 8, 10, or 14, has a remainder of 5?

ANSWER: 845

TOSS-UP

12) Energy – *Short Answer* Researchers at Pacific Northwest National Lab are studying the relationship between soil carbon and microbial activity in soils. Most soil carbon is stored inorganically as part of what large group of minerals?

ANSWER: CARBONATES

BONUS

12) Energy – *Multiple Choice* Fermi National Accelerator scientists are looking for physics beyond the Standard Model in the form of decay pathways that do not conserve lepton flavor. Which of the following particles has already been observed violating this conservation principle?

- W) Electrons
- X) Neutrinos
- Y) Protons
- Z) Bosons

ANSWER: X) NEUTRINOS

TOSS-UP

13) Chemistry – *Short Answer* How many electrons in one atom of elemental sulfur are located in *s*-orbitals?

ANSWER: 6

BONUS

13) Chemistry – *Short Answer* What gas, whose monomethyl derivative is a component of rocket fuel, is formed by bubbling ammonia gas through hypochlorite solution?

ANSWER: HYDRAZINE (ACCEPT: N_2H_4)

TOSS-UP

14) Physics – *Multiple Choice* Which of the following is closest to the most probable radius, in angstroms, of an electron in the ground state of a hydrogen atom?

W) 0.05

X) 0.5

Y) 5

Z) 50

ANSWER: X) 0.5

BONUS

14) Physics – *Short Answer* A parallel circuit consisting of three paths has an equivalent resistance of 4 ohms. If one of the paths containing a 12-ohm resistor is disconnected from the circuit, then in ohms, what is the new equivalent resistance?

ANSWER: 6

TOSS-UP

15) Earth and Space – *Multiple Choice* The Earth's core contains approximately one-third of the Earth's mass. Which of the following percentages is closest to the percentage of the core's mass that is contained within the outer core?

- W) 5
- X) 30
- Y) 65
- Z) 95

ANSWER: Z) 95

BONUS

15) Earth and Space – *Multiple Choice* Which of the following statements is TRUE of lateral and medial moraines *[mah-RAYNS]*?

- W) A lateral moraine is a type of medial moraine
- X) A medial moraine is a type of lateral moraine
- Y) Two lateral moraines can merge to form a medial moraine
- Z) Medial moraines are only present at the maximum extent of a glacier, while lateral moraines are present along the entirety of a glacier's flow path.

ANSWER: Y) TWO LATERAL MORAINES CAN MERGE TO FORM A MEDIAL MORaine

TOSS-UP

16) Energy – *Multiple Choice* Scientists at Pacific Northwest National Lab are supercooling liquid water to 136 kelvins, at which it undergoes a phase transition to a glass-like substance. Which of the following quantities is positive for the freezing of supercooled liquid water?

- W) Change in enthalpy of the water
- X) Change in entropy of the water
- Y) Change in Gibbs free energy of the water
- Z) Change in entropy of the universe

ANSWER: Z) CHANGE IN ENTROPY OF THE UNIVERSE

BONUS

16) Energy – *Short Answer* Researchers at Oak Ridge National Lab are studying the nuclear fusion reactions occurring in the Sun using the Titan supercomputer. What is the primary fusion pathway that occurs in the Sun?

ANSWER: PROTON-PROTON CHAIN (ACCEPT: PP CHAIN)

TOSS-UP

17) Biology – *Multiple Choice* Which of the following organisms is haploid?

- W) Female grasshopper
- X) Male grasshopper
- Y) Female ant
- Z) Male ant

ANSWER: Z) MALE ANT

BONUS

17) Biology – *Short Answer* The metal-ligating section of chlorophyll is based on what group of organic macrocycles that contain four pyrrole [**PEER-ohl**] rings?

ANSWER: PORPHYRIN

TOSS-UP

18) Earth and Space – *Short Answer* The Chandra [**CHAN-drah**] Observatory observes radiation in what region of the electromagnetic spectrum?

ANSWER: X-RAY

BONUS

18) Earth and Space – *Short Answer* Place the following three natural satellites in order of increasing size: 1) Moon; 2) Phobos; 3) Deimos.

ANSWER: 3, 2, 1

TOSS-UP

19) Math – *Short Answer* A geometric sequence has second term -5 and third term 3 . What is its first term?

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

BONUS

19) Math – *Short Answer* To the nearest integer, what is the integral from $x = 0$ to $x = 4$ of x times the square root of open parenthesis $x^2 + 9$ close parenthesis dx ?

ANSWER: 33

TOSS-UP

20) Physics – *Short Answer* Consider a planet that is orbiting the Sun in uniform circular motion and has total mechanical energy E . What is the total mechanical energy, in terms of E , of a planet orbiting at twice the radius, also in uniform circular motion?

ANSWER: $E/2$ (ACCEPT: $0.5E$)

BONUS

20) Physics – *Short Answer* To the nearest kilojoule, how much work is done by three moles of an ideal gas being heated at constant pressure from 43 degrees Celsius to 83 degrees Celsius?

ANSWER: 1

TOSS-UP

21) Chemistry – *Short Answer* Identify all of the following three techniques that could determine the optical purity of a sample: 1) Polarimetry [*polar-IH-meh-tree*]; 2) Thin-layer chromatography; 3) Mass spectrometry.

ANSWER: 1

BONUS

21) Chemistry – *Short Answer* Consider a solution of one-molar calcium chloride. At a temperature of 60 degrees Celsius and in atmospheres to one significant figure, what is the osmotic pressure of this solution?

ANSWER: 80

TOSS-UP

22) Biology – *Short Answer* In alcohol fermentation, pyruvate is first decarboxylated to form what molecule?

ANSWER: ACETALDEHYDE

BONUS

22) Biology – *Short Answer* The unsaturated fatty acids present in the cell membrane primarily possess what stereochemistry on their double bond?

ANSWER: CIS (ACCEPT: Z)

TOSS-UP

23) Math – *Short Answer* What is the greatest integer that is less than or equal to the log base 2 of 2019?

ANSWER: 10

BONUS

23) Math – *Short Answer* If the sides of a triangle have lengths 5, 6, and 9, what is the cosine of the largest angle?

ANSWER: $-1/3$