High School
Set 4

TOSS-UP

1) Math – *Multiple Choice* When graphed in the complex plane, which of the following is the best description of the graph of all the complex solutions to the equation $x^6 - 64 = 0$?

W) One point
X) Two points
Y) The vertices of a regular hexagon
Z) A circle

ANSWER: Y) THE VERTICES OF A REGULAR HEXAGON

BONUS

1) Math – *Short Answer* What is the slope-intercept form of the equation of the slant asymptote of the function f of x equals the fraction with numerator $4x^2 - 10x$ and denominator $2x + 1$?

ANSWER: $y = 2x - 6$

TOSS-UP

2) Physics – *Short Answer* Of the different types of heat transfer, which is responsible for transferring the most heat from the Sun to Earth?

ANSWER: RADIATION

BONUS

2) Physics – *Short Answer* What principle states that when waves occupy the same space at the same time, their displacements add together?

ANSWER: SUPERPOSITION

TOSS-UP

3) Biology – *Short Answer* A nonsense mutation occurs when a codon coding for an amino acid is changed to what type of codon?

ANSWER: STOP (ACCEPT: TERMINATION)

BONUS

3) Biology – *Multiple Choice* Which of the following is the limiting factor for photosynthesis rate in most plants?

W) Insolation
X) Humidity
Y) Manganese concentration
Z) Atmospheric carbon dioxide

ANSWER: Z) ATMOSPHERIC CARBON DIOXIDE

TOSS-UP

4) Chemistry – *Short Answer* If a reaction is second order with respect to concentration of A, by what factor would the rate of the reaction be multiplied if the concentration of A were quartered?

ANSWER: 1/16 (ACCEPT: 0.0625)

BONUS

4) Chemistry – *Multiple Choice* Which of the following electron configurations is correct for neutral copper?

W) [Ar] $4s^2$ $3d^9$ ***[A-R-4-s-2-**short pause**-3-d-9]***
X) [Ar] $4s^1$ $3d^{10}$ ***[A-R-4-s-1-**short pause**-3-d-10]***
Y) [Ar] $3d^{11}$ $3d^9$ ***[A-R-3-d-11-**short pause**-3-d-9]***
Z) [Ar] $3d^{10}$ $4p^1$ ***[A-R-3-d-10-**short pause**-4-p-1]***

ANSWER: X) [AR] $4S^1$ $3D^{10}$

TOSS-UP

5) Earth and Space – *Multiple Choice* A binary star system appears as a single point of light, but the presence of a second star can be determined from changes in the doppler shift of its spectral absorption lines. What type of binary is this?

W) Astrometric
X) Eclipsing
Y) Spectroscopic ***[spek-troh-SCAW-pik]***
Z) Visual

ANSWER: Y) SPECTROSCOPIC

BONUS

5) Earth and Space – *Short Answer* Identify all of the following three types of galaxies that are expected to have substantial ongoing star formation: 1) Elliptical; 2) Spiral; 3) Irregular.

ANSWER: 2, 3

TOSS-UP

6) Energy – *Short Answer* Argonne National Lab researchers are studying the charge-separation mechanisms in the light reactions of bacterial photosynthesis. One of the main products of this reaction is what cofactor, which acts as a reducing agent during carbon fixation?

ANSWER: NADPH (do not accept: NADP+, NADP)

BONUS

6) Energy – *Short Answer* Researchers at Ames Lab have developed a new refrigeration technology based on magnetocaloric ***[mag-NEE-toh-cah-LOR-ik]*** cooling for commercial use. If a refrigerator removes 30 Joules from a low-temperature reservoir and adds 50 Joules to a high-temperature reservoir each cycle, then what is its coefficient of performance?

ANSWER: 1.5 (ACCEPT: 3/2, 1 1/2)

TOSS-UP

7) Math – *Short Answer* The volume of a right circular cone is 12. What is the new volume if the height remains constant and the radius of the base is doubled?

ANSWER: 48

BONUS

7) Math – *Short Answer* If the line tangent to the graph of the differentiable function f of x at the point (–2, 6.5) passes through the point (9.5, –3), then what is f prime of x when $x = -2$?

ANSWER: –19/23

TOSS-UP

8) Physics – *Short Answer* Rank the following three processes in increasing order of the temperature at which they occur at standard pressure: 1) Ice melts; 2) Dry ice sublimates ***[SUB-lim-ates]***; 3) Helium boils.

ANSWER: 3, 2, 1

BONUS

8) Physics – *Short Answer* Identify all of the following three devices that, on their own, can convert AC current to DC current: 1) Diode; 2) Rectifier; 3) Transformer.

ANSWER: 1, 2

TOSS-UP

9) Biology – *Short Answer* What cytoskeletal component is the major constituent of the mitotic spindle apparatus?

ANSWER: MICROTUBULES (do not accept: MICROFILAMENTS)

BONUS

9) Biology – *Short Answer* Identify all of the following three statements that are true of parthenogenesis ***[par-then-oh-JEN-eh-sis]***: 1) Parthenogenesis involves budding; 2) Parthenogenesis involves the development of unfertilized eggs into offspring; 3) Parthenogenesis can create a genetic clone of the parent.

ANSWER: 2, 3

TOSS-UP

10) Chemistry – *Short Answer* Rishi graphs the pressure exerted by an ideal gas on its chamber on the *y*-axis and its temperature in degrees Celsius on the *x*-axis. To the nearest degree Celsius, what is the *x*-intercept of this graph?

ANSWER: –273

BONUS

10) Chemistry – *Multiple Choice* Which of the following solids is more soluble in one-molar hydrochloric acid than it is in pure water?

W) Barium sulfate
X) Barium bromide
Y) Calcium hydrogen phosphate
Z) Calcium chloride

ANSWER: Y) CALCIUM HYDROGEN PHOSPHATE

TOSS-UP

11) Earth and Space – *Short Answer* Before the evolution of photosynthesis, small amounts of oxygen were produced when UV radiation split water into hydrogen and oxygen gas. What is the general term for this reaction?

ANSWER: PHOTOLYSIS (ACCEPT: PHOTODISSOCIATION, PHOTODECOMPOSITION)

BONUS

11) Earth and Space – *Multiple Choice* Which of the following is an example of a plate boundary that may have both deep- and shallow-focus earthquakes?

W) Transform
X) Continent-continent convergent
Y) Ocean-continent convergent
Z) Ocean-ocean divergent

ANSWER: Y) OCEAN-CONTINENT CONVERGENT

TOSS-UP

12) Energy – *Short Answer* Scientists at Ames Lab are studying the interactions between gold nanoparticles and the heteroatom in butane-thiol ***[THIGH-awl]***. What element is this heteroatom?

ANSWER: SULFUR

BONUS

12) Energy – *Multiple Choice* Researchers at Thomas Jefferson National Accelerator Facility are using Monte Carlo methods to evaluate integrals in very high dimensional spaces. Which of the following best explains the advantage of Monte Carlo techniques in these settings?

W) Direct integration techniques are too computationally intensive in high dimensions
X) Monte Carlo integration is known to be more accurate than direct integration
Y) Monte Carlo techniques are easier to combine with machine learning methods
Z) Direct integration techniques are susceptible to numerical overflow in high dimensions

ANSWER: W) DIRECT INTEGRATION TECHNIQUES ARE TOO COMPUTATIONALLY INTENSIVE IN HIGH DIMENSIONS

TOSS-UP

13) Math – *Short Answer* 8 is one-fourth percent of what number?

ANSWER: 3200

BONUS

13) Math – *Short Answer* If x is proportional to y and inversely proportional to z^2, and if $x = 3$ when $y = 4$ and $z = 8$, what is the value of x when $y = 6$ and $z = 10$?

ANSWER: 72/25 (ACCEPT: 2.88, 2 22/25)

TOSS-UP

14) Physics – *Short Answer* You are pushing your broken car to prevent it from sliding down a hill. Unfortunately, as you apply 300 newtons of force directly up the hill, the car slides 4 meters down the hill. In joules, how much work have you performed on the car during this period?

ANSWER: −1200 (do not accept: 1200)

BONUS

14) Physics – *Multiple Choice* In a carnival ride, participants stand in an upright cylindrical room that starts rotating rapidly, and they end up pressed against the walls with their feet above the ground. Which of the following forces balances the gravity on the riders?

W) Normal force
X) Frictional force
Y) Centripetal force
Z) Centrifugal force

ANSWER: X) FRICTIONAL FORCE

TOSS-UP

15) Biology – *Short Answer* Plasma cells and their precursors, plasmablasts, are differentiated forms of what type of lymphocyte?

ANSWER: B (ACCEPT: B CELL, B LYMPHOCYTE)

BONUS

15) Biology – *Short Answer* Identify all of the following three types of interactions that are examples of symbiosis:
1) Commensalism; 2) Mutualism; 3) Parasitism.

ANSWER: ALL

TOSS-UP

16) Chemistry – *Multiple Choice* Which of the following thermodynamic properties necessarily implies that a reaction is spontaneous?

W) Negative delta G
X) Negative delta H
Y) Positive delta S
Z) Positive W

ANSWER: W) NEGATIVE DELTA G

BONUS

16) Chemistry – *Short Answer* A certain electrochemical cell has a standard cell potential of 1.5 volts for a reaction that transfers 3 electrons. To two significant figures and in kilojoules, what is the standard Gibbs free energy change of this cell?

ANSWER: –430 (do not accept: 430)

TOSS-UP

17) Earth and Space – *Multiple Choice* Which of the following weathering processes is due to pressure release?

W) Exfoliation
X) Growth of salt crystals
Y) Thermal expansion and contraction
Z) Hydrolysis and oxidation

ANSWER: W) EXFOLIATION

BONUS

17) Earth and Space – *Short Answer* Identify all of the following three statements that are true of augite: 1) It is an example of a pyroxene ***[pie-ROX-een]***; 2) It has one direction of cleavage;
3) It is found in basalt.

ANSWER: 1, 3

TOSS-UP

18) Energy – *Short Answer* Scientists at the Joint BioEnergy Institute are developing methods to break down the second-most-abundant polymer found in wood for biofuel production. What is the name of this difficult-to-break-down polymer?

ANSWER: LIGNIN

BONUS

18) Energy – *Short Answer* Scientists at Oak Ridge National Lab are producing neutrons via spallation. Normally, these neutrons are then slowed down by passing them through a certain type of material before they are used for neutron imaging. What is the term for materials that demonstrate this behavior?

ANSWER: MODERATOR