

High School  
Set 2

TOSS-UP

1) Biology – *Short Answer* What is the term for the specialized reproductive organ that characterizes angiosperms?

ANSWER: FLOWERS

BONUS

1) Biology – *Short Answer* Identify all of the following three molecules of which ribosomes are composed: 1) RNA; 2) DNA; 3) Proteins.

ANSWER: 1, 3

## TOSS-UP

2) Chemistry – *Short Answer* What relationship predicts that the partial pressure of gas-phase molecules above a liquid varies exponentially with the reciprocal of temperature?

ANSWER: CLAUDIUS-CLAPEYRON (ACCEPT: CLAUDIUS-CLAPEYRON EQUATION, CLAUDIUS-CLAPEYRON RELATION)

## BONUS

2) Chemistry – *Short Answer* What is the oxidation state of the sulfur atom in the sulfate ion?

ANSWER: +6 (ACCEPT: 6)

## TOSS-UP

3) Earth and Space – *Short Answer* What is the name of the geologic principle that states that, in an un-deformed sequence of sedimentary rocks, the youngest beds are always at the top and the oldest at the bottom?

ANSWER: PRINCIPLE OF SUPERPOSITION (ACCEPT: SUPERPOSITION, LAW OF SUPERPOSITION)

## BONUS

3) Earth and Space – *Multiple Choice* An Ekman spiral in the surface ocean is created by the combined effect of what two influences?

- W) Wind and water upwelling
- X) Wind and water downwelling
- Y) Coriolis force and water downwelling
- Z) Coriolis force and wind

ANSWER: Z) CORIOLIS FORCE AND WIND

## TOSS-UP

4) Energy – *Multiple Choice* Scientists at Brookhaven National Lab are studying artificial photosynthesis. To do so, they have coupled chromophores to catalysts by adding long alkyl [*AL-kul*] tails to each one. These alkyl tails then tether the two molecules together. Which of the following forces is most influential in providing the tethering force?

- W) London dispersion
- X) Dipole-dipole
- Y) Hydrogen bonds
- Z) Ionic

ANSWER: W) LONDON DISPERSION

## BONUS

4) Energy – *Short Answer* Scientists at Pacific Northwest National Lab are developing sodium-ion batteries. Identify all of the following three statements that are potential advantages of these batteries:

1) They are less flammable than lithium-ion batteries; 2) They are more efficient than lead-acid batteries; 3) They are rechargeable.

ANSWER: ALL

## TOSS-UP

5) Math – *Multiple Choice* Which of the following best describes the relationship between the lines with equations  $\underline{5x + 4y = 20}$  and  $\underline{12x - 15y = 60}$ ?

- W) Parallel
- X) Perpendicular
- Y) Intersecting but not perpendicular
- Z) Coincident

ANSWER: X) PERPENDICULAR

## BONUS

5) Math – *Short Answer* One of the zeroes of the polynomial  $x^3 + 2x^2 + 36x + 72$  is the complex number  $-6i$ . What is the value of the real zero of the polynomial?

ANSWER:  $-2$

## TOSS-UP

6) Physics – *Short Answer* Metal detectors function by using an alternating magnetic field to generate small loops of electric current in metal objects. What is the term for these loops?

ANSWER: EDDY CURRENTS

## BONUS

6) Physics – *Short Answer* A beam of light exits a uniform material into vacuum with an incident angle of 30 degrees. If the angle of refraction is 45 degrees, then what is the index of refraction of the material?

ANSWER:  $\sqrt{2}$

## TOSS-UP

7) Biology – *Short Answer* What is the term for metabolic reactions that require the input of energy to build up complex molecules?

ANSWER: ANABOLIC (ACCEPT: ANABOLISM)

## BONUS

7) Biology – *Multiple Choice* Which of the following best demonstrates paracrine [*para-krin*] signaling?

- W) A tumor cell creates its own growth factors
- X) An allergen results in localized histamine release
- Y) The pituitary gland secretes vasopressin [*VAY-zoh-pressin*] in response to thirst
- Z) The pancreas produces insulin after a meal

ANSWER: X) AN ALLERGEN RESULTS IN LOCALIZED HISTAMINE RELEASE

## TOSS-UP

8) Chemistry – *Multiple Choice* Which of the following is a valid combination of units to express entropy?

- W) Joule-kelvins
- X) Newton-meters per degree Celsius
- Y) Watts per second-kelvin
- Z) Coulomb-volts per joule-kelvin

ANSWER: X) NEWTON-METERS PER DEGREE CELSIUS

## BONUS

8) Chemistry – *Multiple Choice* Which of the following changes would shift the equilibrium to the left for the exothermic reaction of solid calcium oxide with carbon dioxide gas to yield solid calcium carbonate?

- W) Decreasing the volume of the container
- X) Increasing the temperature
- Y) Increasing the pressure in the container by adding an inert gas
- Z) Doubling both the forward and reverse rate constants

ANSWER: X) INCREASING THE TEMPERATURE



## TOSS-UP

9) Earth and Space – *Multiple Choice* Which of the following groups of stars exhibits the empirical relationship that luminosity is proportional to mass to the 3.5 power?

- W) Giants
- X) Supergiants
- Y) White dwarfs
- Z) Main sequence

ANSWER: Z) MAIN SEQUENCE

## BONUS

9) Earth and Space – *Short Answer* What is the term for small variations in a celestial object's rate of precession due to the gravitational influence of nearby bodies?

ANSWER: NUTATION

## TOSS-UP

10) Energy – *Short Answer* Pacific Northwest National Lab researchers are studying the factors that lead to type one diabetes. One of the main causes is the death of what specific cell type within the pancreatic islets [*EYE-lets*]?

ANSWER: BETA CELLS

## BONUS

10) Energy – *Multiple Choice* Ames Lab researchers are trying to understand the ground state of crystals using a jellium model. Jellium is a quantum model in which positive charges are assumed to be a uniform jelly. This is most similar to the assumptions made by which of the following atomic models?

- W) Bohr model
- X) Rutherford model
- Y) Atomic orbital model
- Z) Plum pudding model

ANSWER: Z) PLUM PUDDING MODEL

TOSS-UP

11) Math – *Short Answer* Solve the following equation for  $x$ :  
 $\log_{\text{base } 2} \text{ of } \underline{\text{open parenthesis } x - 6 \text{ close parenthesis}} = 4?$

ANSWER: 22

BONUS

11) Math – *Short Answer* What is the sum of the distinct prime factors of 1,449?

ANSWER: 33



## TOSS-UP

12) Physics – *Multiple Choice* Only two forces are acting on a large rigid body: one is 5 newtons upwards, and one is 5 newtons downwards. However, the object is not at equilibrium. Which of the following could be the reason why?

- W) External forces are acting on the object
- X) The net force is non-zero
- Y) The net torque [*tork*] is non-zero
- Z) The object had a non-zero initial speed

ANSWER: Y) THE NET TORQUE IS NON-ZERO

## BONUS

12) Physics – *Short Answer* In kilocalories, how much energy is needed to heat a cubic meter of water from 15 degrees Celsius to 20 degrees Celsius?

ANSWER: 5000

## TOSS-UP

13) Biology – *Short Answer* Operant and classical conditioning are both examples of what general type of learning through which animals relate one stimulus with another?

ANSWER: ASSOCIATIVE

## BONUS

13) Biology – *Short Answer* Identify all of the following three statements that are true of quantitative traits: 1) They are usually polygenic; 2) Without selection, they will be bimodally distributed in a population; 3) Eye color in fruit flies is a quantitative trait.

ANSWER: 1

## TOSS-UP

14) Chemistry – *Short Answer* Consider the reduction of ferric oxide with solid carbon to yield carbon monoxide and solid iron. How many atoms of carbon must be consumed to reduce one molecule of ferric oxide?

ANSWER: 3

## BONUS

14) Chemistry – *Short Answer* What is the resulting normality when 10 milliliters of a 3-molar sulfuric acid solution are added to 20 milliliters of a one-molar sodium hydroxide solution?

ANSWER:  $4/3$  (ACCEPT:  $1 \frac{1}{3}$ )

## TOSS-UP

15) Earth and Space – *Short Answer* According to Bowen's Reaction Series, in fractional crystallization of a magma, what mineral will precipitate out of the magma first?

ANSWER: OLIVINE

## BONUS

15) Earth and Space – *Short Answer* The Gulf Stream and the Canary Current bound what major ocean gyre [*JI-er*]?

ANSWER: NORTH ATLANTIC

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## TOSS-UP

16) Energy – *Short Answer* Researchers at Brookhaven National Lab are using a de-alloying technique to create nanostructured materials. The film that is their starting material is an alloy that is composed of the two most common elements in Earth's core. What are these two elements?

ANSWER: IRON AND NICKEL (ACCEPT: FE AND NI, IN ANY ORDER)

## BONUS

16) Energy – *Multiple Choice* Researchers at Fermi National Accelerator Lab are searching for supersymmetric pairs to known elementary particles. Which of the following best explains why these pairs need not have the same mass as their Standard Model counterparts?

- W) Supersymmetry is unrelated to gravity
- X) The mass of supersymmetric particles grows with the renormalization scale
- Y) Supersymmetry can be spontaneously broken
- Z) Supersymmetric pair particles are all required to be massless

ANSWER: Y) SUPERSYMMETRY CAN BE SPONTANEOUSLY BROKEN



## TOSS-UP

17) Math – *Short Answer* A pyramid with 36 edges has how many vertices?

ANSWER: 19

## BONUS

17) Math – *Short Answer* Consider an infinite geometric series with sum equal to  $\frac{13}{7}$  and first term  $\frac{5}{4}$ . What is the value of the common ratio  $r$  for this series?

ANSWER:  $\frac{17}{52}$

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## TOSS-UP

18) Physics – *Multiple Choice* Sophie is plotting the kinetic energy of a 5-kilogram mass on the  $y$ -axis and its speed on the  $x$ -axis. If she uses a log-log plot, which of the following curves would best fit her data?

- W) A parabola [*puh-RAB-uh-la*]
- X) A line with slope 1
- Y) A line with slope 2
- Z) A horizontal line

ANSWER: Y) A LINE WITH SLOPE 2

## BONUS

18) Physics – *Multiple Choice* A wire on the  $x$ -axis is carrying current in the positive  $x$  direction. At the point  $(0, 1, 0)$ , in what direction does the magnetic field generated by the wire point?

- W) Positive  $z$
- X) Negative  $z$
- Y) Positive  $y$
- Z) Negative  $y$

ANSWER: W) POSITIVE Z