

High School
Set 8

TOSS-UP

1) Energy – *Short Answer* Scientists at SLAC National Accelerator Lab are studying how the size of metal nanoparticles in catalytic converters affects the rate of decomposition of nitrogen oxides. For the reaction that these nanoparticles are catalyzing, what are the signs of ΔG and ΔS , respectively?

ANSWER: DELTA G NEGATIVE AND DELTA S POSITIVE
(ACCEPT: NEGATIVE AND POSITIVE, in that order)

BONUS

1) Energy – *Short Answer* SLAC National Accelerator Facility scientists are studying the receptor GABA-B [*GAB-ah bee*]. Identify all of the following statements that are true of this receptor: 1) It is expressed by excitatory interneurons; 2) It is an ion channel; 3) It is a transmembrane protein.

ANSWER: 1, 3

TOSS-UP

2) Math – *Short Answer* At the point with coordinates (natural log of 2, e), what is the partial derivative with respect to x of the expression e to the x times the natural log of y ?

ANSWER: 2

BONUS

2) Math – *Short Answer* What is the cube of the complex number $4 + 5i$?

ANSWER: $-236 + 115i$

TOSS-UP

3) Physics – *Short Answer* Consider a spherical planet with a mass twice that of Earth and a radius twice that of Earth. In meters per second squared, what is the magnitude of the acceleration due to gravity on the surface of this planet?

ANSWER: 4.9 (ACCEPT: 49/10, 4 9/10)

BONUS

3) Physics – *Short Answer* Consider a clock moving at 50% of the speed of light relative to a stationary observer. How long, in minutes and to two significant figures, would it take for the speeding clock's second hand to complete two revolutions as measured by the stationary observer?

ANSWER: 2.3

TOSS-UP

4) Biology – *Short Answer* Chylomicrons [*KYE-loh-microns*] transport what class of macronutrients away from the small intestines?

ANSWER: FATS (ACCEPT: LIPIDS)

BONUS

4) Biology – *Short Answer* Identify all of the following three quantities regarding enzyme kinetics that change when an enzyme is in the presence of a competitive inhibitor: 1) V-max; 2) Michaelis constant; 3) Structure of the enzyme-substrate complex.

ANSWER: 2

TOSS-UP

5) Chemistry – *Short Answer* What is the term for the value of a reaction coordinate that is reduced by the addition of a catalyst?

ANSWER: ACTIVATION ENERGY (ACCEPT: DELTA G DOUBLE DAGGER)

BONUS

5) Chemistry – *Short Answer* How many straight-chain structural isomers does C_6H_{12} possess?

ANSWER: 3

TOSS-UP

6) Earth and Space – *Multiple Choice* Sinuous [*SIN-yoo-us*] rilles on the Moon are thought to have been created by which of the following?

- W) Rivers of water
- X) Meteor impacts
- Y) Tectonic activity
- Z) Lava flows

ANSWER: Z) LAVA FLOWS

BONUS

6) Earth and Space – *Short Answer* The faintest objects you can see with your eyes have a magnitude of 6. If a telescope has a diameter 1000 times that of your eye, what is the magnitude of the faintest object you can see with this telescope?

ANSWER: 21

TOSS-UP

7) Energy – *Multiple Choice* Researchers at SLAC National Accelerator Lab are using the LCLS to produce X-rays for molecular imaging. How does the LCLS produce X-rays?

W) By using a solid crystal gain medium to produce photons with all possible phase offsets

X) By using electrons accelerated in a vacuum to produce photons with all possible phase offsets

Y) By using a solid crystal gain medium to produce photons in phase

Z) By using electrons accelerated in a vacuum to produce photons in phase

ANSWER: Z) BY USING ELECTRONS ACCELERATED IN A VACUUM TO PRODUCE PHOTONS IN PHASE

BONUS

7) Energy – *Short Answer* Scientists at Lawrence Berkeley National Lab are part of the CUORE [*kyoo-OR-ay*] experiment, which is studying beta decay. Specifically, they are testing the hypothesis that what particle is its own antiparticle?

ANSWER: NEUTRINO (ACCEPT: ANTINEUTRINO, ELECTRON NEUTRINO, ELECTRON ANTINEUTRINO)

TOSS-UP

8) Math – *Short Answer* What is the largest integer n such that 5 to the n th power divides 21 factorial?

ANSWER: 4

BONUS

8) Math – *Short Answer* Triangle ABC has all angles with integral degree measures, and the measure of angle A equals 12 times the measure of angle B . How many possible degree measures are there for angle C ?

ANSWER: 13

TOSS-UP

9) Physics – *Multiple Choice* Which of the following best describes how the kinetic energy of ejected electrons depends on the frequency and the intensity of light in the photoelectric effect?

W) Increases linearly with intensity, inversely proportional to frequency

X) Increases linearly with frequency, inversely proportional to intensity

Y) Increases linearly with intensity, independent of frequency

Z) Increases linearly with frequency, independent of intensity

ANSWER: Z) INCREASES LINEARLY WITH FREQUENCY,
INDEPENDENT OF INTENSITY

BONUS

9) Physics – *Short Answer* A hydrogen atom has an ionization energy of 13.6 electron volts in its ground state. To the nearest electron volt, what is the energy of the photon produced when an electron transitions from the $N = 2$ level to the $N = 1$ level in a hydrogen atom?

ANSWER: 10

TOSS-UP

10) Biology – *Multiple Choice* Which of the following best describes the direct impact of the founder effect in population evolution?

- W) There is a loss of genetic variability
- X) There is a formation of new species
- Y) There is a build-up of deleterious mutations
- Z) There is a loss of individual fitness

ANSWER: W) THERE IS A LOSS OF GENETIC VARIABILITY

BONUS

10) Biology – *Short Answer* Identify all of the following three plant hormones that would generally result in stem elongation when applied to a plant: 1) Ethylene; 2) Auxins; 3) Gibberellins [*jib-er-ELL-ins*].

ANSWER: ALL (yes, ethylene really is a correct answer)

TOSS-UP

11) Chemistry – *Multiple Choice* In a proton NMR spectrum, a proton associated with which of the following carbon atoms would be predicted to have the largest chemical shift?

- W) Alkyl [*AL-kul*] carbon
- X) Alkenyl [*AL-ken-ill*] carbon
- Y) Carbonyl [*carboh-nil*] carbon
- Z) Aryl [*AIR-il*] carbon

ANSWER: Y) CARBONYL CARBON

BONUS

11) Chemistry – *Short Answer* Rank the following three organic compounds in order of increasing standard heat of formation:

- 1) Nonane [*NO-nayn*]; 2) Hexane; 3) Propane.

ANSWER: 1, 2, 3

TOSS-UP

12) Earth and Space – *Short Answer* Spring tides occur at what two lunar phases?

ANSWER: NEW, FULL (ACCEPT: NEW MOON, FULL MOON, in any order)

BONUS

12) Earth and Space – *Short Answer* Place the following three layers of oceanic crust from deepest to shallowest: 1) Layered gabbro; 2) Pillow lavas; 3) Sheeted dikes.

ANSWER: 1, 3, 2

TOSS-UP

13) Energy – *Short Answer* Scientists at Pacific Northwest National Lab are studying the regeneration of collagen in fish scales. What is the most common amino acid found in collagen?

ANSWER: GLYCINE (ACCEPT: GLY, G)

BONUS

13) Energy – *Short Answer* Scientists at the DIII-D **[D3D]** Facility are using a tokamak **[TOH-kah-mak]** to study what type of reaction?

ANSWER: NUCLEAR FUSION (ACCEPT: FUSION)

TOSS-UP

14) Math – *Short Answer* Identify all of the following three types of figures that must have turn symmetry: 1) Isosceles triangle; 2) Parallelogram; 3) Kite.

ANSWER: 2

BONUS

14) Math – *Short Answer* What is the approximation for the sine of 2 that results from using the first 3 nonzero terms of the Taylor series for sine of x centered at 0?

ANSWER: 14/15

TOSS-UP

15) Physics – *Short Answer* Materials that obey Hooke's Law will return to their original state unless they are stretched beyond a certain limit, which will cause permanent distortion. What is this limit?

ANSWER: ELASTIC LIMIT (ACCEPT: YIELD POINT, YIELD STRENGTH, YIELD STRESS)

BONUS

15) Physics – *Short Answer* Consider a transformer with 100 turns on the primary coil and 300 on the secondary coil. If 50 volts of alternating current is put across the primary and the secondary is connected to a circuit with a resistance of 40 ohms, then, in watts, what is the power in the secondary coil?

ANSWER: 562.5 (ACCEPT: 1125/2, 562 1/2)

TOSS-UP

16) Biology – *Short Answer* H3K9me3 is a commonly-encountered modification that can greatly impact transcription. What type of protein does this modification affect?

ANSWER: HISTONE (ACCEPT: HISTONE H3)

BONUS

16) Biology – *Multiple Choice* Which of the following is NOT a widely-conserved element of the mollusk body plan?

- W) Foot
- X) Visceral mass
- Y) Mantle
- Z) Shell

ANSWER: Z) SHELL

TOSS-UP

17) Chemistry – *Multiple Choice* For calcium, which of the following energy sublevels is closest in energy to the 4s sublevel?

- W) 3s
- X) 3d
- Y) 4p
- Z) 4d

ANSWER: X) 3d

BONUS

17) Chemistry – *Short Answer* A certain reaction has a free energy change of negative 5 kilojoules per mole at 300 kelvins. To two significant figures, what is the equilibrium constant of this reaction at this temperature?

ANSWER: 7.4

TOSS-UP

18) Earth and Space – *Multiple Choice* Which of the following air masses is responsible for causing lake-effect snow in the Great Lakes region?

- W) Maritime tropical
- X) Continental tropical
- Y) Maritime polar
- Z) Continental polar

ANSWER: Z) CONTINENTAL POLAR

BONUS

18) Earth and Space – *Multiple Choice* Which of the following geologic settings is indicative of a transgressive sequence?

- W) Limestone deposited on top of shale
- X) Sand deposited on top of limestone
- Y) Sand deposited on top of shale
- Z) Shale deposited on top of limestone

ANSWER: W) LIMESTONE DEPOSITED ON TOP OF SHALE