

### TOSS-UP

1) EARTH AND SPACE SCIENCE *Short Answer* By name or number, indicate all of the following 3 changes to a sample of gas that would increase the width of its spectral lines:

- 1: increasing the temperature of the gas
- 2: decreasing the density of the gas
- 3: rotating the gas sample rapidly

ANSWER: 1 AND 3

### BONUS

1) EARTH AND SPACE SCIENCE *Short Answer* Indicate, by name or number, all of the following 4 minerals which is/are CORRECTLY paired with its cleavage directions:

- 1: hornblende; 2 directions, not at 90°
- 2: halite; 3 directions, not at 90°
- 3: calcite; 4 directions
- 4: muscovite; 1 direction

ANSWER: 1 AND 4

### TOSS-UP

2) BIOLOGY *Short Answer* By number, indicate all of the following 3 statements that is/are true regarding the differences between a fungus and a plant:

- 1: a fungus is filamentous in its growth, while a plant is made up of several types of cells organized into tissues and organs
- 2: a fungus reproduces sexually with nuclear exchange, while some plants have motile sperm with flagella
- 3: a fungus has cell walls composed of chitin, while a plant has cell walls composed of cellulose

ANSWER: 1, 2, AND 3 (ALL OF THEM)

### BONUS

2) BIOLOGY *Multiple Choice* In which of the following groups of fungi does the fusion of hyphae lead directly to the formation of a zygote, which divides by meiosis when it germinates?

- W) zygomycetes
- X) ascomycetes
- Y) basidiomycetes
- Z) oomycetes

ANSWER: W) ZYGOMYCETES

### TOSS-UP

3) MATHEMATICS *Short Answer* What are the rectangular coordinates of the point whose polar coordinates are given by  $(\sqrt{3}, \pi/6)$

ANSWER:  $(3/2, \sqrt{3}/2)$

### BONUS

3) MATHEMATICS *Short Answer* Give the number of petals for each of the following 4 rose curves:

- 1:  $3\cos 3\theta$
- 2:  $3\cos 4\theta$
- 3:  $2\sin 5\theta$
- 4:  $2\sin 6\theta$

ANSWER: 1: 3, 2: 8, 3: 5, 4: 12

### TOSS-UP

4) PHYSICS *Multiple Choice* Which of the following statements is NOT true about electric field lines?

- W) the tangent of an electric field line at any point is in the direction of the electric field vector at that point
- X) where the magnitude of the field  $E$  is strong, the lines are closer together
- Y) in a uniform field, the lines are straight, parallel, and uniformly placed
- Z) field lines are directed away from negative charges and toward positive charges

ANSWER: Z) FIELD LINES ARE DIRECTED AWAY FROM NEGATIVE CHARGES AND TOWARD POSITIVE CHARGES

### BONUS

4) PHYSICS *Short Answer* A block with a mass of 5.0 kg is resting on a frozen pond a frictionless surface. It is tied to a post set in the ice with a 4.00 m rope. Once pushed, the block revolves uniformly in a circle around the post. If the block makes 15 complete revolutions every minute, what is the force, in newtons, exerted by the rope on the block, leaving your answer in terms of  $\pi$ ?

ANSWER:  $5\pi^2$  N

### TOSS-UP

5) ENERGY *Multiple Choice* Which of the following first-generation biofuels is produced through hydrocracking biological oil feedstocks, such as vegetable oils and animal fats?

- W) green diesel
- X) biodiesel
- Y) bioether
- Z) biogas

ANSWER: W) GREEN DIESEL

### BONUS

5) ENERGY *Short Answer* A  $pV$ -diagram shows a series of thermodynamic processes, which form a rectangle. The point at the bottom left is  $a$ , top left is  $b$ , top right is  $c$ , and bottom right is  $d$ . Point  $a$  has a corresponding volume and pressure, respectively, of 1 L and 100 Pa, and point  $c$  has a corresponding volume and pressure, respectively, of 3 L and 150 Pa. In process  $ab$ , 100 J of heat are added to the system, and in process  $bc$ , 500 J of heat are added to the system. What is  $\Delta U$  for the process  $abd$ ?

ANSWER: 300 J

**TOSS-UP**

6) CHEMISTRY *Multiple Choice* Which of the following choices best describes the steel alloy, formed when carbon atoms fit in the holes in the iron lattice?

- W) homogeneous
- X) heterogeneous
- Y) substitutional
- Z) interstitial

ANSWER: Z) INTERSTITIAL

**BONUS**

6) CHEMISTRY *Short Answer* What is the pH of the solution when 0.10 mol of HCl is added to sufficient water to produce 1.0 L of solution, assuming complete proton transfer by HCl?

ANSWER: 1

**TOSS-UP**

7) EARTH AND SPACE SCIENCE *Multiple Choice* Which of the following choices best describes a situation in which strongly rising air produces low pressure at the surface of the Earth?

- W) thermal low
- X) dynamic low
- Y) thermal high
- Z) dynamic high

ANSWER: X) DYNAMIC LOW

**BONUS**

7) EARTH AND SPACE SCIENCE *Multiple Choice* Which of the following spectral lines is most dominant in stars of the spectral class K?

- W) ionized helium
- X) hydrogen
- Y) ionized calcium
- Z) titanium oxide

ANSWER: Y) IONIZED CALCIUM

**TOSS-UP**

8) BIOLOGY *Short Answer* When epinephrine binds to  $\beta$ -adrenergic receptors on the plasma membranes of liver cells, what molecule acts as a second messenger, which eventually diffuses inside the cytoplasm and activates protein kinase-A?

ANSWER: CYCLIC AMP (cAMP)

**BONUS**

8) BIOLOGY *Multiple Choice* Which of the following major orders of insects best fits the key characteristics described?  
two pairs of wings; front pair of wings is a hard cover that partially protects the transparent rear pair of flying wings; heavily armored exoskeleton; biting and chewing mouthparts; complete metamorphosis

- W) hymenoptera
- X) hemiptera
- Y) coleoptera
- Z) lepidoptera

ANSWER: Y) COLEOPTERA

**TOSS-UP**

9) MATHEMATICS *Short Answer* Find the slope of the normal line to the circle with equation  $x^2 + y^2 = 100$  at the point (6, 8).

ANSWER: 4/3

**BONUS**

9) MATHEMATICS *Short Answer* Evaluate the indefinite integral of  $xe^x dx$ .

ANSWER:  $xe^x - e^x + C$

**TOSS-UP**

10) PHYSICS *Short Answer* Two point charges with charges of +5 C and -5 C, respectively, are separated by a distance of 0.01 m in a uniform electric field with a magnitude of  $6.0 \times 10^6$  N/C that is directed parallel to the plane of the points. What is the magnitude of the electric dipole moment of these point charges?

ANSWER: 0.05 C m

**BONUS**

10) PHYSICS *Short Answer* In a similar scenario, two point charges with charges of +12 C and -12 C, respectively, are separated by a distance of 0.25 m. They reside in a uniform electric field of magnitude  $5.0 \times 10^4$  N/C, directed parallel to the plane of the points. If the direction of the electric dipole moment  $p$  from the negative to positive charge is  $90^\circ$  clockwise from the electric field direction, what is the magnitude of the torque?

ANSWER:  $1.5 \times 10^5$  N m

**TOSS-UP**

11) ENERGY *Short Answer* What is the standard Gibbs free energy of formation of solid aluminum, Al?

ANSWER: 0 J

**BONUS**

11) ENERGY *Short Answer* By name or number, indicate all of the following 3 statements that is/are

TRUE about coal mining:

- 1: after surface mining, the overburden is replaced and the land is reclaimed
- 2: surface mining is more expensive than underground mining
- 3: in longwall mining, large areas of rock are preserved to support the roof and walls of the mine

ANSWER: 1 AND 2

#### TOSS-UP

12) CHEMISTRY *Short Answer* You have three plots to determine the order of a reaction. All three plots have an x-axis of time, but plot A has a y-axis of  $[A]$ , plot B has a y-axis of  $\ln[A]$ , and plot C has a y-axis of  $1/[A]$ . Assuming the slope of each plot is a straight line, by name or number, indicate all of the following 3 choices which have a positive slope of  $k$ :

- 1: plot A
- 2: plot B
- 3: plot C

ANSWER: 3 ONLY

#### BONUS

12) CHEMISTRY *Multiple Choice* Which of the following pairs of isomers is not an example of a structural isomer?

- W) *n*-pentane and isopentane
- X) 1-pentanol and 2-pentanol
- Y) butane and methylpropane
- Z) *cis*-butene and *trans*-butene

ANSWER: Z) *CIS*-BUTENE AND *TRANS*-BUTENE