

### TOSS-UP

1) PHYSICS *Short Answer* Assuming that  $g=10 \text{ m/s}^2$ , what is the speed of a potted plant dropped from 20 m tall ledge just before it hits the ground?

ANSWER: 20 m/s

### BONUS

1) PHYSICS *Short Answer* If the speed of sound in a certain medium is 360m/s, what is the wavelength, in meters, of a sound wave that has a frequency of 60 hertz?

ANSWER: 6

---

### TOSS-UP

2) CHEMISTRY *Multiple Choice* Element X has the electron configuration  $[\text{Kr}] 5s^1$ . Element Y has the electron configuration  $[\text{Xe}] 6s^2 4f^{14} 5d^{10} 6p^4$ . What would be the theoretical chemical formula for the ionic compound comprised of X and Y atoms?

W) XY

X)  $X_2Y$

Y)  $XY_2$

Z)  $X_2Y_2$

ANSWER: X)  $X_2Y$

### BONUS

2) CHEMISTRY *Short Answer* By name or number, rank the following four molecules in order of increasing lattice energy: 1)  $\text{CaCl}_2$  2)  $\text{CaF}_2$  3)  $\text{LiCl}$  4)  $\text{LiF}$

ANSWER: 3, 4, 1, 2

---

### TOSS-UP

3) EARTH AND SPACE *Short Answer* By name or number, order the following three cloud types from earliest to latest in cloud development:

- I. Cumulonimbus
- II. Cumulus Humilis
- III. Cumulus Congestus

ANSWER: II III I

### BONUS

3) EARTH AND SPACE *Multiple Choice* Which of the following combinations of wavelength,  $\lambda$  (*lambda*), and amplitude,  $A$ , of an ocean wave would cause the wave to break?

W)  $A = 1\text{m}$ ,  $\lambda = 9\text{m}$

X)  $A = 1.5\text{m}$ ,  $\lambda = 10\text{m}$

Y)  $A = 2\text{m}$ ,  $\lambda = 20\text{m}$

Z)  $A = 3\text{m}$ ,  $\lambda = 25\text{m}$

ANSWER: X)  $A = 1.5\text{m}$ ,  $\lambda = 10\text{m}$

---

### TOSS-UP

4) MATH *Short Answer* Find the derivative of  $\sec(x)\tan(x)$

ANSWER:  $\sec^3(x) + \sec(x)\tan^2(x)$

### BONUS

4) MATH *Short Answer* Find the derivative of  $x^x$

ANSWER:  $x^x(\ln(x)+1)$  ACCEPT  $x^x\ln(x) + x^x$

---

### TOSS-UP

5) BIOLOGY *Short Answer* Identify all of the following three that are direct functions of the thyroid gland?

I) Stimulate metabolic processes

II) Induces contractions during labor

III) Lowers blood calcium levels

ANSWER: I and III

**BONUS**

5) BIOLOGY *Short Answer* What hormone do the S cells of the duodenum secrete to eventually lead to the release of bicarbonate in the pancreas?

ANSWER: Secretin

---

**TOSS-UP**

6) PHYSICS *Short Answer* Earnest Rutherford used what type of particle to prove the existence of the nucleus in an atom?

ANSWER: Alpha particle

**BONUS**

6) PHYSICS *Short Answer* Jimothy spins a ball with mass 5kg attached to a 2m-long string in a horizontal circle. If the ball is going 16 m/s, what is the tension on the string?

ANSWER: 20 N

---

**TOSS-UP**

7) CHEMISTRY *Short Answer* How many electrons with both a principal quantum number of 5 and an orbital quantum number of 3 are present within a ground state electron configuration atom of lead?

ANSWER: 14

**BONUS**

7) CHEMISTRY *Short Answer* Given that the molar mass of Argon gas is 39.9 g/mol, what is the density of Argon gas at STP to at least two significant figures?

ANSWER: 1.8 g/L (Accept 1.78 g/L)

---

**TOSS-UP**

8) EARTH AND SPACE *Multiple Choice* Which of the following can be used to describe the temperature trend from the center of the Sun to the upper limit of the chromosphere?

W) Increase, then decrease

X) Decrease, then increase

Y) Increase, then decrease, then increase

Z) Decrease, then increase, then decrease

ANSWER: X) Decrease, then increase

**BONUS**

8) EARTH AND SPACE *Short Answer* By name or number, order the following three forms of plagioclase in order of increasing sodium content:

I. Labradorite

II. Bytownite

III. Albite

ANSWER: III I II

---

**TOSS-UP**

9) MATH *Short Answer* What is  $\lim_{x \rightarrow 1} \frac{x-1}{\ln(x)}$  (read as the limit as x approaches one of the fraction with numerator x - 1 and denominator natural log of x)

ANSWER: 1

**BONUS**

9) MATH *Multiple Choice* Find minimum value of  $x^2 + 4y^2$  given that  $x + y = 5$ ;

W) 16

X) 20

Y) 25

Z) 32

ANSWER: X) 20

---

**TOSS-UP**

10) BIOLOGY *Short Answer* Identify all of the following three that are functions of the pons and medulla?

I) Transfer sensory information between the peripheral nervous system and the forebrain

II) Coordinate large scale body movements

III) Monitors motor commands sent by the cerebrum

ANSWER: I and II

**BONUS**

10) BIOLOGY *Short Answer* What are the group of neurons in the hypothalamus that coordinate the circadian rhythm in mammals?

ANSWER: Suprachiasmatic nucleus (ACCEPT: SCN)

---

**TOSS-UP**

11) PHYSICS *Multiple Choice* In terms of  $F$ , by what factor does the electrical force between two charged particles  $q_1$  and  $q_2$  change if their distance is doubled,  $q_1$  is tripled, and  $q_2$  is halved?

W) By a factor of  $\frac{1}{2}F$

X) By a factor of  $\frac{3}{4}F$

Y) By a factor of  $\frac{3}{8}F$

Z) By a factor of  $\frac{1}{4}F$

ANSWER: Y) By a factor of  $\frac{3}{8}F$

**BONUS**

11) PHYSICS *Multiple Choice* Jim and Tim work at the LHC and stumble upon a decay channel where two muons and two antimuons were produced. Which of the following particles could Jim and Tim have found the decay channel for?

W) Higgs boson

X) W plus boson

Y) W minus boson

Z) Z boson

ANSWER: W) Higgs boson

---

### TOSS-UP

12) CHEMISTRY *Short Answer* Out of the 3 following molecules, rank them in order of increasing boiling point. 1) 1-propanol, 2) iso-butane 3) butane

ANSWER: 2, 3, 1

### BONUS

12) CHEMISTRY *Short Answer* Rank the following substances in order of increasing deviation from ideal gas behavior. 1) N<sub>2</sub> 2) SO<sub>2</sub> 3) CO<sub>2</sub> 4) SF<sub>6</sub>

ANSWER: 1, 3, 2, 4

---

### TOSS-UP

13) EARTH AND SPACE *Short Answer* The flat, sediment-laden beds of predominantly red clay that cover up the majority of the ocean floor are known as what?

ANSWER: Abyssal plains

### BONUS

13) EARTH AND SPACE *Multiple Choice* What is the primary difference between mudstone and shale?

W) Mudstone is a sedimentary rock, while shale is metamorphic

X) Mudstone breaks into blocks, while shale splits into flat, thin layers

Y) Mudstone contains sand-sized particles, while shale contains clay-sized particles

Z) Mudstone forms in larger quantities than shale

ANSWER: X) Mudstone breaks into blocks, while shale splits into flat, thin layers

---

### TOSS-UP

14) MATH *Multiple Choice* The graph formed by the equation  $r = 3\cos \theta$  is best described as a:

W) Ray

X) Line

Y) Circle

Z) Hyperbola

ANSWER: Y) circle

### BONUS

14) MATH *Short Answer* Tim is hurt standing on the corner of a 4 by 5 grid. In order to heal himself, he must touch a piece of specular hematite diagonal from him. If Tim can only walk on the lines of the grid, how many ways are there for him to get the magical healing powers of specular hematite?

ANSWER: 126

---

### TOSS-UP

15) BIOLOGY *Short Answer* What is the structure in the forebrain that detects odors in the nasal cavity?

ANSWER: Olfactory Bulbs

### BONUS

15) BIOLOGY *Short Answer* Name all of the following parts of a child or adult brain that develop from the hindbrain in the embryo:

- I. Pons
- II. Cerebrum
- III. Cerebellum
- IV. Medulla Oblongata

ANSWER: I, III, IV (PONS, CEREBELLUM, MEDULLA OBLONGATA)

---

### TOSS-UP

16) PHYSICS *Short Answer* At what fraction of the speed of light to the nearest hundredth does an object have to move to have a lorentz factor of 2?

ANSWER: 87/100

### BONUS

16) PHYSICS *Short Answer* Which principle in General Relativity states that inertial forces and gravitational forces are indistinguishable?

ANSWER: Equivalence Principle

---

### TOSS-UP

17) CHEMISTRY *Multiple Choice* At which of the following conditions do most gases behave like an ideal gas?

- W) Low pressure, Low Temperature
- X) High pressure, High Temperature
- Y) Low pressure, High Temperature
- Z) High pressure, Low Temperature

ANSWER: Y) Low pressure, High Temperature

### BONUS



17) CHEMISTRY *Question Type* Given that the heat of formation for one mole of  $\text{NO}_2(\text{g})$  is +33.9 kJ/mol and that the heat of formation for one mole of  $\text{NO}(\text{g})$  is +90.4 kJ/mol, what is  $\Delta H$  of the synthesis reaction between NO and  $\text{O}_2$  that produces 1 mole of  $\text{NO}_2$ ?

ANSWER: -113 kJ/mol

---

### TOSS-UP

18) EARTH AND SPACE *Short Answer* The rock containing the fossil of Danny the dinosaur is millions of years old. Which of the following radioactive isotopes would NOT be used to date the rock?

W) carbon-14

X) Potassium-40

Y) uranium-235

Z) uranium-238

ANSWER: W) carbon-14

### BONUS

18) EARTH AND SPACE *Multiple Choice* It's Tim's week with the kids. To entertain them, he gives them a form of amphibole to play with. Which of the following forms of amphibole should Tim NOT give his kids to avoid giving them lung cancer with fibrous needles and losing custody?

W) Actinolite

X) Glaucophane

Y) Anthophyllite

Z) Hornblende

ANSWER: W) Actinolite

---

### TOSS-UP

19) MATH *Short Answer* What is the maximum number of points of intersection for two circles and one square?

ANSWER: 10

### BONUS

19) MATH *Short Answer* What is the radius of the circle formed by the parametric equations  $x=3+3\cos t$ ,  $y=4+3\sin t$  for  $0 \leq t < 2\pi$  (when  $t$  is of the range 0 to  $2\pi$ )?

ANSWER: 9

---

### TOSS-UP

20) BIOLOGY *Multiple Choice* During Meiosis, chiasmata form between chromosomes at sites of which process?

W) Separation of Homologs

X) Crossing Over

Y) Independent Assortment

Z) Sister Chromatid Cohesion

ANSWER: X) CROSSING OVER

### BONUS

20) BIOLOGY *Short Answer* Identify all of the following three statements that are typically true for prokaryotes: 1) Circular chromosomes; 2) Long telomeres and telomerase activity; 3) Multiple origins of replication.

ANSWER: 1 ONLY

---

### TOSS-UP

21) PHYSICS *Short Answer* A 0.6 m guitar string has a fundamental frequency of 300 Hz. What is the speed of the standing wave formed by plucking the guitar string in m/s?

ANSWER: 360 m/s

### BONUS

21) PHYSICS *Multiple Choice* Tim is tired of writing the entire round for DOE and places himself in a human cannon facing the ocean. What is the maximum distance that he can launch himself away from land, assuming his launch speed is 40 m/s and that  $g=10 \text{ m/s}^2$ ?

ANSWER: 160 m (depressing)

---

### TOSS-UP

22) CHEMISTRY *Short Answer* Give the flame color tests of the following three elements:

- I. Sulfur
- II. Potassium
- III. Sodium

ANSWER: I Blue II Violet III Yellow

### BONUS

22) CHEMISTRY *Multiple Choice* What is the name of the region in a phase diagram for a mixture of components where the mixture exists as two or more phases?

- W) Miscibility gap
- X) Triple point
- Y) Azeotrope
- Z) Alloy gap

ANSWER: W) Miscibility gap

---

### TOSS-UP

23) EARTH AND SPACE *Short Answer* What are the long, low cliffs produced at vertical displacements along dip-slip faults called?

ANSWER: fault scarps

### BONUS

23) EARTH AND SPACE *Multiple Choice* A certain air mass is rising over the appalachian mountains. Given an environmental lapse rate of 6 C/1000ft and a wet adiabatic lapse rate of 7 C/1000 ft, what type of cloud would be formed by the air mass?

W) Cumulonimbus

X) Cumulus

Y) Stratus

Z) Altocumulus

ANSWER: Y) Stratus

---

### TOSS-UP

24) MATH *Multiple Choice* A frog swims 8 miles downstream in 2 hours. She returns upstream in 4 hours. How fast does the frog swim in still water in miles per hour?

W) 2

X) 3

Y) 4

Z) 6

ANSWER: X) 3

### BONUS

24) MATH *Short Answer* What is the distance between (2, 7) and the graph of  $-3y+x=1$  in simplest radical form?

ANSWER:  $2\sqrt{10}$

---

### TOSS-UP

25) BIOLOGY *Short Answer* What type of cellular junction would provide strong connections between cells and cytoskeleton?

ANSWER: Adherens Junction

**BONUS**

25) BIOLOGY *Short Answer* What epidermal cells attach to sensory neurons and function in sensing touch

ANSWER: Merkel Cells (Accept Merkel Ranvier Cells and Tactile Epithelial Cells)

---