

ROUND 17

TOSS-UP

1) PHYSICS *Multiple Choice* Water flows at 2.0 meters per second through a tube of radius 1 centimeter. The dynamic viscosity of the water is 1.0×10^{-3} pascal seconds. Which of the following best represents the Reynolds number and the nature of the flow, given that the density of water is 1.0×10^3 kilograms per cubic meter?

- W) 40,000; turbulent
- X) 40,000; laminar
- Y) 20,000; turbulent
- Z) 20,000; laminar

ANSWER: W) 40,000; TURBULENT

BONUS

1) PHYSICS *Multiple Choice* A 1000-watt oven is connected to a 240-volt AC power source. Which of the following is nearest the peak voltage across the oven?

- W) 120
- X) 270
- Y) 340
- Z) 370

ANSWER: Y) 340

TOSS-UP

2) ENERGY *Multiple Choice* Which of the following cooking pot materials is most useful for an induction cooktop?

- W) Copper
- X) Cast iron
- Y) Aluminum
- Z) Glass

ANSWER: X) CAST IRON

BONUS

2) ENERGY *Short Answer* What functional unit in coal-based power production efficiently removes particulate matter?

ANSWER: ELECTROSTATIC PRECIPITATOR

TOSS-UP

3) CHEMISTRY *Short Answer* Which approximation is used in quantum mechanics to separate the electronic and vibrational wave functions into isolated components?

ANSWER: BORN-OPPENHEIMER

BONUS

3) CHEMISTRY *Multiple Choice* In which of the following scattering angles is Rayleigh **[RAY-lee]** scattering from unpolarized light the most intense?

- W) 0°
- X) 45°
- Y) 90°
- Z) 180°

ANSWER: Y) 90°

TOSS-UP

4) BIOLOGY *Short Answer* What tree is deciduous **[di-SIJ-oo-uhs]**, dioecious **[dy-EE-shus]**, and has leaves that do not possess a central vein but do have dichotomous **[dy-KOT-uh-muhs]** venation?

ANSWER: GINKGO BILOBA (ACCEPT: GINKGO, MAIDENHAIR)

BONUS

4) BIOLOGY *Multiple Choice* In the Meselson-Stahl experiment, the mechanism for DNA replication was investigated using *Escherichia coli* **[e-schuh-ri-KEE-uh koh-LY]** as a model. *E. coli* was grown in medium with heavy nitrogen until all the DNA was labeled with the heavy isotope. Then, the *E. coli* was transferred to fresh medium with lighter nitrogen and the bacteria replicated once. The DNA was extracted from the bacteria using a density gradient to separate light-nitrogen DNA, heavy-nitrogen DNA, and light/heavy mixed DNA to decide whether replication was conservative or semiconservative. Which of the following results was predicted if replication was conservative?

- W) All the DNA would be light
- X) All of the DNA would be an intermediate density
- Y) Half of the DNA would be light, and half would be heavy
- Z) Half of the DNA would be intermediate, and half would be light

ANSWER: Y) HALF OF THE DNA WOULD BE LIGHT, AND HALF WOULD BE HEAVY

TOSS-UP

5) MATH *Multiple Choice* Which of the following equations represents two intersecting lines?

W) $x^2 + y^2 = 9$

X) $x^2 - y^2 = 9$

Y) $x^2 + 4y^2 = 1$

Z) $x^2 - y^2 = 0$

ANSWER: Z) $x^2 - y^2 = 0$

BONUS

5) MATH *Short Answer* Find the open intervals over which a function whose derivative is $5x^2(x + 5)(x - 3)$ [**5 x squared times open parenthesis x plus 5 close parenthesis times the quantity x minus 3**] is increasing.

ANSWER: $(-\infty, -5)$ AND $(3, \infty)$

TOSS-UP

6) EARTH AND SPACE *Multiple Choice* The helium flash occurs in what stage of stellar evolution?

W) Main sequence

X) Subgiant branch

Y) Asymptotic giant branch

Z) Tip of the red giant branch

ANSWER: Z) TIP OF THE RED GIANT BRANCH

BONUS

6) EARTH AND SPACE *Short Answer* The spectral lines of stars have a finite width. What are the two phenomena responsible for this observation?

ANSWER: DOPPLER EFFECT (ACCEPT: DOPPLER SHIFT OR DOPPLER BROADENING)
AND HEISENBERG UNCERTAINTY PRINCIPLE (ACCEPT: NATURAL BROADENING)

TOSS-UP

7) PHYSICS *Multiple Choice* Which of the following experiments provided evidence in favor of the wave theory of light?

- W) Young's double slit experiment
- X) Michelson-Morley experiment
- Y) Robert Millikan's oil-drop experiment
- Z) Huygens' experiment

ANSWER: W) YOUNG'S DOUBLE SLIT EXPERIMENT

BONUS

7) PHYSICS *Multiple Choice* If bombarding a beryllium target by alpha particles produces a neutron, which of the following must also be produced?

- W) Lithium
- X) Boron
- Y) Carbon
- Z) Nitrogen

ANSWER: Y) CARBON

TOSS-UP

8) CHEMISTRY *Multiple Choice* In a recent experiment, you identified an amino acid at the active site of an enzyme. Given your knowledge that basic amino acids are generally found at enzyme active sites, which of the following is most likely to be the amino acid that you have found?

- W) Histidine [**HIS-ti-deen**]
- X) Aspartate
- Y) Serine [**SER-een**]
- Z) Phenylalanine [**fen-l-AL-uh-neen**]

ANSWER: W) HISTIDINE

BONUS

8) CHEMISTRY *Short Answer* In two-photon fluorescence spectroscopy, it is common to use a molecule that has a very strong two-photon absorption cross-section. What are the names of the highly fluorescent and commonly used molecules that are generally abbreviated CV and GFP?

ANSWER: CRYSTAL VIOLET AND GREEN FLUORESCENT PROTEIN

TOSS-UP

9) BIOLOGY *Short Answer* What is the name of the symbiont that can have crustose, foliose, or fruticose forms?

ANSWER: LICHEN

BONUS

9) BIOLOGY *Multiple Choice* Which of the following types of DNA damage or distortion would be most likely to lead to an insertion or deletion during replication, resulting in a frameshift mutation?

W) Depurination

X) Alkylation [*al-kuh-LAY-shuhn*]

Y) Tautomerization [*taw-TOM-uh-ri-ZAY-shuhn*]

Z) Intercalation

ANSWER: Z) INTERCALATION

TOSS-UP

10) MATH *Short Answer* Evaluate $\tan(\sin^{-1}(-1/2))$ [*tangent of the inverse sine of negative one half*].

ANSWER: $\frac{-\sqrt{3}}{3}$ (DO NOT ACCEPT: $-1/\sqrt{3}$)

BONUS

10) MATH *Short Answer* Evaluate $\int_1^{\infty} \frac{x^2}{(x^3+3)^2} dx$ [*the integral from 1 to infinity of the fraction with numerator x squared and denominator open parenthesis x cubed plus 3 close parenthesis squared dx*].

ANSWER: 1/12

TOSS-UP

11) EARTH AND SPACE *Multiple Choice* What chemical, produced by planktonic algae, is the major source of cloud-condensation nuclei over the open oceans?

- W) Nitric acid
- X) Dimethyl sulphide [**dy-METH-uhl SUHL-fyd**]
- Y) Hydrochloric acid
- Z) Sodium carbonate peroxyhydrate [**puh-rok-see-HY-drayt**]

ANSWER: X) DIMETHYL SULPHIDE

BONUS

11) EARTH AND SPACE *Multiple Choice* The rostral bone evolved to allow for the powerful beak-like bite characteristic of what dinosaur group?

- W) Therapods
- X) Ceratopsians [**ser-uh-TOP-see-uhns**]
- Y) Sauropods [**SAWR-uh-pods**]
- Z) Hadrosaurs [**HAD-ruh-sawrs**]

ANSWER: X) CERATOPSIANS

TOSS-UP

12) PHYSICS *Multiple Choice* Which of the following ways will allow you to increase the capacitance of a parallel-plate capacitor?

- W) Decreasing the plate separation
- X) Increasing the plate separation
- Y) Decreasing the surface area of each plate
- Z) Increasing the charge on the plates

ANSWER: W) DECREASING THE PLATE SEPARATION

BONUS

12) PHYSICS *Multiple Choice* An electron and positron collide and annihilate [**uh-NY-uh-layt**] one another. Which of the following is nearest the energy released, in mega electronvolts?

- W) 0.5
- X) 1
- Y) 2
- Z) 10

ANSWER: X) 1

TOSS-UP

13) ENERGY *Short Answer* What is the electrode material of choice for capacitive deionization of seawater?

ANSWER: CARBON

BONUS

13) ENERGY *Short Answer* Microwave ovens work by creating radiation energy that is absorbed by the water, fats, and sugars in food, which in turn is converted to atomic motion and heat. Providing your answer in scientific notation with one significant figure, if the wavelength of microwave radiation is 10 centimeters, what is the frequency in hertz?

ANSWER: 3×10^9

TOSS-UP

14) CHEMISTRY *Multiple Choice* Iron minerals can be subdivided into different categories based on their gangue [**GANG**] content. Into which of the following categories would you place a mineral that is made up primarily of aluminum oxide?

- W) Basic gangue
- X) Acid gangue
- Y) Autofluxing
- Z) Primary gangue

ANSWER: X) ACID GANGUE

BONUS

14) CHEMISTRY *Short Answer* Which principle of quantum mechanics determines the transition probability for a molecule, based on the overlap of its vibrational states?

ANSWER: FRANK-CONDON

TOSS-UP

15) BIOLOGY *Short Answer* Hemosiderin [**hee-moh-SID-er-in**] is a protein used to store what chemical that can be toxic when free in the cell?

ANSWER: IRON (ACCEPT: IRON-2, FERRITIN)

BONUS

15) BIOLOGY *Short Answer* Consider only the compartments of the chloroplast directly impacted by the proton movement in photosynthesis. If a chemical were to block ATP synthase from being able to transport protons, which compartment would increase in acidity?

ANSWER: THYLAKOID SPACE (ACCEPT: THYLAKOID LUMEN)

TOSS-UP

16) MATH *Multiple Choice* Which of the following is a first order non-linear ordinary differential equation?

W) $y' + y = 0$ [**y prime plus y equals zero**]

X) $y'' - 2y^2 - 2 = 0$ [**y double prime minus 2y squared minus 2 equals zero**]

Y) $y' - xy = 0$ [**y prime minus xy equals zero**]

Z) $y' - 2y^2 - 2 = 0$ [**y prime minus 2y squared minus two equals zero**]

ANSWER: Z) $y' - 2y^2 - 2 = 0$

BONUS

16) MATH *Short Answer* What is the area, in square meters, of a triangle whose sides are of length 10, 12, and 14 meters?

ANSWER: $24\sqrt{6}$

TOSS-UP

17) EARTH AND SPACE *Multiple Choice* Which of the following mechanisms transfers angular momentum in accretion disks?

- W) Viscosity
- X) Gravity
- Y) Advection
- Z) Coriolis forces

ANSWER: W) VISCOSITY

BONUS

17) EARTH AND SPACE *Multiple Choice* The secondary rainbow in a double rainbow requires which of the following optical processes?

- W) One refraction and two internal reflections
- X) One internal reflection and two refractions
- Y) Two internal reflections and two refractions
- Z) Two refractions, one reflection, and surface diffraction

ANSWER: Y) TWO INTERNAL REFLECTIONS AND TWO REFRACTIONS

TOSS-UP

18) BIOLOGY *Multiple Choice* Which of the following marine snails produces a deadly toxin?

- W) Blood ark
- X) Amethyst olive
- Y) Eastern melampus
- Z) Geographic cone

ANSWER: Z) GEOGRAPHIC CONE

BONUS

18) BIOLOGY *Multiple Choice* The toxin from the death cap mushroom is alpha-amanitin. This toxin primarily binds and inhibits RNA polymerase **[POL-uh-muh-rays]** II. Transcription of which of the following types of RNA would be most impacted by poisoning with alpha-amanitin?

- W) siRNA
- X) mRNA
- Y) rRNA
- Z) tRNA

ANSWER: X) mRNA

TOSS-UP

19) PHYSICS *Multiple Choice* The wavelength shift of light from a quasar gives the recessional speed $v \approx 2.18 \times 10^8$ meters per second. If the Hubble constant is 21.8 millimeters per second per light year, what is the approximate distance of the quasar in light years?

- W) 10^8
- X) 10^9
- Y) 10^{10}
- Z) 10^{11}

ANSWER: Y) 10^{10}

BONUS

19) PHYSICS *Multiple Choice* A lady in a spacecraft travelling away from the Earth at $4/5$ the speed of light gives birth to a child at 1:00 p.m., which, according to the spacecraft's clock, is only 3 hours after the spacecraft departed from the Earth. Assuming constant acceleration during those 3 hours, what is the child's birth time according to a stationary clock on the Earth?

- W) 2:00 p.m.
- X) 4:00 p.m.
- Y) 6:00 p.m.
- Z) 7:30 p.m.

ANSWER: W) 2:00 p.m.

TOSS-UP

20) ENERGY *Multiple Choice* The first solid-state quantum process was created at Yale University in 2009. The two qubits, artificial atoms, were made up of a billion atoms acting like a single atom that could occupy two different energy states. The billion atoms were comprised of what element?

- W) Silicon
- X) Aluminum
- Y) Titanium
- Z) Copper

ANSWER: X) ALUMINUM

BONUS

20) ENERGY *Short Answer* Water is the product of four-electron transfer in a polymer electrolyte membrane fuel cell; what is the product of two-electron transfer?

ANSWER: HYDROGEN PEROXIDE (ACCEPT: H_2O_2)

TOSS-UP

21) CHEMISTRY *Multiple Choice* You want to process a fiber polymer whose solvent cannot be melted or evaporated. Which of the following techniques should be used?

- W) Wet spinning
- X) Dry spinning
- Y) Extrusion
- Z) Injection molding

ANSWER: W) WET SPINNING

BONUS

21) CHEMISTRY *Short Answer* Deuteriochloroform [**DOO-ter-uh-KLAWR-uh-fawrm**] is often used as the internal standard in carbon-13 nuclear magnetic resonance spectroscopy. At what chemical shift value in parts per million is the resonance centered?

ANSWER: 77.0 (ACCEPT: 77)

TOSS-UP

22) BIOLOGY *Multiple Choice* Which of the following is NOT in the order Artiodactyla [**art-ee-oh-DAK-tuh-luh**]?

- W) Chevrotain
- X) Warthog
- Y) Giraffe
- Z) Hyrax

ANSWER: Z) HYRAX

BONUS

22) BIOLOGY *Multiple Choice* Which of the following is NOT true of the platypus?

- W) They are one of the few venomous mammals
- X) They lack teats
- Y) Their eggs are holoblastic
- Z) They have ten sex chromosomes

ANSWER: Y) THEIR EGGS ARE HOLOBLASTIC

TOSS-UP

23) MATH *Short Answer* There is a well-shuffled deck of 52 cards containing 13 cards each of spades, clubs, diamonds, and hearts. You draw 2 cards without replacement. What is the probability that both cards are diamonds?

ANSWER: 1/17

BONUS

23) MATH *Short Answer* Given the equation: $x + 1/x = 3$ [***x plus 1 over x equals 3***], what is the value of $x^4 + 1/x^4$ [***x to the fourth plus 1 over x to the fourth***]?

ANSWER: 47

TOSS-UP

24) EARTH AND SPACE *Multiple Choice* Which of the following is the double-degenerate model for Type Ia supernovae [***soo-per-NOH-vee***]?

W) The cores of a binary system undergo common envelope evolution collapse and explode after iron fusion

X) A red giant overflows its Roche [***ROHSH***] lobe and dumps matter onto a white dwarf until the white dwarf exceeds the Chandrasekhar [***chun-druh-SAY-ker***] mass

Y) Two white dwarfs collide to create a new object, which exceeds the Chandrasekhar mass

Z) A main sequence star overflows its Roche lobe and dumps matter onto a white dwarf until the white dwarf exceeds the Chandrasekhar mass

ANSWER: Y) TWO WHITE DWARFS COLLIDE TO CREATE A NEW OBJECT, WHICH EXCEEDS THE CHANDRASEKHAR MASS

BONUS

24) EARTH AND SPACE *Multiple Choice* How is the ratio of oxygen-18 to oxygen-16 useful in serving as a proxy for paleoclimatic [***pay-lee-oh-kly-MAH-tik***] temperatures in ice-core samples?

W) Oxygen-16 is preferentially stored in ice and only released during warmer periods

X) Oxygen-16 changes into oxygen-18 at higher temperatures

Y) Oxygen-18 is released from water molecules at higher temperatures

Z) Water with oxygen-18 freezes at lower temperatures than water with oxygen-16

ANSWER: W) OXYGEN-16 IS PREFERENTIALLY STORED IN ICE AND ONLY RELEASED DURING WARMER PERIODS

TOSS-UP

25) PHYSICS *Multiple Choice* If the magnitude of a magnetic field is multiplied by 4, by what factor is the magnitude of the energy difference ΔE [**delta E**] between electron states

$m_s = \pm \frac{1}{2}$ multiplied?

- W) 4
- X) 2
- Y) 1/2
- Z) 1/4

ANSWER: W) 4

BONUS

25) PHYSICS *Short Answer* During Bragg diffraction, x-rays are shone on a crystal to determine the crystal's structure. Providing your answer in scientific notation, if x-rays with 1 nanometer wavelength are incident on a crystal and the second maximum appears at 30 degrees, what is the lattice spacing, in meters, of the crystal being studied?

ANSWER: 2×10^{-9}