

TOSS-UP

1) PHYSICS *Short Answer* Which 3 flavors of quarks have an electric charge of $+\frac{2}{3}$?

ANSWER: Up, Charm, Top

BONUS

1) PHYSICS *Short Answer* Order the six flavors of quarks in order from least mass to greatest mass.

ANSWER: Up, Down, Strange, Charm, Bottom, Top

TOSS-UP

2) CHEMISTRY *Multiple Choice* In which of the following situations would a chemical reaction be nonspontaneous at low temperatures but spontaneous at high temperatures?

W) Positive ΔH , positive ΔS

X) Positive ΔH , negative ΔS

Y) Negative ΔH , positive ΔS

Z) Negative ΔH , negative ΔS

ANSWER: W) Positive ΔH , positive ΔS

BONUS

2) CHEMISTRY *Short Answer* What was the first artificially created element, which is also a spontaneous fission product of uranium?

ANSWER: Technetium

TOSS-UP

3) EARTH AND SPACE *Multiple Choice* Which of the following is not a criterion for a substance to be classified as a mineral?

W) Definite chemical formula

X) Orderly crystalline structure

Y) Generally inorganic

Z) Naturally occurring or human-made

ANSWER: Z) Naturally occurring or human-made

BONUS

3) EARTH AND SPACE *Short Answer* Name all of the following pairs of igneous minerals with their metamorphosed counterparts that are correctly paired:

- I. Olivine, Serpentine
- II. Dolomite, Tremolite
- III. Quartz, Kyanite

ANSWER: I II

TOSS-UP

4) MATH *Multiple Choice* The range of $\sin^{-1}(x)$ is closest to:

W) $[-2\pi, 2\pi]$ (*open-bracket negative two pi to two pi, closed bracket*)

X) $[-\pi, \pi]$ (*open-bracket negative pi to pi, closed bracket*)

Y) $[-\pi/2, \pi/2]$ (*open-bracket negative pi over two to pi over two, closed bracket*)

Z) $[-\pi/4, \pi/4]$ (*open-bracket negative pi over four to pi over four, closed bracket*)

ANSWER: Y) $[-\pi/2, \pi/2]$

BONUS

4) MATH *Short Answer* Find the value of $\tan(75^\circ)$ in simplest radical form.

ANSWER: $(\sqrt{3} + 3) / (3 - \sqrt{3})$ or $2 + \sqrt{3}$

TOSS-UP

5) BIOLOGY *Multiple Choice* The action of plant hormones, the closer an axillary bud to be more inhibited the closer it is to an active apical bud. This phenomenon is known as:

W) apical meristem

X) apical dominance

Y) apical impulse

Z) apical foramen

ANSWER: X) APICAL DOMINANCE

BONUS

5) BIOLOGY *Short Answer* Identify all of the following 4 plant tissues that are NOT types of primary meristems:

1. Protoderm
2. Procambium
3. Vascular Cambium
4. Ground Meristem

ANSWER: 3. VASCULAR CAMBIUM

TOSS-UP

6) PHYSICS *Short Answer* What is the baryon number of a deuterium nucleus?

ANSWER: +2

BONUS

6) PHYSICS *Short Answer* While studying beta decay, Pauli used which two conservation laws to predict the discovery of neutrinos?

ANSWER: Energy, Momentum

TOSS-UP

7) CHEMISTRY *Short Answer* How many degrees of freedom does a molecule of HCl have?

ANSWER: 6

BONUS

7) CHEMISTRY *Short Answer* How many isomers of hexane exist?

ANSWER: 5

TOSS-UP

8) EARTH AND SPACE *Short Answer* A sinuous ridge of stratified drift formed when sediment-laden water flows through the bottom of a glacier is known as what?

ANSWER: Esker

BONUS

8) EARTH AND SPACE *Short Answer* The period of a binary system with stars A and B is 4 yrs, and the semimajor axis of the ellipse they form is 8 AU. Given that the mass of star A is .75 solar masses, what is the mass of star B?

ANSWER: .25

TOSS-UP

9) MATH *Short Answer* Differentiate $y = x^{(1/n)}$ with respect to x

ANSWER: $dy/dx = x^{((1-n)/n)} / n$

BONUS

9) MATH *Short Answer* Arthur and Sarah is playing a game with an unfair coin that is rigged to come up heads with probability $\frac{2}{5}$ and tails with probability $\frac{3}{5}$. Arthur goes first, they take turns, and the first player to flip heads wins. What is Arthur's probability of winning?

ANSWER: 5/8

TOSS-UP

10) BIOLOGY *Short Answer* When epinephrine binds with the membrane receptor, what is the second messenger produced from adenylyl cyclase that relays the signal to cause glycogen breakdown?

ANSWER: Cyclic AMP

BONUS

10) BIOLOGY *Short Answer* What kinase do the two messengers inositol triphosphate and diacylglycerol stimulate and what ion second messenger is released?

ANSWER: Protein Kinase C and Ca^{2+}

TOSS-UP

11) PHYSICS *Short Answer* Bob is on top of a 20m tall building and is pulling up a 10m long rope. If the density of the rope is 0.5kg/m, how much work does Bob have to do to pull up the rope completely?

ANSWER: 25g

BONUS

11) PHYSICS *Multiple Choice* Which of the following statements is NOT true about leptons?

W) All leptons have a spin of $1/2$

X) All leptons have a charge of -1

Y) No lepton has a mass greater than that of a top quark

Z) Tau neutrinos have a greater mass than that of up quarks

ANSWER: X) All leptons have a charge of -1

TOSS-UP

12) CHEMISTRY *Short Answer* According to Bredt's rule, what is the minimum amount of members in a bicyclic compound for it to be stable?

ANSWER: 9

BONUS

12) CHEMISTRY *Multiple Choice* Which of the following is why the observed van't Hoff's factor for an electrolyte is less than the expected factor

W) Electrolytic Repulsion

X) Coagulation

Y) Complete dissociation

Z) Ion Pairing

ANSWER: Z) Ion Pairing

TOSS-UP

13) EARTH AND SPACE *Short Answer* What type of fracture would result from the tearing of a metal, such as copper?

ANSWER: Hackly

BONUS

13) EARTH AND SPACE *Multiple Choice* In which of the following circumstances would total ocean productivity be the highest

W) Summer in the poles

X) Spring in the midlatitudes

Y) Summer in the tropics

Z) Winter in the tropics

ANSWER: W) Summer in the poles

TOSS-UP

14) MATH *Short Answer* What is the directrix of the parabola with the equation $y=2x^2+8x+6$ as an improper fraction?

ANSWER: $y = -17/8$ (DO NOT ACCEPT: $-17/8$)

BONUS

14) MATH *Short Answer* Evaluate the infinite sum $5/3 + 8/9 + 11/27 + 14/81 + \dots$

ANSWER: $13/6$ (ACCEPT: $1\ 7/6$)

TOSS-UP

15) BIOLOGY *Multiple Choice* In interphase, during which subphase is the DNA polymerase holoenzyme most active?

W) G₀ phase

X) G₁ phase

Y) G₂ phase

Z) S phase

ANSWER: Z) S phase

BONUS

15) BIOLOGY *Multiple Choice* In which of the following groups of organisms does the nuclear envelope remain intact and unserved during cell division?

W) bacteria

X) diatoms and yeasts

Y) dinoflagellates

Z) archaea

ANSWER: X) diatoms and yeasts

TOSS-UP

16) PHYSICS *Multiple Choice* Which of the following orders the 4 fundamental forces from weakest to strongest?

W) Gravity, Weak, Strong, Electromagnetic

X) Weak, Gravity, Electromagnetic, Strong

Y) Gravity, Weak, Electromagnetic, Strong

Z) Gravity, Electromagnetic, Weak, Strong

ANSWER: Y) Gravity, Weak, Electromagnetic, Strong

BONUS

16) PHYSICS *Short Answer* Tim goes outside for the first time and walks 30m south, 8m east, and 24m north in 30 mins. Give, in m/h:

- I. Tim's average speed
- II. Tim's average velocity

ANSWER: I. 124 m/h II. 20 m/h

TOSS-UP

17) CHEMISTRY *Multiple Choice* Which of the following could cause copper to spontaneously reduce?

W) Ag^+

X) Al^{3+}

Y) Fe^{3+}

Z) Fe^{2+} and Al^{3+}

ANSWER: W) Ag^+

BONUS

17) CHEMISTRY *Short Answer* How many sigma and pi bonds respectively are present within one molecule of 2-pentene?

ANSWER: 14 sigma, 1 pi

TOSS-UP

18) EARTH AND SPACE *Multiple Choice* Which of the following is made when molten rock is instantly cooled?

W) Rocks with aphanitic texture

X) Rocks with phaneritic texture

Y) Rocks with porphyritic texture

Z) Rocks with glassy texture

ANSWER: Z) Rocks with glassy texture

BONUS

18) EARTH AND SPACE *Multiple Choice* Tim is planning to go outside for the first time. Before he goes outside, he checks the doppler radar, where he sees an area of heavy precipitation shaped like a hook. What type of cyclone is this hook echo associated with?

W) Hurricane

X) Tornado

Y) Tropical depression

Z) Tropical disturbance

ANSWER: X) Tornado

TOSS-UP

19) MATH *Short Answer* Four fair 6-sided dice are rolled. The sum of the numbers displayed on the dice is 8. What is the probability that 2's were rolled on all four dice?

ANSWER: 1/35

BONUS

19) MATH *Short Answer* Alice and Bob are playing a game with a fair coin. Alice wins if the last three throws were Heads, Heads, Tails. Bob wins if the last three throws were Tails, Heads, Heads. The game stops whenever any of them wins. What is the probability that Bob wins?

ANSWER: 3/4

TOSS-UP

20) BIOLOGY *Short Answer* Name all of the following groups of plants with a dominant sporophyte generation:

1. Bryophytes
2. Seedless Vascular Plants
3. Gymnosperms

ANSWER: 2 AND 3 (SEEDLESS VASCULAR PLANTS AND GYMNOSPERMS)

BONUS

20) BIOLOGY *Multiple Choice* The filamentous outgrowth that anchors various non-vascular plants, such as mosses and liverworts, during the gametophyte stage is known as:

- W) Gametophore
- X) Protonema
- Y) Peristome
- Z) Rhizoid

ANSWER: Z) RHIZOID

TOSS-UP

21) PHYSICS *Short Answer* Which fundamental force is symmetrical in nuclei?

ANSWER: Strong Nuclear

BONUS

21) PHYSICS *Short Answer* Assuming $g = 9.8$, a 5kg block is traveling with a velocity of 19.6 m/s and has a coefficient of kinetic friction of 0.5 with the ground. How many seconds does it take for the block to stop?

ANSWER: 4 seconds

TOSS-UP

22) CHEMISTRY *Short Answer* What law of thermodynamics states that thermal equilibrium is a transitive property?

ANSWER: The Zeroth law of thermodynamics

BONUS

22) CHEMISTRY *Short Answer* Name all of the following 4 processes where latent heat is absorbed: evaporation; condensation; water melts; water freezes

ANSWER: Evaporation, Water melts

TOSS-UP

23) EARTH AND SPACE *Multiple Choice* Which of the following is a bright blue-white star in the summer sky?

W) Vega

X) Rigel

Y) Spica

Z) Sirius

ANSWER: W) Vega

BONUS

23) EARTH AND SPACE *Multiple Choice* Which of the following conditions would result in the formation of a lenticular galaxy?

W) Collision with another galaxy

X) Rapid movement through a gas cloud

Y) Heavy amount of accretion by a supermassive black hole

Z) The presence of large clouds of intermolecular gas

ANSWER: X) Rapid Movement through a gas cloud

TOSS-UP

24) MATH *Multiple Choice* In how many ways can a hexagon be triangulated?

W) 5

X) 6

Y) 9

Z) 14

ANSWER: Z) 14

BONUS

24) MATH *Short Answer* How interior diagonals does an icosahedron have?

ANSWER: 36

TOSS-UP

25) BIOLOGY *Multiple Choice* Sporophylls of angiosperms are called:

W) Carpels and Sepals

X) Sepals and Anthers

Y) Carpels and Stamens

Z) Stamens and Anthers

ANSWER: Y) CARPELS AND STAMENS

BONUS

25) BIOLOGY Short Answer A heterosporous plant species has two types of sporophylls that give rise to the female and male gametophytes, respectively. What are these two types of sporophylls?

ANSWER: MEGASPOROPHYLL AND MICROSPOROPHYLL