**TOSS-UP**

1) CHEMISTRY *Multiple Choice* Which of the following solutions would have the highest normality of solute?

W) 1 M H2SO4

X) 0.5 M H3PO4

Y) 0.5 M H2C2O4

Z) 1 M HCl

ANSWER: X) 0.5 M H3PO4

**BONUS**

1) CHEMISTRY *Short Answer* A titration is done to find the concentration of a sample of phosphoric acid. 20.0 mL of the unknown H3PO4 solution is titrated with 0.1 M NaOH. It takes 5.0 mL of the base to reach the first equivalence point. Given that pKa1 of H3PO4 is 2.1, pKa2 is 7.3 and pKa3 is 12.3, answer the following two questions about this titration, rounding your answers to the nearest tenth.

1. What is the pH at the first equivalence point?
2. What is the pH at the second equivalence point?

ANSWER: 4.7; 9.8

**TOSS-UP**

2) PHYSICS *Multiple Choice* Which of the following quarks has a charge that is not identical to that of the other choices?

W) up

X) top

Y) charm

Z) strange

ANSWER: Z) STRANGE

**BONUS**

2) PHYSICS *Short Answer* By name or number, identify all of the following four statements that are true about quarks.

1. The earliest quark theory included three types of quarks: up, down and strange.
2. One of the earliest pieces of evidence for the quark model was the magnetic moment of the neutron despite its lack of a net charge.
3. Because baryons contain an odd number of quarks, they have a net color.
4. A neutron consists of 1 up quark and 2 anti-up quarks.

ANSWER: 1 AND 2

**TOSS-UP**

3) BIOLOGY *Multiple Choice* In what phase of the cell cycle does DNA synthesis take place?

W) G1 phase

X) S phase

Y) G2 phase

Z) M phase

ANSWER: X) S PHASE

**BONUS**

3) BIOLOGY *Short Answer* If there are 20 centromeres in a cell at metaphase, how many chromosomes are in each daughter cell following cytokinesis?

ANSWER: 20

**TOSS-UP**

4) MATH *Multiple Choice* Which of the following is equivalent to sqroot (3) - i

W) 2 cis (pi/3)

X) cis (-pi/3)

Y) 2 cis (pi/6)

Z) 2 cis (-pi/6)

ANSWER: Z) 2 cis (-pi/6)

**BONUS**

4) MATH *Short Answer* Evaluate the following expression: (2 – 2sqroot3 i) (4 sqroot 2 + 4 sqroot 2 i). Give your answer in polar form.

ANSWER: 32 cis (-pi/12)

**TOSS-UP**

5) EARTH AND SPACE SCIENCE *Short Answer* If the average density of the universe equals critical density, space-time is said to be what?

ANSWER: FLAT

**BONUS**

5) EARTH AND SPACE SCIENCE *Multiple Choice* Which of the following best approximates the critical density of the universe?

W) 9 \* 10^-18 kg/m^3

X) 9 \* 10^-21 kg/m^3

Y) 9 \* 10^-24 kg/m^3

Z) 9 \* 10^-27 kg/m^3

ANSWER: Z) 9 \* 10^-27 kg/m^3

**TOSS-UP**

6) ENERGY *Short Answer* 40 joules of energy are added to a container in the form of heat. At the same time, the system does 20 joules of work against its surroundings. What is the change in internal energy?

ANSWER: + 20 JOULES

**BONUS**

6) ENERGY *Short Answer* By name or number, identify all of the following three functions that will be positive for the vaporization of water at 120 degrees Celsius.

I. entropy

II. enthalpy

III. Gibbs free energy

ANSWER: I AND II

**TOSS-UP**

7) CHEMISTRY *Short Answer* Assuming ideal behavior, what is the value of gamma, the molar heat capacity ratio, for carbon dioxide?

ANSWER: 7/5

**BONUS**

7) CHEMISTRY *Multiple Choice* Which of the following expressions is equivalent to dG, where dG denotes the differential Gibbs free energy?

W) Vdp – SdT

X) Vdp + SdT

Y) -pdV + TdS

Z) -pdV - SdT

ANSWER: W

**TOSS-UP**

8) PHYSICS *Short Answer*  The parallel-axis theorem shows that a rigid body has its lowest moment of inertia about an axis through what point on the object?

ANSWER: CENTER OF MASS

**BONUS**

8) PHYSICS *Short Answer* A solid cylinder, a solid sphere and a hollow cylinder are all rolled down a ramp. Assuming that the radius and mass of each object is the same, order the three objects from the first to arrive at the bottom of the ramp to the last to arrive at the bottom of the ramp.

ANSWER: SOLID SPHERE, SOLID CYLINDER, HOLLOW CYLINDER

**TOSS-UP**

9) BIOLOGY *Short Answer* By name or number, identify which two of the following four proteases are endoproteases.

1. carboxypeptidase

2. aminopeptidase

3. trypsin

4. chymotrypsin

ANSWER: 3 AND 4

**BONUS**

9) BIOLOGY *Short Answer* By name or number, identify all of the following four statements that are true about the digestive system.

1. In the small intestine, endoproteases function before exoproteases.

2. Bile flows into the small intestine from the gallbladder.

3. Bile is used to transport carbohydrates into the epithelial cells.

4. Disaccharides can directly go into the blood stream.

ANSWER: 1 AND 2

**TOSS-UP**

10) MATH *Short Answer* Given that a random variable X can be modeled by a continuous uniform distribution on the closed interval from 4 to 8, what is the probability density function on this interval?

ANSWER: f(X) = 1/4

**BONUS**

10) MATH *Short Answer* Triangle ABC is a right triangle with hypotenuse AC of length 20. Side AB can be represented by a random variable X modeled by a continuous uniform distribution on the closed interval from 14 to 18. What is the probability that side BC will have a length less than or equal to 12?

ANSWER: 1/2

**TOSS-UP**

11) EARTH AND SPACE SCIENCE *Short Answer* What is the name for long, narrow creases in the seafloor that form the deepest parts of the ocean?

ANSWER: DEEP-OCEAN TRENCHES

**BONUS**

11) EARTH AND SPACE SCIENCE *Short Answer* There are only two trenches in the Atlantic Ocean. One of them is the South Sandwich Trench. What is the other?

ANSWER: PUERTO RICO TRENCH

**TOSS-UP**

12) ENERGY *Short Answer* What is the byproduct of hydrogen fuel cells?

ANSWER: WATER

**BONUS**

12) ENERGY *Short Answer* In a hydrogen fuel cell, what gases are used at the anode and cathode, respectively?

ANSWER: HYDROGEN AND OXYGEN

**TOSS-UP**

13) CHEMISTRY *Multiple Choice* Which of the following compounds or ions does not have the same molecular geometry as the other choices?

W) H2O

X) SO2

Y) I3 -

Z) SF2

ANSWER: Y) I3 -

**BONUS**

13) CHEMISTRY *Short Answer*  Let the function f(molecule) = a1 + a2 + a3… an, where the nth term corresponds to the hybridization of the nth carbon atom in the molecule such that the a\_n term represents the number of atomic orbitals needed to make the hybrid orbital on the nth carbon. For example, sp2 hybridization corresponds to 3. Calculate f(2-phenylhexane).

ANSWER: 42

**TOSS-UP**

14) PHYSICS *Multiple Choice* A man fires a rifle. Given that *a* is the magnitude of the momentum right after the shot and *b* is the magnitude of the bullet right after the shot, which of the following is the relationship between *a* and *b*?

W) *a* > *b*

X) *a* < *b*

Y) *a* = *b*

Z) *a* = 2*b*

ANSWER: Y) *a* = *b*

**BONUS**

14) PHYSICS *Short Answer* A 2000 kg truck moving at 25 m/s collides with a stationary 3000 kg truck. After the collision, the trucks stick together. What is the final velocity of the 2000 kg truck?

ANSWER: 10 m/s

**TOSS-UP**

15) BIOLOGY *Short Answer*  What is the collective name for the atrial and ventricular contractions?

ANSWER: SYSTOLE

**BONUS**

15) BIOLOGY *Multiple Choice* When a healthier human being has a slower heart rate, which of the following phases of cardiac cycle takes more time?

W) atrial contraction

X) ventricle contraction

Y) systolic contraction

Z) no contraction

ANSWER: Z) NO CONTRACTION

**TOSS-UP**

16) MATH *Short Answer* If 2^4 \* 3^8 = n \* 6^4, what is the value of n?

ANSWER: 81

**BONUS**

16) MATH *Multiple Choice* Yash, Jack and Sid are the members of a science team that has to respond to a true or false question. Each member independently answers the question. On average, Yash answers the question correctly 80% of the time. Jack answers the question correctly 80% of the time as well. Sid is a biologist and answers the question correctly 50% of the time. The team response is the answer chosen by two or more members of the team. What is the probability that the team response is correct?

W) 64%

X) 72%

Y) 75%

Z) 80%

ANSWER: Z) 80%

**TOSS-UP**

17) EARTH AND SPACE SCIENCE *Multiple Choice* Which of the following statements about thermoclines is TRUE?

W) Thermoclines are only present in ocean water in high latitude regions.

X) Thermoclines are only present in ocean water in low latitude regions.

Y) Thermoclines are present in ocean water in both high latitude and low latitude regions

Z) Ocean water in both high latitude and low latitude regions have an isothermal water column.

ANSWER: X

**BONUS**

17) EARTH AND SPACE SCIENCE *Short Answer* Using the word bank of “increases”, “decreases” and “remains the same”, identify the change in density with increased water depth in

1. Ocean water in low latitude regions
2. Ocean water in high latitude regions

ANSWER: INCREASE; REMAINS THE SAME

**TOSS-UP**

18) ENERGY *Multiple Choice* Which of the following statements is FALSE about hydroelectricity?

W) Hydroelectric plants can be ramped up and down very quickly to adapt to changing demands.

X) Hydroelectric plants have long economic lives, with some still in service after 50-100 years.

Y) Hydroelectric plants produce less carbon dioxide, reducing greenhouse gas emissions.

Z) Hydroelectric plants can be created without disruption to surrounding ecosystems, allowing the environment to survive.

ANSWER: Z

**BONUS**

18) ENERGY *Short Answer* What country is the world’s largest hydroelectric producer?

ANSWER: CHINA

**TOSS-UP**

19) CHEMISTRY *Short Answer* What functional group is characterized by a carbon triple bonded to a nitrogen?

ANSWER: NITRILE

**BONUS**

19) CHEMISTRY *Short Answer* In a lab, a student is given a reactant with its only functional group being a nitrile group. He is first instructed to hydrolyze the nitrile. This forms a compound with functional group A. He is then instructed to add his compound to methanol solution with acidic catalysis. This forms a compound with function group B. What are functional groups A and B?

ANSWER: A 🡪 CARBOXYLIC ACID; B 🡪 ESTER

**TOSS-UP**

20) BIOLOGY *Multiple Choice* Cattle trample and kill small plants surrounding a water hole as they stand near it to drink water. This is an example of which of the following?

W) amensalism

X) commensalism

Y) mutualism

Z) parasitism

ANSWER: W) AMENSALISM

**BONUS**

20) BIOLOGY *Short Answer* By name or number, identify all of the following three statements that correctly explain why patients with sickle cell anemia have difficulty breathing at high altitudes.

I. elongation of the red blood cells reduces surface to volume ratios

II. self-associated hemoglobin proteins have altered cooperative binding affinities

III. soluble oxygen is unable to diffuse through the membrane of sickle cell affected red blood cells

ANSWER: I AND II

**TOSS-UP**

21) PHYSICS *Short Answer* Sprockets A and B of a bicycle are connected with a chain. Sprocket A has 20 teeth while Sprocket B has 50 teeth. Given that the angular speed of Sprocket B is 10 rad/s, what is the angular speed of Sprocket A?

ANSWER: 25 rad/s

**BONUS**

21) PHYSICS *Short Answer* If the angular speed about the center of mass of a wheel is 20 rad/s and the radius of the object is 20 cm, what must be the center of mass velocity in meters per second in order for the wheel to roll without slipping?

ANSWER: 4 m/s

**TOSS-UP**

22) EARTH AND SPACE SCIENCE *Multiple Choice* Which of the following best approximates the normal lapse rate in the troposphere?

W) 2.5 degrees Celsius per kilometer

X) 4.5 degrees Celsius per kilometer

Y) 6.5 degrees Celsius per kilometer

Z) 8.5 degrees Celsius per kilometer

ANSWER: Y) 6.5 degrees Celsius per kilometer

**BONUS**

22) EARTH AND SPACE SCIENCE *Short Answer* The coldest temperatures anywhere in the atmosphere occur at what point?

ANSWER: MESOPAUSE

**TOSS-UP**

23) MATH *Short Answer* What is log base 2 of log base 2 of log base 2 of 16?

ANSWER: 1

**BONUS**

23) MATH *Short Answer* A box contains 4 fair coins and 6 biased coins. Whenever a fair coin is flipped, it comes up heads with probability 0.5. Whenever a biased coin is flipped, it comes up heads with probability 0.8. A coin is randomly chosen from the box and then flipped. What is the probability that it will come up tails? Give your answer to two decimal places.

ANSWER: 0.32

**TOSS-UP**

24) ENERGY *Short Answer* : What industrial process is used to extract sulfur from underground deposits?

ANSWER: FRASCH PROCESS

**BONUS**

24) ENERGY *Short Answer* In the Hall-Heroult process, what mineral is used to lower the melting point of alumina?

ANSWER: CRYOLITE

**TOSS-UP**

25) MATH *Multiple Choice* What is the ratio of the area of a square that circumscribes a circle to the area of a square that inscribes the same circle?

W) sqroot (2)

X) sqroot (3)

Y) 2

Z) sqroot (6)

ANSWER: Y) 2

**BONUS**

25) MATH *Short Answer*  If a + b = 2 and a^2 + b^2 = 5, what is the value of a^3 + b^3?

ANSWER: 11