**TOSS-UP**

1) CHEMISTRY *Multiple Choice* What is the average formal charge on each nitrogen atom in the azide ion?

W) +2/3

X) +1/3

Y) -1/3

Z) -2/3

ANSWER: Y) -1/3

**BONUS**

1) CHEMISTRY *Short Answer* In an experiment for the International Chemistry Olympiad competition, a student must collect a sample of gas above water at standard temperature and pressure. He finds that the amount of gas above water he has collected is significantly lower than is expected. Assuming that the student made no mistakes in running the experiment, identify all of the following four gases that the student could have been collecting.

1. NH3
2. CH4
3. H2
4. SO2

ANSWER: 1 and 4

**TOSS-UP**

2) BIOLOGY *Short Answer* What hypothesis developed by Jean-Baptiste Lamarck states that physiological changes acquired over the life of an organism may be transmitted to offspring?

ANSWER: INHERITANCE OF ACQUIRED CHARACTERISTICS

**BONUS**

2) BIOLOGY *Multiple Choice* In a certain population of 1000 polymorphic birds in which brown is dominant and black is recessive, 910 brown birds are found. They are tested and it is found that 420 of the brown birds are heterozygous. What is the allele frequency of the allele that codes for brown color?

W) 0.3

X) 0.4

Y) 0.6

Z) 0.7

ANSWER: Z) 0.7

**TOSS-UP**

1. 3) PHYSICS *Short Answer* A 1 kg ball is thrown at a wall at a velocity of 5 m/s. The ball remains in contact with the wall for 0.2 seconds and returns at a velocity of 4 m/s. What is the magnitude of the force the wall exerted on the ball?

ANSWER: 45 N

**BONUS**

3) PHYSICS *Short Answer*  By name or number, identify all of the following steps that are part of the Carnot cycle.

I. isothermal compression

II. isothermal expansion

III. adiabatic compression

IV. adiabatic expansion

ANSWER: ALL OF THEM

**TOSS-UP**

4) EARTH AND SPACE SCIENCE *Short Answer* What class of star is primarily characterized by neutral helium lines in its absorption spectrum?

ANSWER: B

**BONUS**

4) EARTH AND SPACE SCIENCE *Multiple Choice* Core collapse is the cause of all types of supernova except for which of the following?

W) 1a

X) 1b

Y) 1c

Z) 2b

ANSWER: W) 1A

**TOSS-UP**

5) MATHEMATICS *Short Answer* Calculate the slope of the line tangent to the graph of e^-2x at x=0.

ANSWER: -2

**BONUS**

5) MATHEMATICS *Short Answer* A jeweler has a 20 gram ring that is 60% gold and 40% silver. He wants to melt it down and add enough gold to make it 80% gold. How many grams of gold must be added?

ANSWER: 20 grams

**TOSS-UP**

6) ENERGY *Multiple Choice* Which of the following is not a state function?

W) heat

X) enthalpy

Y) entropy

Z) Gibbs free energy

ANSWER: W) HEAT

**BONUS**

6) ENERGY *Short Answer* By name or number, identify all of the following three statements that are true for an isothermal process.

I. The change in internal energy is zero.

II. The heat taken in by the system is equal to the negative of the work done by the system.

III. The work done by the system is equal to the change in Helmholtz free energy of the system.

ANSWER: I, II AND III

**TOSS-UP**

7) CHEMISTRY *Multiple Choice* Which of the following acids is NOT diprotic?

W) sulfuric acid

X) oxalic acid

Y) phosphorus acid

Z) hypophosphorus acid

ANSWER: Z) HYPOPHOSPHORUS ACID

**BONUS**

7) CHEMISTRY *Short Answer* By name or number, identify all of the following four statements that are true about the equilibrium for the Haber Process, given that the forward ammonia producing reaction is exothermic.

I. Increasing the volume of the container would produce more ammonia.

II. Increasing the temperature would produce more ammonia.

III. Increasing the pressure in the container would produce more ammonia.

IV. An extraneous reaction that produces more nitrogen gas within the container would produce more ammonia.

ANSWER: III AND IV

**TOSS-UP**

8) BIOLOGY *Multiple Choice*  Which of the following polymers contain nitrogen?

W) starch

1. X) glycogen

Y) cellulose

Z) chitin

ANSWER: Z) CHITIN

**BONUS**

8) BIOLOGY *Short Answer* What is the name of the region in which chromatids remain attached to one another until anaphase?

ANSWER: CENTROMERE

**TOSS-UP**

9) PHYSICS *Short Answer* A ball is dropped from the top of a 320 meter high building. Assuming the acceleration due to gravity can be approximated by 10 m/s^2 and neglecting air resistance, what is the time the ball is in the air?

ANSWER: 8 SECONDS

**BONUS**

9) PHYSICS *Short Answer* By name or number, identify all of the following statements that are true about an object starting from rest and accelerating uniformly.

I. Its kinetic energy is proportional to its displacement.

II. Its displacement is proportional to the square of the elapsed time.

III. Its kinetic energy is proportional to the square of its speed.

IV. Its velocity is proportional to the square of the elapsed time.

ANSWER: I, II AND III

**TOSS-UP**

1. 10) EARTH AND SPACE SCIENCE *Short Answer* By name or number, identify all of the following four statements that are true about faults.
2. I. Normal and reverse faults are types of dip-slip faults.
3. II. Normal faults occur mainly where the crust is being extended, such as a divergent boundary.
4. III. Reverse faults occur mainly where the crust is being shortened, such as a convergent boundary.
5. IV. Reverse faults are associated with the most powerful earthquakes.

ANSWER: ALL OF THEM

**BONUS**

10) EARTH AND SPACE SCIENCE *Short Answer* Developed in the 1970s to succeed the Richter scale, what is the name of the most common scale used to measure the size of earthquakes in terms of energy released?

ANSWER: MOMENT MAGNITUDE SCALE

**TOSS-UP**

11) MATH *Multiple Choice* If log base 7 of x squared is equal to log base 3 of 9, then the absolute value of x is equal to which of the following?

W) 7

X) sqroot 7

Y) 7 raised to 1/4th power

Z) sqroot 2

ANSWER: W) 7

**BONUS**

11) MATH *Multiple Choice* Matt and Hoon are walking around a circular track. It takes Matt 10 minutes and Hoon 6 minutes to complete each lap. They start at the same time and the same point on the track and walk in the same direction on the track. After how many minutes will they meet for the first time after they start walking?

W) 15

X) 30

Y) 42

Z) 60

ANSWER: W) 15

**TOSS-UP**

12) ENERGY *Multiple Choice* What country has the highest installed capacity of geothermal electricity?

W) United States

X) China

Y) Russia

Z) Germany

ANSWER: W) UNITED STATES

**BONUS**

12) ENERGY *Short Answer* What process is the collective name for the set of chemical reactions that convert a mixture of carbon monoxide and hydrogen into liquid hydrocarbons?

ANSWER: FISCHER-TROPSCH PROCESS

**TOSS-UP**

13) CHEMISTRY *Short Answer* What law states that the solubility of a gas in a liquid is directly proportional to the pressure of that gas above that liquid?

ANSWER: HENRY’S LAW

**BONUS**

13) CHEMISTRY *Short Answer*  By name or number, identify all of the following four properties of a liquid that decreases upon addition of a solute.

1. Boiling point
2. Freezing point
3. Osmotic pressure
4. Vapor pressure

ANSWER: II AND IV

**TOSS-UP**

14) BIOLOGY *Multiple Choice* Chloride ion channels include which of the following?

W) gap junctions

X) aquaporins

Y) hydrophilic proteins

Z) carbohydrates

ANSWER: Y) HYDROPHILIC PROTEINS

**BONUS**

14) BIOLOGY *Multiple Choice* Which of the following processes in eukaryotic cells will proceed regardless of the presence of oxygen?

W) electron transport

X) glycolysis

Y) citric acid cyle

Z) oxidative phosphorylation

ANSWER: X) GLYCOLYSIS

**TOSS-UP**

15) PHYSICS *Short Answer*  What is the name of the most efficient thermodynamic cycle whose efficiency cannot be exceeded?

ANSWER: CARNOT CYCLE

**BONUS**

15) PHYSICS *Multiple Choice* At constant temperature, Gibbs free energy is a function of which two variables?

W) internal energy and entropy

X) internal energy and enthalpy

Y) enthalpy and entropy

Z) enthalpy and Helmholtz free energy

ANSWER: Y) ENTHALPY AND ENTROPY

**TOSS-UP**

16) EARTH AND SPACE SCIENCE *Short Answer* What planet in our solar system has the largest revolution period?

ANSWER: NEPTUNE

**BONUS**

16) EARTH AND SPACE SCIENCE *Short Answer* Order the following four elements in a mature star from that found most near the center of the star to that found most near the surface of the star.

1. Iron
2. Carbon
3. Oxygen
4. Hydrogen

ANSWER: 1, 3, 2, 4

**TOSS-UP**

17) MATH *Multiple Choice* Given that log base a of 5 equals x and log base a of 7 equals y, express log base a of sqroot 1.4 in terms of x and y.

W) xy/2

X) (x-2y)/2

Y) (y+x)/2

Z) (y-x)/2

ANSWER: Z) (y-x)/2

**BONUS**

17) MATH *Multiple Choice* Alma wants to mail a package which requires $1.53 in postage and has only 5 cent and 8 cent stamps. What is the smallest number of stamps she can use to total exactly $1.53?

W) 20

X) 21

Y) 23

Z) 24

ANSWER: X) 21

**TOSS-UP**

18) ENERGY *Multiple Choice* Which of the following is an intensive property?

W) mass

X) volume

Y) heat capacity

Z) pressure

ANSWER: Z) PRESSURE

**BONUS**

18) ENERGY *Short Answer* In the cathode of a hydrogen fuel cell, what is the product of the reduction of oxygen?

ANSWER: WATER

**TOSS-UP**

19) CHEMISTRY *Short Answer* What is the average oxygen-oxygen bond order in ozone?

ANSWER: 1.5

**BONUS**

19) CHEMISTRY *Short Answer* The bond order of N2 is 3. Give the bond order for each of the following three species:

1. N2 +

2. N2 –

3. N2 2-

ANSWER: 2.5, 2.5, 2

**TOSS-UP**

20) BIOLOGY *Short Answer*  Colorblindness is a sex-linked recessive characteristic in humans. If a colorblind female is crossed with a normal male, what percentage of the F1 males will be colorblind?

ANSWER: 100%

**BONUS**

20) BIOLOGY *Multiple Choice* In cats, black fur color is caused by an X-linked allele; the other allele at this locus causes orange color. The heterozygote is tortoiseshell. What kinds of offspring would you expect from the cross of a black female and an orange male?

W) Tortoiseshell females; tortoiseshell males

X) Black females; orange males

Y) Orange females; orange males

Z) Tortoiseshell females; black males

ANSWER: Z

**TOSS-UP**

21) PHYSICS *Multiple Choice* Which of the following statements is FALSE about the one-dimensional particle in a box model?

W) The wavefunction is zero at each end of the box.

X) The sum of the wavefunction squared over the length of the box is 1.

Y) The potential energy is zero everywhere in the box.

Z) The energy of the particle is directly proportional to the length of the box.

ANSWER: Z

**BONUS**

21) PHYSICS *Short Answer* Identify all of the following three statements that are true about hydrogen-like atoms.

I. He+, Li 2+ and C 5+ are all hydrogen-like atoms.

II. The energy of the electron in a hydrogen-like atom scales with the square of the atomic number.

III. The energy of the electron is directly proportional to the square of the principal quantum number.

ANSWER: I AND II

**TOSS-UP**

22) EARTH AND SPACE SCIENCE *Multiple Choice* What kind of volcano results from eruptions of mostly small pieces of scoria and pyroclastics?

W) cinder cone

X) composite

Y) shield

Z) supervolcano

ANSWER: W) CINDER CONE

**BONUS**

22) EARTH AND SPACE SCIENCE *Short Answer* What is the name for volcanic regions thought to be fed by an anomalously hot underlying mantle?

ANSWER: HOT SPOT

**TOSS-UP**

23) MATH *Multiple Choice* The sum of the third and fourth terms in a sequence of consecutive integers is 47. The sum of the first five terms of the sequence is which of the following?

W) 72

X) 90

Y) 105

Z) 115

ANSWER: Z) 115

**BONUS**

23) MATH *Multiple Choice* On a test, the passing students had an average of 83, while the failing students had an average of 55. If the overall class average was 76, what percent of the class passed?

W) 45%

X) 55%

Y) 65%

Z) 75%

ANSWER: Z) 75%

**TOSS-UP**

24) BIOLOGY *Short Answer* : How many different combinations of maternal and paternal chromosomes can be packaged in gametes made by an organism with a diploid number of 12?

ANSWER: 24

**BONUS**

24) BIOLOGY *Multiple Choice* In what stage of mitosis are chromosomes usually photographed for use in a karyotype?

W) prophase

X) metaphase

Y) anaphase

Z) telophase

ANSWER: X) METAPHASE

**TOSS-UP**

25) CHEMISTRY *Short Answer*  What is the electron pair geometry of XeF4?

ANSWER: OCTAHEDRAL

**BONUS**

25) CHEMISTRY *Multiple Choice* What is the formal charge of the central atom in ozone?

W) -1

X) 0

Y) +1

1. Z) +2

ANSWER: Y) +1