1. Math toss up multiple choice: How many factors does 210 have?

W) 8

X) 12

Y) 16

Z) 32

2. Math bonus short answer: A is a randomly selected divisor of 210^3. B is a randomly selected divisor of 210^2. Find the probability that A is a factor of 210^2 and B is a factor of 210

Answer: 1/16

3. Earth and Space toss up short answer: For each of the following three, say what model of landscape evolution it represents.

I. A short-lived pulse of rapid uplift

II. An uplift rate which gradually increases and then gradually decreases

III. A moderate but constant uplift rate

Answer: Davis’s, Penck’s Hack’s

4. Earth and Space bonus short answer: What isotope, useful for dating landscape which is less than four million years old, requires the material of quartz.

Answer: Chlorine-36

5. Physics toss up short answer: Two metal balls are each dropped, the first from a height of 45 meters and the second from a height of 65 meters. When the first ball hits the ground, the second is halted with a magnetic field. When the field is turned off and the ball again enters freefall, how long will it take to reach the ground?

Answer: 2 seconds

6. Physics bonus short answer: A ball is thrown into the air with a speed of 50 meters per second. A second later, a second ball is thrown into the air with the same speed. How long will it take for these two balls to collide?

Answer: 9/2 s

7. Biology toss up short answer: Which of the following developmental concepts does the development of C. elegans not illustrate?

W) An inducer’s effect can depend on its concentration gradient

X) The response of an induced cell involves the establishment of a unique pattern of gene activity

Y) The signal-transduction pathways activated by inducers are unique to embryonic cells

Z) Sequential inductions direct the formation of complex structures in the developing embryo

8. Biology bonus short answer: Order the following four steps of Cell signaling and induction from first to last

I. A cell surface protein inducer is synthesized

II. An inducer binds to receptors on the nearest vulval precursor cell.

III. A chemical signal is sent from a nearby cell called the anchor cell

IV. An inducer binds to specific receptors on the two adjacent vulval precursor cells.

Answer: III, II, I, IV

9. Chemistry toss up multiple choice: Which of the following is closest to the fraction of occupied space in a cubic close-packed structure

W) .64

X) .74

Y) .84

Z) .94

Answer: X

10. Chemistry bonus short answer: Predict the likely structure of solid ammonium chloride, assuming that the ammonium ion can be approximated as a sphere with radius 151 pm and the radius of a chlorine ion is 181 pm.

Answer: Cesium Chloride structure

11. Math toss up short answer: Find the sum of the roots of the polynomial

X^3-5x^2+4x-20

Answer: 5

12. Math bonus short answer: Let r, s, and t be the roots of the polynomial

X^3+42x+42

Find (r+s)^2+ (r+t)^2+(s+t)^2

Answer: -84

13. Earth and Space toss up short answer: What is the name for a vein of coarse grained *granite,* crystallized from a water-rich magma in the late stages of solidification. Thbais vein provides ores of many rare elements such as lithium and beryllium, and cuts across a much finer grained country rock.  
Answer: pegmatite

14. Earth and Space bonus: There are two ways that glaciers can flow. In the first, forces within a glacier cause individual ice crystals to slip, and millions of these deform the glacier. In the second, due to high pressure the melting point of the ice at the bottom of the glacier is lowered and it slides along the barrier between the glacier and the ground. Name respectively, these two types of flow.

Answer: Plastic flow Basal slip

15. Physics toss up short answer: A man is walking toward you at a speed of .6 c. If the man’s height is 5 meters, what height will he appear to be while walking toward you.

Answer: 5 meters

16. The same man as in the previous problem shines a flashlight towards you with an initial frequency of 10^14 hertz. What frequency of light will you detect?

Answer: 2\*10^14

17. Biology toss up multiple choice: Which of the following ecosystems has the lowest primary production per square meter

W) A salt marsh

X) An open ocean

Y) A coral reef

Z) A grassland

Answer: X

18. Biology bonus short answer: Coastal water polluted with phosphate and nitrogenous compounds from duck farms showed detectable levels of phosphates but not nitrogen. In experiments, algae were grown in water samples that were controls or enriched with phsohate or ammonium. The greatest algal growth was observed in the nitrogen-enriched samples; phosphate-enriched and control samples both had similar growth. From these results, name all of the following four which one could conclude.

I. Reducting the levels of phosphate in these waters will not help reduce phytoplankton production

II. Adding nitrogen to these waters will help reduce eutrophication

III. The high levels of phosphates in the water is helping to control algal growth

IV. Nitrogen is the limiting nutrient in these waters

Answer: I and IV

19. Chemistry toss up multiple choice: A cold pack used to treat an athletic injury would be an example of what type of system?

W) open

X) closed

Y) isolated

Z) separated

Answer: X

20 Chemistry bonus short answer: To one significant figure, how much work in Joules is done on a gas when it expands by 500 mL against a pressure of 1.2 atm?

Answer: -60 J

21. Math toss up multiple choice: Triangle ABC is isosceles, with angles ABC and ACB are each equal to 72 degrees, and angle BAC equal to 36 degrees. Angle ABC is bisected. Let D be the point of intersection of the bisecting line and line AC. If BC=1, find BD.

Answer: 1

22. Math bonus short answer: Quadrilateral ABCD has AB=15, BC=20, CD=7, and DA=24. Compute BD

Answer: 20

23. Earth and Space toss up short answer: What is the modern explanation of the origin of the planets**,** which proposes that the planets, including Earth, formed in a rotating disk of gas and dust that surrounded the sun as it formed

Answer: Solar Nebula Theory

24. Earth and Space toss up multiple choice: About how many asteroids are more than 100 km in diameter?

W) 20

X) 200

Y) 2000

Z) 20000

Answer: X

25. Physics toss up short answer The electric potential V is a function of the coordinates x, y, and z. If 4 is the partial derivative with respect to x of the potential at a point is 8, the partial derivative with respect to y is 4, and the partial derivative with respect to z is 1, find the magnitude of the electric field at that point.

Answer: 9

26. Physics bonus short answer: Particle p has a charge of -2 coulombs. Particle q has a charge of -5 coulombs. Particle r has a charge of -6 coulombs. If p, q, and r are placed in an equilateral triangle with side length of 4 m, what is the electric potential energy of the system. Express your answer as a fraction in terms of e0 and pi.

Answer: 13/(4pie0)

27. Biology toss up multiple choice: Which of the following is a result of biological magnification?

W) Top-level predators are most harmed by toxic environmental chemicals

X) DDT has spread throughout every ecosystem and is found in almost every organism

Y) The greenhouse effect will be most significant at the poles

Z) Energy is lost at each trophic level of a food chain

Answer: W

28. Biology bonus multiple choice: For each of the following four organisms, give its trophic level:  
I. Cyanobacteria

II) grasshopper

III) eagle

IV) fungi

Answer: primary producer, primary consumer, tertiary consumer, detrivore

29. Chemistry toss up short answer: Name all of the following four which is or are state functions:

I. The work done by a system

II. heat

III. Internal energy

IV. Enthalphy

Answer: III and IV

30. Chemistry bonus short answer: At 25 degrees Celsius, the enthalpy of fusion of Sodium metal is 2.6 kJ/mol and the enthalpy of sublimation is 101 kJ/mol. What is its enthalpy of vaporization to two significant figures?

Answer: 98 kJ/mol

31. 2 coins are tossed. One has probability .4 of landing on heads, the other has probability .6. Find the probability that there will be an even number of heads

32. Two coins are each tossed, then both tossed again and again until both show heads. 1. What is the expected number of throws until this occurs 2. Find the probability that before the throw where we stop there will be at least one set of throws with one head and one tail.

Answer: 4, 2/3

33. Earth and Space toss up short answer: For each of the following three pairs of celestial objects, give which of the two has higher mass

I. Mercury, Earth’s moon

II. Venus, Earth

III. Uranus, Neptune

Answer: 1st, 2nd, 2nd

34. Earth and Space bonus short answer: Name all of the following four statements which is or are true.

I. Earth has less than 200 impact craters

II. Jupiter, Saturn, Uranus, and Neptune contain liquid hydrogen due to the high pressure

III. Saturn would float if put in a big enough bathtub

IV. All four Jovian planets have ring systems.

Answer: I, III, and IV

35. Physics toss up multiple choice: Which of the following is not true about collisions?

W) The speeds of the two objects after the collision are deterministic

X) In an elastic collision between objects with the same mass, all energy will be transferred from the object with greater initial speed to the object with lesser initial speed.

Y) In an inelastic collision, energy is lost in the form of heat

Z)After collision both particles cannot be moving in the same direction as before.

Answer: X

36. Physics bonus short answer: 5 balls are moving to the right and 8 balls are moving to the left along the x axis, all having a speed on 1 meter per second. Currently, the balls moving to the right are to the left of the y-axis with the rightmost ball at (-1/2,0), the balls moving to the left are to the right of the y-axis with the rightmost one at (1/2,0), and balls are spaced out by a distance of 1 meter. After many collisions, some number of the 13 balls will be going to the left, and some will be going to the right. How many will be going in each direction?

Answer: 5 to the right, 8 to the left

37. Biology toss up short answer: In a mark-recapture study of a lake trout population, 40 fish were captured, marked, and released. In a second capture, 45 fish were capture, 9 of these were marked. What is the estimated number of individuals in the lake trout population?

Answer: 200

38. Biology bonus short answer: Name all of the following four which is or are true about how (K-N)/K in a logistic model for population growth influences dN/dT

I. The increase in population numbers is greatest when N is small

II. As N approaches K, r, the intrinsic rate of increase, becomes smaller

III. When N=K, population growth is zero

IV. If K is large, the populations begins growing exponentially

Answer: III and IV

39. Chemistry toss up multiple choice: Which of the following has the highest magnitude of enthalpy of combustion?

W) carbon

X) octane

Y) methane

Z) ethanol

Answer: X

40. Chemistry bonus short answer: The lattice enthalpy of a solid cannot be measured directly. However, we can obtain it indirectly by combining other measurements in an application of what law?

Answer: Hess’s

41. Math toss up multiple choice: Complex number a=1+i. If a\*b is a positive integer, which of the following could equal b?

W) -1+i

X) –1-i

Y) 1-i

Z) 1+i

Answer: Y

42. Math bonus short answer: 5 times in a row, a complex number is selected at random from the set {(-1+isqrt3)/2, (-1-isqrt3)/2} and multiplied by a, where a’s starting value is 1. Find the probability that after a is multiplied by each of the five numbers, a=1.

Answer: 5/16

43. What is the classification for galaxies with an obvious disk and nuclear bulge but no visible gas or dust and no few or no hot bright stars?

Answer: S0

44. An elliptical galaxy with a major axis of 20000 light years and a minor axis of 8000 light years would be classified what with numerical index?

Answer: (E)6

45. Physics toss up short answer: Under relativity, the Galilean coordinate transformation is no longer valid. What transformation must be used instead?

Answer: Lorentz Transformation

46. A spaceship moving away from the earth with speed .9 c fires a robot space probe in the same direction as its motion, with speed .7 relative to the spaceship. What is the probe’s velocity relative to the earth, in terms of c to 2 significant figures?

Answer: .98 c  
47. Biology toss up multiple choice: What inequality, which states that rB>C, implies that natural selection would favor altruistic acts when the benefit to the receiver, reduced by the coefficient of relatedness, exceeds the cost to the altruist?

Answer: Hamilton’s rule

48. Biology bonus short answer: A honeybee returning to the hive from a food source performs a waggle dance with the run oriented straight to the left on the vertical surface. Most likely, this means food is located

W) 90 degrees left of the line from the hive to the sun

X) In the opposite direction, straight to the right of the hive

Y) Above the hive and slightly to the left

Z)In the opposite direction and very close to the hive

Answer: W

49. Chemistry toss up multiple choice: Which of the following is closest to the change in entropy when 100 J of energy is transferred reversibly to a large flask of water at 57 degrees Celsius.

W) .1 J/K

X) .2 J/K

Y) .3 J/K

Z) .4 J/K

Answer: Y

50. A liquid with a molar heat capacity of 42 J/molK is heated from -173.1500000 degrees Celsius to -1.3228172 degrees Celsius. What is the change of entropy of the liquid.

Answer: 42