[Note: A ten-question (questions 99 through 108) matching table occurs on page 21. Since it might be managed more quickly, you may wish to deal with it early.]

Multiple Choice

On your NCS answer sheet, fill in the circle of the letter choice that best completes the statement or answers the corresponding question.

1. Pat and Chris both travel from Los Angeles to New York along the same route. Pat rides a bicycle while Chris drives a fancy sports car. Unfortunately, Chris's car breaks down in Phoenix for over a week, causing the two to arrive in New York at exactly the same time. Which statement is true?
a. Pat and Chris had the same average speed.
b. Chris had the higher average speed.
c. Pat had the higher average speed.
d. Their average speeds cannot be compared.
e. None of the above.

2. If we ignore air resistance, the acceleration of an object that is falling downward is constant. How would the acceleration change if we do *not* ignore air resistance? As the object falls,
a. The acceleration increases steadily.
b. The acceleration increases more and more rapidly
c. The acceleration does not change.
d. The acceleration decreases steadily.
e. The acceleration decreases more and more rapidly
f. The acceleration decreases more and more slowly
g. Not enough information to say.

3. If the mass and weight of an astronaut are measured on the earth and on the moon, the masses will be found to be _____ and the weights, _____
a. the same ... the same
b. different ... different
c. the same ... different
d. different ... the same
e. None of the above.

4. Given that the circumference of the moon's orbit is 4.0×10^4 km, which calculation shows the correct conversion of a speed of 1 orbit per 28.3 days to the same speed in meters per sec?
a. (1orbit/28.3day)(4.0X10^{4}km/orbit)(1day/24hr)(3600sec/1hr)(10^{3}m/1km)
b. (1orbit/28.3day) (4.0X10^{4}km/orbit)(24hr/1day)(1hr/3600sec)(1km/10^{3}m)
c. (1orbit/28.3day) (1orbit/4.0X10^{4}km)(1day/24hr)(1hr/3600sec)(10^{3}m/1km)
d. (1orbit/28.3day) (4.0X10^{4}km/orbit)(1day/24hr)(1hr/3600sec)(10^{3}m/1km)
e. (1orbit/28.3day) (4.0X10^{4}km/orbit)(1day/24hr)(1hr/3600sec)(1km/10^{3}m)

5. If a car requires 30 seconds to accelerate from zero to 90 km per hour, its average acceleration is, most nearly,
a. 800 m/ sec^2
b. 80 m/ sec^2
c. 8 m/sec^2
d. 0.8 m/sec^2
e. 0.08 m/sec^2

6. If a ball is dropped from rest, it will fall 20 m during the first two seconds. How far will it fall during the third and fourth seconds?
a. 20 m
b. 30 m
c. 40 m
d. 50 m
e. 60 m

7. A ball is thrown straight up into the air with an unspecified velocity. If we do not ignore air resistance, the acceleration of the ball as it is traveling upward has a magnitude
a. equal to 9.8 m/s^2.
b. greater than 9.8 m/s^2.
c. less than 9.8 m/s^2.
d. zero.
e. None of the above, because the acceleration depends upon the speed.

8. A car traveling westward at 20 m/s turns around and travels eastward at 13 m/s. If this takes place in 7 s, what is the average acceleration of the car?
a. 1 m/s^2 west
b. 4.7 m/s^2 west
c. 7 m/s^2 west
d. 7 m/s^2 east
e. None of the above.

9. You decide to launch a ball vertically so that a friend located 101 m above you can catch it. What is the minimum launch speed you can use?
a. 4.5 m/s
b. 150 m/s
c. 30 m/s
d. 45 m/s
e 90 m/s

10. If an object moves in a straight line with a constant speed, we can conclude that
a. the object has inertia.
b. there are no forces acting on the object.
c. there must be at least two forces acting on the object.
d. there can be no more than two forces acting on the object.
e. None of the above.

11. A subway train is moving with constant velocity along a level section of track. The net force on the first subway car is _____ the net force on the last subway car.
a. Finite, but equal and opposite to
b. much greater than
c. slightly greater than
d. less than
e. None of the above.

12. A ball with a weight of 20 N is thrown vertically upward. What is the acceleration of the ball just as it reaches the top of its path?
a. zero
b. 10 m/s^2 downward
c. 10 m/s^2 upward
d. 20 m/s^2 downward
e. 20 m/s^2 upward

13. A parachutist reaches terminal speed when
a. her weight goes to zero.
b. the force of air resistance exceeds her weight.
c. the force of air resistance equals her weight.
d. the force of air resistance equals her mass.
e. only when she spreads our her limbs to increase the air resistance.

14. You apply a 75-N force to pull a child's wagon across the floor at a constant speed of 0.5 m/s. If you increase your pull to 90 N, the wagon will
a. continue to move at 0.5 m/s.
b. speed up immediately and then move at the faster constant speed of 0.6 m/s.
c. speed up gradually until it reaches the speed of 0.6 m/s and then move at tthat constant speed.
d. continue to speed up as long as you keep pulling.
e do none of the above.

15. A book sits at rest on a table. Which force does Newton's third law tell us is equal and opposite to the gravitational force acting on the book?
a. the normal force by the table on the book
b. the normal force by the book on the table
c. the gravitational force by the book on the Earth
d. the net force on the book
e. None of the above.

16. A migrating bird is initially flying south at 6 m/s. To avoid hitting a high-rise building, the bird veers and changes its velocity to 8 m/s east over a period of 2 s. What is the magnitude of the bird's average acceleration during this 2-s interval?
a. 1 m/s^2
b. 3 m/s^2
c. 4 m/s^2
d. 5 m/s^2
e. None of the above is within 10% of the correct answer.

17. A red ball is thrown straight down from the edge of a tall cliff with a speed of 40 m/s. At the same time a green ball is thrown straight up with the same speed. If the green ball travels up, stops, and then drops to the bottom of the cliff, how many seconds later than the red ball does the green ball arrive at the bottom of the cliff?
a. 1 second
b. 2 seconds
c. 4 seconds
d. 8 seconds
e. Because the height of the cliff is unspecified, there is not enough information to say.

Scenario 18
A gun is held horizontally and fired. At the same time the bullet leaves the gun's barrel an identical bullet is dropped from the same height. Neglect air resistance.

18. Refer to **Scenario 18** above. Which bullet will hit the ground with the greatest velocity?
a. The bullet that was fired, because it feels the force of gravity over a longer distance.
b. The bullet that was dropped, because it falls for a longer time
c. It will be a tie, because the acceleration of gravity is the same for both.
d. The bullet that was fired.
e. The bullet that was dropped.

19. You are applying a 400-newton force to a freezer full of chocolate chip ice cream in an attempt to move it across the basement, but it will not budge. The weight of the freezer (including ice cream) is 1000 N, and $\mu = 0.6$. The frictional force exerted by the floor on the freezer is
a. 400 N
b. greater than 400 N but less than 600 N
c. greater than 600 N but less than 1000 N
d. 600 N
e. 1000 N.

20. A ball with a weight of 20 N is thrown vertically upward. What are the size and direction of the force on the ball just as it reaches the top of its path?
a. zero
b. 10 N upward
c. 10 N downward
d. 20 N upward
e. None of the above.

21. You leap from a bridge with a bungee cord tied around your ankles. As you approach the river below, the bungee cord begins to stretch and you begin to slow down. The force of the cord on your ankles to slow you is _____ your weight and is _____.
a. less than.....increasing
b. equal to.....exactly
c. greater than.....decreasing
d. Less than.....decreasing
e None of the above statements is true.

22. A car initially traveling westward at 16 m/s has a constant acceleration of 4 m/s^2 eastward. How far has the car traveled after 16 s?
a. 768 m
b. 512 m
c. 256 m
d. 0 m
e. None of the above is within 10% of the correct answer.

23. What is the acceleration due to earth's gravity at a distance of 10 earth radii from the earth's center?
a. 10 m/s/s
b. 1 m/s/s
c. 0.01 m/s/s
d. 0.001 m/s/s
e. None of the above

24. Mercury has a radius of about 0.38 Earth radii and a mass of only 0.055 Earth masses. Estimate the acceleration due to gravity on Mercury.
a. 1.45 m/s^2
b. 3.81 m/s^2
c. 26.3 m/s^2
d. 69.1 m/s^2
e. None of the above is within 10% of the correct answer.

25. Two objects have different masses but the same kinetic energies. If you stop them with the same retarding force, which one will stop in the shorter distance?
a. the heavier one, because it has a larger inertia.
b. the lighter one, because it has less momentum.
c the lighter one, because it requires less impulse to stop
d. both stop in the same distance, because of the work energy theorem.
e. both stop in the same distance because of the impulse/momentum theorem
f. None of the above is completely true.

26. Two objects have different masses but the same momenta. If you stop them with the same retarding force, which one will stop in the shorter distance?
a. the heavier one, because it is moving slower than the lighter one
b. the lighter one, because it wil stop faster
c. both stop in the same distance because of the impulse/momentum theorem.
d. both stop in the same distance, because of the work energy theorem.
e. None of the above is completely true.

27. A tennis ball on the end of a string travels in a horizontal circle at a constant speed. The circle has a circumference of 2 m, the ball has a speed of 3 m/s, and the centripetal force is 1.5 N. How much work is done on the ball each time it goes around?
a. zero
b. 3 J
c. 4.5 J
d. 6 J
e. 13.5 J
f. None of the above is within 10% of the correct answer.

28. A 1-kg ball falling freely through a distance of one meter loses 10 J of gravitational potential energy. How much does the kinetic energy of the ball change if this occurs in a vacuum?
a. gain of 1 J
b. gain of 10 J
c. loss of 1 J
d. loss of 10 J
e. None of the above

29. Under what conditions is the kinetic energy (KE) conserved, in the strict sense of the word, during a collision?
a. It is always conserved.
b. When the collision is totally elastic.
c. When there is no net outside force.
d. When there is no friction.
e. KE is never conserved during a collision because its value does not remain constant.

30. The numerical value of G, the gravitational constant, was determined
a. from knowledge of the earth's mass density and volume
b. from the law of universal gravitation and the value of the acceleration due to gravity.
c. from the value of the moon's acceleration.
d. by measuring the force between masses in the laboratory.
e. From a very precise knowledge of the mass of the earth.

31. The law of universal gravitation is written $F = GMm/r^2$, but we used the form $F = mg$ when we studied projectile motion. Which of the following arguments validates this?
a. The first form is not valid for projectile motion.
b. The first form does not work because it requires two masses.
c. The first form is not valid near the surface of the earth.
d. The second form is simpler and therefore preferable to the first.
e. None of the above is a valid and true reason for using the second form.

32. A 300-kg satellite experiences a gravitational force of 1200 N. What is the radius of the satellite's orbit? (R_E = Earth's Radius)
a. 0.4 R_E
b. 0.58 R_E
c. 1.5 R_E
d. 1.58 R_E
e. 2.5 R_E

33. You have a mass of 70 kg. How fast (in mph) would you have to run to have the same momentum as an 18-wheeler (m = 20,000 kg) rolling along at 1 mph? (1 mi = 1609 m.)
a. 8.9×10^5 m/s
b. 4.6×10^5 m/s
c. 7.8×10^3 m/s
d. 2.9×10^2 m/s
e. 1.3×10^2 m/s
f. None of the above answers is within 10 % of the correct result.

34. Air bags are used by stunt people when they fall off buildings to reduce the that occurs during the collision.
a. change in momentum
b. work
c. impulse
d. change in velocity
e. force
f. None of the above.

35. A very hard rubber ball (m = 0.6 kg) is falling vertically at 10 m/s just before it bounces on the floor. The ball rebounds back at essentially the same speed. If the collision with the floor lasts 0.03 s, what is the average force exerted by the floor on the ball?
a. 20 N
b. 90 N
c. 200 N
d. 400 N
e. None of the above is within 10% of the correct answer.

36. When a star undergoes a supernova explosion, the total linear momentum of the star
a. increases suddenly
b. increases in the outward direction
c. decreases rapidly at first and then more slowly as the star expands.
d. decreases at a nearly uniform rate once the explosion has occurred.
e. There is not enough information to say.
f. None of the above is correct.

37. A 800-kg frictionless roller coaster starts from rest at a height of 20 m. What is its kinetic energy when it goes over the top of a hill that is 15 m high?
a. 4000 J
b. 12,000 J
c. 40,000 J
d. 120,000 J
e. None of the above answers is within 10% of the correct result.

38. How much energy is required to light a 60-W bulb for 4 h? (1 W = 1 Joule/sec)
a. 8.6×10^5 J
b. 1.4×10^4 J
c. 8.6×10^3 J
d. 2.4×10^2 J
e. None of the above answers is within 10% of the correct result.

39. A ball is thrown horizontally at 30 m/s from a flatcar that is moving in a straight line at 40 m/s. Relative to a person on the ground, what is the horizontal speed of the ball when it is thrown directly sideways?
a. 10 m/s
b. 30 m/s
c. 40 m/s
d. 50 m/s
e. 70 m/s
f. None of the above.

40. A person who weighs 600 N when at rest is riding in the rotating cylinder ride. The cylinder rotates fast enough to create an 800-N centrifugal force outward in the horizontal direction. What is the magnitude of the person's "weight" (i.e.,the combination of the gravity force and the inertial pseudo-force) in the rotating reference frame, most nearly?

a. 600 N
b. 800 N
c. 1200 N
d. 1400 N
e. 1600 N
f. None of the above answers is within 10% of the correct result.

41. If Newton had attempted to launch his apple horizontally in order to make it travel in a circle around the Earth, what horizontal speed would it have to have to stay at the same small height above the earth's (presumed smooth for the present discussion) surface? (Take the radius of the earth to be $6.4X10^6$ m)

a. $6X10^2$ m/s
b. $8X10^3$ m/s
c. $6X10^4$ m/s
d. $8X\ 10^5$ m/s
e. $6X\ 10^6$ m/s
f. None of the above is within 10% of the correct answer.

42. A 160-kg satellite orbits a distant planet with a radius of 4000 km and a period of 280 min. From the radius and period, you calculate the satellite's acceleration to be 0.56 m/s^2. What is the gravitational force on the satellite, most nearly?

a. 50.4 N
b. 90 N
c. 720 N
d. 12,000 N
e. None of the above is within 10% of the correct value.

43. According to the special theory of relativity, all laws of nature are the same in reference systems which _____ relative to an inertial system.

a. have a constant acceleration
b. move at a constant velocity
c. move in ellipses
d. move in circles at a constant speed
e. None of the above

44. In his theory of special relativity, Einstein
a. abandoned the Galilean principle of relativity.
b. abandoned Maxwell's equations for electricity and magnetism.
c. reconciled the apparent conflict between the Galilean principle of relativity and Maxwell's equations.
d. postulated the existence of an absolute reference system.
e. postulated that the speed of light is constant in vacuum, and the same in all inertial frames.
f. All of the above completions yield true statements.
g. None of the above.

45. The second postulate of special relativity does NOT require that the speed of light
a. is a constant in a vacuum and equal to c.
b. is independent of the motion of the receiver.
c. is independent of the motion of the source.
d. is independent of the direction of propagation
e. In fact, the second postulate requires all of the above.

46. As a friend passed you at a very high speed, she reported that she simultaneously exploded a firecracker at each end of her skateboard. Which one exploded first from your point of view?
a. the one at the front
b. the one at the back
c. They exploded simultaneously.
d. The answer depends on the speed of the skateboard.
e. None of the above is a correct answer to the question.

47. If inertial mass and gravitational mass were NOT the same,
a. the law of universal gravitation would need to be modified.
b. Newton's second law would need to be modified.
c. objects with different masses falling in a vacuum near the earth's surface would no longer experience the same acceleration.
d. objects falling in a vacuum near the earth's would no longer experience a force proportional to their gravitational mass.
e. All of the above statements are true.

48. Superman wants to travel back to his native Krypton for a visit, a distance of $3X10^{13}$ meters. (At nearly the speed of light, it takes light nearly 10^5 seconds to travel this distance.) If Superman is able to hold his breath for 10^3 s and travel at any speed less than that of light, can he make it before he suffocates?
a. Not unless he stops off for a breath on his way.
b. Not unless he goes faster than light.
c. No way.
d. Yes, because in his frame his biological clock slows down to give him more time
e. Yes because in his frame of reference the distance is contracted to a much smaller value.

49. In the twin paradox one twin remains on earth while the other makes a trip to a distant location and back at the same constant speed, close top c. Each argues that his brother will have aged less than he. When the twins are reunited on earth, which of their claims will prove to be valid? The valid claim is that of
a. the twin who remained on earth, because he did not undergo any acceleration.
b. the twin who made the trip, because he had to accelerate to turn around.
c. Actually, neither: they are the same age, because the speed was held constant out and back.
d. The answer depends upon the details of the turnaround.
e. None of the above statements is true.

50. If you approach a light beacon while traveling at one-half the speed of light (0.5c), you will measure the speed of light from the beacon to be
a. 0.5c
b. 0.7c
c. c
d. 1.5c
e. None of the above is within 10% of the correct answer.

51. A ham sandwich consists of one slice of ham (5 g) and two slices of bread (10 g each). You have 1 kg of ham and 1 kg of bread. You make as many sandwiches as you can. What is the mass of the sandwiches, most nearly?
a. 0.75 kg
b. 1.00 kg
c. 1.25 kg
d. 2.00 kg
e. None of the above is within 10% of the correct answer.

52. Joule's experiments with hanging weights turning paddle wheels in water
a. showed that the same amount of work always generated the same amount of heat.
b. showed that heat was not a fluid.
c. were used to define the calorie.
d. showed that heat could be converted 100% to mechanical energy.
e. All of the above.
f. None of the above.

53. Which of the following is NOT assumed in our model of the ideal gas? The gas molecules
a. rebound elastically when they collide with the container wall.
b. have no internal structure.
c. are indestructible.
d. do not interact except when they collide.
e. May sometimes break up into their separate atoms
f. All of the above are properties of our ideal gas.

54. The first law of thermodynamics
a. is a restatement of the law of conservation of energy which includes heat as energy
b. allows that internal energy can be completely converted into work.
c. treats mass as another form of energy.
d. guarantees that the work extracted by a cyclic heat engine can never be less than the heat inserted.
e. All of the above statements are true of the first law.

55. A hypothetical balloon filled with an ideal gas has a volume of 10^5 liters at 27°C under one atmosphere of pressure. At what temperature, most nearly, will its volume be 10^4 liters under one atmosphere of pressure?
a. -273°C
b. -243°C
c. -203°C
d. -163°C
e. -123°C

56. Two objects are in thermal equilibrium if
a. they have the same temperature.
b. they are each in thermal equilibrium with the same third object.
c. they are in thermal contact and there is no net flow of thermal energy.
d. any one of the above statements is true.
e. None of the above.

57. Climates near the coasts tend to be more moderate than in the middle of the continent
a. Because water has a relatively high specific heat.
b. Because water has a high latent heat of vaporization.
c. Because the coasts have lower elevations.
d. Because it rains a lot on the coasts.
e. Because breezes blow downhill fro the mountains.
f. None of the above: coastal climates are not always more moderate than those inland.

58. Aluminum and air have almost the same value (0.2cal/gm-deg C) for their specific heats. Therefore, 100 calories of heat will raise the temperature of 1 liter of aluminum _____ 1 liter of air. (Assume T = 20°C, and P = 1 atm.)
a. much more than
b. slightly more than
c. about the same as
d. slightly less than
e. much less than

59. Two liters of an ideal gas is heated from 300 K to 1250 K while the pressure is maintained at 1 atm. What is the final volume of the gas, most nearly?
a. 16 liters
b. 8 liters
c. 4 liters
d. 2 liters
e. 1 liter
f. None of the above is within 10% of the correct answer.

60. What would happen to a pot of water on a hot stove if the latent heat of vaporization required for converting water to steam were equal to zero?
a. The water would not boil.
b. The water would boil at a higher temperature.
c. The water would all turn to steam very rapidly.
d. The water would not form steam.
e. None of the above.

61. The boiling point of liquid nitrogen at atmospheric pressure is 77 K. Which of the following Absolute temperatures is the closest to the temperature of an open container of liquid nitrogen Which is setting in a room temperature laboratory ?
{JG: Replace for better clarity: ....absolute temperatures is closest to the temperature of the liquid nitrogen setting in an open container in a lab where the room temperature is 27 °C?}
a. 76 K
b. 77 K
c. 78 K
d. 293 K
e. 300 K
f. None of the above is within 10% of the correct answer.

62. Given that 1 g of hydrogen combines completely with 8 g of oxygen to form water, how many grams of water can you make with 8 g of hydrogen and 32 g of oxygen?
a. 4 g
b. 32 g
c. 36 g
d. 40 g
e. None of the above.

63. If you double the absolute temperature of an ideal gas and double its pressure, what happens to its volume? The volume
a. quadruples
b. doubles
c. is cut in half
d. is cut to one-fourth
e. None of the above

64. A steel railroad rail is 556 m long. How much does its length change during a day when the low temperature is 50° F (18° C) and the high temperature is 91° F (33° C)? Steel has a coefficient of thermal expansion, $\alpha = 1.2 \times 10^{-5}$ /°C.
a. 0.001 cm
b. 0.01 cm
c. 0.1 cm
d. 1.0 cm
e. 10.0 cm

65. If a liter of gas has a pressure of 2.0 atmosphere, what will the pressure be if the average kinetic energy of the molecules is doubled, while the volume reduced to half its original value?
a. 0.5 atm
b. 1 atm
c. 2 atm
d. 4 atm
e. 8 atm.
f. None of the above is within 10% of the correct answer.

66. One liter of an ideal gas is heated from 300 °C to 900 °C while the pressure is maintained at 1 atm. What is the final volume of the gas, most nearly?
a. 1 liters
b. 2 liters
c. 3 liters
d. 4 liters
e. None of the above is within 10% of the correct answer

67. It is NOT possible to convert completely
a. heat into internal energy.
b. mechanical energy into internal energy.
c. potential energy into mechanical work.
d. work into heat.
e. All of the above transformations are in fact possible.

68. The second law of thermodynamics requires
a. that a refrigerator can operate only if work is supplied.
b. that it is impossible to build a heat engine that can do mechanical work by extracting thermal energy that does not also exhaust heat to the surroundings.
c. that it is impossible to run a heat engine entirely on heat from its own exhaust.
d. that in each cycle of a heat engine the total entropy of the engine and its surroundings increases.
e. All of the above.

69. A heat engine
a. converts thermal energy into mechanical energy.
b. converts mechanical energy into thermal energy.
c. violates the first law of thermodynamics.
d. can as a matter of principle always be made more efficient.
e. None of the above.

70. The second law of thermodynamics
a. says that it is impossible to reach the absolute zero of temperature.
b. says that the total entropy of an isolated system tends to increase.
c. is the basis for the definition of temperature.
d. is the basis for the definition of internal energy.
f. is simply the law of conservation of energy with heat included as a form of energy.
g. None of the above completions yields a true statement.

71. Which of the following disagrees with the second law of thermodynamics?
a. Heat naturally flows from hot objects to cold objects.
b. No engine can transform all of its heat input into mechanical work.
c. The entropy of an isolated system can never decrease.
d. Perpetual motion machines are possible, but difficult.
e. Refrigerators cannot run without work being done on them
f. All of the above agree with the second law of thermodynamics.

72. A ringing bell is inserted into a large glass of water. The bell and the water are initially at the same temperature and are insulated and isolated from their surroundings. Eventually the bell stops vibrating and the water comes to rest. Which of the following statements is FALSE?
a. The mechanical energy of the bell has been completely converted into internal energy of the combined system.
b. The final temperature of the combined system is greater than the initial temperature.
c. The entropy of the combined system has increased.
d. The total energy of the system is the same at the end as at the beginning.
e. None of the above statements is false.

73. How many different outcomes are there for the flipping of five different coins, and what fraction of those yields the most ordered result (i.e., all heads or all tails), respectively?
a. 4 and 50%, respectively.
b. 8 and 25%, respectively.
c. 16 and 12.5%, respectively.
d. 32 and 6.25%, respectively.
e. None of the above are correct within ± 1%.

74. An engineer has designed a machine to produce electricity by using the difference in the temperature of ocean water at depths of 0 and 50 m. If the surface temperature is 20° C and the temperature at 50 m below the surface is 10° C, what is the maximum work this machine can extract per joule of heat put in at the surface, most nearly?
a. 0.012 J
b. 0.034 J
c. 0.05 J
d. 0.13 J
e. None of the above is within ±10% of the correct answer.

75. In which of the systems listed below is the entropy **decreasing**?
a. A gas being cooled.
b. A plate as it is shattered.
c. An egg as it is is scrambled.
d. A drop of dye as it diffuses in a cup of water.
e. A small pond being warmed by sunlight
f. In none of the above systems is the entropy decreasing.

76. A hot piece of metal is dropped into an insulated container of cold water. After the system has reached its equilibrium temperature, the
a. entropy of the metal has decreased.
b. entropy of the water has increased.
c. net change in entropy of the system is positive.
d. final temperature of the system lies between the initial temperatures of the metal and the initial temperature of the water.
e. All of the above statements are true.

77. Consider the human body to be a heat engine with an efficiency of 20%. This means that
a. only 20% of the food you eat is digested.
b. 80% of the energy you obtain from food is destroyed.
c. you should spend 80% of each day lying quietly without working.
d. only 20% of the energy you obtain from food can be used to do mechanical work.

78. The efficiency of an ideal heat engine can be improved by _____ the input temperature and _____ the exhaust temperature.
a. increasing ... increasing
b. increasing ... decreasing
c. decreasing ... increasing
d. decreasing ... decreasing
e. None of the above: the efficiency of the ideal heat engine is independent of temperature.

79. A heat engine takes in energy at a rate of 1600 W at 1000 K and exhausts heat at a rate of 1200 W at 400 K. What is the actual efficiency of this engine?
a. 25%
b. 40%
c. 50%
d. 75%
e. None of the above is within 10% of the correct efficiency.

80. An ideal heat engine has a theoretical efficiency of 47% and an exhaust temperature of 127° C. What is its input temperature, most nearly ?
a. 230° C
b. 480° C
c. 600° C
d. 750° C
e. None of the above is within 10% of the correct answer

81. An air-conditioner mechanic is testing a unit by running it on the workbench in an isolated room. The unit removes 100 cal/min from the refrigerated chamber, utilizing a work input of 420 J/min. By how much does the internal energy of the room outside the refrigerated chamber change, most nearly, in each minute?
a. It decreases by 100 cal/min.
b It decreases by 200 cal/min
c. It decreases by 520 cal/min.
d. It stays the same.
e. It increases by 520 cal/min
f. It increases by 200 cal/min.
g. It increases by 100 cal /min

82. How much work per second (power) is required by a refrigerator that takes 800 J of thermal energy from a cold region each second and exhausts 1200 J each second to a hot region? (1W = 1J/sec)
a. 2000 W
b. 1200 W
c. 800 W
d. 400 W
e. None of the above is within 10% of the correct answer.

83. Which of the following are NOT electromagnetic waves?
a. radio
b. TV
c. infrared light
d. microwaves
e X-rays
f. All of the above are electromagnetic waves.

84. Which is a correct observation of what happened in our cathode ray tube demonstrations?
a. The end of the glass tube opposite the cathode glows.
b. A metal cross casts a shadow.
c. The particles are seen only when an accelerating voltage is applied
d. The stream of particles is deflected by an magnetic field.
e. All of the above.

85. Rutherford's model predicted that atoms should be unstable (the electrons should spiral into the nucleus) over very short time periods. What causes this instability in Rutherford's model?
a. The positive charge in the nucleus was too far from the electrons to hold them in orbit.
b. The attractive force between the positive nucleus and the electrons would pull them together.
c. An accelerating charge must radiate energy.
d. Nature abhors a vacuum.
e None of the above.

86. When light is incident on a metallic surface, the emitted electrons
a. are called photons.
b. have arbitrarily high energies.
c. have a maximum energy that depends on the intensity of the light.
d. Are referred to as cathode rays.
e None of the above

87. Two hydrogen atoms have electrons that jump from the n = 3 energy level to the n = 1 level. One jumps directly to the n = 1 level emitting one photon, while the other jumps to the n = 2 level first and then to the n = 1 level, emitting two photons. The total energy of the pair of photons is _____ that of the single photon.
a. is greater than
b. is the same as
c. is less than
d. is not able to be compared with
e. None of the above is relevant because frequencies determine energies for photons.

88. Einstein was able to account for the experimental observations of the photoelectric effect by assuming that
a. the metal contained atomic resonators.
b. light is a wave phenomenon.
c. light consists of particle-like wave packets, now referred to as photons.
d. electrons boil off when they get hot enough.
e The intensity of the electromagnetic field was the determinant of the electrons' energies.
f. None of the above.

89. A clean surface of potassium metal will emit electrons when exposed to blue light. If the **intensity** of the blue light is increased, the _____ of the ejected electrons will also increase.
a. maximum kinetic energy
b. number
c. average speed
d. average kinetic energy
e. All of the above quantities increase with intensity.
f. None of the quantities a) through d) increases with the blue lightintensity.

90. A clean surface of metal will emit electrons when exposed to light. If the color of the light is changed from red to blue without changing the intensity, the _____ of the ejected electrons will also increase.
a. mass
b. number
c. maximum kinetic energy
d. charge
e None of the above will increase with the stated change in color.

91. Which of the following lists photons in order of **increasing** energy?
a. X ray, radio, infrared, visible, ultraviolet
b. infrared, visible, ultraviolet, X ray, radio
c. radio, infrared, X ray, visible, ultraviolet
d. radio, infrared, visible, ultraviolet, X ray
e. None of the above.

92. Which of the following is NOT a feature of the Bohr model of the atom?
a. an quantized electron angular momentum
b. electrons in planetary-like orbits
c. quantized energy levels
d. accelerating electrons that do not radiate
e. All of the above are features of the Bohr model.

93. Which of the following is NOT considered to be a success of Bohr's theory of the atom?
a. Obtaining the numerical values for the spectral lines in hydrogen.
b. Explaining why there are more lines in emission spectra than absorption spectra.
c. Explaining why the frequency distributions in emission spectra are discrete rather than continuous.
d. Providing the general features of the periodic table.
e. All of the above are considered successes of the Bohr theory.

94. In 1923, the French graduate student Louis de Broglie proposed that
a. photons behave like particles.
b. electrons behave like waves.
c. the energy levels in atoms are quantized.
d. the behavior of electrons must be explained by quantum mechanics.
e. DeBroglie proposed none of the above.

95. The de Broglie wavelength of a particle with a mass m and a speed v is given by
a. mv
b. λ/mv
c. mv/h
d. h/mv
e. None of the above.

96. Bohr could never really explain why an electron was limited to certain orbits. De Broglie explained this by showing that electrons in Bohr's allowed orbits
a. form standing-wave patterns about the nucleus.
b. have elliptical orbits like the planets around the sun.
c. occupy a continuum of orbits but only radiate from some.
d. obey Maxwell's equations.
e. None of the above.

97. Bohr gave the following reason for the electron in the hydrogen atom existing only in certain discrete energy levels.
a. This agrees with Newtonian mechanics.
b. This agrees with Maxwell's equations.
c. This was implied by the Rutherford atom
c. All of the above were cited.
d. He simply postulated it, offering no logical basis.

98. Two hydrogen atoms have electrons in the n = 3 energy level. One of the electrons jumps to the n = 2 level, while the other jumps to the n = 1 level. Which property is the same for the two photons that are emitted?
a. velocity
b. frequency
c. energy
d. color
f. wave length
e. None of the above.
(Note added in class: The labels e.) and f.) are obviously interchanged above. Be careful to Insert the letter of the correct answer **AS PRINTED**.)

.....Continue Exam with question 99 on next page 21

The following ten questions (#99-#108) request you to matching of the man with his contribution. For each numbered question, fill in the circle on your NCS answer sheet corresponding to the letter describing the person's achievement.

99. Galileo ____	(A.) Showed that atom is nuclear, not pudding-like.
100. Newton ____	(B.) Allowed only certain selected orbits for atomic electrons.
101. Joule ____	(C.) His atomic hooks turned out to be electrons extra to or missing from filled electron shells.
102. Carnot ____	(D.) Postulated that energy of light is proportional to its frequency.
103. Avogadro ____	(E.) Postulated Maxwell's laws as same in all inertial frames, and that light consists of photon packets.
104. Dalton ____	(F.) Showed that mechanical energy converts to heat always with same fixed ratio.
105. Rutherford ____	(G.) Proposed that each liter of gas (at STP) contained the same number of particles.
106. Einstein ____	(H.) Reversed Aristotle by presenting steady motion as natural undisturbed state of an object.
107. Planck ____	(I.) Identified acceleration as the result of a net force.
108. Bohr ____	(J.) Designed ideal heat engine to prove the Second Law of Thermodynamics.

.....Continue Exam with question 109 on next page 22

109. A 30-kg crate is being pushed across a horizontal floor by a horizontal applied force of 270 N. If the coefficient of sliding friction is 0.4, and the speed is 7 m/s at time t = 0, how far does the crate move in the next nine seconds, most nearly ?

a) 27 m; b) 100 m; c) 200 m; d) 250 m; e) 400 m;
f) None of these answers is within 10% of the correct answer.

Scenario for 110-111. Suppose that a moon of Jupiter travels in a circle about the planet at a distance of 1.6×10^8 m once in every 10 days, and that has a mass of 3×10^{22} kg. Then place the best answers to the following two questions into your NCS answer sheet.

110. If the speed of the moon is written approximately as 10^n m/day, then, most nearly, the speed is :

a) 10^2 m/day; b) 10^4 m/day; c) 10^6 m/day; d) 10^8 m/ day; e) 10^{10} m/ day

111. Also the acceleration of the moon is most nearly:

a) 0.6×10^4 m/(day)^2; b) 0.6×10^8 m/(day)^2; c) 0.6×10^{12} m/(day)^2;
d) 0.6×10^{16} m/(day)^2; e) 0.6×10^{20} m/(day)^2.

112. A 1200-kg frictionless roller coaster starts from rest at a height of 30 m. It travels up and down 60 m under a frictional force of 400 N to the crest of a hill that is 26 m high. What is its kinetic energy at the top of the 26 m hill, most nearly ?

a) 36,000 J; b) 24,000 J; c) 12,000 J; d) 7,200 J; e) 4,800 J; f) 0 J.

113. An observer drops a ball in a train traveling along a straight, horizontal track with a constant acceleration of 7.5 m/sec^2 in the forward direction. The observer is unaware of the acceleration and notices that the ball falls in a straight line that is slanted toward the back of the train. The acceleration of the ball along this line has a magnitude, most nearly equal to:

a) 5 m/s^2; b) 7.5 m/s^2; c) 10 m/s^2; d) 10.6 m/s^2; e) 12.5 m/s^2; f) 14.1 m/s^2.

114. Two objects (e.g. an electron and a positron), each of rest mass, m, and each traveling with a speed of 0.8c, collide head-on and annihilate in the collision entirely into electromagnetic radiation. How much energy is emitted as radiation?
a) mc^2; b) 1.25 mc^2; c) 1.67 mc^2; d) 2.0 mc^2; e) 2.5 mc^2; f) 3.34 mc^2.

115. A train is traveling along a straight, horizontal track at a constant speed of $v = 0.9995c = (1\text{-}0.5\text{x}10^{-3})c$. A warning light on the ground flashes once each second. An observer in the train measures the time between flashes to be, most nearly:

a) 10^{-3} s; b) 10^{-2} s; c) 10^{-1} s; d) 1 s; e) 10^{2} s; f) 10^{3} s; g) 10^{4} s; h) 10^{5} s; i) 10^{6} s;

116. One liter of gaseous (diatomic) oxygen combines completely with two liters of gaseous (diatomic) hydrogen to form a gas of water molecules (steam), when all of the gases are contained at the same temperature and pressure. One concludes from this that a water molecule has twice as many hydrogen atoms as it has oxygen atoms. If one also knows the volume of the steam finally produced (at the same temperature and pressure as the original hydrogen and oxygen), one can also choose the correct formula for water from the chemical formulas, H_2O, H_4O_2, and H_6O_3, etc..., all of which have twice as many hydrogen atoms as oxygen atoms in each molecule, as required.
Then suppose that the correct formula for the water molecule were H_4O_2, and compute the volume (at the same temperature and pressure) of steam finally produced. The final volume in that case would be, most nearly:

a) 8 liters; b) 4 liters; c) 2 liters; d) 1 liter; e) 0.5 liter; f) 0.25 liter;
g) 0.125 liter.

117. If 100 g of ice at 0° C is mixed with 300 g of water at 50° C in a completely insulated container, what is the final equilibrium temperature, most nearly ? (Recall that the latent heat of fusion of ice is 80 cal/g.)

a) 0° C; b) 7.5° C; c) 17.5° C; d) 22.5° C; e) 27.5° C; f) 32.5° C; g) 37.5° C; h) 42.5° C; i) 52.5° C;

118. What is the de Broglie wavelength of a Volkswagen (mass = 1000 kg) traveling at 45 m/s (100 mph)? (Planck's constant is $h = 6.63 \times 10^{-34}$ J·s.) The de Broglie wavelength is most nearly:

a) 1.47×10^{-39} m; b) 1.47×10^{-38} m; c) 2.21×10^{-38} m; d) 1.99×10^{-29} m; e) 2.98×10^{-28} m.
f) None of the above is within 10% of the correct answer.

119. The energy levels of the Hydrogen atom are correctly given by the formula of the Bohr model; as follows, $E_n = -13.6/n^2$ where n = 1, 2, 3,...gives the lowest orbits. (The energy units are "electron Volts": 1 (eV) = 1.6 X 10^{-19} J , and we use these units also in the question below.) Calculate the energy (in electron volts) emitted when an electron jumps from the third (n=3) Bohr orbit to the first (lowest, n =1) orbit. The energy is, most nearly:

a) 0.85 eV ; b) 1.51 eV ; c) 3.4 eV ; d) 10.2 eV; e) 12.1 eV; f) 12.35 eV.
g) None of the above is within 10% of the correct answer.

120. What is the frequency of the photon emitted in the electron jump of problem 119, just above? (Planck's constant is h = 6.63 × 10^{-34} J·s. = 4.1 x 10^{-15} eV-sec.) The frequency of the photon is, most nearly,

a) 2.1 x 10^{14}/sec; b) 3.6 x 10^{14}/sec; c) 8.3 x 10^{14}/sec; d) 2.4 x 10^{15}/sec;
e) 2.9 x 10^{15}/sec; f) 3.01 x 10^{15}/sec. g) None of the above is within 10% of the correct answer.

**********End of Exam**********