Multiple Choice: *Select the best of the answer from those listed, and pencil in its letter-circle in the corresponding line of your NCS answer sheet.*

1. In discussing special relativity, we consider a phenomena from the viewpoint of
a.   a single inertial system.
b.   a single non-inertial system.
c.   two inertial systems.
d.   two non-inertial systems.
e.   None of the above.

2. Why did physicists postulate the existence of the ether?
a.   To make it select which reference system must be considered the absolute one.
b.   To account for the time difference measured in the Michelson-Morley experiments..
c.   To provide the medium through which light could travel.
d.   To account for the slowing of the earth in its annual journey around the sun.
e.   None of the above.

3. In the Michelson-Morley experiments two light beams were raced at right angles to each other to detect a possible slight difference in their speeds. The experiment showed that
a.   The beam traveling along the direction of the earth's motion always won.
b.   The beam traveling along the direction of the earth's motion always lost.
c.   The races always ended in ties.
d.   The results depended on the season of the year (i.e., on the direction of earth's motion)
e.   A slight speed difference was observed, but declared too small to be taken seriously.

4. If you approach a light beacon while traveling at six-tenths the speed of light (0.6c), you will measure the speed of light from the beacon to be
a.   0.40 c
b.   0.60 c
c.   0.80 c
d   1.0 c
e.   1.6 c

5. On which of the following will observers in different inertial systems agree about the results?
a.   The simultaneity of events at separate locations.
b.   The rate at which their clocks run
c.   The lengths they measure along the direction of their relative travel
d.   The synchronization of their own clocks with the moving clocks of the other frame.
e.   The observers will agree on none of the above.

6. A train is traveling along a straight, horizontal track at a constant speed that is only very slightly less than that of light. A warning light on the ground flashes once each second. An observer in the train measures the time between flashes to be
a.   Somewhat greater than one second.
b.   Equal to one second.
c.   Somewhat less than one second.
d.   Much greater than one second.
e.   Much less than one second
f.   Since the times cannot be compared, the question is ill-posed and has no answer.

7. A rocket ship is 80 m long when measured at rest. What is its length as measured by an observer who sees the rocket ship moving past at 99.98% of the speed of light? The relativistic adjustment factor for V =0.9998c is $\gamma = 1/ (1-v^2/c^2)^{1/2} = 50$.
a. 1.6 m
b. 30.0 m
c. 80 m
d. 130 m
e. 4000 m
f. None of the above is within 10% of the correct answer.

8. An electron with a velocity slightly less than the speed of light is being accelerated by a constant force acting in the same direction as the velocity. Which of the following characterizations of the motion is FALSE?
a. It experiences a decreasing acceleration.
b. Its momentum increases at a constant rate.
c. The net work done on it equals the change in kinetic energy .
d. Its total energy continually increases.
e. Its kinetic energy continually increases
f. All of the above characterizations are true, so that none is false.

9. A proton with velocity slightly less than the speed of light is being accelerated by a constant force. Which of the following is true?
a. The change in momentum is equal to the impulse.
b. The proton's momentum increases at a constant rate.
c. The total net work done by the force equals the change in the proton's kinetic energy.
d. The proton's velocity increases more slowly as it approaches the speed of light.
e. The proton's speed can never exceed c, although its momentum can become arbitrarily large.
f. All of the above statements are true of the proton moving under a constant force.
g. None of the above statements is true.

10. Which of the following expressions gives the relativistic kinetic energy of an object?
a. $KE = (1/2) mv^2$
b $KE = mc^2$
c. $KE = \gamma mc^2$
d. $KE = (\gamma -1)mc^2$
e. $KE = 0.5 mv^2$
f. None of the above.

11. The conclusions of the special theory of relativity
a. are true only for objects moving at very high speeds.
b. have not yet been experimentally verified.
c. apply only to tiny atomic particles.
d. are believed to be true for all motions of all objects.
e. None of the above completions yields a true statement.

12. Einstein's two postulates of the special theory of relativity
a.   stipulate explicitly that nothing can travel faster than the speed of light
b.   provide for a rest mass that increases to infinity as the speed approaches c.
c.   apply only to tiny atomic particles.
d.   require that all of the laws of physics are the same in every inertial frame.
e.   do not specifically address the question of the speed of light
f.   None of the above completions yields a true statement.

13. Imagine a spaceship that is so far from any large masses so that the effects of gravity are negligible. At a certain moment this spaceship has an upward velocity of 100 m/s and an upward acceleration of 10 m/s^2. If you drop a ball in this ship, you will find that it falls to the floor with an acceleration of
a.   110 m/s
b.   100 m/s
c.   100.5 = {(10)2 +(100)2}1/2 m/s
d.   10 m/s
e.   None of the above is within 10% of the correct answer.

14. Einstein's Principle of Equivalence states
a.   that the inertial mass is identical to the gravitational mass.
b.   that light is deflected as it passes by a large mass by the mass' gravitational field.
c.   that the space around a large mass is actually warped by the very presence of the mass.
d.   that constant acceleration is completely equivalent to a uniform gravitational field.
e.   none of the above.

15. Two balls of different mass are simultaneously released in a vacuum in a spaceship which is subject to a constant acceleration in the upward direction. If the speed of the space ship is nearly equal to the speed of light as two balls are released from the same height, which one will hit the floor first?
a.   the heavier one, because the pseudo-force is proportional to the mass.
b.   the lighter one because a given force can accelerate it more rapidly.
c.   It is not possible to say from the information given.
d   Because they are traveling with nearly the speed of light already, neither ball will fall at all.
f.   They will both hit at the same time.
g.   None of the above is correct.

16. Suppose two teams of astronauts in sealed containers who think they are accelerating through space are actually sitting on the surfaces of Earth and Mercury. The gravitational field on Mercury is 60% of that near Earth. Which team thinks it has the larger acceleration?
a.   The team on Mercury
b.   The team on Earth
c.   Both teams think their accelerations are the same.
d.   Both teams know that neither team can determine their acceleration.
e.   Both teams claim the largest acceleration, and neither can show that the other is wrong.
f.   None of the above is correct.

17. Imagine a spaceship that is so far from any large masses that the effects of gravity are negligible. This spaceship has a forward velocity of 460 m/s and an acceleration in the forward direction of 6 km/s^2. What is the acceleration is measured in this spaceship of a ball released at rest?
a. 6 m/s2
b. 10 m/s2
c. 450 m/s2
d. 460 m/s2
e. 470 m/s2
f. None of the above is within 10% of the correct answer.
   Note that the units 6 km/s-s should be 6 m/s-s. Therefore the correct answer to the questin as written is < f) None of the above.>, and not a) as written in the key.

18. The general theory of relativity
a. is an extension of the special theory of relativity to include accelerations.
b. explains the gravitational force by a warping of space itself by the very presence of mass.
c. is only peripherally concerned with the Principle of Equivalence.
d. predicts that light, since it has no mass, will not be deflected by a gravitational field.
e. makes no assumption about the inertial vs the gravitational mass of an object
f. None of the above is a true statement about the General Theory of Relativity.

19. The Greek "atomists" believed in atoms
a. because of experiments with combining gases.
b. because of diffusion experiments.
c. solely because of philosophical arguments.
d. because they believed the alchemists.
e. None of the above.

20. Which of the following is a chemical compound?
a. hydrogen
b. oxygen
c. carbon
d. water
e sulfur
f. salt water
g. None of the above is a compound.

21. The law of definite proportions states that   have definite   ratios of their constituent elements.
a. compounds … mass
b. compounds … volume
c. mixtures … mass
d. mixtures … volume
e. elements….mass
f. elements…..volume
g. The law states none of the above.

22. If 4 grams of oxygen combine completely with 3 grams of carbon to form carbon monoxide, CO, (1 carbon atom and 1 oxygen atom in each molecule), how many grams of oxygen does it take to combine completely with 3 grams of carbon to form carbon dioxide, CO_2, (1 carbon atom and 2 oxygen atoms)?
a. 2
b. 4
c. 6
d. 8
e. 10
f. None of the above is within 10% of the correct answer.

23. In ammonia, 14 g of nitrogen combines completely with 3 g of hydrogen. How many grams of hydrogen does it take to combine completely with 56 g of nitrogen?
a. 3 g
b. 6 g
c. 9 g
d. 12 g
e   24 g
f. 56 g
g. None of the above is within 10% of the correct answer.

24. Given that 12 g of carbon combines completely with 16 g of oxygen to form carbon monoxide, how many grams of carbon monoxide can be made from 48 g of carbon and 90 g of oxygen?
a. 138 g
b. 112 g
c. 90 g
d. 48 g
e. 42 g
f. None of the above is within 10% of the correct answer.

25. Assume that you have equal volumes of oxygen (atomic mass = 16) and hydrogen (atomic mass = 1) at the same temperature and pressure. If each molecule of oxygen and hydrogen contains two atoms, how do the numbers of oxygen and hydrogen atoms in the gases compare?
a. They are the same.
b. The oxygen has sixteen times as many .
c. The hydrogen has sixteen times as many.
d   The oxygen has twice as many .
e   The hydrogen has twice as many.
f. There is not enough information to say.

26. Suppose that one liter of nitrogen (N) were to combine with 3 liters of hydrogen (H) to form 2/p liters of a hypothetical compound "spammonia". If the molecules of nitrogen, N_2, and hydrogen, H_2, have 2 atoms each, how many atoms of hydrogen and nitrogen are there in 1 molecule of "spammonia"?
a. 2 H atoms and 1 N atom
b. 2 H atoms and 2 N atoms
c. 3 H atoms and 1 N atom
d. 3 H atoms and 2 N atoms
e   3p H atoms and p N atoms
f. 3p H atoms and 2p N atoms.

g. None of the above is the correct answer.

27. If an atom of titanium is four times as massive as an atom of carbon, what is the atomic mass of titanium?
a. 3 amu
b. 12 amu
c. 24 amu
d. 48 amu
e. 60 amu
f. None of the above is within 10% of the correct answer.

28. One liter of water has a mass of 1 kg, and the chemical formula for water molecule is H_2O. How many molecules of water are there in 1 liter of water, most nearly?
a. 55.6
b. 1.08×10^{22}
c. 6.02×10^{23}
d. 5.6×10^{24}
e. 3.34×10^{25}
f. None of the above is within 10% of the correct answer.

29. Which of the following is NOT a feature of our ideal gas? The gas particles
a. have a fixed mass.
b. have no internal structure.
c. are indestructible.
d. do not interact except when they collide.
e. travel in straight lines from one container wall to the next
f. always rebound elastically after colliding with the container wall.
g. All of the above statements are true for the ideal gas.
h. None of the above statements is true.

30. The pressure that a gas exerts on the walls of its container is a direct result of
a. the repulsive forces between gas molecules.
b. the combined volume of the gas molecules.
c. the collisions of the gas molecules with the walls.
d. the combined mass of the gas molecules.
e. the attractive forces between gas molecules.
f None of the above.

31. If the heel of a woman's shoe has an area of 1 square centimeter and the woman has a mass of 70 kilograms, what pressure can she exert on the floor if she puts all of her weight on one heel?
a. 70 kg/·cm^2
b. 70 kg/·m^2
c. 70 N/·m^2
d. 70 N/cm^2
e. 700 N/·m^2
f. 700 N / cm^2
g. None of the above is within 10% of the correct answer.

32. If a liter of gas has a pressure of 1 atmosphere, what will the pressure be if the average speed of the molecules is doubled, while the volume is held at one liter?
a. 0.5 atm
b. 1 atm
c. 2 atm
d. 4 atm
e. None of the above is within 10% of the correct answer.

33. Which of the following statements is true for an ideal gas? The average   an ideal gas particle is proportional to the absolute temperature.
a. speed of
b. momentum of
c. impulse upon
d. work done on
e. kinetic energy of
f. of none of the above for

34. The mass of an oxygen molecule is 16 times that of a hydrogen molecule. If the gases are maintained at the same temperature, what is the ratio of the root mean square speed ($<v^2>_{AVG}^{1/2}$) of an oxygen molecule to that of a hydrogen molecule?
a. 1/256
b. 1/16
c. 1/4
d. 1
e. 4
f. 16
g. 256
h. None of the above.

35. If you hold the temperature of an ideal gas constant as you 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.

36. Two liters of an ideal gas is heated from 273 °C to 546 °C while the pressure is maintained at 1 atm. What is the final volume of the gas most nearly?
a. 4 liters
b. 3 liters
c. 2 liters
d. 1 liters
e. 0.5 liter
f. None of the above is within 10% of the correct answer.

37. Which of the states of matter occurs at the highest temperature?
a. plasma
b. liquid
c. solid
d. gas
e. The answer depends upon the material in question.

38. Density is defined as
a. weight per unit volume
b. weight per unit area
c. mass per unit volume
d. mass per unit area
e. force per unit volume
f. force per unit area
g. None of the above.

39. Pressure is defined as
a. mass per unit volume
b. mass per unit area
c. force per unit volume
d. force per unit area
e. weight per unit volume
f. weight per unit area
g. None of the above.

40. Heat is the
a. same as temperature.
b. thermal energy that is transferred from one object to another.
c. potential energy associated with temperature.
d. massless fluid generated by doing work on the system.
e. Internal energy of a substance.
f. None of the above.

41. Joule's experiments with hanging weights turning paddle wheels in water
a. showed that heat was not a fluid.
b. showed that 1.0 joule of work are equivalent to 4.2 calories of heat.
c. were used to define the calorie.
d. showed that heat could be converted 100% to mechanical energy.
e. showed that 4.2 joules of work are equivalent to 1 calorie of heat
f. None of the above completions yields a true statement.

42. Which of the following statements does NOT correctly describe what happens when a hot block is placed in contact with a cool block?
a. Heat flows from the hot block to the cool block.
b. The average kinetic energy of the particles decreases in the hot block and increases in the cool block.
c. The temperature of the hot block decreases and that of the cool block increases.
d. Energy flows from the hot block to the cool block.
e. Temperature flows from the hot block to the cool block.
f. All of the above statements correctly describe what happens, and none is false.

43. The zeroth law of thermodynamics
a. is a restatement of the law of conservation of energy.
b. says that heat cannot be completely converted to mechanical energy.
c. is the basis for the definition of temperature.
d. is the basis for the definition of internal energy.
e. asserts the impossibility of achieving an absolute zero temperature.

44. The first law of thermodynamics
a. is the basis for the definition of entropy.
b. is the basis for the definition of temperature.
c. is the basis for the definition of internal energy.
d. says that heat cannot be completely converted to mechanical energy.
e. asserts the impossibility of achieving an absolute zero temperature.
f. None of the above completions yields a true statement.

45. The first law of thermodynamics, like the law of conservation of momentum and other conservation laws, is valid only
a. if no work is done on the system.
b. when there is no friction.
c. When all of the forces acting are conservative.
d. if there is no heat loss or gain.
e. if the system is isolated.
f. None of the above completions yields a true statement.

46. If a system undergoes no change in internal energy during some process, we can say that
a. the system lost no heat.
b. no work was done on the system.
c. the system neither lost (or gained) heat, nor had work done on (or by) it.
d. the amount of work done by the system was equal in magnitude to the heat gained.
e. the change in heat energy produced a temperature change.
f. All of the above are correct.
g. None of the above completions yields a true statement.

47. During a process, 10 joules of work are performed on a system, while the system gives off 4 joules of heat. The internal energy of the system
a. increases by 6 joules
b. decreases by 4 joules
c. increases by 14 joules
d. remains the same
e. is never affected by work done on it.
f. None of the above completions yields a true statement.

48. When an ideal gas was compressed, its internal energy increased by 90 J and it gave off 60 J of heat. How much net work was done on the gas?
a. 0 J
b. 30 J
c. 60 J
d. 90 J
e. 150 J
f. None of the above completions yields a true statement.

49. The third law of thermodynamics
a. is a restatement of the law of conservation of energy.
b. says that heat cannot be completely converted to mechanical energy.
c. says that we can never reach the absolute zero of temperature.
d. says that all motion ceases at absolute zero.
e. Is the basis for defining the absolute temperature as $T_A = T_C + 273$, in Kelvins.
f. None of the above completions yields a true statement.

50. Why is steam at 100° C more dangerous to skin than water at 100° C?
a. The steam is hotter, and therefore burns skin more quickly.
b. The steam has more internal energy per gram to deliver to the skin tissue.
c. The steam has a higher specific heat than water and therefore delivers more heat per degree of cooling.
d. The steam has smaller viscosity, and therefore tends to stick more to the skin.
e. The steam has larger viscosity, and therefore tends to stick more to the skin.
f. None of the above completions yields a true statement.

51. The latent heat of fusion (melting) for water is 334 kJ/kg. How much energy would it take to melt 1 g of ice at 0° C to form water at 0° C most nearly ?
a. 14 cal
b. 80 cal
c. 540 cal
d. 14,000 cal
e. 80,000 cal
f. None of the above completions yields a true statement.

52. Which of the following is the best thermal conductor?
a. ceramic
b. water
c. wood
d. copper
e. styrofoam
f. All of the above are about the same as regards thermal conductivity.

53. In convection, thermal energy is transported by
a. the movement of a fluid.
b. the collisions of particles.
c. electromagnetic fields.
d. the propagation of sound waves.
e. electrons flowiong through the material.

54. In radiative heat transfer, thermal energy is transported by
a. the movement of a fluid.
b. the collisions of particles.
c. electromagnetic or sound waves.
d. the propagation of sound waves.
e. electromagnetic waves
f. None of the above.

55. Which color star is the hottest?
a. infra-red
b. red
c. yellow
d. greeen
e. blue
f. It is impossible to say.

The following problems may be more challenging computationally than those preceding. Select the best of the answers listed, and pencil in its letter circle in the corresponding line of your NCS answer sheet.

56. Two rocket ships are recorded by a space station both to be approaching at 80% of the speed of light from opposite directions along the same line of travel. Recall that the Galilean transformation of v along the line of motion $(v = v' + V)$ has to be replaced by the Lorentz transformation , $v = (v'+V)/(1+v'V/c^2)$. Then compute the speed which the observer in one rocket ship measures for the other rocket ship.

a. 0.36c
b. 0.64c
c. 0.80c
d. 0.98c
e. 1.00c
f. 1.60c
g. None of the above is within 10% of the correct answer.

57. A neutron at rest has a 50% probability of decaying in 10.6 minutes (= 636 seconds), and a fifty percent probability of surviving for more than 636 seconds. Is it possible for a neutron to travel to the earth from a location 3.939×10^{11} m from earth and still to survive with the same 50% probability? Choose from those offered below the answer which is most nearly correct.

a. It is not possible, because the proton would have to travel faster than the speed of light.
b. Yes it is possible, but only if it travels through a warp in spacetime.
c. Yes, it is possible, but only if it travels with a speed equal to   0.9 c
d. Yes, it is possible, but only if it travels with a speed equal to   0.99 c
e. Yes, it is possible, but only if it travels with a speed equal to   0.999 c
f. Yes, it is possible, but only if it travels with a speed equal to   0.9999 c

58. 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_6O_3, 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. 6.00 liters
b. 3.00 liters
c. 2.00 liters
d. 1.00 liter
e. 0.50 liter
f. 0.33 liter
g. 0.17 liter
h. None of the above is within 10% of the correct answer.

59. If 5 g of steam at 100° C are mixed with 45 g of ice at 0° C in a completely insulated container, what is the final equilibrium temperature, most nearly ? (Use 80 cal/gm for the latent heat of fusion, 540 cal/gm for the latent heat of vaporization, and 1 cal/gm -° for the specific heat of water.)
a. 10° C
b. 20° C
c. 30° C
d. 40° C
e. 50° C
f   60° C
g. 70° C
h. 80° C
i   90° C
j. None of the above is within 5° C of the correct answer.

60. Suppose that the steel rail of a train track is 3.0 km long, and that the coefficient of thermal expansion for this steel is 1.1 x 10^{-5} per ° C. Compute the expansion of this rail in meters which occurs due to the temperature change from the winter's low of -20° C to the summer's high of 40° C. The expansion would be, most nearly:

a. 1 m
b. 2 m
c. 4 m
d. 8 m
e. 16 m
f. 32 m
g. None of the above is within 10% of the correct answer.

End of Exam III