SOLUTIONS w Types Created #21 & #22

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. Why did physicists postulate the existence of the ether?
a. Because they recognized that light required an ethereal spiritual content.
b. To account for the time difference measured in the Michelson-Morley experiments.
(c) Because other physical waves always required a medium in which to propagate.
d. To account for the slowing of the earth in its annual journey around the sun.
e. To make it select which reference system must be considered the absolute one.
f. None of the above.

2. In discussing special relativity, we consider physical phenomena from the viewpoint of two observers in
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.

3. If you approach a light beacon while traveling at four-tenths the speed of light (0.4c), you will measure the speed of light from the beacon to be
a. 1.60 c
b. 1.40 c
(c.) 1.00 c
d 0.6 c
e. 0.4 c
f. None of the above is within 10% of the correct answer.

4. In the Michelson-Morley experiments a light beam is split into two light beams at right angles and the whole apparatus is rotated to detect any slight difference in their speeds. The experiment showed that as the apparatus rotated, the bright and dark interference fringes
a. varied very slightly according the velocity of the experiment's location resulting from the earth's rotation.
b. varied very slightly according the velocity of the experiment's location resulting from the earth's orbital velocity around the sun.
c. varied very slightly according the velocity of the experiment's location resulting from the sun's velocity through the galaxy.
(d.) varied not at all.
e. None of the above.

5. On which of the following claims will observers in different inertial systems agree?
a. That two events at separated locations occurred simultaneously .
(b.) That the net work done on a moving is equal to the increase in its kinetic energy.
c. That a specific clock at rest in one inertial system ticks at the rate of 1 tick per second.
d. That a specific meter stick at rest in one inertial system has a length of 1 m.
d. That a set of spatially separated clocks which one observer has carefully synchronized in his own frame do in fact tick synchronously.
e. The observers will agree on all of the statements, (a) through (d), above.
f. The observers will agree on none of the statements, (a) through (d), above.

6. A train is traveling along a straight, horizontal track at a constant speed that is only very slightly less than c. A warning light on the ground flashes once each second. An observer in the train measures the time between flashes to be
(a.) Much greater than one second.
b. Much less than one second.
c. Somewhat less than one second.
d. Somewhat greater than one second.
e. Equal to one second.
f. None of the above: the question is ill-posed.

7. A rocket ship is 50 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. 2500 m
b. 100 m
c. 50 m
d. 7.05 m
(e.) 1 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 TRUE?
a. It experiences a decreasing acceleration. T
b. Its momentum increase is equal to the impulse. T
c. The net work done on it equals the change in kinetic energy. T
d. Its total energy continually increases. T
e. Its kinetic energy continually increases T
(f.) All of the above characterizations (a through e) are true. T
g. None of the above answers (a through f) is true. F

9. A proton is accelerated by a constant force from rest to a speed slightly less than the speed of light. Which of the following is true?
a. The time rate of change of its momentum is constant. T
b. The proton's final momentum is greater than mv_f, where v_f is the particle's final velocity. T
c. The total net work done by the force equals the change in (γmc^2), where $\gamma = 1/[1-(v_f/c)^2]^{1/2}$. T
d. The proton's velocity increases more slowly as it approaches the speed of light. T
e. The proton's speed can never exceed c, although its momentum can become arbitrarily large. T
f. The proton's speed can never exceed c, although its energy can become arbitrarily large. T
(g.) All of the above statements (a through f) are true about this proton. T
h. None of the above statements is true. F

10. Which of the following expressions gives the relativistic kinetic energy of an electron?
a. K.E. = $0.5\ mc^2$
b K.E. = $(1/2)\ mv^2$
c. K.E. = γmc^2
(d.) K.E. = $(\gamma - 1)mc^2$
e. K.E. = mc^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. F
b. have not yet been experimentally verified. F
c. apply only to tiny atomic particles. F
(d.) are believed to be true for all motions of all objects. T
e. All of the above (a through d) yield true statements. F
f. None of the above (a through e) is true. F

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

13. Einstein's Principle of Equivalence states explicitly
a. that the inertial mass is identical to the gravitational mass. F
b. that light is deflected as it passes by a large mass by the mass' gravitational field. F
c. that the space around a large mass is actually warped by the very presence of the mass. F
(d.) that constant acceleration is completely equivalent to a uniform gravitational field. T
e. All of the above are part of the Principle of Equivalence as stated by Einstein. F
f. None of the above (a through e) are stated by Einstein's Principle of Equivalence. F

14. 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.

15. 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. The two 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 statements (a through e) is correct.

16. 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/s^2
b. 10 m/s^2
c. 444 m/s^2
d. 466 m/s^2
e. 460 m/s^2
f. None of the above is within 10% of the correct answer.

17. 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 due to 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. Does not require that the inertial and the gravitational mass of an object are equal.
f. All of the above (a through e) are true statements about the General Theory.
g. None of the above is a true statement about the General Theory of Relativity.

18. 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. All of the above (a through d) are true
f. None of the above statements is true.

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

20. The law of definite proportions states that all_____ 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.

21. If 8 grams of oxygen combine completely with 6 grams of carbon to form carbon dioxide, CO_2, (with1 carbon atom and 2 oxygen atoms in each molecule), how many grams of oxygen does it take to combine completely with 15 grams of carbon to form carbon ~~dioxide,~~ monoxide CO, (with 1 carbon atom and 1 oygen atom in each molecule)?

a. 2
b. 4
c. 6
d. 8
e. 10
f. 12
g. None of the above is within 10% of the correct answer.

If $\frac{M_C}{M_O}\Big|_{CO_2} = \frac{1\,m_C}{2\,m_O} = \frac{6}{8}$ for CO_2, then $\frac{1\,m_C}{1\,m_O} = \frac{M_C}{M_O}\Big|_{CO} = \frac{6}{4}$ for CO

& in CO $m_O = \frac{4}{6}\cdot M_C = \frac{60}{6} = 10\,gm$ (e)

22. In forming ammonia14 g of nitrogen combines completely with 3 g of hydrogen. How many grams of nitrogen does it take to combine completely with 9 g of ~~oxygen~~ hydrogen?

a. 3 g
b. 5 g
c. 7 g
d. 14 g
e. 42 g
f. 56 g
g. None of the above is within 10% of the correct answer.

Since $\frac{M_N}{M_H} = \frac{14}{3} \Rightarrow M_N = \frac{14}{3}\cdot M_H$

$= \frac{14}{3}\cdot 9 = 42\,gm\ N$ (e)

23. 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 24 g of carbon and 90 g of oxygen?

a. 138 g
b. 112 g
c. 90 g
d. 84 g
e. 56 g
f. 36 g
g. None of the above is within 10% of the correct answer.

$\frac{16}{12}\cdot 24 = M_O$ required to combine completely w 24g C.

$= 32\,gm\ O$

& can make $32 + 24 = 56\,gm\ CO$ (e)

(& 58gm of O are leftover)

24. 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.

25 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". (p denotes a small integer number) 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. 6p H atoms and 2p N atoms.
g. None of the above is the correct answer.

Suppose that spammonia has a chemical formula $N_a H_b$
Then $V_N/V_H = 1/3 \Rightarrow b/a = 3$ or $b = 3a$.
Then $1\ell[N] + 3\ell[H] = \frac{2}{p}\ell[N_a H_{3a}]$
Since each $N_a H_{3a}$ molecule has $2a$ atoms
each $N_a H_{3a}$ molecule must have p N atoms & $3p$ H atoms (e)

26. If an atom of titanium is four times as massive as an atom of carbon, what is the atomic mass of titanium? (1 amu = 1 Atomic Mass Unit)

a. 4 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.

27. 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? (Recall that Avogadro's number is $N_A = 6 \times 10^{23}$ per mole)

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.

1 mole H_2O = 18 gm = (2·1+16) gm and contains $N_A = 6\times10^{23}$ molecules
Then $\frac{10^3 \text{ gm}}{18 \text{ gm}} = 55.6$ moles & 1kg contains $(55.6)N_A =$
333.6×10^{23} molecules
$= 3.34 \times 10^{25}$ molecules (e)

28. 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.

29. The pressure that an ideal 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. All of the above.
g. None of the above.

30. If the tip of a metal punching tool has an area of 1 mm^2 and a force of 1 N is exerted when the hammer strikes it , what pressure does the tip exert on the material being cut?

a. 1 N/m^2
b. 10^2 N/m^2
c. 10^3 N/m^2
(d.) 10^6 N/m^2
e. 10^8 N/m^2
f. 10^{10} N/m^2
g. None of the above is within 10% of the correct answer.

$P = F/A = \frac{1N}{(1\,mm)^2} = \frac{1N}{(10^{-3})^2 m^2} = 10^6 N/m^2$ (d)

31. If a liter of gas has a pressure of 1 atmosphere, what will the pressure be if the speed of each molecule is halved, while the volume is held at one liter?

(a.) 0.25 atm
b. 0.5 atm
c. 1.0 atm
d. 2.0 atm
e. 4.0 atm
f. None of the above is within 10% of the correct answer.

$PV = CT_A$ & $T_A \propto \langle \frac{1}{2} m v_i^2 \rangle_{AVG}$.

If $v_i \to v/2$, $v_i^2 \to v^2/4$ & $T_A^i \to T_A^f/4$

Then $P_f = CT_A'/V \to \frac{CT_A}{4V} = P/4 = 1/4\,\ell = 0.25\,atm$ (a)

32. Which of the following insertions makes a true statement about 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

33. 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 mean squared speed, ($\langle v^2 \rangle_{AVG}$) , of an oxygen molecule to that of a hydrogen molecule?

a. 256
b. 16
c. 4
d. 1
e. 1/4
(f.) 1/16
g. 1/256
h. None of the above is within 10% of the correct answer..

34. If you hold the temperature of an ideal gas constant as you quadruple its pressure, what must happen to its volume? The volume

a. quadruples
b. doubles
c. remains the same.
d. is cut in half
(e.) is cut to one-fourth
f. None of the above.

$P_i V_i = CT_i$
$P_f V_f = CT_f$
$\Rightarrow \frac{P_i}{P_f}\frac{V_i}{V_f} = \frac{T_i}{T_f} = 1$ since $T_i = T_f$

So that $\frac{P_i}{P_f} = \frac{1}{4} = \frac{V_f}{V_i}$ (e)

35. One liter of an ideal gas is heated from 27 °C to 627°C while the pressure is held constant at 1 atm. What is the final volume of the gas most nearly?

a. 23 liters
b. 3 liters
c. 1 liters
d. 0.5 liters
e. 0.04 liter
f. None of the above is within 10% of the correct answer.

$T_i = 273 + 27 = 300K$
$T_f = 273 + 627 = 900K$

$P_i V_i = c T_i$
$P_f V_f = c T_f$
$\Rightarrow \frac{V_f}{V_i} \cdot \frac{P_f}{V_i} = \frac{T_f}{T_i} = \frac{900}{300}$
$\& P_f = P_i \Rightarrow V_f = 3V_i$ (b)
$= 3 P_i$ liters

36. Which of the following states of matter occurs at the highest temperature?

a. plasma
b. liquid
c. solid
d. gas
e. The answer depends upon the specific material in question.

37. 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.

38. 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.

39. Heat is the

a. same as temperature.
b. thermal energy that is transferred from one object to another of lower temperature.
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.

40. 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 is 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 1.0 calorie of heat
f. None of the above completions yields a true statement.

41. 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. T
b. The average kinetic energy of the particles decreases in the hot block and increases in the cool block. T
c. The temperature of the hot block decreases and that of the cool block increases. T
d. Energy flows from the hot block to the cool block. T
e. Temperature flows from the hot block to the cool block. F
f. All of the above statements correctly describe what happens, and none is false. F

42. 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.
f. None of the above completions yields a true statement.

43. 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.

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44. 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. 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.
f. None of the above completions yields a true statement.

45. The first law of thermodynamics,

a. treats heat transferred as a form of energy.
b. states that heat and work energy added to a substance increases the substance's internal energy .
c. Requires that internal energy must decrease if a gas does work on the outside world by expanding against a pressure while no heat is transferred in or out.
d. implies that work must be done if a gas receives heat but does not increase its temperature.
e. All of the above completions yield true statement about the first law..
f. None of the above completions (a through d) yields a true statement.

46. If a system undergoes no change in internal energy during some process, we can say that

a. the system transferred no heat out during the process. F
b. no work was done on the system. F
c. the system neither lost (or gained) heat, nor had any work done on (or by) it. F
d. the net amount of work done by the system was equal in magnitude to the net heat gained. T
e. the change in heat energy produced a temperature change. F
f. All of the above are correct. F
g. None of the above completions yields a true statement.

$Q^{IN}_{NET} - W^{OUT}_{NET} = \Delta U = 0$ (d)

47. During a process, 18 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 4 joules.
b. decreases by 4 joules.
c. increases by 14 joules.
d. decreases by 14 joules.
e. remains the same.
f. is never affected by work done on it.
g. None of the above completions yields a true statement.

$Q^{IN}_{NET} + W^{IN}_{NET} = \Delta U$

$-4 + 18 = +14\,J$

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.

$Q^{IN}_{NET} + W^{IN}_{NET} = \Delta U$

$-60 + W^{IN}_{NET} = 90 \Rightarrow W^{IN}_{NET} = 90 + 60 = 150\,J$

49. What Celsius temperature corresponds most closely to a temperature of 100 Kelvins?

a 373° C
b. 127° C
c. 27° C
d. -73° C
e. -173° C
f. None of the above is within 10%.

$T_C = T_K - 273°$

$T_K = 100 \Rightarrow T_C = -173°C$ (e)

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 as it condenses.
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 or 80 cal/gm. How much energy would it take to melt 0.500 kg of ice at 0° C to form water at 0° C most nearly ?

a. 20 cal
b. 80 cal
c. 83.5 kJ
(d.) 40,000 cal
e. 80,000 cal
f. None of the above completions yields a true statement.

$Q = m \cdot L_f = 500 \cdot 80 = 40{,}000$ cal.

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 flowing through the material.
f. None of the above.

54. In radiative heat transfer, 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 flowing through the material.
f. None of the above.

55. How much heat is required to raise the temperature of 50 g of water from 99°C to 101°C, most nearly ? For the latent heat of vaporization of water use 540 cal/gm; for its specific heat, 1cal/gm-°C; and for the the specific heat of steam, 0.5cal/ gm-°C.

a. 500 cal
b. 6,000 cal
c. 12,000 cal
(d.) 27,000 cal
e. 55,000 cal
f. None of the above is within 10% of the correct answer.

At 99° H_2O is Liquid
At 101° H_2O is steam

$Q = m L_v \quad 50\,gm \cdot 540\,cal/gm = 27{,}000$ cal

$\Delta \pm 50$ cal to heat H_2O & steam is a small addition ($<< 10\%$)

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 60% 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 the speed which the observer in one rocket ship measures for the other rocket ship is, most nearly,

a. 0.36c
b. 0.64c
c. 0.88c
d. 0.98c
e. 1.00c
f. 1.60c
g. None of the above is within 10% of the correct answer.

$$v = \frac{v'+V}{(1+v'V/c^2)} = \frac{(0.60+0.60)c}{[1+(0.6)(0.6)]} = 0.882\,c$$ (c)

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 4.37×10^{11} m from earth and still to survive with the same 50% probability, or greater? 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 space time.
c. Yes, it is possible, but only if it travels with a speed greater than 0.9 c
d. Yes, it is possible, but only if it travels with a speed greater than 0.99 c
e. Yes, it is possible, but only if it travels with a speed greater than 0.999 c
f. Yes, it is possible, but only if it travels with a speed greater than 0.9999 c

Neutron can travel $D = cT$ at (nearly) the speed of light in half-life $T = 636$ sec.
$= (636)(3\times10^8) = 1.91\times10^{11}$ m in Neutron's rest frame

But observer in neutron's rest frame sees the distance from earth $D' = 4.37\times10^{11}$ m to be contracted by factor γ to D'/γ.

Then if $D'/\gamma = D$, or $\gamma = D'/D = \frac{4.37\times10^{11}}{1.91\times10^{11}} = 2.28$

Then Neutron can travel to earth & have same 50% survival probability
$(1/\gamma^2) = (1-v^2/c^2) \Rightarrow v = c(1-1/\gamma^2)^{1/2} = 0.9c$ (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) (All of the gases here 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 infer the correct formula for water from among the chemical formulas, H_2O, H_4O_2, and H_6O_3, etc..., all of which have the required ratio of two hydrogen atoms for each oxygen atom in each molecule.

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 of steam in that case would be, most nearly:

a. 6 liters
b. 3 liters
c. 2 liters
d. 1 liter
e. 0.17 liter
f. 0.33 liter
g. 0.50 liter
(h) 0.67 liter
i. None of the above is within 10% of the correct answer.

For H_2O one O atom is required for each water molecule, so that 1 l of O molecules produces 2 l of water molecules.

For H_6O_3 each molecule requires 3 O's & so only 1/3 as many are made from 1 l of O_2, or $\frac{2}{3}$ l = 0.67 l

59. If 5 g of steam at 100° C are mixed with ~~50~~ 20 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 -°C for the specific heat of water.)

a. 15° C
b. 25° C
c. 35° C
d. 45° C
e. 55° C
(f) 65° C
g. 75° C
h. 85° C
i 95° C
j. None of the above is within 5° C of the correct answer.

to condense steam at 100°C & cool it to T_f

$Q_S = M_S \cdot L_V + M_S \cdot C_W (100 - T_f)$ must be extracted

to melt ice & raise it to T_f

& $Q_I = M_I L_f + M_I \cdot C_W (T_f - 0)$ must be delivered to ice

Then $Q_S = Q_I \Rightarrow$ $M_S L_V + C_W M_S (100 - T_f) = M_I L_f + M_I C_W (T_f - 0)$

$(5 \cdot 540) + 1 \cdot 5 (100 - T_f) = 20 \cdot 80 + 20 \cdot 1 (T_f - 0)$

$2700 + 500 - 1600 = 25 T_f$

$\frac{1600}{25} = T_f$

$T_f = 64°C$ (f)

60. Suppose that the steel rail of a train track is 1.8 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 80° 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.

$\Delta L = \alpha L \Delta t = (1.1 \times 10^{-5})(1.8 \times 10^{3})[80 - (-20)]$

$= (1.98) \times 10^{-5+3+2} = 1.98 \text{ m}$ (b)

END of EXAM III