Solutions to 117 EX III F06

Exam III F06(This is Version B of the exam {w.crrx #6 &#17})Page 2 of 15(v.B)

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. Identify your exam on line 1 of your NCS sheet: From the top line above, this is

a. Version A

b. Version B

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. 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.

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. 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.

6. 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 mass 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 clock meter stick at rest in one inertial system has a length of 1 m.

Note that the line below is labeled f, out of order, to correct a typographical error.

f. 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 none of the above statements..

7. 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.

8. A rocket ship is 100 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. 100 m
b. 98 m
c. 50 m
d. 14.1 m
(e.) 2 m
f. None of the above is within 10% of the correct answer.

9. 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. TRUE
b. Its momentum increase is equal to the impulse. TRUE
c. The net work done on it equals the change in kinetic energy. TRUE
d. Its total energy continually increases. TRUE
e. Its kinetic energy continually increases TRUE
(f.) All of the above characterizations (a through e) are true.
g. None of the above answers (a through f) is true.

10. 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. TRUE : FORCE $= \Delta P/\Delta t$
b. The proton's final momentum is greater than mv_f, where v_f is the particle's final velocity. TRUE $\vec{p}_f = \gamma m \vec{v}_f$
c. The total net work done by the force equals the change in (γmc^2), where $\gamma = 1/[1 - (v_f/c)^2]^{1/2}$. TRUE : WORK-ENERGY THM.
d. The proton's velocity increases more slowly as it approaches the speed of light. TRUE
e. The proton's speed can never exceed c, although its momentum can become arbitrarily large. TRUE
f. The proton's speed can never exceed c, although its energy can become arbitrarily large. TRUE
(g.) All of the above statements (a through f) are true about this proton.
h. None of the above statements is true.

11. Which of the following expressions gives the relativistic kinetic energy of an electron?

(a.) K.E. $= (\gamma - 1)mc^2$ = TOTAL ENERGY − REST ENERGY
b K.E. $= (1/2)\, mv^2$
c. K.E. $= \gamma mc^2$
d. K.E. $= 0.5\, mc^2$
e. K.E. $= mc^2$
f. None of the above.

12. 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. All of the above (a through d) yield true statements.
f. None of the above (a through e) is true.

13. Einstein's two postulates of the special theory of relativity
a. stipulate explicitly that nothing can travel faster than the speed of light
b. specify that the rest mass must always 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. FALSE (2nd postulate)
f. All of the above completions yield true statements.
g. None of the above completions yields a true statement.

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. All of the above are part of the Principle of Equivalence as stated by Einstein.
f. None of the above (a through e) are stated by Einstein's Principle of Equivalence.

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. because accln is equivalent to grav'ty force.
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. 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 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~~ (delete "is": typographical error) measured in this spaceship of a ball released at rest?

a. 6 m/s^2
b. 10 m/s^2
c. 450 m/s^2
d. 460 m/s^2
e. 470 m/s^2
(f.) None of the above is within 10% of the correct answer.

If the acceleration were 6 m/s2 then @ would be correct. Since it is 6 km/s2, (f) is the correct answer. [Apologies – it was a typographical error.]

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. 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.

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

20. 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.

21. 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.

22. If 8 grams of oxygen combine completely with 6 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 1.5 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. 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 36 g of carbon and 90 g of oxygen?

a. 138 g
b. 112 g
c. 90 g
d. 84 g
d. 52 g
e. 36 g
f. None of the above is within 10% of the correct answer.

$36 + 3 \cdot 16 = 84g$ (& have $90 - 48 = 42g$ of O leftover)

24. In ammonia, 14 g of nitrogen combines completely with 3 g of hydrogen. How many grams of nitrogen does it take to combine completely with 12 g of hydrogen?

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.

$\frac{14}{3} \times 12 = 56g$ of N

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. 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. 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.

Since $m_{CARBON} = 12.000$ is the standard atomic mass.

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 $N_A = 6 \times 10^{23}$ per mole)

$M_{H_2O} = 18$ AMU $\Rightarrow$ 1 mole $H_2O = 18$ gm

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.

$n = \frac{10^3 g}{18 g}$ = no of moles = 55.6 moles

& No of particles = $N = N_A \cdot n = 55.6 \times 6 \times 10^{23}$
$= 333.3 \times 10^{23} = 3.3 \times 10^{25}$

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.

$P = \frac{F}{A}$ & $F = \sum_i \frac{\Delta p_i}{\Delta t}$

30. If the tip of a metal punching tool has an area of 1 mm^2 and a force of 100 N is exerted when the hammer strikes it , what pressure does the tip exert on the material being cut?

a. 10^2 N/m^2
b. 10^4 N/m^2
c. 10^6 N/m^2
d. 10^8 N/m^2
e. 10^{10} N/m^2
f. 10^{12} N/m^2
g. None of the above is within 10% of the correct answer.

$P = F/A = \frac{100N}{(10^{-3})^2 m^2} = 10^{2+6} = \frac{10^8 N}{m^2}$

31. 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. 0.25 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.

$PV = NkT_A$ & $\frac{3}{2}kT_A = \langle \frac{1}{2} m v^2 \rangle_{AVG}$ implying that
$v \to 2v \Rightarrow T_A \to 4T_A$. & Pressure is 4x larger = 4 atm:

$\frac{P_f V_f}{P_i V_i} = \frac{NkT_f}{NkT_i} = \frac{P_f}{P_i} \cdot \frac{1}{1} = \frac{T_f}{T_i} = \frac{4T_i}{T_i} = 4$

$P_f = 4P_i$

(since $V_f = V_i$: $\frac{V_f}{V_i} = 1$)

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 root mean square speed, $(\langle v^2 \rangle_{AVG})^{1/2}$, 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..

$T_O = T_H \Rightarrow \langle \frac{1}{2} m_O v_O^2 \rangle = \langle \frac{1}{2} m_H v_H^2 \rangle$

& $m_O = 16\, m_H \Rightarrow \frac{m_O v_O^2}{m_H v_H^2} = 1 = \frac{16 m_H v_O^2}{m_H v_H^2}$

Then $\frac{\sqrt{\langle v_O^2 \rangle}}{\sqrt{\langle v_H^2 \rangle}} = \sqrt{\frac{1}{16}} = \frac{1}{4}$

34. If you hold the temperature of an ideal gas constant as you triple its pressure, what happens to its volume? The volume changes by a factor of

a. 9
b. 3
c. 1
d. 1/3
e. 1/9
f. None of the above.

$PV = Const$: $\frac{P_f V_f}{P_i V_i} = \frac{Const}{Const} = 1 = \frac{3P_i V_f}{P_i V_i} \Rightarrow \frac{V_f}{V_i} = \frac{1}{3}$

35. Two liters of an ideal gas is heated from 273 °C to 819°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.

$T_{Ai} = 546 = 273 + 273$

$T_{Af} = 1092 = 819 + 273$

$\frac{P_f V_f}{P_i V_i} = \frac{N k T_f}{N k T_i} = \frac{1092}{546} = 2$

& $P_f / P_i = 1 \Rightarrow V_f = 2 V_i$

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 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. ✓
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.

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.

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 equal the increase of the substance's internal energy .
c. requires that internal energy must decrease if a gas expands so rapidly that not heat can be transferred into it or out of it.
d. implies that work must be done by the gas if it receives heat while its internal energy remains the same.
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 lost no heat.
b. no work was done on the system.
c. the system neither lost nor gained heat, and had zero 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, 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. decreases by 4 joules
b increases by 4 joules
c. decreases by 14 joules
(d.) increases 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.

48. When an ideal gas was compressed, its internal energy increased by 30 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.

$\Delta U = Q^{IN} + W^{IN}$
$+30 = -60 + W^{IN}$
$+90\,J = W^{IN}$

49. Given that Avogadro's number is $6X10^{23}$, and that the atomic mass of Nitrogen is 14, the mass of a single Nitrogen atom is, most nearly,
a. 4.3×10^{-23} g
b. 4.3×10^{-22} g
c. 2.3×10^{-22} g
(d.) 2.3×10^{-23} g
e. $2.3 \times 10^{+23}$ g
f. None of the above masses is correct within 10%.
g. Not enough information is given to calculate the mass of an atom.

1 mole of N atoms = 14g contains N_A atoms
Therefore each N atom has a $m_N = \frac{14}{6X10^{23}} = 2.3x10^{-23}$ gm.

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. : 540 cal/gm = Latent Heat of Vaporization
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 0.25 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.

52. Which of the following is the best thermal conductor?
a. ceramic
b. water
c. wood
d. copper ... because of its free (metallic) electrons.
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. Which color of flame is the hottest?
a. infra-red
b. red
c. yellow
d. green
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 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 , $v = (v'+V)/(1+v'V/c^2)$ for relativistic velocities. 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. 0.80c
(d.) 0.88c
e. 0.98c
f. 1.00c
g. 1.60c
h. None of the above is within 10% of the correct answer.

$v = \frac{0.6c + 0.6c}{1 + \frac{(0.6c)(0.6c)}{c^2}} = \frac{1.2c}{1.36} = 0.88c$

The other rocket ship is moving with $v' = 0.6c$ in the frame of the space station, whose $V = 0.6c$ w.r.t observer's frame (&ship).

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 4.26×10^{12} 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.
(Recall that the relativistic adjustment factor is $\gamma = 1/[1-(v/c)^2]^{0.5}$

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 equal to 0.9 c (γ = 2.23)
d. Yes, it is possible, but only if it travels with a speed equal to 0.99 c (γ = 7.07)
(e.) Yes, it is possible, but only if it travels with a speed equal to 0.999 c (γ = 22.4)
f. Yes, it is possible, but only if it travels with a speed equal to 0.9999 c (γ =70.7)

N can travel at most $636 \cdot c = 636 \times 3 \times 10^8 \text{ m/sec} \cdot 5\text{sec} = 1.908 \times 10^{11}$ m

Then to succeed in challenge, distance in earth's frame (4.26×10^{12} m) must be contracted to 1.908×10^{11} in N's rest frame.

Thus $\frac{L}{\gamma} = L'$ requires $\frac{L}{\gamma} \leq \frac{L'}{L} \Rightarrow \gamma \geq \frac{L}{L'} = \frac{4.26 \times 10^{12}}{1.91 \times 10^{11}} = 2.23 \times 10$

i.e $\gamma \geq 22.3$ requires $v = 0.999c$ (e)

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 between the number of hydrogen atoms and the number of oxygen atoms in each molecule.

Then suppose that the correct formula for the water molecule were H_8O_4, 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. 6.00 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.

If there were 1 O per H_2O, (instead of 4 as in H_8O_4)
then 1 l O would produce 2 l. of H_2O (steam),
because O comes in diatomic molecules of 2 atoms each
than if the (H)-compound were H_8O_4, 4 times as
many O atoms would occur in each H_8O_4 molecule.
and so the volume would be 4x smaller than 2 l: 0.5 l

Alternatively, 1 l O supplies 2 N O atoms where N_o is no
of O molecules in 1 l. It can therefore make $\frac{2N}{4} = \frac{N}{2}$ H_4O_8 atoms
which then occupy $\frac{1}{2}$ the volume of NO_2 molecules, or 0.5 l.

59. If 5 g of steam at 100°C are mixed with 33.75 g of ice at 0°C inside 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.

STEAM gives up heat Ice gains heat

$-5 \cdot 540 - 5 \cdot 1 (T_f - 100) + (33.75)(80) + (33.75) \cdot 1 (T_f - 0) = 0$

i.e.,

$-[\text{Heat out of steam to condense \& cool to } T_f] + [\text{Heat into ice to melt \& warm to } T_f] = 0$

$-2700 - 500 - 5T_f + 2700 + 33.75 T_f = 0$

$28.75 T_f = 500 \Rightarrow T_f = 17.4°$ (a)

60. Suppose that the steel rail of a train track is 6.0 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.

$\Delta L = L_0 \alpha \Delta T = 6 \times 10^3 \text{ m} \cdot (1.1) \times 10^{-5} \times [40 - (-20)] =$

$(6 \times 60) 1.1 \times 10^{-2} = 3.96 \text{ m}$

END of EXAM III