117 Ex III S06 Solutions

Matching Table: Questions 1 through 10

For each numbered question fill in on the corresponding line of your NCS answer sheet the circle under the letter of the correct answer.

F	**1. First Postulate of Special Relativity**	**A. Equals $(1-v^2/c^2)^{-1/2}$ times (mv).**
D	**2. Second Postulate of Special Relativity**	**B. Has a zero value which can never be attained in an actual system.**
H	**3. Total Relativistic Energy**	**C. Extrapolates to zero pressure (P = 0) at T_C = -273°C**
A	**4. Relativistic Momentum**	**D. Light obeys Maxwell's equations of Electrodynamics**
J	**5. Chemical Elements**	**E. Work energy plus heat energy added equals increase in internal energy.**
C	**6. Ideal Gas Model**	**F. Reaffirms Galilean Principle of Relativity**
B	**7. Kelvin Temperature Scale**	**G. Measures internal energy needed to convert solid into liquid.**
E	**8. First Law of Thermodynamics**	**H. Equals sum of rest energy and kinetic energy.**
G	**9. Latent Heat of Fusion**	**I. Kinetic plus potential energy of all the individual atoms and molecules.**
I	**10. Internal Energy**	**J. Always combine into compounds in integer ratios**

Multiple Choice

Insert into your NCS answer sheet the letter of the single choice that best completes the statement or answers the question.

11. The first postulate of special relativity
    a. says that there is no absolute reference frame. YES
    b. is a reaffirmation of the Galilean principle of relativity. YES
    c. states that the laws of physics are the same in all inertial reference systems. YES
    d. applies also to the implication of Maxwell's equations that the speed of light in vacuum is constant. YES
    (e.) All of the statements (a) through (d) are true.
    f None of the statements (a) through (d) is true

✓

12. Which of the following completions, (a) through (d), of the following is **not true**? The second postulate of special relativity
   a. requires that the speed of light be equal to the same value, $c = 3X10^8$m/sec, in every inertial frame. TRUE
   b. requires that the speed of light be independent of the speed of the source emitting the light TRUE
   c. requires that the speed of light be independent of the speed of the observer receiving the light TRUE
   d. is already implied by the first postulate of special relativity if Maxwell's equations of electromagnetism are specified to be true physical laws. TRUE
   e. None of the above completions (a) through (d) yields a true statement; i.e., all are untrue. FALSE
   f. All of the completions (a) through (d) yield true statements. TRUE

13. In his theory of special theory of relativity, Einstein
   a. abandoned the Galilean principle of relativity. FALSE
   b. abandoned Maxwell's equations for electricity and magnetism. FALSE
   c. Showed that the ether medium for Maxwell's electromagnetic waves had to be at rest with respect to the distant stars. FALSE
   d. postulated the existence of an absolute reference system. FALSE
   e. postulated the Principle of Equivalence FALSE
   f All of the above statements (a) through (e) yield true statements about Einstein's Special Theory NO!
   g. None of the above completions, (a) through (e) yields a true statement. ✓ YES

14.. On which of the following observations, (a) through (e), will two observers in different inertial systems agree about the results?
   a. The simultaneity of events at separate locations. NO
   b. The rate at which one another's clocks run NO
   c. The lengths they measure along the direction of their relative travel NO
   d. The synchronization of their own clocks with the moving clocks of the other frame. NO
   e The speed of their motion relative to one another. YES
   f The observers will agree on none of the items (a) through (e) above. FALSE
   g. The observers will agree on all of items (a) through (e) above. FALSE

15. As a space ship approaches you in outer space at a speed of $0.9 X 10^8$ m/sec (equal to 30% of the speed of light), its rotating beacon sends out a series of light pulses. You measure the speed of this each pulse to be
   a. $3.9 X 10^8$ m/sec
   b. $2.7 X 10^8$ m/sec
   c. $2.1 X 10^8$ m/sec
   d. $1.8 X 10^8$ m/sec
   e. $0.9 X 10^8$ m/sec
   f. None of the above is within 5% of the actual speed.

Speed = c = 3×10^8 m/sec
& 2.7×10^8 is off by 10%

16. As a friend passed you at a very high speed, you exploded two firecrackers simultaneously, one at each end of her skateboard. What happened from her point of view?
   a. The one at the front exploded second
   b. The one at the back exploded first
   c. The front and back firecrackers exploded simultaneously.
   d. The one at the back exploded second
   e. The answer depends on the speed of the skateboard.
   f. None of the above answers, (a) through (e) is a correct answer to the question.

Scenario A (for problems 17, 18, and 19):
A rocket ship is 220 m long when measured at rest. An observer, O, who sees the rocket ship moving past at 99.9% of the speed of light measures its length by marking the location of its nose and its tail simultaneously and then measuring the distance between the two locations.?

17. What is the relativistic adjustment factor, γ, for the situation in Scenario A, most nearly ?
   a. 1.0
   b. 2.1
   c. 7.1
   d. 22.4
   e 70
   f. None of the above is within 10% of the correct adjustment factor.

$\gamma = [1-(v/c)^2]^{-1/2}$ Let $v/c = 1-\epsilon = 0.999 \Rightarrow \epsilon = 0.001$

then $1-(v/c)^2 = 1-(1-\epsilon)^2 = 2\epsilon - \epsilon^2 \approx 2\epsilon$, since $\epsilon^2 \ll \epsilon$.

& $\gamma = 1/\sqrt{2\epsilon} = \frac{1}{\sqrt{.002}} = 22.36$

18. Suppose that the rocket in Scenario A speeds up to a constant velocity for which the relativistic factor is $\gamma = 73$. What length would the observer, O, in Scenario A above measure for the rocket ship, most nearly ?
   a. 293 m
   b. 220 m
   c. 147 m
   d. 73 m
   e. 10 m
   f 3 m
   g. None of the above is within 10% of the correct answer.

$L' = \frac{220}{\gamma} = 3.01$ m.

19. An observer, Õ, on the rocket ship of Scenario A above watches the observer, O, measure the length of the ship. Afterwards he criticizes O's measurement by saying
   a. that he measured O's meter stick and found that it was in fact shorter than a meter ✓
   b. that O did not actually measure position of the two ends of the ship at the same time, but that instead he first fixed the location of the front of the ship and then, afterwards, that of the back. ✓
   c. that when O claimed to have insured that he was locating the front and back at the same time by firing light pulses which then arrived half way between at the same time, his light pulses were not in fact fired at the same time ✓
   d. None of the above objections(a) through (c) above, is true and valid. FALSE
   e. All of the objections, (a) through (c) above, are true and valid TRUE

20. Einstein's Equivalence Principle is supported by the fact that
   a. Light is observed to be deflected when passing massive objects, as he predicted. TRUE
   b. The gravitational mass in Newton's Law of Universal Gravitation and the inertial mass in Newton's Second Law have, within the diminishing experimental error, the same values. TRUE
   c. The inertial pseudo-force required to explain the physics in an accelerated frame is proportional to the mass, m, of the object observed. TRUE
   d No experiment has been devised which exhibits a measurable difference between a gravitational force and an acceleration of the local frame of reference. TRUE
   e In fact, none of the "facts" cited in (a) through (d) above actually supports the Principle of Equivalence. FALSE
   (f.) In fact, all of the facts cited in (a) through (d) above actually support the Principle of Equivalence. TRUE

21. An electron is being accelerated by a constant force to nearly the speed of light. Which of the following statements, (a) through (e), is **false**?
   a. Its kinetic energy increases steadily. TRUE
   b. Its relativistic momentum increases at a constant rate. TRUE $F = \Delta \vec{p}/\Delta t = const$
   c. Its speed can approach, but not exceed, the speed of light. TRUE
   d. Its total energy continually increases. TRUE $E = \gamma mc^2$
   (e.) The power, or energy per unit time, required to accelerate it increases rapidly FALSE
   f. None of the above statements (a) through (e) is false.
   g All of the statements (a) through (e) above are false.

$$\text{Power} = \frac{\Delta W}{\Delta t} = \frac{F \cdot \Delta x}{\Delta t} \approx Fc \approx \text{constant}$$

22. Which of the following expressions gives the kinetic energy of a moving object?
   a. $E = mc^2$ REST ENERGY
   b. $E = \gamma mc^2$ TOTAL ENERGY
   (c.) $E = (\gamma-1)mc^2$ TOTAL ENERGY — REST ENERGY = KINETIC
   d. $E = (mv^2)/2$ ← LOW VELOCITY APPROXIMATION to KE
   e. None of the above.

23 The implications of the special theory of relativity
   a. are true only for objects moving at very high speeds. FALSE
   b. have not yet been experimentally verified. FALSE
   c. apply only to tiny atomic particles. FALSE
   d. cannot be tested except when speeds are comparable to c. FALSE (e.g.: Energy released by annihilation of massive e^+ & e^-)
   e are superseded by the implications of the quantum theory of matter
   (f.) None of the above completions (a) thrugh (e) yields a true statement. TRUE
   g. All of the above completions (a) through (e) yield true statements. FALSE

24 Superman wants to travel back to his native Krypton for a visit, a distance of $3X10^{13}$ meters. (It takes light 10^5 seconds to travel this distance.) If Superman can hold his breath for 1000 s and travel at any speed less than 0.9999c, can he make it before he suffocates?
   (a.) No, and he always falls short by more than 10%of the trip distance.
   b. No, but he always falls short by less than 10% of the trip distance.
   c. Yes, but always just barely, with less than 1% of the trip distance to spare.
   d. Yes, because he can reduce the contracted distance he travels to as small a value as he likes by setting his speed closer to that of light.
   e. Yes, because for him his biological clock slows down to give him more time
   f. None of the above completions yields a true statement.

S needs time dilation by $\gamma \geq 10^5/10^3 = 100$
& can achieve with $1-\epsilon = 0.9999 \Rightarrow \epsilon = 1\times10^{-4}$; $\gamma = \frac{1}{\sqrt{2\epsilon}} = \frac{10^2}{\sqrt{2}}$
so that he falls short by $\approx 40\%$

25 If the inertial mass, m_I in Newton's II law and the gravitational mass m_G in Newton's law of gravitation were NOT the same for the same object, then

a. the form of Newton's law of universal gravitation would not need to be modified. F
b. the form of Newton's second law would not need to be modified. F
c. Einstein's prediction that the path of light is bent by gravitational fields would stand, since light is massless. F
(d.) An object with masses ($m_I \neq m_G$) would fall in vacuum near the earth's surface with acceleration a =(constant)(m_G/m_I), which will differ from one object to another. T
e. All of the above statements are true. F
f. None of the above statements is true F

26. The law of definite volume proportions for gaseous reactants (all under the same standardized temperature and pressure conditions)

a. states that equal volumes of different gases always contain equal numbers of atoms. F: Equal No of molecules
b. was first proposed on purely philosophical grounds F
c. follows automatically from the law of definite mass proportions F
(d.) summarizes the fact that reactant gas volumes which combine completely to form compounds always have ratios equal to the ratios of small integers.. T
e. None of the above completions (a) through (d) yields a true statement. F
f All of the above completions (a) through (d) yield true statements. F

27. One mole of potassium sulfide molecules consists of 1 mole of sulfur (S) atoms(A=32) and 2 moles of potassium (K) atoms (A=39). If you combine 1 kg of sulfur with 1 kg of potassium to make potassium sulfide, how many moles of potassium sulfide can you make?

a. 39
b. 32
c. 31.
d. 26
(e.) None of the above is within 10% of the correct answer.

Each K_2S atom has $2 \cdot 39 = 78$ Amu of K & 32 Amu of S.
Therefore 1 kg of K will be exhausted before 1 kg of S.
Also 1 kg K = $10^3/39 = 25.6$ moles of K Atoms can make $\frac{25.6}{2} = (12.8)$ moles of K_2S

28 Suppose, hypothetically, that in question 27 above, all of the reactants were diatomic gases, and suppose that 2 liters of potassium combines entirely with 1 liter. of sulfur to form potassium sulfide, also a gas. Then, if the chemical formula for potassium sulfide were K_6S_3, how many liters of K_6S_3 would be produced, most nearly?

a. 3
b. 2
c. 1
(d.) 2/3
e. 1/3
f. None of the above is within 10% of the correct answer.

K_6S_3 has 6 K atoms per molecule & 2l of K_2 has 2·2l atoms of K
& therefore $Vol_{K_6S_3} = \frac{1}{6} \cdot 2 \cdot 2l = 2/3\, l$

29. Two gases are kept at the same temperature. If the molecules of gas A have 1/4 the mass of those of gas B, what is the ratio of the mean squared speed, ($\langle v^2 \rangle_{AVG}$), of the A molecules to that of the B molecules?

(a.) 4
b. 2
c. 1
d. 1/2
e. 1/4

$kT_A = \langle KE \rangle_A = kT_B = \langle KE \rangle_B$
i.e $\frac{1}{2} m_A v_A^2 = \frac{1}{2} m_B v_B^2$
$v_A^2/v_B^2 = m_B/m_A = 4$

30 One liter of gaseous element A combines with 3 liters of gaseous element B to form 1 liter of a gaseous compound A_PB_Q. If the molecules of the gases, A and B, have 2 atoms each, how many atoms of A and how many of B are there in each molecule of C?

a. ~~2 B atoms and 3A atoms~~
b. ~~1B atom and 3A atoms~~
c. 3 B atoms and 1 A atom
d. ~~3 B atoms and 2 A atoms~~
(e.) 6B atoms and 2 A atoms
f. None of the above chemical formulas would produce one liter of compound, C.

$\frac{P}{Q} = \frac{V_A}{V_B} = 1/3$: excludes (a) (b) (d)
and $\frac{2V_A}{P} = V_C = 1l \Rightarrow P = 2$ & (e) is correct

31 Which of the following is **NOT** assumed in our model of the ideal gas? The gas

a. particles rebound elastically when they collide with the container wall. T
b. particles have no internal structure. T
c. particles are indestructible. T
d. particles do not interact except when they collide. T
(e.) particles are always individual gas atoms F may be molecules
f. All of the above properties (a) through (e) are properties of our ideal gas. F
g. In fact, none of the above properties, (a) through (e), is a property of our ideal gas. F

32 The pressure that a molecular gas exerts on the walls of its rigid container increases with

a. the average magnitude of one component (e.g., p_x) of the momentum of the molecules. T: $F \propto \Delta p_x$
b. the speed with which the molecules travel to their next collision with the wall. T: $\frac{1}{\Delta t} \propto v_i$
c. the density of gas molecules . T: $P = N k T_A / V$ & $N/V \propto \rho$
d. the absolute temperature in K. T: P = "
(e.) All of the above completions (a) through (d) yield true statements.
f. None of the above completions (a) through (d) yields a true statement. FALSE

33\. 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 reduced to half its original value , while the volume is doubled?

(a.) 0.5 atm
b. 1 atm
c. 2 atm
d. 4 atm
e. None of the above is within 10%.
f. None of the above, because a statement about the temperature is required to specify the final pressure.

$\overline{KE} \rightarrow \frac{1}{2}\overline{KE} \Rightarrow T_A \rightarrow \frac{1}{2}T_A = T_f$, $V_i \rightarrow V_f = 2V_i$; $P_i = \frac{NkT_A}{V_i} \rightarrow P_f = \frac{NkT_A}{2V_i \cdot 2} = \frac{P_i}{4}$

FALSE: $\langle KE \rangle = \frac{3}{2} k T_A$ Fixes T_A

34 The two fixed points used to define the modern Fahrenheit temperature scale are those of

a. boiling water and a mixture of ice and salt.
b. the human body temperature and a mixture of ice and salt.
c. the human body temperature and freezing water.
(d.) boiling water and freezing water.
e. None of the above

35 What Celsius temperature corresponds most closely to 110° F?

a. 139° C
b. 81° C
c. 60 C
(d.) 43° C
e. 25° C
f. None of the above answers is within 10% of the correctr answer

$T_C = (T_F - 32) \cdot 5/9 = 43.3°C$

36 Which of the following doubles with a doubling of the absolute temperature of an ideal gas?

a. average momentum
b. average speed
c. average velocity
d. average mass
(e.) Average of the square of the speed
f. All of the quantities, (a) through (d) above, double with the absolute temperature.
g None of the quantities, (a) through (d) above, doubles with the absolute temperature

$\langle KE \rangle = \langle \frac{1}{2} m v^2 \rangle$ doubles with T_A so that $\langle v^2 \rangle$ doubles also.

37 Which of the following doubles with a doubling of the Celsius temperature of an ideal gas?

a. average momentum
b. average speed
c. average kinetic energy
d. product of pressure and volume
e. All of the quantities, (a) through (d) above, double with the ~~absolute~~ Celsius temperature
(f.) None of the quantities, (a) through (d) above, doubles with the ~~absolute~~ Celsius temperature

NONE of the physical quantities is proportional to T_C.

38 The pressure in a rigid container filled with gas increases when it is heated because

a. the walls must do more work on the gas as T increases. F: No displacement, NO WORK
(b.) the walls must exert a larger impulse to turn back the particles.. T
c. the number of gas particles increases with temperature. F
d. the volume of the gas increases with temperature. VOL = constant if container is rigi[d]
e. All of the above completions (a) through (d) yield true statements. F
f. None of the above completions (a) through (d) yields a true statement. F

39. Avogadro suggested that each liter of gas under identical conditions has the same

a. mass
b. number of atoms
(c.) number of molecules
d. density
e. None of the above.

40. What happens to the volume of an ideal gas if you double its pressure and its absolute temperature? The volume

a. It quadruples
b. It doubles
(c.) It stays the same.
d. It is cut in half
e. It is cut to one-fourth its original value
f. None of the above is a valid and correct answer to the question.

$P_f = 2P_i$
$T_f = 2T_i$

$$\frac{P_f V_f = \cancel{c} T_f}{P_i V_i = \cancel{c} T_i}$$

$$\left(\frac{P_f}{P_i}\right)\left(\frac{V_f}{V_i}\right) = \frac{T_f}{T_i}$$

$$\cancel{2} \cdot \left(\frac{V_f}{V_i}\right) = \cancel{2}$$

$$V_f = V_i$$

41. In radiative heat transfer, thermal energy is transported by
   a. electromagnetic fields
   b. the collisions of particles.
   c. the movement of a fluid.:
   d. the propagation of sound waves.
   e. physical vibrations of the intervening medium.
   f. All of the mechanisms (a) through (e) above transmit thermal energy in radiative transfer.
   g. None of the mechanisms (a) through (e) above transmits thermal energ in radiative transfer.

42. Joule's experiments with hanging weights turning paddle wheels in water
   a. showed that mechanical energy was converted to heat by viscous forces. T
   b. showed that 4.2 joules of work are equivalent to 1 calorie of heat. T
   c. fixed the ratio between the Joule and the (independently defined) calorie. T
   d. led to a generalization of the law of conservation of mechanical energy. T
   e. None of the above completions, (a) through (d) provides a true statement.
   f. All of the above completions, (a) through (d) provide a true statements.

43. Two objects are in thermal equilibrium if they have the same temperature, i.e.
   a. they have the same internal energy.. NO
   b. they have the same internal energy per unit mass. NO
   c. they are in thermal contact and there is no net flow of thermal energy
   d they have the same specific heat NO.
   e. All of the above completions, (a) through (d) provide true statements
   f. None of the above completions, (a) through (d) provides a true statement.

44. Which of the following completions, (a) through (d) below, leads to a **false** statement? The first law of thermodynamics
   a guarantees that if work is done on a system in some process and no net heat is ejected, the internal energy of the system must increase. T $W_{IN} + 0 = \Delta U > 0$.
   b. is a restatement of the law of conservation of energy. T
   c. allows that heat can be completely converted into work. T
   d. treats heat as another form of energy. T
   e. All of the above statements (a) through (d) are true of the first law: None is false.
   f None of the above statements (a) through (d) is true of the first law: All are false.

45. If during some process a system has no change in internal energy, we can say that
   a. the system ejected no heat.
   b. no work was done on the system.
   c. the net amount of work done by the system was equal to zero.
   d The system received no heat.
   e. None of the above assertions can be made on the basis of this statement.
   f All of the above assertions are guaranteed by the condition stated.

46. Which of the following statements about a cup of water and a gallon of water at the same temperature is correct?
   a. They will transfer the same heat energy to a third object at lower temperature.
   b. They have the same internal energies.
   c. The average molecular speed in the gallon is less than that in the cup
   d. The average molecular speed in the cup of water is less that that in the gallon.
   (e) The average kinetic energy of a molecule is the same for both the cup and the gallon. $\langle KE \rangle = \frac{3}{2} kT_A$
   f. None of the above statements, (a) through (e) is true.
   g All of the above statements, (a) through (e) are true.

47. When an ideal gas was compressed and then allowed to expand, its internal energy increased by 70 J, it gave off 30 J of heat, and in expanding performed 10 J of work. How much work was done on the gas in the original compression?
   a. 10 J
   b. 30 J
   c. 60 J
   d. 70 J
   (e.) 110 J
   f. None of the above is within 10% of the correct answer.

$W_{IN} - W_{OUT} + Q_{IN} - Q_{out} = \Delta U$ ($Q_{IN} \to 0$)

$W_{IN} = W_{out} + Q_{out} + \Delta U = 70 + 30 + 10 = 110\,J$

48. 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. guarantees that temperature is useful for predicting heat transfer.
   f. None of the above completions correctly characterizes the third law.

49. Why do climates near the coasts tend to be more moderate than near the middle of the continent?
   a. Because water has a high latent heat of vaporization.
   b. Because the coasts have lower elevations, and cool air flows downhill.
   (c.) Because water has a relatively high specific heat.
   d. Because it rains a lot on the coasts.
   e Because water has a high latent heat of fusion
   f. None of the above.

50. In our laboratory measurement of the specific heat of copper, a hot copper cylinder is immersed in a cup of cold water, and allowed to come to equilibrium. During this process heat transfer to or from the equilibrating (copper + water) system may cause the result to be erroneous. For our experimental procedure, it is clear that such heat transfer is most likely to lead to net heat's being transferred
   a. into the system, and therefore to an increase in the computed specific heat of Cu.
   b. out of the system, and therefore to an increase in the computed specific heat of Cu.
   c. into the system, and therefore to a decrease in the computed specific heat of Cu.
   d. out of the system, and therefore to a decrease in the computed specific heat of Cu.
   (e) In fact, it is not clear whether net heat will be transferred in or out of the system, so that the effect on the computed specific heat can not be predicted reliably.

Because the water is cooler than the Room temperature & the Cu slug is hotter. Therefore some heat may flow into the sample at first and later some may flow out.

51. If it takes about 6600 cal to raise the temperature of a 700-g metal statue by 44° C, of which of the following materials is the statue most likely composed?
    a. Aluminum, with specific heat c = 0.215 cal/g-°C
    b. Copper, with specific heat c = 0.092 cal/g-°C
    c. Gold, with specific heat c = 0.031 cal/g-°C
    d. Silver, with specific heat c = 0.057 cal/g-°C
    e. None of the above is within 10% of the correct answer.

$c = \frac{\Delta Q}{m \Delta T} = \frac{6600}{(700)(44)} = 0.21 \frac{cal}{gm\,°C}$

(Al)

52. In convective energy 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. physical vibrations of the intervening medium.
    f. All of the mechanisms (a) through (e) above transmit thermal energy in convection.
    g. None of the mechanisms (a) through (e) above transmits thermal energy in convection.

53. In one lab experiment the touching panels of various materials setting on the table suggested that the steel panel was cooler than the styrofoam panel, despite the fact that the thermometer measured the same temperature for both (and reasonably so, since they had plenty of time to come to temperature equilibrium with the air in the room). If one knew also that steel was a much better heat conductor than styrofoam one might reasonably infer that
    a. that our sense of touch is a good built-in thermometer. F
    b. that styrofoam stays hot longer than steel. F
    c. that our touch may be measuring not the temperature, but the rate of heat transfer.
    d. that just because an object is hot to touch it may still not be dangerous. F
    e. All of the completions (a) through (d) above provide reasonable inferences. F
    f. None of the completions (a) through (d) above provides a reasonable inference. F

54. 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. F
    b. when there is no friction. F
    c. when all of the forces acting are conservative. F
    d. if there is no heat loss or gain. F
    e. if the third law of thermodynamics is valid.. F
    f All of the above completions (a) through (e) yield a true statements. F
    g. None of the above completions (a) through (e) yields a true statement. T

The following six problems #55 - #60 may require more computation than average, and you may wish to allocate your effort according.,

55. A super-train is traveling along a straight, horizontal track at a constant speed, V=0.9c. It fires a super-rocket in the forward direction with a speed , v'=0.95c. (Recall that, relativistically, $v = (v'+V)/(1+Vv'/c^2)$.) An observer in the train station will measures the speed of the rocket, most nearly, to be
   a. 1.85 c
   b 1.71 c
   c. 1.0 c.
   d. 0.95 c
   e. 0.90 c
   f. 0.86 c
   g. 0.63 c
   h 0.05 c
   i 0.00 c
   j None of the above is within 10% of the correct speed.

$$\frac{v}{c} = \frac{(0.95+0.90)}{1+(0.9)(0.95)} = \frac{1.85}{1.955} = 0.9973$$

$$v = 0.9973c$$

56. If a particle of rest mass, m= 1 kg, is accelerated from rest to a speed of v = 0.999c, what is its final total energy (= rest energy + kinetic energy), most nearly ?
   a. 9×10^{20} J
   b. 2×10^{20} J
   c. 9×10^{18} J
   d. 2×10^{18} J
   e. 9×10^{16} J
   f. 2×10^{16} J
   g. None of the above is within 10% of the correct answer.

$$E_{TOT} = \gamma mc^2 = \frac{mc^2}{\sqrt{1-v^2/c^2}} = mc^2/\sqrt{2\epsilon} = 22.4mc^2$$

$\{$ If $0.999 = v/c = 1-\epsilon$, $\epsilon = 10^{-3}$, and $1-(v/c)^2 = (1+v/c)(1-v/c) \approx 2\epsilon$ so that $\gamma = \frac{1}{\sqrt{2\epsilon}}\}$

$$E_{TOT} = 22.4\, mc^2 = (22.4)(1)(3\times10^8)^2 \frac{kg\, m^2}{sec^2}$$

$$= 2.02 \times 10^{18} J$$

57. One liter of an ideal gas is heated from 300 °C to 875 °C while the pressure doubles from 1 atmosphere to two atmospheres. What is the final volume of the gas, most nearly?

a. 0.25 liter
b. 0.33 liter
c. 0.50 liter
(d.) 1 liter
e. 2 liters
f. 3 liters
g. 4 liters
h. None of the above is within 10% of the correct answer

$$\frac{P_f V_f}{P_i V_i} = \frac{Nk T_f}{Nk T_i} \Rightarrow \frac{P_f}{P_i} \cdot \frac{V_f}{V_i} = \frac{T_f}{T_i}$$

$T_i = 573\,K$, $T_f = 1148\,K$ & $\frac{P_f}{P_i} = 2$

$$\frac{V_f}{V_i} = \frac{1148}{573} \cdot \frac{1}{2} = 1.00.$$

58. A hypothetical balloon filled with an ideal gas has a volume of 10^5 liters at 30°C under one atmosphere of pressure. At what temperature, most nearly, will its volume be 10^6 liters under ten atmospheres of pressure?

a. 3000°C
b. 2700°C
c. 2400°C
d. 2100°C
e. 1800°C
f. 1500°C
(g.) None of the above is within 10% of the correct Celsius temperature

$$\frac{T_f}{T_i} = \frac{P_f}{P_i} \cdot \frac{V_f}{V_i}$$

$$T_f = (10 \cdot 10)(303\,K) = 30{,}300\,K$$

$\frac{V_f}{V_i} = \frac{10^6}{10^5} = 10$

$\frac{P_f}{P_i} = \frac{10}{1} = 10$

$T_i = 303\,K$

59. The latent heat of fusion for water is 334 kJ/kg, and its specific heat is 4.2kJ/kg-°C. How much energy would it take to melt 2 kg of ice at 0° C to form water at 70° C?

a. 140 kJ
b. 244 kJ
c. 588 kJ
d. 668 kJ
e 962 kJ
(f.) 1256 kJ
g. None of the above is within 10 % of the correct answer.

$Q = 2\,kg \cdot 334\,\frac{kJ}{kg} + (2\,kg)(70\,K) \cdot 4.2\,\frac{kJ}{kg\,K}$

$= 668 + 588 = 1256\,kJ$

60. If 200 g of steam at 100° C and 100 g of ice at 0° C are enclosed in an insulated container, what is the final equilibrium temperature, most nearly ? (Recall that the latent heat of fusion of water is 80 cal/g, and the latent heat of vaporization is 540 cal/g).

a. 60° C
b. 70° C
c. 80° C
d. 90° C
(e) 100° C
f. None of the above is within 10% of the correct answer.

Assume $100°C > T_f > 0°C$; i.e have only water at end

& SET: HEAT OUT of STEAM = HEAT INTO WATER

$(200)(540) + (100 - T_f)200 = (100)80 + 100(T_f - 0°C)$

& find $108{,}000 - 8000 + 20{,}000 - 0 = 300 T_f$

$120{,}000$

$400°C = T_f$ IMPOSSIBLE

to have Temp > 100°. CONCLUDE that STEAM is able to melt ice & heat ice water to 100° before steam has completely condensed to water.

Then final state is mixture of steam & WATER and $T_f \equiv 100°C$

.......End of Exam