Phys 117 EXAM III S07: SOLUTIONS

1 In discussing special relativity, we consider a phenomenon 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. Physicists postulated 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. All of the above.
f. 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 race always ended in a tie.
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.
f. None of the above.

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
f. None of the above is within 10% of the correct answer.

5.. On which of the following observations will two observers in different inertial systems agree about the results?
a. The simultaneity of events at separate locations. X
b. The rate at which one another's clocks run X
c. The lengths they measure along the direction of their relative travel X
d. The synchronization of their own clocks with the moving clocks of the other frame. X
e. The magnitude of their relative velocities. ✓
f. The observers will agree on none of the items (a) through (e) above. X
g. The observers will agree on all of items (a) through (e) above. X

6. In his theory of special relativity, Einstein
a. abandoned for light waves the prediction of Galilean Relativity that the velocity would be larger or smaller for observers in different inertial frames. ✓
b. retained the prediction of Maxwell's electromagnetic equations for the speed of light. ✓
c. postulated that all the laws of physics are the same in every inertial frame. ✓
d. postulated that the speed of light in vacuum has the same value in every inertial frame. ✓
e. All of the above are true of Einstein's special theory of relativity.
f. None of the above is true of Einstein's special theory of relativity.

7. The second postulate of special relativity states that the speed of light in vacuum
a. is a constant relative Mach's inertial frame fixed to the distant stars. X
b. is constant relative to the ether. X
c. depends on the motion of the source. X
d. depends on the motion of the receiver. X
e. None of the above completions is true of Einstein's second postulate.
f. In fact, Einstein stated only one postulate for his special theory of relativity X

8. A train is traveling along a straight, horizontal track at a constant speed that is only slightly less than that of light. An observer, T, in the train determines that firecrackers go off simultaneously in the engine and in the caboose. An observer, G, on the ground determines that the firecracker in the _____ went off first.
a. engine (because the signal from the engine reaches observer G before it reaches observer T) X
b. caboose (because the signal from the caboose reaches observer G before it reaches observer T) ✓
c. engine (because the signal from the engine reaches observer T after it reaches observer G) X
d. engine (because the signal from the engine reaches observer T before it reaches observer G) X
e. None of the above: they went off simultaneously for both observers. X
f. None of the above can be valid because the answer depends on the speed of the train. X

9. Which of the following expressions gives the relativistic kinetic energy of a moving object of mass, m?
a. $E = mc^2$ REST Engy
b. $E = \gamma mc^2$ TOTAL "
c. $E = (\gamma-1)mc^2$ ← REL. KE. & $(\gamma-1) \rightarrow \frac{v^2}{2c^2}$ for small v to yield
d. $E = (mv^2)/2$ NON REL. KE ←
e. None of the above. X

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

11. The second postulate of special relativity requires that the speed of light

a. is a constant in a vacuum and always equal to the same value $c = 3 \times 10^8$ m/s. ✓
b. is independent of the motion of the receiver. ✓
c. is independent of the motion of the source. ✓
d. is independent of the direction of propagation. ✓
e. has the value implied by Maxwell's equations of electromagnetism. ✓
f. All of the above completions yield true statements.
g. None of the above completions yields a true statement. X

12. 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 that of light, 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.

13. In the twin paradox one twin remains on earth while the other makes a trip to a distant location and back at the same constant speed, close to c. Each argues that his brother will have aged less than he. When the twins are reunited on earth, which of their claims will prove to be valid? The valid claim is that of
a. the twin who remained on earth, because his inertial frame experienced an acceleration.
b. the twin who made the trip, because he always remained in the same inertial frame.
c. Actually, neither: they are the same age, because the speed was held constant out and back.
d. the twin who remained on earth, because he always remained in the same inertial frame.
e. The answer depends upon the details of the turnaround.
f. None of the above statements is true.

14. An electron is being accelerated by a constant force to nearly the speed of light. Which of the statements (a) through (e) is **false**?
a. Its kinetic energy continually increases.
b. Its momentum increases at a constant rate
c. It can approach but not exceed the speed of light.
d. Its total energy continually increases.
e. The acceleration during each Δt is smaller than that during the preceding Δt.
f. All of the above statements, (a) through (e), are false.
g. All of the statements, (a) through (e), above are true; none is false.

15. 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 $L = 80/50$
b. 40.0 m
c. 80 m
d. 600 m
e. 4000 m
f. None of the above is within 10% of the correct answer.

16. 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 need to be modified. X Not so; these laws could still stand each on its own merits.
b. the form of Newton's second law would need to be modified. X Not so
c. the basis for Einstein's prediction that the path of light is bent by gravitational fields would be validated automatically. X False: this would contradict, not validate, PRINCIPLE OF EQUIVALENCE
d. objects of different masses falling in a vacuum near the earth's surface would have to experience different accelerations. ← Possible, but not necessary: If $m_I = C m_G$
e. All of the above statements are true. F
(f.) None of the above statements is true T

Then $a = \frac{F_G}{m_I} = \frac{GM_E}{(R_E)^2} \cdot \frac{m_G}{m_I} = \frac{GM_E}{(R_E)^2} \cdot \frac{1}{C}$ would be same for any mass.

17. Suppose two teams of astronauts who think they are accelerating through space in sealed laboratories are actually sitting on the surfaces of Earth and Mercury. The gravitational field on Mercury is much smaller than that of Earth. If both teams are at any given moment in frames which are very nearly inertial, which of the following statements about their speeds is true?
a. The team on Mercury correctly believes their speed is less that that of the team on Earth.
b. The team on Earth correctly believes their speed is less that that of the team on Mercury.
c. The team on Mercury correctly believes their speed is greater that that of the team on Earth.
d. The team on Earth correctly believes their speed is greater that that of the team on Mercury.
e. Both teams correctly agree that their speeds are the same.
(f.) Neither team can determine whether its speed is greater or less that than that of the other. by the principle of Galilean Relativity.

18 The Greek "atomists" believed in atoms
a. because of experiments with combining gases.
b. because of diffusion experiments.
c. by analogy with the stars and planets.
(d.) on the philosophic grounds that there had to be in the end a particle which could not be cut into two.
e. because they believed the alchemists.
f. for none of the above reasons.

19. How does the number of molecules in 1 liter of diatomic oxygen compare with the number of molecules in 1 liter of carbon dioxide if they are both at the same temperature and pressure? (Molecular masses: $m_{CO2} = 44$; $m_{O2} = 32$)
a. There are 3/2 times as many carbon dioxide molecules as oxygen.
b. There are 3/2 times as many oxygen molecules as carbon dioxide.
c. There are 32/44 times as many carbon dioxide molecules as oxygen
d. There are 32/44 times as many oxygen molecules as carbon dioxide.
(e.) The volumes described both contain the same number of molecules. Avogadro's Hypothesis
f. It is not possible to say with certainty.

20. On the Atomic Mass Scale, atomic and molecular masses are usually expressed in
a. kg
b. gm
c. micrograms = 10^{-6} gm
d. nanograms = 10^{-9} gm
e. Units of 10^{-23} gm
(f.) ratios of the masses to 1/12 of the mass of carbon

21. If 6 grams of carbon combine completely with 8 grams of oxygen to form carbon monoxide, how many grams of carbon does it take to combine completely with 24 grams of oxygen to form carbon monoxide?
    a. 2
    b. 6
    c. 12
    d. 18 $6/8 = x/24 \Rightarrow x = 18$.
    e. 24
    f. 30
    g. None of the above is within 10% of the correct answer

22. What Celsius temperature corresponds most closely to a temperature of 200 Kelvins?
    a. 127° C
    b. 27° C
    c. -73° C $T_A = T_C + 273$
    d. -173° C
    e. None of the above is within 10%.

23. Which of the following is a compound?
    a. hydrogen ✗
    b. oxygen ✗
    c. carbon ✗
    d. water ✓
    e. nitrogen ✗
    f. None of the above: they are all elements. ✗
    g. All of (a) through (e) above are compounds ✗

24. 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 $\frac{F}{A} = \frac{W}{1\,cm^2} = \frac{mg}{1\,cm^2} = \frac{70 \cdot 10\,N}{cm^2} = \frac{700\,N}{cm^2}$
    c. 70 N/cm^2
    d. 700 N/cm^2
    e. None of the above is correct within 10%.

25. Two gases are kept at the same temperature. If the molecules of gas A have 2 times the mass of those of gas B, what is the ratio of the mean squared speed of the B molecules to that of the A molecules?
    a. 4
    b. 2 $\frac{3}{2} k_B T_A = \frac{1}{2} m_A v_A^2 = \frac{1}{2} m_B v_B^2 = \frac{3}{2} k_B T_B$ & $T_A = T_B$
    c. 1
    d. 1/2 $\Rightarrow \frac{m_A}{m_B} = \frac{v_B^2}{v_A^2} = 2$
    e. 1/4
    f. None of the above is within 10% of the correct ratio
    g. None of the above because the ratio does not depend upon the molecular masses.

26. Which of the following is NOT assumed in our model of the ideal gas? The gas molecules
   a. rebound elastically when they collide with the container wall. ✓
   b. have no internal structure. ✓
   c. have a fixed finite mass. ✓
   d. do not interact except when they collide. ✓
   e. may sometimes break up into their separate atoms ✗
   f. None of the properties (a) through (e) above is a property of our ideal gas. F
   g. All of the properties (a) through (e) above are properties of our ideal gas. F

27. Which of the following statements is true for an ideal gas? The average _____ of an ideal gas is proportional to the _____ temperature.
   a. momentum ...Kelvin
   b. speed ... Celsius
   c. kinetic energy ... Celsius
   d. speed ... Kelvin
   e. kinetic energy ... Kelvin
   f. None of the above completions yields a true statement F

28. If a liter of gas has a pressure of 0.5 atmospheres, what will the pressure be if the average kinetic energy of the molecules is doubled, while the volume is increased to twice its original value? (1 atmosphere = 101×10^3 N/m^2 = 10^5 Pa, approximately.)
   a. 0.5 atm.
   b. 1 atm.
   c. 2 atm.
   d. 4 atm.
   e. 8 atm.
   f. None of the above is within 10%.

$\frac{P_f V_f}{P_i V_i} = \frac{4T_f}{4T_i} = 2 \Rightarrow P_f = 2\frac{V_i}{V_f} P_i = 2/2\, P_i = P_i$

29. Suppose that two liters of a diatomic gas Z combines with six liters of diatomic hydrogen to form 1/3 liter of the hypothetical gas, "Z-hydride". How many atoms of Z and of H (hydrogen) would there be in 1 molecule of "Z-hydride"? (All volumes are at Standard Temperature & Pressure.)
   a. 3 H and 1 Z: ZH_3
   b. 6 H and 2 Z: Z_2H_6
   c. 9 H and 3 Z: Z_3H_9
   d. 12 H and 4 Z: Z_4H_{12}
   e. 15 H and 5 Z: Z_5H_{15}
   f.. 18 H and 6 Z: Z_6H_{18}
   g. There is a unique correct answer, but it is none of the above.
   h. It is not possible to say from the data given.

Formula is $Z_n H_{3n}$ from 6/2 volume ratio
Final Vol is $\frac{1}{3} \cdot \frac{1}{2} = 1/6 \times$ initial Vol of Z
so that there are $\frac{1}{6}$ as many $Z_n H_{3n}$ molecules as there are (diatomic) Z molecules or $\frac{1}{12}$ as many $Z_n H_{3n}$ molecules as Z atoms:
$n = 12$: $Z_{12} H_{36}$ is formula

30. One mole of ammonia molecules consists of 1 mole of nitrogen atoms (Atomic mass =14) and 3 moles of hydrogen atoms (Atomic mass =1). If you combine 420 g of nitrogen with 100 g of hydrogen to make ammonium, how many moles of ammonia can you make, most nearly?
   a. 520
   b. 420
   c. 100
   d. 30
   e. It is not possible to say.
   f. It is possible to say, but none of the answers a) through d) above is within 10%.

NH_3: 1 mole is 17g.
Then $\frac{420g}{14} N = 30$ moles of N atoms
require $3 \times 30 = 90$ moles of H atoms $= 90$gm,
& 100g is available, so that 10g H atoms are leftover

31. Two gases are kept at the same temperature. If the molecules of gas B have 9 times the mass of those of gas A, what is the ratio of the root mean square speed, $\langle (v^2)^{1/2} \rangle_{AVG}$, of the A molecules to that of the B molecules?

a. 9
(b) 3
c. 1
d. 1/3
e. 1/9
f. None of the above is within 10% of the correct answer.

$\frac{3}{2} k_B T_A = \frac{1}{2} m_A v_A^2 = \frac{1}{2} m_B v_B^2 = \frac{3}{2} k_B T_B$ ∆ $T_A = T_B$

$\sqrt{\frac{v_A^2}{v_B^2}} = \sqrt{\frac{m_B}{m_A}} = 3$

32. In convection, thermal energy is transported by
a. the movement of the fluid under thermal pressure
b. the movement of the fluid under pressure of sound waves.
c. the movement of the fluid by electromagnetic fields.
d. the movement of the fluid the propagation of sound waves.
(e.) the movement of the fluid due to gravity. due to change in density with Temp.
f. None of the above.

33. Which of the following four states of matter occurs at the highest temperature?
(a.) plasma
b. liquid
c. solid
d. gas
e. None of the above: the correct answer depends upon the particular material.

34. Pressure is
a. mass per unit volume.
b. mass per unit area.
c. force per unit volume.
(d.) force per unit area.
e. momentum per unit area.
f. energy per unit area.
g. None of the above.

35. Joule's experiments with hanging weights turning paddle wheels in water
(a.) first showed that the same amount of frictional work always generated the same amount of heat. T
b. first showed that heat was not a fluid. X Rumford knew this already
c. were used to define the calorie, as the unit of heat F
d. first showed that heat could be converted 100% to mechanical energy. F. D. Ho.
e. All of the above completions yield true statements. F
f. None of the above is true. F

36. Two objects are in thermal equilibrium if
a. they have the same temperature. ✓
b. they are each in thermal equilibrium with the same third object. ✓
c. they are in thermal contact and there is no net flow of thermal energy. ✓
(d.) All of the above completions yield true statements. ✓
e. None of the above completions (a) through (c) yields a true statement. F

37. The first law of thermodynamics
   a. is a statement of the law of conservation of energy which includes heat as a form of energy. T
   b. requires that internal energy can be completely converted into work. F
   c. treats mass as another form of energy. F
   d. guarantees that the work extracted by a cyclic heat engine can never be less than the heat inserted. F
   e. All of the above statements (a through d) are true of the first law. F
   f. None of the above statements (a through d) is true of the first law. F

38. When an ideal gas was compressed, its internal energy increased by 50 J and it gave off 30 J of heat. How much work was done on the gas?
   a. 30 J
   b. 50 J
   c. 80 J
   d. 110 J
   e. None of the above.

$W^{IN} = \Delta U + Q^{OUT} = 50 + 30 = 80J$

39. The third law of thermodynamics
   a. is a restatement of the law of conservation of energy. F
   b. says that heat cannot be completely converted to mechanical energy. F
   c. says that we can never reach the absolute zero of temperature. T
   d. says that all motion ceases at absolute zero. F
   e. guarantees that temperature is useful for predicting heat transfer. F
   f. None of the above completions yields a true statement. F

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

41. Why do winter lakes freeze from the upper surface down?
   a. Because water has a high latent heat of vaporization. X
   b. Because lakes have lower elevations, and cool air flows downhill. X
   c. Because water has a relatively high specific heat. X
   d. Because below 4°C water becomes less dense as it cools towards 0° C. ✓
   e. Because water has a high latent heat of fusion X
   f. None of the above is true. X

42. Water has a specific heat of 1.0 cal/gm-°C. and a latent heat of fusion of 80 cal/gm. How many calories must be removed from 75gm of water at 10°C in order to freeze it entirely into ice?
   a. 6750 cal.
   b. 6075 cal
   c. 5250 cal.
   d. 90 cal.
   e. 81 cal.
   f. None of the above is within 10% of the correct answer.

$Q^{OUT} = (75 \cdot 80) + 1 \cdot 75 \cdot 10$
$= 6000 + 750$ cal.

43. Suppose that the specific heat of copper is 0.20 cal/gm °C? In an experiment a 200 gm slug of copper at 80°C is inserted into 200 gm bath of water at 20°C. If there is heat lost from the copper/water system to the surroundings as it comes to the final equilibrium temperature, we can be sure that the final temperature is
    a. more than 70°C;
    b. more than 50°C;
    c. more than 30°C;
    d. less than 20°C;
    e. less than 30°C.
    f. None of the above conclusions is certain

No : $20° < T_f < 80°$

$200\,gm \times 0.2 \times (80 - T_f) = 200 \cdot 1 (T_f - 20°C)$

$3200 + 4000 = (200 + 40) T_f$

$\Rightarrow T_f = 30°$ without losses

44. How many calories are required to heat 300 g of water from 3°C to 10°C, most nearly?
    a. 7.0
    b. 300
    c. 2000
    d. 3000
    e. 20,000
    f. None of the above is within 10% of the correct answer

$300 \times 1 \times 7° = 2100\,cal = 2000$ most nearly

45. Joule's experiments in which hanging weights turned paddle wheels in water
    a. showed that a specific amount of work always converted into the same amount of heat. T
    b. showed that 4.2 joules of work are equivalent to 1 calorie of heat. T
    c. were used to fix the ratio of the unit of heat energy to the unit of work energy. T
    d. showed that mechanical energy could be converted 100% to heat. T
    e. All of the above statements are true of Joule's experiments. T
    f. None of the above statements is true. X

46. Which of the following statements does **NOT** correctly describe what happens when a hot block is placed in thermal contact with a cool block? (I.e., which of items (a) through (d) below is **false**?)
    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. Temperature flows from the hot block to the cool block.
    e. All of the above statements (a) through (d) are false. F
    f. None of (a) through (d) is false: all correctly describe what happens. F

47. The first law of thermodynamics
    a. states that a temperature of absolute zero can never be attained. F
    b. says that heat cannot be completely converted to mechanical energy. F
    c. is the basis for the definition of temperature.
    d. is the basis for the definition of entropy. F
    e. includes the second law of thermodynamics as a special case. F
    f. states the impossibility of attaining a temperature of absolute zero. F
    g None of the above. F

48. During a process, 40 joules of heat are transferred into a system, while the system itself does 15 joules of work and exhausts 10 joules of heat. The internal energy of the system
    a. decreases by 15 joules.
    b. decreases by 25 joules.
    c. remains the same.
    (d.) increases by 15 joules.
    e. increases by 25 joules.
    f. None of the above is within 10%

$\Delta U = 40 - 15 - 10 = +15\,J$

49. A 60-m long copper wire (coefficient of thermal expansion of $1.7 \times 10^{-5}/°C$) experiences a temperature change of 20°C. What is the change in length of the wire, most nearly ?
    a) 0.33 mm; b) 1 mm; c) 1.7 mm; d) 12 mm; (e) 20 mm.

$\Delta L = \alpha L_0 \Delta T = 1.7 \times 10^{-5} \times 60m \times 20 = 2,040 \times 10^{-5}\,m = 2.04 \times 10^{-2}\,m$
$= 20.4 \times 10^{-3}\,m$
$= 20.4\,mm$

50. If the internal energy of an ideal gas increases by 80 J when 150 J of work are done to compress it, how much heat is transferred in the process?
    a. 80 J of heat out of the gas
    b. 80 J of heat into the gas
    c. 70 J of heat into the gas
    (d.) 70 J of heat out of the gas
    e. 230 J of heat into the gas
    f. None of the above is within 10% of the correct answer.

$Q_{IN} + W_{IN} = \Delta U$
$Q_{IN} = 80 - 150 = -70\,J$
$Q_{OUT} = +70\,J$

51. Given that ice has a specific heat that is one-half that of water, when the temperature of 5 grams of water and that of 5 grams of ice both drop by 6°C
    (a.) the water gives off twice as much heat as the ice.
    b. the ice gives off twice as much heat as the water.
    c. both give off the same amount of heat, but the ice does so quicker.
    d. both give off the same amount of heat, but the water does so quicker.
    e. None of the above.

52. Why is steam at 100°C more dangerous to tissue than water at 100°C?
    a. The steam is hotter.
    (b.) The steam has more internal energy per gram.
    c. The steam has a higher specific heat.
    d. The steam has less viscosity.
    e. In fact water is more dangerous than steam at 100°C.
    f. None of the above is a true statement about steam and water.

53. Which type of bench would have the warmest equilibrium temperature on a cold winter day?
    a. aluminum
    b. marble
    c. wood
    d. iron
    (e.) None of the above: all would come to the same temperature

Due to a printing error answer (e) was omitted from the printed exam. Therefore all answers were accepted since the question, as finally printed, was poorly posed.

54. Aluminum and air have almost the same values for their specific heats: 0.21cal./gm °C and 0.24 cal./gm °C, respectively. Therefore, 10^4 calories of heat will raise the temperature of 1 liter of aluminum _____ 1 liter of air. (Assume T = 20°C, and P = 1 atm.)
    a. much more than
    b. slightly more than
    c. about the same as
    d. slightly less than
    e. much less than
    f. It is not possible to say.

because 1 l of Al has (immensely!) much more mass than 1 l of Air

(The remaining problems may require more computation than those above.)

55. 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. 0.64c
    b. 0.800c
    c. 0.976c
    d. 1.00c
    e. 1.28c
    f. 1.600c
    g. None of the above is within 0.5% of the correct answer.

$v = (0.8 + 0.8)c \,/\, (1 + (0.8)(0.8)) = \frac{1.6c}{1.64} = 0.976c$

56 . 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 9.5 x 10^{15} m from earth and still to survive with the same 50% probability? (Recall that c = 3 X 10^{8} m/sec, and choose the most nearly correct answer.)

a. It is not possible, because the proton would have to travel faster than the speed of light.
It is possible, but only it it travels with a speed such that the relativistic adjustment factor, $\gamma = (1-v^2/c^2)^{-1/2}$ is greater than:

b. 5
c. 50
d. 500
e. 5000
(f.) 50,000

In $T_{1/2}$ = 636 sec, N can travel $R = 1.9 \times 10^{11}$ m at speed $\approx c$
Then distance, $D = 9.5 \times 10^{15}$ must be contracted to this length (or less)

$$D = \frac{9.5 \times 10^{15}}{\gamma} \leq 1.9 \times 10^{11} = R$$

$$5 \times 10^{4} \leq \gamma$$

The following problem is misnumbered: It should be deleted

56. 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. If the neutron travels through the earth's atmosphere at a speed of 0.99995c = (1-5X10^{-5})c what time will the earthbound observer measure for half of the neutrons to decay, most nearly? (Hint: For v/c = (1-ε), and ε<<1, $\gamma = 1/(2\varepsilon)^{1/2}$, approximately.)

a. 636 X 10^{-2} s
b. 636 X 10^{-1} s
c. 636 s
d. 636 X 10^{+1} s
(e.) 636 X 10^{+2} s
f. 636 X 10^{+3} s

$$\Delta t = \gamma \Delta t' = \frac{\Delta t'}{\sqrt{1 - v^2/c^2}} \approx \frac{\Delta t'}{\sqrt{(1+v/c)(1-v/c)}} = \frac{\Delta t'}{\sqrt{2\epsilon}}$$

where $\epsilon = 1 - v/c = 0.00005 = 5 \times 10^{-5}$

$$\Delta t = \frac{636}{\sqrt{2.5 \times 10^{-5}}} = \frac{636}{\sqrt{10^{-4}}} = (10^2)(636)\,\text{sec}$$

57. If a liter of gas initially has a pressure of 1.0 atmosphere, what will the pressure be if the average kinetic energy of the molecules is doubled, while the volume is reduced to 0.4 liter?

a. 0.2 atm
b. 0.5 atm
c. 2.0 atm
(d.) 5.0 atm
e. 10.0 atm
f. None of the above is within 10% of the correct answer.

$(KE)_i \rightarrow (KE)_f = 2(KE)_i \Rightarrow T_f = 2T_i$

because $T = \frac{2}{3}\langle KE\rangle_{AVG}/k_B \ll \langle KE\rangle_{AVG}$

Then $\frac{P_f V_f}{P_i V_i} = \frac{N k_B T_f}{N k_B T_i} \Rightarrow P_f = P_i\left(\frac{V_i}{V_f}\right)\frac{T_f}{T_i} = (1.0)\left(\frac{1}{0.4}\right)(2.0) = 5\ atm$

58. Your car's right rear tire has to support a weight of 3000N. Normally the tire pressure is 20N per cm^2 and the contact area of your tire with the road is 150 cm^2. If the tire pressure is suddenly reduced to 15N per cm^2, what must the new contact area be in order to support the car?

a. 450 cm^2
b. 225 cm^2
(c.) 200 cm^2
d. 100 cm^2
e. 50 cm^2
f.. None of the above is within 10% of the correct answer.

$F_1 = 3000N = P_1 \cdot A_1 = F_2 = P_2 A_2$

$\Rightarrow A_2 = \frac{A_1 P_1}{P_2} = \frac{3000}{15} = 200\ cm^2$

59. If 100 g of steam at 100° C and 100 g of ice at 0° C are mixed in a completely insulated container, what is the final equilibrium temperature, most nearly ? Recall that the latent heat of fusion of ice is 80 cal/g, and the latent heat of vaporization of water is 540cal/gm.

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

$+100\,gm \cdot 540\,cal/gm = +5.4\times10^4\,cal$ = Latent heat released as steam condenses to water

$-100\,gm \cdot 80\,cal/gm = -8\times10^3\,cal$ = Latent heat of Fusion absorbed by ice as it melts to H_2O

Then when steam has condensed to H_2O at 100° & ice has melted to water at H_2O $(5.4-0.8)10^4\,cal = 4.6\times10^4\,cal$ is excess heat provided by steam over heat absorbed by ice.

Since 100 cal will increase T of 1gm H_2O from 0°C to 100°C, it takes only 10^4 cal to increase T of 100 gm H_2O " ;

Since 4.6×10^4 cal is available $T_f = 100°C$ & some steam remains uncondensed in final EQUILIBRIUM STATE

(2) 95°C is most NEARLY correct.

60. Four grams of liquid X at 36°C are added to two grams of Liquid Y at 30°C. The specific heat of liquid X is 1.5 cal/gm °C , and that of liquid Y is 3.0 cal/gm °C. The final equilibrium temperature of the mixture is, within 0.1 °C,

a. 31°C
b. 32°C
c. 33°C
d. 34°C
e. 35°C
f.. None of the above is within 0.1°C of the correct answer

Heat removed from X = Heat added to Y:

$C_X \cdot m_X \cdot (36° - T_f) = C_Y m_Y (T_f - 30°)$

$(1.5)(4)(36° - T_f) = (3.0)(2)(T_f - 30°)$

$(6)(36) + (6)(30) = (T_f)(6+6)$

$= T_f$

$\frac{396}{12}$

$33°C = T_f$

End of Exam III

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Physics 117 Exam III, Cover Page

A) GENERAL INSTRUCTIONS

This exam consists of 60 questions worth two points each for a maximum of 120 points.

ALL ANSWERS MUST BE ENTERED INTO THE NCS ANSWER SHEET BY MEANS OF HEAVY BLACK MARKS WITH A NUMBER 2 PENCIL. (Only a pencil mark will work; the optical scanner cannot read inked answers no matter what color or how dark.)

The questions are numbered from 1 to 60: make sure you enter your single letter answer into the answer line with the same number as the question you are answering.

Only the computer readable NCS answer sheet will be handed in. Keep this exam for you future use.

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B) PREPARE YOUR ANSWER SHEET IN ADVANCE:

1) SIGN YOUR PERSONAL SIGNATURE INTO THE TOP MARGIN ABOVE THE NAME BOX of the NCS SHEET.
2) PRINT YOUR NAME, **FAMILY NAME FIRST**, INTO THE BOXES PROVIDED AND DARKEN THE CIRCLE FOR THE CORRESPONDING LETTER BELOW EACH BOX
3) INSERT YOUR STUDENT ID NUMBER UNDER "IDENTIFICATION NUMBER" AND DARKEN THE CORRESPONDING CIRCLES BELOW EACH NUMBER.
4) MAKE NO STRAY MARKS ON THE ANSWER SHEET AND ERASE CLEANLY IF NECESSARY.

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C) GENERAL ADVICE

Many students will not have time to finish this exam if they proceed at a leisurely pace. Therefore it is probably advantageous to earmark time-consuming items for later attention and skip forward to questions that can be answered more easily. No subtractions will be made for wrong answers, so that last minute best guessing is probably an advantageous strategy.

IF YOU NEED HELP, ASK!.....AND ASK EARLY RATHER THAN LATE.

ALSO FOR FAIRNESS' SAKE, PLEASE STOP WRITING WHEN THE EXAM ENDS. A PENALTY OF 8% OF THE RAW SCORE MAY BE IMPOSED UPON STUDENTS WHO TRY TO TAKE UNFAIR ADVANTAGE OF THE COLLECTION PROCESS BY CONTINUING TO WRITE AFTER THE END HAS BEEN ANNOUNCED, WHATEVER THE IMAGINED JUSTIFICATION.