Detailed Solutions of EXAM III F05, Physics 117.

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

2. What was the purpose in postulating the existence of the ether?
a. To make it select which reference system must be considered the absolute one. X
b. To account for the time difference measured in the Michelson-Morley experiments. X
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. X
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. X
b. The beam traveling along the direction of the earth's motion always lost. X
c. The races always ended in ties. ✓
d. The results depended on the season of the year (i.e., on the direction of earth's motion) X
e. A slight speed difference was observed, but declared too small to be taken seriously X
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 Always measure $v_{LIGHT} = 0$ in any inertial frame!
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. 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 observers will agree on none of the items (a) through (d) above.
f. The observers will agreee on all of items (a) through (d) above. X

6. In his theory of special relativity, Einstein
a. abandoned the prediction of Galilean relativity about the velocities of light waves in different inertial frames. YES, $v_{LIGHT} = c$ Not $c \pm v$
b. retained the prediction of Maxwell's electromagnetic equations for the speed of light. YES
c. postulated that all the laws of physics are the same in every inertial frame. YES
d. postulated that the speed of light in vacuum has the same value in every inertial frame. YES
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. X

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

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. False
a. engine (because the signal from the engine reaches observer G before it reaches observer T)
b. caboose (because the signal from the caboose reaches observer G before it reaches observer T) and that from the engine reaches G after reaching T
c. engine (because the signal from the engine reaches observer T after it reaches observer G) False
d. engine (because the signal from the engine reaches observer T before it reaches observer G)
e. They went off simultaneously for both observers. False
f. None of the above because the answer depends on the speed of the train. X

9. Which of the following expressions gives the total relativistic energy of a moving object of mass, m?
a. $E = mc^2$ = Rest Engy.
b. $E = \gamma mc^2$ = KE + RestE = $(\gamma - 1)mc^2 + mc^2$
c. $E = (\gamma - 1)mc^2$ = K.E
d. $E = (mv^2)/2$ = KE when $v/c \ll 1$.
e. None of the above.

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

11. The second postulate of special relativity requires that the speed of light
a. is a constant in a vacuum and equal to c. ✓
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.

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. No. See (d)
b. No, but he always falls short by less than 10% of the trip distance. No. "
c. Yes, but always just barely, with less than 1% of the trip distance to spare. No. See (d)
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. TRUE
e. Yes, because for him his biological clock slows down to give him more time No. for him his biological clock does NOT slow down.
f. None of the above completions yields a true statement. X

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. FALSE
b. the twin who made the trip, because he always remained in the same inertial frame. FALSE
c. Actually, neither: they are the same age, because the speed was held constant out and back. FALSE
d. The answer depends upon the details of the turnaround. FALSE
e. None of the above statements is true.

[Note: (a) would be true if "an acceleration" were replaced by "no acceleration".]

14. An electron is being accelerated by a constant force to nearly the speed of light. Which of the following is **false**?

a. Its kinetic energy increases steadily. TRUE
b. Its momentum increases, but at a diminishing rate FALSE $\Delta \vec{p}_{REL}/\Delta t = \vec{F}$ = constant
c. It can approach but not exceed the speed of light. TRUE
d. Its total energy continually increases. TRUE
e. Its rest mass increases to large values as the speed approaches c. FALSE: REST MASS is constant
f. All of the above answers are true and correct: none is false. NOT SO
g. All of the above answers are false. NOT SO

NOTE: (a) & (b) were both graded correct, finally.

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 Length contracts to $L'_\gamma = 80/50 = 1.6$ m.
b. 30.0 m
c. 80 m
d. 130 m
e. 4000 m
f. None of the above is within 10% of the correct answer.

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. No! form is same with m_G's
b. the form of Newton's second law would need to be modified. No! Form is same with m_I's.
c. the basis for Einstein's prediction that the path of light is bent by gravitational fields would be undercut. TRUE, because principle of equivalence would be unacceptable.
d. objects of different masses falling in a vacuum near the earth's surface would experience different accelerations. → Not necessarily: accln $g = \frac{F_G}{m_I} = \frac{GM_E^2}{R_E^2} \cdot \frac{m_G}{m_I}$ would be still the same for all m, if only m_G/m_I were same for all masses
e. All of the above statements are true. ✗
f. None of the above statements is true ✗

17. Suppose two teams of astronauts who think they are accelerating through space are actually sitting on the surfaces of Earth and Mercury. The gravitational field on Mercury is much smaller than that of Earth. Which of the following statements about their absolute 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. — Laws 1 and can not!

} See Note on (f) below

Physics do Not distinguish one inertial frame from another,

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 philosophic arguments.
e. because they believed the alchemists.
f. for none of the above reasons.

19. How does the number of molecules in 1 liter of 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.

} See (e) below

e. The volumes described both have the same number of molecules. LAW of definite gas volume proportions
f. It is not possible to say with certainty. ✗

20. How does the number of atoms in 1 liter of oxygen (O_2) gas compare with the number of atoms in 1 liter of carbon dioxide (CO_2) gas 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 atoms in carbon dioxide as in oxygen. Each molecule has 3 atoms vs 2 for O_2
b. There are 3/2 times as many atoms in oxygen as in carbon dioxide. ✗
c. There are 32/44 times as many atoms in carbon dioxide as atoms in oxygen ✗
d. There are 32/44 times as many atoms in oxygen molecules as atoms in carbon dioxide. ✗

} MASS IS IRRELEVANT

e. The volumes described both have the same number of atoms. FALSE: Both have same No of Molecules.
f. It is not possible to say with certainty ✗

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 20 grams of oxygen?
    a. 6
    b. 9
    c. 12
    (d.) 15
    e. 20
    f. 30
    g. None of the above is within 10% of the correct answer

$\frac{20}{8} \times 6 = 15\,gm\ C.$

22. What Celsius temperature corresponds most closely to 200 K?
    a. 127° C
    b. 27° C
    (c.) -73° C
    d. -173° C
    e. None of the above is within 10%.

$200K = T_C + 273°C$

$T_C = -73°C$

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.

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
    c. 70 N/cm^2
    (d.) 700 N/cm^2
    e. None of the above is correct within 10%.

$\frac{F}{A} = \frac{70g}{1cm^2} = \frac{700N}{cm^2}$

25. Two gases are kept at the same temperature. If the molecules of gas A have 4 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
    c. 1
    d. 1/2
    e. 1/4
    f. None of the above: the ratio does not depend upon the molecular mass.

$T_A = \langle \frac{1}{2} M_A v_A^2 \rangle = T_B = \langle \frac{1}{2} M_B v_B^2 \rangle$

$\frac{C}{2} M_A / \frac{C}{2} M_B = v_B^2 / v_A^2 = 4$

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 NOT Assumed! ... Would change No of particles & alter results!
f. None of the properties (a) through (e) above is a property of our ideal gas.
g. All of the properties (a) through (e) above are properties of our ideal gas.

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 } Need Ks NOT °C
d. speed ... Kelvin
e. kinetic energy ... Kelvin
f. None of the above completions yields a true statement

28. If a liter of gas has a pressure of 0.5 atmosphere, what will the pressure be if the average kinetic energy of the molecules is doubled, while the volume is reduced to one fourth of its original value?
a. 0.5 atm
b. 1 atm
c. 2 atm
d. 4 atm
e. 8 atm
f. None of the above is within 10%.

$P_f V_f = cT_f$, $P_i V_i = cT_i$ $\Rightarrow \frac{P_f V_f}{P_i V_i} = \frac{cT_f}{cT_i} \Rightarrow \frac{P_f}{P_i} = \frac{1}{4} \cdot 2 \cdot 4$

& $T_f = 2T_i$, $V_f = V_i/4$

$P_f = (8)(0.5) = 4.0$ atm

29. Suppose that two liters of a diatomic gas Z combines with six liters of diatomic hydrogen to form 1 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"?
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. There is a unique correct answer, but it is none of the above.
g. It is not possible to say from the data given.

Let n be no. of molecules in 1 ℓ. Then
$Z_2 + H_2 \rightarrow Z_pH_q$ requires $2n \cdot 2 = 1 \cdot p n$ to balance Z atoms
$6n \cdot 2 = 1 \cdot q n$ " H atoms
Thus $p = 4$, $q = 12$

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 900 g of nitrogen with 900 g of hydrogen to make ammonium, how many moles of ammonia can you make, most nearly?
a. 642
b. 300
c. 64
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%.

900 gm H = 900 moles of H atoms @ 1 gm H atoms per mole.
900 gm N = 64.3 moles of N atoms @ 14 gm N " per mole.
Then can make 64.3 moles NH_3 & have $900 - (3 \cdot 64.3) = 707$ moles of H atoms left over.

31. Two gases are kept at the same temperature. If the molecules of gas A have 9 times the mass of those of gas B, what is the ratio of the root mean square speed 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.

$\langle \frac{1}{2} m_A v_A^2 \rangle = cT_A = \frac{\langle m_A v_A^2 \rangle}{\langle m_B v_B^2 \rangle} = 1$

$\langle \frac{1}{2} m_B v_B^2 \rangle = cT_B$

i.e. $\sqrt{\frac{\langle v_A^2 \rangle}{\langle v_B^2 \rangle}} = \sqrt{\frac{m_B}{m_A}} = \sqrt{1/9} = 1/3$

32. In convection, thermal energy is transported by
a. the movement of the fluid under thermal pressure ? What is thermal pressure?
b. the movement of the fluid under pressure of sound waves. NO.
c. the movement of the fluid by electromagnetic fields. No.
d. the movement of the fluid the propagation of sound waves. No.
(e) the movement of the fluid due to work done by gravity. true: expansion reduces density & more dense fluid falls
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 work always generated the same amount of heat.
b. first showed that heat was not a fluid. No: Rumford did that
c. were used to define the calorie, as the unit of heat No: cal is a thermal property of H_2O
d. first showed that heat could be converted 100% to mechanical energy. ··· it cannot! (2nd LAW)
e. All of the above completions yield true statements. ✗
f. None of the above is true. ··· (a) is true

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. ✓
e. None of the above is true.