

48. The first postulate of special relativity
- a. says that there is no absolute reference frame. ✓
 - b. is a reaffirmation of the Galilean principle of relativity. ✓
 - c. states that the laws of physics are the same in all inertial reference systems. ✓
 - d. applies also to the implication of Maxwell's equations that the speed of light in vacuum is constant. ✓
 - e.** All of these statements are true. ✓

49. A rocket is 8 m long when measured at rest. What is its length as measured by an observer who sees the rocket ship moving past at 99.9% of the speed of light? The relativistic adjustment factor, $\gamma = 1/(1-v^2/c^2)^{1/2}$, for 0.999c is 22.4.
- a. 179.2 m
 - b. 37.9 m
 - c. 22.4 m
 - d. 1.7 m
 - e.** None of the above is within 10% of the correct answer.
- contracted $L' = 8/22.4 = 0.36m = L/\gamma$*

50. An electron is being accelerated by a constant force to nearly the speed of light. Which of the following is NOT true?
- a. Its kinetic energy increases steadily. ✓
 - 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.** Its rest energy increases steadily. **FALSE** mc^2 is constant

*ERROR CORRECTION:
Delete answer **e***

51. A train is traveling along a straight, horizontal track at a constant speed of 0.9c. A warning light on the ground flashes once each second. An observer in the train measures the time between flashes to be, most nearly,
- a. 0.1 s
 - b. 0.9 s
 - c. 1.0 s
 - d. 1.11 s
 - e. 1.67 s
 - f.** 2.3 s
 - g. None of the above is within 10% of the correct answer.
- $\gamma = \frac{1}{\sqrt{1-(0.9)^2}} = 2.3$
Dilated $\Delta t' = \gamma \Delta t = (2.3)(1)$*

52. If the speed, v, of a particle of rest mass m increases from 0.99999c to 0.9999999c, {so that v/c increases from $(1 - 10^{-5})$ to $(1 - 10^{-7})$ }, by what factor does its total energy increase, most nearly?
- a. $(1+10^{-7})$
 - b. $(1+10^{-6})$
 - c. $(1+10^{-5})$
 - d. 3.3
 - e. 4.67
 - f.** 10
 - g. None of the above is within 10% of the correct answer.
- $E_{TOT} = \gamma mc^2$ $\frac{\gamma_f}{\gamma_i} = \frac{\sqrt{2 \cdot (1 - v_i/c)}}{\sqrt{2 \cdot (1 - v_f/c)}} = \sqrt{\frac{10^{-5}}{10^{-7}}} = 10$
Since $1 - v^2/c^2 = (1 + v/c)(1 - v/c) \approx 2(1 - v/c)$ when $v/c \approx 1$*

53. The law of definite proportions states that _____ have definite _____ ratios of their constituent elements.
- a.** compounds ... mass ✓
 - b. compounds ... volume **x** ... only if gaseous!
 - c. mixtures ... mass **x**
 - d. mixtures ... volume **x** } **Does not apply to mixtures**
 - e. None of the above, the law of definite proportions is about volumes, not masses. **x**

54. 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 average kinetic energy of the A molecules to that of the B molecules?

- a. 4
b. 2
 c. 1
d. 1/2
e. 1/4

$$T_A = T_B \Rightarrow \langle KE_A \rangle_{Av} = \langle KE_B \rangle_{Av}$$

$$\therefore \frac{\langle KE_A \rangle}{\langle KE_B \rangle} = 1.$$

55. Which of the following is NOT assumed in our model of the ideal gas? The gas particles

- a. rebound elastically when they collide with the container wall. ✓
b. have no internal structure. ✓
c. are indestructible. ✓
d. do not interact except when they collide. ✓
 e. All of the above properties are assumed for our ideal gas. ✓
f. None of the above statements is true of our ideal gas.

56. The pressure that a molecular gas exerts on the walls of its container increases with

- a. the average magnitude of the momentum of the molecules. YES
b. the speed with which the molecules travel to their next collision with the wall. YES
c. the density of gas molecules. YES
d. the average kinetic energy of the gas molecules. YES
 e. All of the above statements are true. YES
f. None of the above answers is correct. X

57. The two fixed points used to define the modern Celsius 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

58. 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. None of the above

NONE! (Avg KE doubles with doubling of KELVIN temperature)

59. The pressure in a container filled with gas increases when it is heated because

- a. the walls do work on the gas. X NOT unless they move!
b. the average momentum of a gas particle increases. NO $\langle \vec{p} \rangle = 0 \dots$ doesn't change
c. the number of gas particles increases. NO: heat does not change No of particles
d. the volume of the gas decreases. NO.
 e. The average momentum change in a collision with the wall increases. YES
f. None of the above.

60. A hypothetical balloon filled with an ideal gas has a volume of 10^5 liters at 27°C under one atmosphere of pressure. At what temperature, most nearly, will its volume be 10^4 liters under one atmosphere of pressure?

ERROR
CORRECT:

$0 \Rightarrow 0$

- a. ~~-273°C~~
- b. -243°C
- c. ~~-203°C~~
- d. ~~-163°C~~
- e. ~~-123°C~~
- f. None of the above is within 10% of the correct answer.

$$T_A = (T_C + 273) \text{K} \quad 27^\circ\text{C} = 300 \text{K};$$

$$\frac{P_i V_i = C T_i}{P_f V_f = C T_f} \Rightarrow 10 = \frac{T_i}{T_f} \Rightarrow T_f = \frac{300}{10} = 30 \text{K}$$

$$= -243^\circ\text{C}$$

61. You exert a force of 3 N on the head of a thumbtack to place it on a board. The tip of the thumbtack has an area less than 10^{-2} mm^2 . The pressure on the board at the tip must be greater than: (Recall $1 \text{ Pa} = 1 \text{ N/m}^2$.)

- a. $3 \times 10^2 \text{ Pa}$
- b. $3 \times 10^3 \text{ Pa}$
- c. $3 \times 10^4 \text{ Pa}$
- d. $3 \times 10^5 \text{ Pa}$
- e. $3 \times 10^7 \text{ Pa}$
- f. $3 \times 10^8 \text{ Pa}$
- g. None of the above is within 10% of the minimal pressure

$$P = \frac{F}{A} > \frac{3 \text{ N}}{10^{-2} \cdot 10^{-6} \text{ m}^2} = 3 \times 10^8 \frac{\text{N}}{\text{m}^2}$$

62. In radiative heat transfer, thermal energy is transported by

- a. the movement of a fluid. ~~X~~
- b. the collisions of particles. ~~X~~
- c. electromagnetic fields. ✓
- d. the propagation of sound waves. ~~X~~
- e. physical vibrations of the intervening medium. ~~X~~

63. Joule's experiments with hanging weights turning paddle wheels in water

- a. showed that heat was not a fluid. ~~NO: RUMFORD showed that.~~
- b. showed that 4.2 joules of work are equivalent to 1 calorie of heat. ✓
- c. were used to define the calorie. ~~NO: WATER'S specific heat defined calorie~~
- d. showed that heat could be converted 100% to mechanical energy. ~~NO: Violates 2nd Law~~
- e. None of the above.

64. The first law of thermodynamics

- a. is a restatement of the law of conservation of energy. ✓
- b. allows that work can be completely converted into internal energy. ✓
- c. treats heat as another form of energy. ✓
- d. guarantees that the work extracted by a cyclic heat engine can never exceed the heat inserted. ✓
- e. All of the above statements are true of the first law. ✓

65. 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. ~~NO~~
- b. They have the same internal energies. ~~NO~~
- c. The average molecular speed in the gallon is less than that in the cup. ~~NO~~
- d. The average molecular speed in the cup of water is less than that in the gallon. ~~NO~~
- e. None of the above. ✓

66. Aluminum and air have almost the same specific heats. Therefore, 100 calories of heat will raise the temperature of 1 liter of air _____ 1 liter of Aluminum. (Assume $T = 20^\circ\text{C}$ and $P = 1 \text{ atm.}$)
- a. much more than
 b. slightly more than
 c. about the same as
 d. slightly less than
 e. much less than
- , because 1 L of air has MUCH LESS MASS than 1 L of Al.*
67. The second law of thermodynamics says
- a. that the energy of an isolated system is conserved. *X 1st Law says that*
 b. that the entropy of the earth can never decrease. *X IF heat is transferred out S decreases*
 c. that it is impossible to reach the absolute zero of temperature. *3rd Law*
 d. that it is impossible to build a heat engine that does more mechanical work than the thermal energy it consumes. *1st Law*
 e. that two objects which are both in thermal equilibrium with the same third object are also in thermal equilibrium with one another. *0th Law*
 f. None of the above.
68. It is impossible to run an ocean liner by taking in seawater at the bow of the ship, extracting internal energy from the water, and dropping ice cubes off the stern because this process violates the _____ law of thermodynamics.
- a. zeroth
 b. first
 c. second, *because none of the heat extracted is exhausted to the surroundings.*
 d. third
 e. Fourth
 f. None of the above. In fact, the U.S. navy is developing just such a propulsion process.
69. What restrictions does the first law of thermodynamics place on building a perpetual motion machine?
- a. It does not place any restriction on the possibility. *X FALSE*
 b. Some heat energy must be exhausted and wasted. *X NO! this is 2nd Law*
 c. Thermal energy cannot be completely converted to mechanical energy. *X "*
 d. The machine must have a very long cyclical period. *IRRELEVANT: NO X.*
 e. The losses due to friction can not exceed hc (= Planck's constant times the speed of light) in any cycle. *X NONSENSE*
 f. None of the above restrictions is imposed by the first law.
70. What restrictions does the second law of thermodynamics place on building a perpetual motion machine?
- a. The work extracted must be less than the heat input. *true*
 b. Some heat energy must be exhausted and wasted. *"*
 c. Thermal energy cannot be completely converted to mechanical energy. *TRUE*
 d. Its efficiency must not exceed the Carnot efficiency. *TRUE*
 e. All of the above restrictions are imposed by the second law.
 f. None of the above answers is true and correct.
71. Consider a certain person's human body to be a heat engine with an efficiency of only 20%. This means that
- a. only 20% of the food he eats is digested. *X IRRELEVANT*
 b. 80% of the energy he obtains from food is destroyed. *? NONSENSE*
 c. he should spend 80% of each day lying quietly. *X IRRELEVANT*
 d. only 20% of the energy he extracts from food can be used to do physical work. *✓ (H)*
 e. None of the above: no quantitative thermodynamic efficiency can be assigned to a human body.

72. A heat engine takes in 800 J of energy at 1200 K and exhausts 600 J at 400 K. What is the theoretical maximum (i.e., Carnot) efficiency of this engine?

- a. 25%
- b. 33.3%
- c. 50%
- d. 66.7%
- e. 75%

$$\eta_c = 1 - T_c/T_H = 1 - 400/1200 = 0.67$$

Error/Correct: **F** ← None of the above is within 10% of the correct answer.

73. An engine exhausts 1200 J of energy for every 3600 J of energy it takes in. What is its efficiency?

- a. 25%
- b. 33%
- c. 50%
- d. 67%
- e. 75%
- f. None of the above is within 10% of the correct answer.

$$\frac{2400}{3600} = 0.67$$

74. A heat engine takes in energy at a rate of 1600 W at 1000 K and exhausts heat at a rate of 1200 W at 400 K. What is the actual efficiency of this engine?

- a. 25%
- b. 40%
- c. 50%
- d. 60%
- e. 75%
- f. None of the above is within 10% of the correct answer.

$$\frac{400}{1600} = 25\%$$

75. What is the probability of rolling a total of 10 with two dice?

- a. 1/36
- b. 3/36
- c. 5/36
- d. 6/36
- e. 10/36
- f. None of the above.

$$10: \left\{ \begin{array}{l} 5+5 \\ 6+4 \\ 4+6 \end{array} \right\}$$

3 possibilities out of $6 \times 6 = 36$
 $3/36 = \text{probability of } 10$

76. A ringing bell is inserted into a large glass of water. The bell and the water are initially at the same temperature and are insulated from their surroundings. Eventually the bell stops vibrating and the comes to rest. Which of the following statements is FALSE?

- a. The mechanical energy of the bell has been completely converted into internal energy of the combined system. **T**
- b. The final temperature of the combined system is lower than the initial temperature. **FALSE!**
- c. The entropy of the combined system has increased. **T**
- d. The water has been warmed in the process **T**
- e. The bell performed work on the water. **T**
- ~~f. None of the statements is false. **T**~~

ERROR CORRECT:

Delete LAST answer →

77. Which of the following statements conflicts with the second law of thermodynamics?

- a. Heat naturally flows from hot objects to cold objects.
- b. No engine can transform all of its heat input into mechanical work.
- c. The entropy of an isolated system can never decrease.
- d. Perpetual motion machines are not possible.
- e. No engine can be less efficient than the Carnot engine with the same maximum and minimum temperatures. **WRONG: Carnot is less → more**
- f. Every heat engine must exhaust heat. ✓
- g. None of the above contradicts the second law.

78. A hot piece of metal is dropped into an insulated container of cold water. After the system has reached its equilibrium temperature, the
- entropy of the metal has decreased. ✓
 - entropy of the water has increased. ✓
 - net change in the entropy of the system is positive. ✓
 - entropy of the system has increased. ✓
 - heat energy has been transferred from metal to water. ✓
 - all of the above statements are true. ✓
 - None of the above statements is true.

79. Which of the following sets of parameters all affect the period of a pendulum? (M = Mass, L = Length, and g = acceleration due to gravity)
- (M, L and g)
 - (M and L)
 - (M and g)
 - (L and g)
 - (L only)
 - None of the above.

$$T = 2\pi \sqrt{L/g}$$

81. The fundamental wavelength for standing waves on a rope fixed at both ends is the length of the rope.
- four times
 - two times
 - the same as
 - one-half
 - one-fourth
 - None of the above



$$\lambda/2 = L \Rightarrow \lambda_0 = 2L$$

82. What is the frequency of the earth's rotation about the sun, most nearly? (1Hz = 1cycle/sec)
- 4×10^{-2} Hz
 - 8×10^{-2} Hz
 - 7×10^{-4} Hz
 - 1×10^{-5} Hz
 - 2×10^{-6} Hz
 - 3×10^{-8} Hz
 - None of the above is within 10% of the correct answer.

$$\frac{1}{yr} = \frac{1}{(365)(24)(60)(60) \text{ sec}} = 3.2 \times 10^{-8} / \text{sec}$$



83. Which of the following lists correctly orders the various electromagnetic waves in the order of increasing frequency?
- radio waves < microwaves < infra-red light < violet light < X-rays < gamma rays ✓
 - ~~microwaves < radio waves < red light < ultraviolet light < X-rays < gamma rays~~
 - ~~infrared light < red light < violet light < ultraviolet light < microwaves < X-rays~~
 - ~~gamma rays < X-rays < ultraviolet light < microwaves < radio waves~~
 - ~~Ultraviolet light < infrared light < gamma rays < X-rays < microwaves~~
 - None of the above orderings is completely correct.

84. The periodic table arranges the elements from right to left in order of increasing atomic mass and in columns corresponding to
- the order in which they were discovered.
 - their chemical properties.
 - their relative abundances.
 - alphabetical order.
 - None of the above.

85. Which is a correct observation of what happened in our cathode ray tube demonstrations?

- a. The end of the glass tube opposite the cathode glowed. ✓
- b. A metal cross cast a shadow. ✓
- c. The particles were seen only when an accelerating voltage is applied ✓
- d. The stream of particles is deflected by an magnetic field. ✓
- e.** All of the above.
- f. None of the the above happened during our demonstration.

86. Thomson's plum pudding model of the atom was abandoned because...

- a. of the cathode ray studies which discovered electrons.
- b. of the large (compared with the H^+ ion) charge to mass ratio of the electron.
- c. the electron charge was shown to be quantized in integer units of the smallest charge.
- d. the atom had to be neutrally charged electrically.
- e.** alpha particles sometimes back scattered. **RUTHERFORD'S EXPERIMENT**
- f. All of the above were reasons for abandoning the Thomson model.

87. When light is incident on a metallic surface, the emitted electrons

- a. are called photons. **X**
- b. have arbitrarily high energies **X**
- c.** have a maximum energy that depends on the intensity of the light. **X TRUE IS INTENSITY → frequency**
- d. Are referred to as cathode rays. **X**
- e. All of the above
- f.** None of the above.

88. Rutherford's model predicted that atoms should be unstable (because the electrons should spiral into the nucleus) in very short time periods. What caused this instability in Rutherford's model?

- a. The positive charge in the nucleus was too strong for the electrons to remain in distant orbits. **'NOT TRUE': Cf. Planets**
- b. The attractive force between the positive nucleus and the negative electrons would pull them together. **NOT TRUE: Cf Planets**
- c.** An accelerating, such as one in uniform circular motion, charge must radiate energy. ✓
- d. Circular orbits are unstable for an attractive inverse square force. **NOT TRUE**
- e. All of the above.
- f. None of the above.

89. A clean surface of potassium metal will emit electrons when exposed to blue light. If the intensity of the blue light is increased, the _____ of the ejected electrons will also increase.

- a. maximum kinetic energy **No! MAX E_k increases w frequency.**
- b.** number ✓ **YES**
- c. average speed **No!**
- d. average kinetic energy **No!**
- e. All of the above quantities increase with intensity. **X**
- f. None of the above completions yields a true statement. **X**

90. Which of the following is NOT a feature of the Bohr model of the atom?

- a. an quantized electron angular momentum ✓
- b. electrons in planetary-like orbits ✓
- c. quantized energy levels ✓
- d. accelerating electrons that do not radiate ✓
- e. photons emitted when electrons jump from one orbit to another. ✓
- f.** All of the above are features of the Bohr model.
- g. None of the features (a) through (e) is a feature of the Bohr model.

91. Which of the following is NOT considered to be a success of Bohr's theory of the atom?
- Obtaining the numerical values for the spectral lines in hydrogen. *Success*
 - Explaining why there the same line frequencies occur in emission spectra as in absorption spectra. *Success*
 - Explaining why the frequency distributions in emission spectra are discrete rather than continuous. *Success*
 - Providing the general qualitative features of the periodic table. *"*
 - All of the above are considered successes of the Bohr theory.
 - None of the items (a) through (d) is considered to be a success of the Bohr model.
92. A clean surface of metal will emit electrons when exposed to light. If the color of the light is changed from red to blue without changing the intensity, the _____ of the ejected electrons will also increase.
- mass
 - number
 - Maximum kinetic energy , *since blue has higher frequency than red light.*
 - charge
 - All of the quantities listed above will increase with the color change.
 - None of the quantities (a) through (d) above will increase with the change in color.
93. Bohr gave the following argument why the electron in the hydrogen atom existing only in certain discrete energy levels
- This agrees with Newtonian mechanics.
 - This agrees with Maxwell's equations.
 - This was implied by the Rutherford atom
 - All of the above were cited.
 - None of the above, Bohr simply postulated it, offering no supporting rationale, except that it explained the Hydrogen spectra.
94. Two hydrogen atoms have electrons in the $n = 3$ energy level. One of the electrons jumps to the $n = 2$ level, while the other jumps to the $n = 1$ level. Which property is the same for the two photons that are emitted?
- velocity *✓ all photons have same velocity = c*
 - frequency *X*
 - energy *X*
 - color *X*
 - wave length *X*
 - All of the above properties are the same for the two photons.
 - g ← f* None of the properties (a) through (e) above is the same for the two photons..