SOLUTIONS 117 S06 Final Exam



(w.Crrx of 5/18/06: #19I, #22, #37, #46, #48, #59, #70, #85, #110, #114.)

**First 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 single best answer.**

| | | |
|---|---|---|
| G | 1. Velocities | A. always changes when a net impulse is applied. $\vec{I} = \vec{F}\Delta t = \Delta\vec{p}$ |
| D | 2. Physical Dimensions | B. all sum together to form a conserved quantity. $\vec{p}^{TOT} = \sum_i \vec{p}_i$ |
| A | 3. Momentum | C. all depend upon the chosen frame of reference and not upon the physical surroundings. |
| H | 4. Gravitational Fields | D. are always the same on both sides of a physical equation. |
| B | 5. The Linear Momenta of an isolated system | E. all can become arbitrarily large, even while speeds remain below a finite limit. $p_{rel} = \gamma m\vec{v} = \frac{1}{\sqrt{1-v^2/c^2}} m\vec{v} \to \infty$ as $v \to c$ |
| I | 6.Kinetic Energies | F. all eject heat in every cycle. 2nd LAW of THERMODYNAMICS |
| J | 7. Inertial Frames | G. always change when a net force is applied. $\vec{F} = m\,\Delta\vec{v}/\Delta t$ |
| C | 8. Inertial or Pseudo-Forces | H. all have the same physical dimension, L/T. |
| E | 9. Relativistic Momenta | I. of all objects increase when net work is performed on them. WORK ENERGY THEOREM: $W^{NET} = \Delta(KE)$ |
| F | 10. Heat Engines | J. are all equivalent because accelerations, not velocities occur in the laws of physics. |

**Second Matching Table: Questions 11 through 20**

| | | |
|---|---|---|
| F | 11. Hot Radiating Objects | A. all exhibit (originally unexpected) wave interference patterns under appropriate circumstances. De Broglie |
| J | 12. Waves | B. all diminish with increasing momentum. $\lambda_{DeB} = h/\lvert p\rvert$ |
| A | 13. Electrons | C. all decrease with decreasing energy. $E_{photon} = hf$ |
| I | 14. Atomic nuclei | D. all have electric charge, Q, only in integer multiples of e, the electron charge. Millikan's Experiment |
| B | 15. De Broglie wavelengths | E. all increase the entropy of the universe. 2nd LAW of THERMOD. |
| C | 16. Frequencies of emitted photons. | F. emit more blue light (compared to red) when T increases. See Fig 23.14 of 5th Edition. |
| H | 17. Average Molecular kinetic energies | G. all have kinetic energies limited by the frequency of the impinging light. $(KE)^{MAX} = hf$ |
| D | 18. Charged microscopic oil drops | H. all increase with increasing temperature. $\langle KE\rangle = \frac{3}{2}kT_A$. |
| E | 19. Physical Processes | I. all are immensely smaller in size and more massive than the electron cloud. |
| G | 20. Photoelectrons | J. all combine by adding amplitudes, not intensities. |

**Continue with Multiple Choice Question No. 21 on next page….**

**MULTIPLE CHOICE: Choose the one most nearly correct and complete answer and insert its letter into your answer sheet.**

21. On a trip to Helena, you start your parked car, drive to Three Forks, stop for a one hour coffee break and arrive and park in Helena exactly two hours after leaving Bozeman. Since it is 100 miles to Helena, your average speed would be 50 mph. Which of the following statements about this trip is correct?
   a. To average 50 mph the car must have exceeded 100 mph for at least 60 minutes of the trip. F
   b. The instantaneous speed was never equal to 50 mph during this trip. F
   c. You can never average 50 mph if the speed is zero for one half of the trip duration. F
   d. Since the car speeds up after each stop and slows down before each stop, it is not possible to determine whether the car traveled faster than 100 mph at some point in the trip. F
   (e.) To average 50 mph the car must have exceeded 100 mph for some part of the trip. T
   f. All of the above statements are correct. F
   g. None of the above statements is correct. F

22. What average speed, most nearly, is required to run a four hour marathon (26 miles)? (1 mi. = 1.609 km.)
   a. 0.005 m/s
   b. 0.03 m/s
   c. 0.05 m/sec
   d. 0.3 m/s
   e. 0.5m/s
   (f.) 3.0 m/s
   g. 5.0 m/s
   h. None of the above answers is with 10% of the correct answer.

$\frac{26\cdot(1.609)(10^3)}{4\cdot 60\cdot 60} = \bar{v} = \frac{D}{T}$

$\frac{2.9\ m}{sec} =$

23. The acceleration of an object at a time, t, during a trip of duration, T, is defined to be :
   a. one half of the sum of the maximum and the minimum velocities divided by T.
   b. the average velocity divided by T.
   c. the total trip distance divided by $T^2$, on dimensional grounds.
   d. the difference between the final velocity and the initial velocity divided by T.
   e. the value of the velocity at the midpoint of the time interval divided by T
   (f.) the difference between the velocities at two times close to t divided by the time difference.
   g. None of the above.

24. If a go-cart requires 30 seconds to accelerate from 0 to 9 km per hour, its average acceleration is, most nearly,
   a. 800 m/ $sec^2$
   b. 80 m/ $sec^2$
   c. 8 m/$sec^2$
   d. 0.8 m/$sec^2$
   (e.) 0.08 m/$sec^2$
   f. None of the above is within 10% of the correct answer

$\bar{a} = \frac{9\,km - 0}{(60)(60)(30)} = \frac{9\times10^3\,m}{108\times10^3\,sec^2} = 0.08\,\frac{m}{sec^2}$

25. In the strobe diagram below the ball is moving from left to right. Which statement best describes the motion? The ball is

...o o o o o o....

a. not accelerating.
(b.) speeding up. : $\Delta x/\Delta t$ is increasing
c. slowing down.
d. moving with a constant speed.
e. none of the above.

26. The motion of a block sliding down a frictionless ramp can be described as motion with
a. a constant speed, independent of the slope of the ramp.
b. a constant speed that depends on the slope of the ramp.
c. an acceleration which increases as the block continues sliding.
d. a constant acceleration which is negative (i.e., slows the object down) due to the force of friction.
e. a constant acceleration equal to or greater than 10 m/s/s.
(f.) None of the above. : it is motion with constant accln $< g$.

27. If a ball is dropped from rest, it will fall 5 m during the first second. How far will it fall during the third second, most nearly ?
a. 15 m $x = \frac{1}{2} g t^2 \Rightarrow \Delta x = \frac{1}{2} g (t_f^2 - t_i^2) = \frac{10}{2} \cdot (9-4) = 25\text{ m}$
(b.) 25 m
c. 40 m
d. 45 m
e. 75 m
f. None of the above is within 25% of the correct answer.

28. The Center of Mass Point of a solid body
a. is certain definite fixed point in a coordinate system fixed to the body itself.
b. moves as though all of the forces applied to the body were applied at its location.
c. moves as though the entire mass of the body were concentrated at its location.
d. may be located outside the physical extension of the body.
e. None of the above answers (a through d) is true and correct.
(f.) All of the above remarks (a through d) are true of the Center of Mass Point.

29. You are applying a 600-newton force to a freezer full of chocolate chip ice cream in an attempt to move it across the basement. It will not budge. The weight of the freezer (including ice cream) is 1500 N. The coefficient of static friction, $\mu_{Static}$ is
(a.) greater than or equal to 0.4
b. greater than 0.4 but less than 0.8.
c equal to 0.4, exactly.
d. less than 0.4.
e less than 0.4 but greater than 0.25
f. None of the above completions yields a true statement.

$F^{NET} = \vec{F}^{App} - \vec{F}_{fr} = 0$, since $\vec{a} = 0$.

$F_{fr}^{MAX} = \mu |N| = \mu W =$

$\mu W = |F_{fr}^{MAX}| \geq |F_{fr}| = F^{App}$

$\mu \geq \frac{F^{App}}{W} = \frac{600}{1500} = \frac{3}{5} = 0.6$

Since $\mu \geq 0.6$, it follows that $\mu \geq 0.4$.

30. Which of the following is *not* a vector quantity?
a. force
b. acceleration
c. weight
d. velocity
e. displacement
(f.) mass
g. None of the above items (a) through (f) is a vector quantity
h. All of the items (a) through (f) are vector quantities.

31. What acceleration, most nearly, is produced by an applied force of 75 N acting on a mass of 6 kg if its velocity is 20 m/s and the frictional force is 40 N?
a. 10 $m/s^2$
b. 9 $m/s^2$
c. 8 $m/s^2$
d. 7 $m/s^2$
(e.) 6 $m/s^2$
f. None of the above is within 10% of the correct answer.

$F_{NET} = \vec{F}_{APP} + \vec{F}_{fr} = ma$

$\left(\frac{75-40}{6}\right)\frac{N}{kg} = 5.83 \frac{m}{(sec)^2} = a$

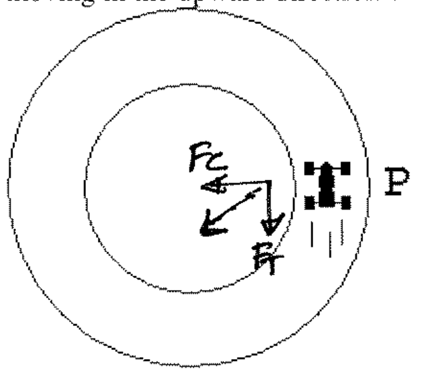
32. A ball with a weight of 20 N is thrown vertically upward. What is the force on the ball just as it reaches the top of its path, most nearly ?
a. 10 N upward
b. 10 N downward
(c.) 20 N downward
d. 20 N upward
e. zero
f. None of the above is within 10% of the correct answer.

33. A ball falling from a great height will reach terminal speed when the __________ goes to zero.
a. velocity
b. gravity force
(c.) net force , because $F_{NET} = 0 \Rightarrow \vec{a} = 0 \Rightarrow$ Speed = constant
d. weight
e. speed
f. mass
g. None of the above insertions yields a true statement.

34. A golf ball is hit with an initial vertical speed of 20 m/s and an initial horizontal speed of 30 m/s. How long will the ball remain in the air? (Neglect air resistance.)
a. 1 s
b. 2 s
c. 3 s
(d.) 4 s
e. 6 s
f. None of the above is within 10% of the correct answer.

$\Delta t = v_0/g = 20/10 = 2$ sec for $v_y$ to come to zero at apex of trajectory, & $\Delta t$ = same = 2 sec to fall back to starting height

**Figure 35-36**
A 500 kg race car is moving counterclockwise on a circular path of radius 300 m as shown in the diagram below. Suppose that at a certain instant when its speed is 140 m/s the car is at point P and moving in the upward direction on the page at a decreasing speed .




35. Refer to **Figure 35-36** above. In what direction, precisely, does the net force point at the instant described?

a. ↑
b. ↓
c. →
d. ←
(e.) None of the above is precisely to direction in which the force points.

The Net Force points in some direction between (b) & (d): Because speed is decreasing there must be a tangential force opposite to velocity

36. Suppose that the race track of Fig 43-44 is covered with a film of oil which reduces the coefficients, (both static and kinetic) of friction on the tires to zero and that the car is kept in its circular paths by cables attached to a post at the center of the track. What, most nearly, is the tension in the cable attached to the car in Fig.38 at the instant described above?

a. $2.2 \times 10^2$ N
b. $3.3 \times 10^2$ N
c. $2.2 \times 10^3$ N
d. $3.3 \times 10^3$ N
e. $2.2 \times 10^4$ N
(f.) $3.3 \times 10^4$ N
g. None of the above is within 10% of the correct answer.

$T = F_c = \frac{mv^2}{r} = \frac{(500)(140)^2}{300} = 3.26 \times 10^4 N$

37. A 2 kg ball is thrown straight down from the edge of a tall cliff with a speed of 30 m/s. At the same time a 1 kg ball is thrown straight up with the same speed. If the 1 kg ball travels up, stops, and then drops to the bottom of the cliff, which ball (if either) will be traveling faster when it reaches the ground below?

a. The 1kg ball, because its mass is smaller and it moves faster
b. The 2kg ball, because its mass is larger and it accelerates at a greater rate.
c. The 1 kg ball, but not for the reason given in (a) above.
d. The 2 kg ball, but not for the reason given in (b) above
(e.) The two balls will be traveling at the same speed when they hit, by WORK ENERGY THEOREM: The work done was same on both, & their initial (KE)'s were the same.
f. There is not enough information to say.

38. A baseball player throws a ball from left field toward home plate. Assume that you can neglect the effects of air resistance. At the instant the ball approaches home plate, the ball's acceleration

a. reaches its maximal value
b. reaches its minimal value
c. has the same magnitude as it had at the highest point of the trajectory.
d. retains its constant value, zero.
e. There is not enough information to say.

39. A mass, m = 0.900kg, hanging on a spring of spring constant , k= 10N/m, oscillates with a period, T= 1.88 s. If another oscillator has a mass half as large and a spring constant twice as large, its period will be (most nearly)?

$T_1 = 2\pi\sqrt{M/k} \rightarrow T' = 2\pi\sqrt{\frac{M/2}{2k}} = 2\pi\sqrt{\frac{M}{4k}} = \frac{1}{2}T_1 = 0.94$

a. 0.47 s
b. 0.94 s
c. 1.88 s
d. 3.76 s
e. 7.52 s
f. None of the above is within 10% of the correct answer.

40. An astronaut weighs 1000 N when measured on the surface of the earth. How large would the force of gravity on him be if he were in an earth satellite at an altitude equal to three times the earth's radius, most nearly ?

$F_G = \frac{G M_E m}{(4R_E)^2} = \frac{gm}{(4)^2} = \frac{1000}{(4)^2} = 62.5$ (a)

Since $g = \left(\frac{G M_E}{R_E^2}\right)$

a. 60N
b. 110 N
c. 330 N
d. 250 N
e. 500 N
f. None of the above is correct within 10%.

41. A future space traveler, Skip Parsec, lands on the planet MSU3, which has half the mass of Earth and twice its radius. If Skip weighs 400 Newtons on Earth's surface, how much does he weigh on MSU3's surface?

$g_{MSU3} = \frac{G \cdot \frac{M_E}{2}}{(2R_E)^2} = \frac{1}{8}\frac{G M_E}{(R_E)^2} = \frac{1}{8} g_E$

$m g_{MSU3} = \frac{1}{8} m g_E = \frac{400}{8} = 50$

a. 1600 N
b. 800 N
c. 400 N
d. 200 N
e. 100N
f. 50 N
g. None of the above is correct within 10%.

42. The numerical value of G, the gravitational constant, was determined

a. from knowledge of the earth's mass density and volume
b. by measuring the force between masses in the laboratory.
c. from the law of universal gravitation and the value of the acceleration due to gravity.
d. from the value of the moon's acceleration.
e. from a very precise knowledge of the mass of the earth.
f. From careful studies of planetary motions.
g. None of the above completions yields a true statement.

43. In an orbiting satellite such as SkyLab , physical objects
a. have mass but no weight.
b. have weight but no mass.
c. have mass but feel no force due to gravity.
d. have neither mass nor weight.
e. fall to the floor with an acceleration of 9.8 m/s/s.
f. conform to all of the above statements (a) through (e).
g. None of the above completions (a) through (f) yields a true statement.

44. Which of the following is true of the momenta of an 18-wheeler parked at the curb and a Volkswagen rolling down a hill?
a. The two momenta are equal.
b. The Volkswagen has the greater momentum
c. The 18-wheeler has the greater momentum.
d. Either could have the greater momentum.
e. The answer depends specifically upon the ratio of the masses.
f. None of the above completions yields a true statement.

45. The acceleration due to gravity on Titan, Saturn's largest moon, is about 0.7 $m/s^2$. What would a 60-kg scientific instrument weigh on Titan?
a. 4.2 N
b. 8.40 N $W = mg_T = 60 \cdot (0.7) = 42.0\ N$
c. 42.0 N
d. 84 N
e. 420 N
f. 840 N
g. None of the above is within 10% of the correct answer.

46. If rockets (attached to the plane) are fired in the backward direction from a moving airplane, the momentum of the airplane will
a. decrease just enough to conserve the momentum of the plane plus rocket system .
b. be unchanged, by conservation of momentum.
c. increase just enough to conserve the momentum of the plane plus rocket system
d. decrease, but not by an amount we can specify
e. increase, but not by an amount that we can specify.
f. None of the above completions yields a true statement.

47. Sally is an astronaut who has a mass of 60 kg. Currently she is conducting experiments in a permanent space station that is orbiting the earth at an altitude equal to the earth's radius. What are Sally's mass and weight as measured in the space station?
a. 0.00 kg and 0 N, respectively.
b. 60 kg and 600 N, respectively
c. 60 kg and 0.00 N, respectively
d. 0.00 kg and 600 N, respectively
e. 60 kg is her mass, but the weight cannot be specified from the data given.
f. None of the above completions yields a true statement.

48. A ball moving at 4 m/s toward the right has a head-on collision with stationary ball of half its mass . Each of the following final velocity pairs satisfies the law of conservation of linear momentum. Which one also preserves kinetic energy? The heavier ball has a velocity of __________, while the lighter has a velocity of __________ to the right.

a. 2 m/s to the right … 4 m/s $= \frac{1}{2} m_1 (2)^2 + \frac{1}{2} \frac{m_1}{2} \cdot (4)^2 = 6 m_1$
b. 1 m/s to the right…..6 m/s $= \frac{1}{2} m_1 (1)^2 + \frac{1}{2} \frac{m_1}{2} \cdot (6)^2 = 9.5 m_1$
c. zero … 8 m/s $= 0 + \frac{1}{2} \frac{m_1}{2} \cdot (8)^2 = 16 m_1$
d. 1 m/s to the left …10 m/s $= \frac{1}{2} m_1 (1)^2 + \frac{1}{2} \frac{m_1}{2} \cdot (10)^2 = 25.5 m_1$
e. 2 m/s to the left … 12 m/s $= \frac{1}{2} m_1 (2)^2 + \frac{1}{2} \frac{m_1}{2} \cdot (12)^2 = 38 m_1$
(f.) None of the above has a final kinetic energy equal to the initial value. $= \frac{1}{2} m_1 (4)^2 = 8 m_1$

49. A 5-kg toy car with a speed of 8 m/s collides head-on with a stationary 3-kg car. After the collision, the cars are locked together with a speed of 4 m/s. How much kinetic energy is lost in the collision?

$p_i^{TOT} = p_f^{TOT} \Rightarrow 5 \cdot 8 = (5+3) v_f \Rightarrow v_f = 5$ m/sec
[Problem is mis-stated $v_f = 4$ is NOT consistent w. initial conditions!]
$(KE_i) = \frac{1}{2} 5 \cdot (8)^2 = 160$ J $\quad \&(KE)_f = \frac{1}{2}(5+3)(5)^2 = 100$ J.
LOST KE $= 160 - 100 = 60$ J (f). {But if one uses $v_f = 4$, $(KE)_f = \frac{1}{2} \cdot 8(4)^2 = 64$ & then $(KE)_{LOST} = 160 - 64 = 96$ & (g) would be correct.}

a. 10 J
b. 20 J
c. 30 J
d. 40 J
e. 50 J
(f.) 60 J.
(g.) None of the above is within 10% of the correct value

Both (f) & (g) were accepted

50. Two objects have different masses but equal kinetic energies. If you stop them with the same retarding force, which one will stop in the shorter distance? By WORK-ENERGY THEOREM,

a. The heavier one.
b. The lighter one.
c. The one with the larger momentum.
d. The one with the smaller momentum
(e.) Both stop in the same distance.
f. It is not possible to say from the data given.

WORK $= F \cdot \Delta x = \Delta(KE)$ is SAME for both
Since F is also same for both
$\Delta x$ must be same.

51. Two objects have different masses but the equal momenta. If you stop them with the same retarding force, which one will stop in the shorter distance? IMPULSE-MOMENTUM THEOREM.

(a.) the heavier one.
b. the lighter one.
c. The one with the larger kinetic energy.
d. Both stop in the same time.
e. There is not enough information to say.

$F \Delta t = \Delta p$ is same for both. Since F is same for both $\Delta t$ must be same for both.
But in same $\Delta t$ heavier, slower one travels a shorter distance that lighter, faster one.
using $p_1 = m_1 v_1 = p_2 = m_2 v_2$

52. Which of the following has the physical dimension of energy?

a. Newton-meter/sec $= E/T$ No!
(b.) kilowatt-sec $= \frac{E}{T} \cdot T = E$ (ok)
c. joule/sec $= E/T$ No!
d. kg-m$^2$/sec$^3$ $= E/T$ No!
e. All of the above have the physical dimension of energy. F
f. None of the units a) through d) has the dimension of a physical energy. F

53. Imagine riding in a glass-walled elevator that goes up the outside of a tall building at a constant speed of 20 meters per second. Assuming that you drop a ball as you pass a window, a person looking out the window will see the ball

a. remain stationary.
b. fall starting with an downward speed of 20 m/s.
c. fall starting with a upward speed of 10 m/s.
d. accelerate downward at 10 $m/s^2$.
e. fall starting from rest.
f. None of the above statements is true

54. A person drops a ball in train traveling along a straight, horizontal track with a constant acceleration of 5 $m/s^2$ in the forward direction. What would the person in the station say about the horizontal forces acting on the ball?

a. There are no horizontal forces acting on the ball.
b. There is a horizontal force acting forward of magnitude g/2
c. There is a horizontal force acting backward of magnitude g/2.
d. There is a horizontal force, but its magnitude cannot be stated in terms of g.
e. There is a centrifugal force.
f. The person in the station could make none of the above statements.

55. A rock is thrown horizontally at 40 m/s from the back of a flatbed truck that is moving with a constant velocity of 20 m/s. Relative to an observer on the ground, what is the horizontal speed of the rock when it is thrown in the forward direction?

a. 10 m/s
b. 20 m/s
c. 30 m/s
d. 40 m/s
e. 50 m/s
f. None of the above speeds is within 10 % of the correct answer.

$v = v' + V = 40 + 20 = 60$

56. A train is traveling along a straight, horizontal track with a constant acceleration in the forward direction. At the instant the speed is 50 mph, a ball is dropped by an observer in the train. An observer on the train determines that the horizontal speed of the ball during the fall is

a. increasing
b. decreasing
c. zero
d. constant and equal to 50 mph.
e. None of the above.

57. An observer drops a ball in a train traveling along a straight, horizontal track with a constant acceleration in the forward direction. What would the observer in the train infer about the horizontal force acting on the ball?

a. There is no horizontal force.
b. A force acts backward.
c. A force acts forward but it is a pseudo-force and not a physical force.
d. There is a centrifugal force.
e. None of the above

58. While driving to the movies you decide to take advantage of a sharp right-hand corner to slide your date over next to you by turning right sharply . (Assume that the seat is frictionless.) From your point of view your date experiences a net force to the left, while a person standing on the roadway says your date experiences

a. a net force to the right.
b. a net force to the left.
c. no net force.
d. a net force backward
e. a net force forward.
f. None of the above completions yields a correct statement.

59. What would an observer in an elevator measure for the magnitude of the free-fall acceleration near the surface of Earth if the elevator accelerates upward at 4 $m/s^2$?

a. 4 $m/s^2$
b. 6 $m/s^2$
c. 10 $m/s^2$
d. 14 $m/s^2$
e. 16 $m/s^2$
f. None of the above.

60. In his theory of special theory of relativity, Einstein

a. abandoned the Galilean principle of relativity.
b. abandoned Maxwell's equations for electricity and magnetism.
c. showed that the ether medium for Maxwell's electromagnetic waves had to be at rest with respect to the distant stars.
d. postulated the existence of an absolute reference system.
e. postulated the Principle of Equivalence
f All of the above statements (a) through (e) yield true statements about Einstein's Special Theory
g. None of the above completions, (a) through (e) yields a true statement.

61. 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. N
b. The rate at which one another's clocks run N
c. The lengths they measure along the direction of their relative travel N
d. The synchronization of their own clocks with the moving clocks of the other frame. N
e The speed of their motion relative to one another. Y
f The observers will agree on none of the items (a) through (e) above. F
g. The observers will agree on all of items (a) through (e) above. F

62. A rocket ship is 220 m long when measured at rest. A stationery 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. A second observer, Õ, on the rocket ship 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.
e. All of the objections, (a) through (c) above, are true and valid

63. Einstein's Equivalence Principle is supported by the fact that

a. Light is observed to be deflected when passing massive objects, as he predicted.
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.
c. The inertial pseudo-force required to explain the physics in an accelerated frame is proportional to the mass, m, of the object observed.
d No experiment has been devised which exhibits a measurable difference between a gravitational force and an acceleration of the local frame of reference.
e In fact, none of the "facts" cited in (a) through (d) above actually supports the Principle of Equivalence.
f. In fact, all of the facts cited in (a) through (d) above actually support the Principle of Equivalence.

64. An electron is being accelerated by a constant force to a speed approaching the speed of light. Which of the following statements, (a) through (e), is **false**?

a. Its kinetic energy increases steadily.
b. Its relativistic momentum increases at a constant rate.
c. Its speed can approach, but not exceed, the speed of light.
d. Its total energy continually increases.
e. The power, or energy per unit time, required to accelerate it becomes constant
f. None of the above statements (a) through (e) is false.
g All of the statements (a) through (e) above are false.

65. 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 $c = 3X10^8$ m/s, 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. No, because for him his moving biological clock speeds up and gives him less time.
f. None of the above completions yields a true statement.

70. Suppose, hypothetically, that in question 69 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 $K_8S_4$, how many liters of $K_8S_4$ would be produced, most nearly?

a. 4
b. 2
c. 1
d. 1/2
e. 1/4
f. None of the above is within 10% of the correct answer.

Since S is diatomic, 1 l S could make 2 l $K_2S$ & 1/4 as much $K_8S_4$ or 2/4 = 1/2 l

71. 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.
b. particles have no internal structure.
c. particles are indestructible.
d. particles do not interact except when they collide.
e. particles travel in stright lines between collisions. (a)
f. All of the above properties (a) through (e) are properties of our ideal gas.
g. In fact, none of the above properties, (a) through (e), is a property of our ideal gas.

72. 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

73. 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 Celsius temperature.
f. None of the quantities, (a) through (d) above, doubles with the Celsius temperature

74. 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.
b. the walls must exert a larger impulse to turn back the particles..
c. the number of gas particles increases with temperature.
d. the volume of the gas increases with temperature.
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.

75. Joule's experiments with hanging weights turning paddle wheels in water
a. showed that mechanical energy was converted to heat by viscous forces.
b. showed that 4.2 joules of work are equivalent to 1 calorie of heat.
c. fixed the ratio between the Joule and the (independently defined) calorie.
d. led to a generalization of the law of conservation of mechanical energy.
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.

76. 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.
b. is a restatement of the law of conservation of energy.
c. allows that heat can be completely converted into work.
d. treats heat as another form of energy.
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.

77. 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: EVERY cyclic heat engine violates all of (a) through (d)
f All of the above assertions are guaranteed by the condition stated.

78. 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. Because cool air from the mountains flows down to the cosats.
g. None of the above causes coastal regions to be more moderate than mid-continental regions..

79. 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 leads 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 cannot be predicted reliably.

80. 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.
   b. when there is no friction.
   c. when all of the forces acting are conservative.
   d. if there is no heat loss or gain.
   e. if the third law of thermodynamics is valid..
   f All of the above completions (a) through (e) yield a true statements.
   g. None of the above completions (a) through (e) yields a true statement.

81. The second law of thermodynamics says
   a. that the energy of an isolated system is conserved. ← 1st LAW says this, NOT 2nd
   b. that the entropy of the earth can never decrease. FALSE! ENTROPY of UNIVERSE can never decrease
   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 ← 1st LAW than the thermal energy it consumes.
   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.

82. 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 heat engine can be less efficient than the Carnot engine with the same maximum and minimum temperatures

   2nd Law says NONE can be MORE Efficient!

   f. Every heat engine must exhaust heat.
   g. None of the above contradicts the second law.

83. An air-conditioner mechanic is testing a unit by running it on the workbench in an isolated room. The unit removes 100 cal/min from the refrigerated chamber, utilizing a work input of 420 J/min. By how much does the internal energy of the room outside the refrigerated chamber change, most nearly, in each minute?
   a. It decreases by 100 cal/min.
   b It decreases by 200 cal/min
   c. It decreases by 520 cal/min.
   d. It stays the same.
   e. It increases by 520 cal/min
   f. It increases by 200 cal/min.
   g. None of the above is within 10% of the correct answer.

$Q_{out} = W_{IN} + Q_{IN} = 420\ J/min + 100\ cal/min$

& NOTE: $420\ J = 100\ cal$.

Then $Q_{out} = 200\ cal/min$

84. An ideal heat engine has a theoretical efficiency of 47% and an exhaust temperature of 127° C. What is its input temperature, most nearly ?

a. 230° C
b. 480° C
c. 600° C
d. 750° C
e. None of the above is within 10% of the correct answer

$\eta_{CARNOT} = 1 - T_C/T_H = 0.47$ , & $T_C = 273 + 127 = 400K$

$1 - 0.47 = 0.53 = T_C/T_H \Rightarrow T_H = T_C/0.53 = 754K = 480°C$

85. An engineer has designed a machine to produce electricity by using the difference in the temperature of ocean water at depths of 0 and 50 m. If the surface temperature is 20° C and the temperature at 50 m below the surface is 14° C, what is the maximum work this machine can extract per joule of heat put in at the surface, most nearly?

a. 0.01 J
b. 0.02 J
c. 0.03 J
d. 0.04 J
e. 0.05 J
f. None of the above is within ±10% of the correct answer.

$\eta_{CARNOT} = \frac{T_H - T_C}{T_H} = \frac{293 - 287}{293} = 0.02 > \frac{W_{out}}{Q_{IN}}$

$W_{out} < 0.02$ J/per Joule of Heat

86. 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 and isolated from their surroundings. Eventually the bell stops vibrating and the water comes to rest. Which of the following statements is TRUE?

a. The mechanical energy of the bell has been completely converted into internal energy of the combined system.
b. The final temperature of the combined system is greater than the initial temperature.
c. The entropy of the combined system has increased.
d. The total energy of the system is the same at the end as at the beginning.
e. All of the abovce statements (a) through (d) are true..

87. A heat engine exhausts 1200 J of energy for every 1800 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.

88. 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 heat engine can be more efficient than the Carnot engine with the same maximum and minimum temperatures
f. Every heat engine must exhaust heat.
g. None of the above contradicts the second law.

89. The efficiency of an ideal heat engine can be improved by __________ the input temperature and __________ the exhaust temperature.
a. increasing ... increasing
b. increasing ... decreasing
c. decreasing ... increasing
d. decreasing ... decreasing
e. None of the above: the efficiency of the ideal heat engine is independent of temperature.

90. How much work per second (power) is required by a refrigerator that takes 800 J of thermal energy from a cold region each second and exhausts 1200 J each second to a hot region? (1W = 1 J/sec)
a. 2000 W
b. 1200 W
c. 800 W
d. 400 W
e. None of the above is within 10% of the correct answer.

91. Which of the following sets of parameters all affect the period of a pendulum? (M = Mass, L = Length, and g = acceleration due to gravity)
a. (M, L and g)
b. (M and L)
c. (M and g)
d. (L and g)
e. (L only)
f. None of the above.

92. The fundamental wavelength for standing waves on a rope fixed at both ends is __________ the length of the rope.
a. four times
b. two times
c. the same as
d. one-half
e. one-fourth
f. None of the above

93. If a certain ultra-violet light has a frequency of $10^{15}$ Hz, its wave length is, most nearly. (1 Hz = 1 cycle/sec, and c = $3X10^8$ m/sec.)
a. $1 X 10^{-7}$ m
b. $3 X 10^{-7}$ m
c. $1 X 10^{7}$ m
d. $3 X 10^{7}$ m
e. $3 X 10^{23}$ m
f. None of the above is within 10% of the correct wavelength.

$\lambda = v/f = \frac{3 \times 10^8}{10^{15}} = 3 \times 10^{-7}$

94. What is the frequency of the earth's rotation about the sun, most nearly? ( 1Hz = 1cycle/sec)
a. $4 \times 10^{-2}$ Hz
b $8 \times 10^{-2}$ Hz
c. $7 \times 10^{-4}$ Hz
d. $1 \times 10^{-5}$ Hz
e. $2 \times 10^{-6}$ Hz
f. $3 \times 10^{-8}$ Hz
g. None of the above is within 10%of the correct answer.

95. The transverse wave speed along a string of length 0.2m fixed at both ends is 100 m/s. What is the frequency of the third standing wave on this string?
a. 750 Hz
b. 625 Hz
c. 500 Hz
d. 375 Hz
e. 250 Hz
f None of the above is correct within 10%.

96. The periodic table arranges the elements according to
a. the order in which they were discovered.
b. their chemical properties.
c. their relative abundances.
d. alphabetical order.
e. None of the above.

97. 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.
f. All of the above were reasons for abandoning the Thomson model.

98. 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.
b. The attractive force between the positive nucleus and the negative electrons would pull them together.
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.
e. All of the above.
f. None of the above.

99. When light is incident on a metallic surface, the emitted electrons
a. are called photons.
b. have arbitrarily high energies.
c. have a maximum energy that depends on the intensity of the light.
d. Are referred to as cathode rays.
e All of the above
f. None of the above.

100. 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
b. number
c. average speed
d. average kinetic energy
e. All of the above quantities increase with intensity.
f. None of the above completions yields a true statement.

101. Bohr gave the following argument why the electron in the hydrogen atom existing only in certain discrete energy levels
a. This agrees with Newtonian mechanics.
b. This agrees with Maxwell's equations.
c. This was implied by the Rutherford atom
d. All of the above were cited.
e. None of the above, Bohr simply postulated it, offering no supporting rationale, except that it explained the Hydrogen spectra.

102. 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.

103. What is the de Broglie wavelength of a Volkswagen (mass = 1000 kg) traveling at 30 m/s (67 mph)? (Planck's constant is $h = 6.63 \times 10^{-34}$ J·s.)
a. $1.47 \times 10^{-39}$ m
b. $2.21 \times 10^{-38}$ m
c. $1.99 \times 10^{-29}$ m
d. $2.98 \times 10^{-28}$ m
e. None of the above is correct within 10%.

$\lambda = h/p = \frac{6.63 \times 10^{-34}\ J\cdot s}{1000\ kg \cdot 30\ m/s} = 2.21 \times 10^{-34-3-1}\ J = 2.2 \times 10^{-38}$

**Note: The following (last seventeen) problems may require somewhat more calculation than the average. You may wish to sequence your work accordingly.**

104. A microwave photon has an energy of $2 \times 10^{-23}$ J. What is its wavelength? (Planck's constant is $h = 6.63 \times 10^{-34}$ J·s.)

a. $10^{-8}$ m
b. $10^{-6}$ m
c. $10^{-4}$ m
(d.) $10^{-2}$ m
e. 1 m
f. None of the above is correct within 10%.

$E_{ph} = hf \Rightarrow f = h/E$

and $f \cdot \lambda = c \Rightarrow \lambda = c/f = \frac{ch}{E}$

$= \frac{(3 \times 10^{8})(6.63 \times 10^{-34})}{2 \times 10^{-23} \text{ J}} \frac{m}{s} \cdot \frac{J \cdot s}{J}$

$= (9.9) \times 10^{8-34+23} \approx 10 \times 10^{-3} \approx 10^{-2}\, m$

105. A 40-kg crate is being pushed across a horizontal floor by a horizontal force of 240 N. If the coefficient of sliding friction is 0.1, what is the acceleration of the crate, most nearly?

a. zero
b. 1 m/s$^2$
c. 2 m/s$^2$
d. 3 m/s$^2$
e. 4 m/s$^2$
(f.) 5 m/s$^2$
g. 6 m/s$^2$
h. None of the above is within 10 % of the correct answer.

$|F_{NET}| = |F_{App}| - |F_{fr}| = 240 - (0.1)(40)(10) = 200\,N$

$= ma = 200\,N \Rightarrow a = \frac{200}{40} = 5\, m/sec^2$

106. A waterfall in southeastern Venezuela is one of the highest uninterrupted waterfalls in the world. If the water is flowing horizontally at a speed of 3m/s as it passes over the lip of the falls, and hits the pool below at a point 51 m out from the lip, what is the height of the falls above the pool, most nearly?

a. 140m
b. 420 m
c. 980 m
d. 1400 m
e. 9800 m
f. None of the above is within 10% of the correct answer.

$(x - x_0) = v_0 t_f = 51m = 3t_f$ in Horizontal direction $\Rightarrow t_f = 17$sec

So that $h = \frac{1}{2} g t_f^2 = \frac{10}{2} \cdot (17)^2 = 1445$ m

107. A man stands on a large platform merry-go-round which is rotating at a constant angular speed, $\omega = 0.43$ radians/second. The normal force between his shoes and the platform is equal to his weight, 500 N, and the coefficient of static friction is $\mu_{STATIC} = 0.11$. How far from the center can he stand without sliding off the platform, most nearly ?

a. 1 m
b. 2 m
c. 3 m
d. 4 m
e. 5 m
f. 6 m
g. None of the above is within 10% of the correct answer.

To travel in a circle a force $F_c = \frac{mv^2}{r} = m\frac{r^2\omega^2}{r} = mr\omega^2 = 50 \cdot (0.43)^2 \cdot r$ is required, where $r$ = distance from center.

But static friction provides this force and has MAX value $F^{MAX}_{STAT} = \mu|N| = (0.11)(500)$

Then $m r_{MAX} \omega^2 = \mu |N| \Rightarrow r_{MAX} = \frac{(0.11)(500)}{50(0.43)^2}$

$= 5.95$ m

108. Suppose Newton lived on another planet and thought of launching his apple horizontally at such a speed as to make it travel around that planet (presumed smooth for the present discussion) in a circle at fixed height. What horizontal speed, most nearly, must it have to have to stay at the same small height above the planet's surface? (Take the radius of the planet to be $1.2X10^9$ m, and the planet's gravitational acceleration to be 8 $m/s^2$.)

a. $10^1$ m/s
b. $10^2$ m/s
c. $10^3$ m/s
d. $10^4$ m/s
e. $10^5$ m/s
f. None of the above is within 10% of the correct answer.

$\frac{v^2}{R_p} = g_p = 8\ m/sec^2 \Rightarrow \sqrt{v^2} = \sqrt{R_p g_p} = v$

$\sqrt{9.6 \times 10^9} = v$

$10^5 \approx$

109. An 800-kg frictionless roller coaster starts from rest at a height of 24 m. It travels 500 m under a frictional force of 144 N to the crest of a hill that is 12 m high. What is its kinetic energy at the top of the 12 m hill, most nearly? (1 kJ = $10^3$ J.)

a. 0 kJ
b. 12 kJ
c. 24 kJ
d. 48 kJ
e. 96 kJ
f. 192 kJ
g. None of the above is within 10% of the correct answer.

$W_G - W_f = \Delta KE$

$mg\Delta h - F_f \cdot D = (KE)_f - (KE)_i \rightarrow 0.$

$800 \cdot 10 \cdot 12 - 500 \cdot 144 = 96\ kJ - 72\ kJ = 24\ kJ$

110. A block weighing 30 N is falling with a kinetic energy of 25 J at time, $t_1 = 0$, when a constant upward force sufficient to provide a net upward force of 6 N is applied. At a particular later time, $t = t_2$ the block has been lifted 5 m above the point where it was at t= 0. What is its kinetic energy at time $t_2$, most nearly?

$W_{NET} = \Delta(KE) = (KE)_f - (KE)_i$

$(6)(5) J = (KE)_f - 25 J$

$(30 + 25) J = (KE)_f$

$55 J = (KE)_f$ at $t = t_2$

a. 145 J
b. 115 J
c. 85 J
d. 55 J
e 30 J
f. 25 J
g. 0 J
h. None of the above is within 10% of the correct answer.

111. What average power is required to accelerate a 1150-kg truck from rest to 16 m/s in 8 s, most nearly? (1 kW = 1000 watts = 1000 J/sec.)

$P = \frac{\Delta W}{\Delta t} = \frac{\Delta(KE)}{\Delta t} = \frac{(KE)_f}{\Delta t} = \frac{1}{2} \frac{(1150)(16)^2}{8 \text{ sec}} \frac{kg\, m^2}{(sec)^3} = 18.4 \times 10^3 \frac{J}{sec}$

$= 18.4$ kw

a. 0 kW
b. 12 kW
c. 15 kW
d. 18 kW
e 24 kW
f. None of the above is within 10% of the correct answer.

112. A person who weighs 800 N when at rest is riding in the rotating cylinder ride. The cylinder rotates fast enough to create a horizontal inertial (centrifugal) pseudo-force of magnitude 600 N acting upon him in the rotating frame. What is the magnitude of the person's weight in the rotating reference frame, most nearly?

a. 500 N
b. 750 N
c. 1000 N
d. 1250 N
e. 1500 N
f. 1750 N
g. None of the above is within 10% of the correct answer.


"Weight" $= \sqrt{(600)^2+(800)^2} = 1000\,N$

113. A train is traveling along a straight, horizontal track at a constant speed of $v = 0.99995c = (1\text{-}5\text{x}10^{-5})c$. 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) $10^{-3}$ s;
b) $10^{-2}$ s;
c) $10^{-1}$ s;
d) 1 s;
e) $10^{2}$ s;
f) $10^{3}$ s;
g) $10^{4}$ s;
h) $10^{5}$ s;
i) $10^{6}$ s;

$$\gamma = \frac{1}{\sqrt{1-v^2/c^2}} = \frac{1}{\sqrt{(1-v/c)(1+v/c)}} \approx \frac{1}{\sqrt{2\epsilon}}$$

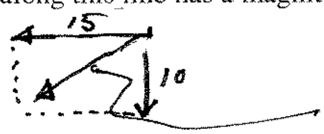
$$= \frac{1}{\sqrt{(2\cdot 5)10^{-5}}} = \frac{1}{\sqrt{10^{-4}}} = 10^2$$

$$\Delta t = \gamma \Delta t' = 100\,\Delta t'$$

if $v/c \approx (1-\epsilon)$, then $v = (1-\epsilon)c$ and $\epsilon = 1 - v/c$ is small when $v/c \approx 1$ OR $v \approx c$.

114. An observer in a moving train drops a ball in a train traveling along a straight, horizontal track with a constant acceleration of 15 m/sec$^2$ in the forward direction. The observer is unaware of the acceleration and notices that the ball falls in a straight line that is slanted toward the back of the train. The acceleration of the ball along this line has a magnitude of __________ m/s$^2$, most nearly.

a. 5.0 m/s$^2$.
b. 10.0 m/s$^2$.
c. 11.1 m/s$^2$.
d. 14.1 m/s$^2$.
(e.) 18.0 m/s$^2$.
f. None of the above is within 10% of the correct answer.




$a = \sqrt{10^2+15^2} = \sqrt{325} = 18.03\ m/(sec)^2$

115. One liter of gaseous (diatomic) oxygen combines completely with two liters of gaseous (diatomic) hydrogen to form a gas of water molecules (steam), when all of the gases are contained at the same temperature and pressure. One concludes from this that a water molecule has twice as many hydrogen atoms as it has oxygen atoms. If one also knows the volume of the steam finally produced (at the same temperature and pressure as the original hydrogen and oxygen), one can also choose the correct formula for water from the chemical formulas, $H_2O$, $H_4O_2$, and $H_6O_3$, etc…, all of which have twice as many hydrogen atoms as oxygen atoms in each molecule, as required.
Then suppose that the correct formula for the water molecule were $H_6O_3$, and compute the volume (at the same temperature and pressure) of steam finally produced. The final volume in that case would be, most nearly:

a) 6 liters;
b) 3 liters;
c) 2 liters;
d) 1 liter;
e) 0.5 liter;
(f) 0.67 liter;
g) 0.33 liter;
h) 0.16 liter

Because $O_2$ is diatomic one liter of $O_2$ would make 2 liters of $H_2O_1$.
But $H_6O_3$ molecules require 3X as many O atoms/molecule as $H_2O$, and will produce 3X smaller volume of $H_6O_3$ than of $H_2O$: $\frac{1}{3} \cdot 2\ell = 0.67\ \ell$ of $H_6O_3$ (f)

116. 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. 1.900 c
b 1.850 c
c. 1.000 c.
(d.) 0.997 c
e. 0.950 c
f. 0.900 c
g. 0.855 c
h. 0.050 c
i. 0.000 c
j. None of the above is correct within 0.002c.

$$\frac{v}{c} = \frac{(0.9 + 0.95)}{1 + (0.9)(0.95)} = \frac{1.85}{1.855} = 0.9973$$

117. 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 five atmospheres of pressure?

a. 30,000°C
b. 27,000°C
c. 24,000°C
d. 21,000°C
e. 18,000°C
(f.) 15,000°C
g. 12,000°C
h. None of the above is within 10% of the correct Celsius temperature

30 °C = 303 K. $V_f/V_i = 10^6/10^5 = 10$

$P_f/P_i = 5/1$

$$\frac{P_f V_f}{P_i V_i} = \frac{NkT_f}{NkT_i}$$

$5 \cdot 10 = T_f/T_i \Rightarrow T_f = (50)(303 K) = 15,150 K$

$= 14,877$ °C

118. A heat engine takes in 1200 J of energy at 900 K and exhausts 900 J at 300 K. What is the theoretical maximum efficiency (i.e., the Carnot efficiency) for this engine, and what is its actual efficiency, respectively ?

a. 33% and 25%, respectively.
b. 33% and 75%, respectively.
c. 33% and 33%, respectively.
d 67% and 67%, respectively
e. 67% and 75%, respectively.
f. 67% and 25%, respectively.
g. None of the above provides both efficiencies within 10%.
h. 70% and 67%, respectively
i In none of the above are both answers correct within 10% of the value

$\eta^{MAX}_{CARNOT} = 1 - T_C/T_H = 1 - \frac{300}{900} = 0.667 = 67\%$

$\eta_{ACTUAL} = \frac{W_{out}}{Q_{IN}} = \frac{1200-900}{1200} = \frac{1}{4} = 25\%$ (f)

119. The energy levels of the Hydrogen atom are correctly given by the formula of the Bohr model; as follows: $E_n = -13.6/n^2$, where n = 1, 2, 3,…gives the lowest orbits. (The energy units are electron Volts: $1 eV = 1.6 \times 10^{-19}$ J.) Calculate the energy emitted when an electron jumps from the third Bohr orbit to the lowest (n=1) orbit.

a 13.6 eV
b. 12.1 eV
c. 3.4 eV
d. 1.5 eV
e None of the above is correct within 10%.

$\Delta E = -13.6\left(\frac{1}{(3)^2} - \frac{1}{(1)^2}\right) = \frac{8}{9}\cdot(13.6) = 12.08\ eV$

120. A certain microwave antenna transmits electromagnetic waves of 1 cm wavelength. What is the energy of one of its emitted photons, most nearly? (Planck's constant is $h = 6.63 \times 10^{-34}$ J·s.)

a. $10^{-22}$ J
b. $2 \times 10^{-22}$ J
c. $10^{-23}$ J
d. $2 \times 10^{-23}$ J
e. $10^{-24}$ J
f. $2 \times 10^{-24}$ J
g. None of the above is correct within 10%.

$E = hf$ for photon $\Rightarrow E = hc/\lambda = \frac{(6.6)(3) \times 10^{-34+8}}{0.01\,m}$ J

and $v = f \cdot \lambda = c$ for Emagnetic wave.

$\Rightarrow f = c/\lambda$

$E = 19.8 \times 10^{-24}$ J
$\approx 2 \times 10^{-23}$

## End of final EXAM S06