First Law Review

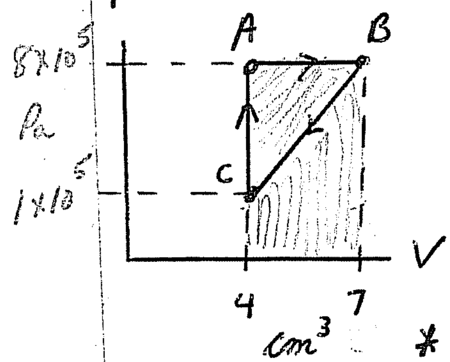
1] The ideal gas in a tank originally has $V = 16.0\ cm^3$, $P = 100$ kPa, and $T = 40.0\ ^\circ C$. It is now compressed isothermally to $8.00\ cm^3$. What is the new pressure? (200kPa)

$\Delta T = 0 \quad \Delta U = 0$

$P_1V_1 = P_2V_2$

$\frac{1600}{8} = 200 kPa$

2] A series of processes that an ideal gas system has undergone is shown below. Find the work done by the system in going
a) from A to B $W = P\Delta V$ (neg due to exp.)
b) from B to C $W = P\Delta V$ (+)
c) from C to A 0
d) entire cycle
e) What is the internal energy change in going around the entire cycle?



$* 1 m^3 = 10^6 cm^3$

−2.4J

a) -2.40 J b) 1.35 J c) 0 J d) -1.05 e) 0 J

$W = W_1 + W_2 + W_3$
$= -2.4 + 1.35 + 0$
$= -1.05$

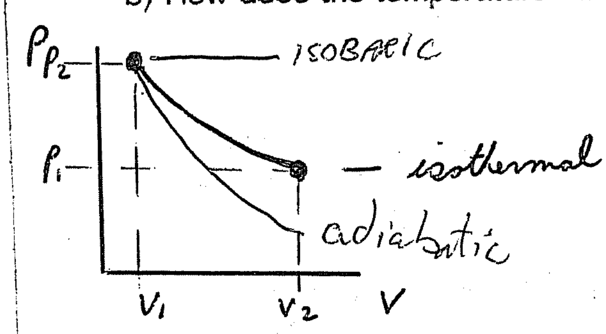
Same point ∴ same T ∴ $\Delta U = 0$

3] A gas expands by 1.2 L at a constant pressure of 2.5×10^5 Pa. During the expansion 500 J of heat is added. Find the change in internal energy of the gas. (200 J)

$\Delta U = Q + W$
$500 - P\Delta V$
$= 500 - 300$
$= 200 J$

done

4] Draw a P-V graph showing a isobaric, isothermal, and adiabatic expansion.
a) Which expansion represents the greatest work? ISOBARIC
b) How does the temperature vary during each expansion? (see teacher)



Isobaric: $PV = nRT$, $\Delta T \propto \Delta V$

Isothermal: $\Delta T = 0$ (defn.)

adiabatic: $\Delta Q = 0$, $\Delta U = -W$; if system expands $W = -$, $\Delta U = -$; lower than isotherm → $\Delta T = -$; reverse if compression higher than isotherm

← #2

5] For the reversible process shown above, the temperature of the ideal gas at A is 327°C. What is the temperature at B and C? (777 °C, -198°C)

Change to K = 600k

$PV = nRT$
$PV = kT$
at A $(8\times10^5)(4\times10^{-6}) = k(600)$
$k = 5.33\times10^{-3}$

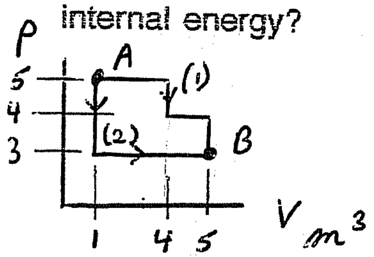
at B $\frac{8\times10^5 \ 7\times10^{-6}}{5.33\times10^{-3}} = 1050 - 273 = 777°C$

C $\frac{1\times10^5 \ 4\times10^{-6}}{5.33\times10^{-3}} = 75 - 273 = -198$

6] In the diagram shown below a system undergoes a process from A to B. How much work is done by the system on a) path 1 and b) path 2? If process 1 is carried out adiabatically, what is the change in the internal energy?

a) -1.92×10^6 J b) -1.2×10^5 J c) -1.92×10^6 J

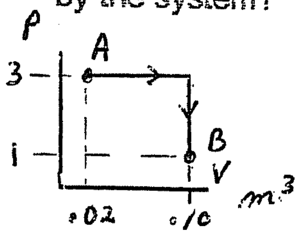
atm — Change to Pa



$W = P\Delta V$ $\quad -(P\Delta V_1 + P\Delta V_2$ area) $\quad W =$ area $= 1.22 \times 10^6$ J $\quad$ adiabatic $Q = 0$, $\Delta U = W = -1.92 \times 10^6$ J

7] In undergoing the process from A to B in the figure below, the increase in internal energy of a substance is 3×10^5 J. How much heat is absorbed by the system? 3.24×10^5 J

atm



$\Delta U = Q + W$

$3 \times 10^5 = Q + (-3 \times 1.013 \times 10^5)(.08)$

$Q = 3.24 \times 10^5$ J

8] Find the change in internal energy of a system when a system absorbs 2000 J of heat and produces 500 J of work? 1500 J

Q+ $\quad$ W− $\quad$ $\Delta U = Q + W = 1500$ J

9] What is the efficiency of a Carnot engine operating between a hot region at 360 °C and a cold region of -125°C? (.766)

633 K $\quad$ 148 K $\quad$ $e = 1 - \frac{T_L}{T_H} = .766$ $\quad$ 76.6%

10] A Carnot engine absorbs 1.0×10^6 J of heat from a resevoir at 300 °C and exhausts heat to a reservoir at 150 °C. Find the work it does? 2.62×10^5 J

423 K $\quad$ 573 K

$e = 1 - \frac{T_L}{T_H}$ finds % useable

$e = .262 \times$ energy in = useful out $= 2.62 \times 10^5$ J

11] A Carnot engine absorbs 200 kJ of heat at 500 K and exhausts 150 kJ. What is its exhaust temperature? (375 K)

waste

$e = \frac{50}{200} = 0.25 = 1 - \frac{T_L}{T_H}$ $\quad$ $\frac{T_L}{T_H} = 1 - .25$

$T_L = .75(500) = 375$ K = 102 °C

12] One kilogram of water at 29 °C is mixed with 1.00 kg of water at 31.0 C. estimate the change in entropy of the system. (+0.046J/kg)

T Ave = 30.5 °C hot = 303.5 K $\quad$ T ave 29.5 °C cold 302.5 K

$\Delta S = \Delta S_{hot}$ (neg) $+ \Delta S_{cold}$ (pos) $= \frac{Q_H}{T} + \frac{Q_C}{T} = \frac{mC\Delta T}{T} + \frac{mC\Delta T}{T}$

$\frac{1 \cdot 4186 (302.5 - 302)}{302.5} + \frac{1 \cdot 4186 (303.5 - 304)}{303.5}$ $\quad 4.6 \times 10^{-2}$

$\frac{4186(-.5)}{303.5} + \frac{4186(.5)}{302.5}$

H:7

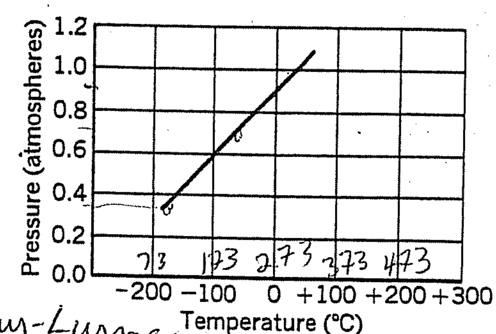
1. Compared with a mole of titanium (atomic mass = 48), the number of atoms in a mole of carbon (atomic mass = 12) is

a. one fourth as great
b. the same
c. twice as great
d. four times as great

Study the information below; then complete statements 2–4.

The graph represents the relation between temperature and pressure for 10 g of oxygen gas.

Heat Review



2. The pressure of the oxygen gas varies

a. directly as the temperature
b. directly as the square of the temperature
c. inversely as the temperature
d. inversely as the square of the temperature

3. At 273° K, the pressure of the gas is closest to

a. 0.5 atm
b. 0.9 atm
c. 1.0 atm
d. 1.5 atm

4. For the relation shown in the graph, the volume of the gas must be

a. continually increasing
b. continually decreasing
c. constant
d. increasing then decreasing

Select the term that best completes each of the following statements.

5. The universal gas constant R may be obtained from the pressure P, temperature T, number of moles n, and volume V according to the relation

a. $R = PVT/n$
b. $R = PTn/V$
c. $R = PV/nT$
d. $R = PT/nV$

6. If 2 moles of gas confined in a 10 m^3 tank at a temperature of 127° C (400 K) exerts a pressure of 1.5×10^6 N/m, the number of moles of this same gas needed to maintain the same pressure in a 50 m^3 tank at −73° C (200 K) is

a. 0.25
b. 0.8
c. 1.2
d. 20

$P_1V_1 = n_1RT_1$

$P_1V_2 = n_2RT_2$

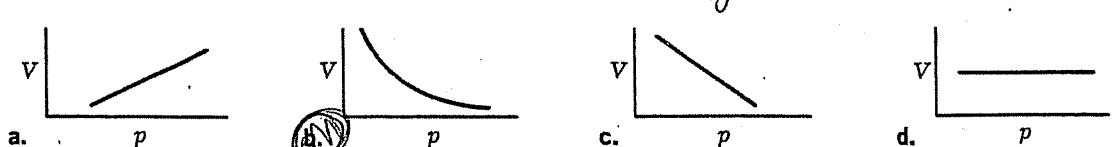
$P_1 = \frac{n_1RT_1}{V_1} = \frac{n_2RT_2}{V_2}$

$\frac{2 \times 400}{10} = \frac{n \times 200}{50}$

7. The values for a gas at standard conditions are

a. $P_0 = 1$ atm; $n_0 = 1$ mole; $T_0 = 273°$ K; $V_0 = 22.4$ liters
b. $P_0 = 1$ atm; $n_0 = 1$ mole; $T_0 = 0°$ K; $V_0 = 1$ liter
c. $P_0 = 0$ atm; $n_0 = 2$ moles; $T_0 = 273°$ K; $V_0 = 10$ liters
d. $P_0 = 0$ atm; $n_0 = 2$ moles; $T_0 = 0°$ C; $V_0 = 1$ liter

8. Assuming constant mass and temperature, the graph that best represents the relation between pressure and volume is (Boyles Law)



9. As the mass of the gas in a given container is doubled, the number of impacts per second on the walls of the container

a. is halved
b. remains the same
c. is doubled
d. is quadrupled ← must double mass which also doubles N

$E_k = \frac{1}{2}mv^2 = \frac{3}{2}kT$

is the answer, F ∝ impacts

10. A gas tank contains 1.0 m^3 of air with a mass of 1.5 kg at a pressure of 1800 mm Hg. If another 0.5 kg of air is pumped into the tank, the pressure becomes

a. 760 mm Hg
b. 1800 mm Hg
c. 2400 mm Hg
d. 3000 mm Hg

11. The number of moles in 6 g of hydrogen (molecular mass = 2) is

a. 1/3
b. 3
c. 6
d. 12

12. If the pressure of 1000 cm^3 of a gas in a closed tank is 2.02×10^6 N/m^2 at a temperature of 27° C, the pressure of this gas at 327° C is

a. 1.4×10^5 N/m^2
b. 1.01×10^6 N/m^2
c. 4.04×10^6 N/m^2
d. 24.24×10^6 N/m^2

13. Metals are especially good conductors of heat because they have many free

a. electrons
b. neutrons
c. nuclei
d. atoms

14. A physical medium is required for the transfer of energy by

a. conduction and radiation only
b. conduction and convection only
c. convection and radiation only
d. conduction, convection, and radiation

15. When a substance is heated but does not change its state,

a. only its molecular kinetic energy increases
b. only its molecular potential energy increases
c. both its molecular potential and kinetic energies increase
d. neither its molecular potential nor kinetic energy increases

16. The specific heat of ice is 0.50 cal/g·C° and that of water is 1.00 cal/g·C°. The amount of heat required to raise the temperature of 100 g of ice at 0° C to water at 5° C is

a. 450 cal
b. 550 cal
c. 7500 cal
d. 8500 cal

17. Ten grams of mercury change from a liquid to a vapor at its boiling point of 357° C when 706 cal are added. The heat of vaporization of mercury is

a. 35.7 cal/g
b. 70.6 cal/g
c. 3570 cal/g
d. 7060 cal/g

18. The mechanical equivalent of heat is 4.18 J/cal. Assuming no losses, the height from which a 1 g mass must fall in order to raise the temperature of 2 g of water 1° C is

a. 214 m
b. 427 m
c. 853 m
d. 1706 m

19. The calorie is the amount of heat needed to raise

a. 1 g of water 1° C
b. 1 g of water 1° K
c. 1 kg of water 1° C
d. 1 kg of water 1° K

Study the paragraph below; then complete statements 20 – 22

A 5.0 g ice cube at 0° C is dropped into 10 g of water at 30° C. The final temperature of the mixture is 0° C.

20. The amount of heat given up by the water in reaching the final temperature is

a. 50 cal
b. 150 cal
c. 300 cal
d. 400 cal

21. The number of calories required to melt the first gram of ice is

a. 5
b. 10
c. 30
d. 80

22. As the ice melts at 0° C, the potential energy of its molecules

a. increases
b. decreases
c. remains the same
d. increases, then decreases

23. Unlike convection and conduction, radiation involves the transfer of energy by
a. molecular motion
b. variations in density
c. electromagnetic waves
d. the flow of air

24. The first law of thermodynamics is concerned with the conservation of
a. energy
b. momentum
c. charge
d. matter

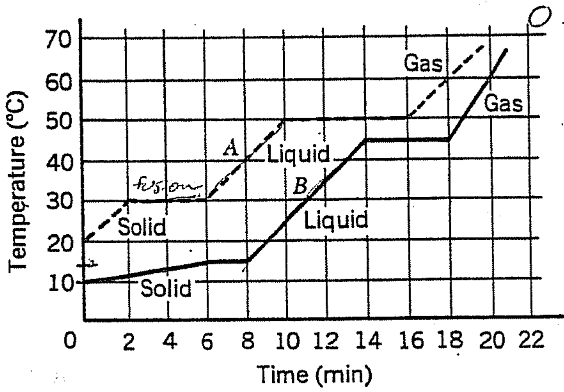
25. If 1.00 g of steam at 100° C loses 560 cal of heat, the resulting temperature is
a. 20° C
b. 80° C
c. 99° C
d. 100° C

26. If 10 g of water at 0° C turns to ice at 0° C, the number of calories of heat released is
a. 0
b. 10
c. 800
d. 5400

27. Ten kilograms of silver (specific heat = 0.056) at 80° C are placed in an insulated container with 10 kg of water (specific heat = 1.00) at 60° C. Assuming no losses to the container or surroundings, the final temperature will be
a. between 80° C and 70° C
b. 70° C
c. between 70° C and 60° C
d. less than 60° C

Study the information below; then complete statements 28-30

The graph shows the addition of heat at a rate of 10 cal/min to a 10 g mass of substance *A* and a 10 g mass of substance *B*.



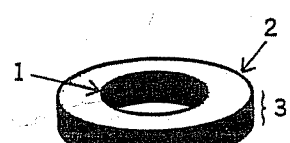
28. The heat of fusion of *A*, compared with that of *B*, is
a. half as great
b. the same
c. twice as great
d. three times as great

29. The specific heat of *A* in the liquid state, compared with that of *B*, is
a. half as great
b. the same
c. twice as great
d. three times as great

30. The specific heat of *B* in the solid state is
a. 0.63 cal/g·C°
b. 1.20 cal/g·C°
c. 110 cal/g·C°
d. 3000 cal/g·C°

31. Losses of mechanical energy due to friction become gains in
a. thermal energy
b. electrical energy
c. nuclear energy
d. gravitational energy

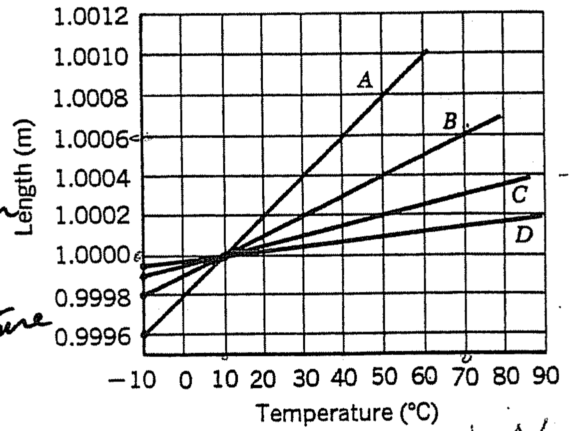
32. In the metal ring at the right, the inner circumference, outer circumference, and height are labeled 1, 2, and 3 respectively. The dimensions that will *increase* if the ring is heated are
a. 1 and 2 only
b. 1 and 3 only
c. 2 and 3 only
d. 1, 2, and 3



33. The maximum density of pure water occurs at
a. −40° C
b. 0° C
c. 4° C
d. 32° C

34. Among the following, the poorest conductor of heat is
a. iron
b. silver
c. copper
d. glass

The change in length of four different metals A, B, C, and D exposed to a range of temperatures is indicated in the graph. The length of each rod at 10° C is 1.0000 m.



$\Delta L = L_0 \alpha \Delta T$

35. The coefficient of expansion of metal B is

a. $1.5 \times 10^{-6} (C°)^{-1}$

b. $1.0 \times 10^{-5} (C°)^{-1}$

c. $1.5 \times 10^{5} (C°)^{-1}$

d. $6.7 \times 10^{5} (C°)^{-1}$

36. The metal that has the smallest coefficient of linear expansion is

a. A

b. B

c. C

d. D

37. At 90° C, bar C compared with bar D is

a. 0.0002 m longer

b. 0.0006 m shorter

c. 1.0008 m longer

d. 1.0002 m shorter

38. For a Carnot engine to have an efficiency of 100 percent, the temperature of the cold reservoir must be

a. 0° K

b. 100° K

c. 0° C

d. 100° C

39. A heat engine is operated in reverse in

a. an electric motor

b. a gasoline motor

c. a refrigerator

d. a jet engine

40. The average kinetic energy of the molecules of a body is a measure of the body's

a. heat

b. temperature

c. mass

d. volume

41. The Carnot efficiency of a steam engine in which the input steam temperature is 250° C and the output steam temperature is 150° C is closest to

a. 20%

b. 40%

c. 60%

d. 100%

42. A measure of the disorder of the molecular motion of a system is obtained from the system's

a. force

b. momentum

c. temperature

d. entropy

43. A machine does 2×10^6 J of mechanical work for an input of 4×10^7 J from the heat source. The efficiency of the machine is

a. 5%

b. 20%

c. 50%

d. 100%

44. The number of molecules in each mole of gas is

a. 1.67×10^{-27}

b. 6.67×10^{-34}

c. 6.25×10^{18}

d. 6.02×10^{23}

45. The temperature of a reservoir to which a Carnot engine will reject no heat is

a. 0° C

b. 0° K

c. 100° C

d. 273° K

46. Thermal energy is transferred between any two bodies of different

a. heats of fusion

b. heats of vaporization

c. specific heats

d. temperatures

47. A gas molecule whose momentum is $+mv$ strikes a wall and bounces back without loss of energy. The change in momentum of the molecule is

48. According to the second law of thermodynamics, the term *entropy* describes the
a. unavailability of energy
b. availability of heat
c. minimum available energy
d. maximum available heat

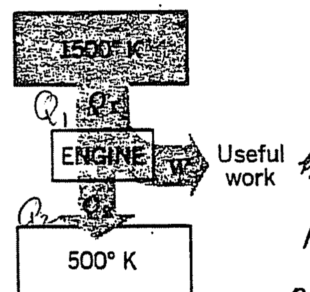
49. Absolute temperature is proportional to
a. average kinetic energy per molecule
b. average potential energy per molecule
c. kinetic energy per cubic centimeter
d. potential energy per cubic centimeter

50. A mass Nm of gas is placed in a cylinder of volume V at a pressure P. The average speed v of the molecules of gas may be obtained from the relation
a. $v = \sqrt{Nm/3PV}$
b. $v = \sqrt{3PV/Nm}$
c. $v = \sqrt{Nm/3P}$
d. $v = \sqrt{PV/3Nm}$

51. An engine whose maximum efficiency is 50 percent gains its energy from a source whose temperature is 1000° K. The temperature of the cold reservoir is
a. 50° K
b. 100° K
c. 500° K
d. 1000° K

Study the information below; then complete statements 52–54.

A source at a temperature of 1500° K puts heat into the engine in the diagram. The engine puts out 5.0×10^4 J of work for a heat input from the source of 1.0×10^5 J. The temperature of the cold reservoir is 500° K.



52. The actual efficiency of the engine is
a. 15%
b. 20%
c. 50%
d. 100%

53. The Carnot efficiency of the engine is
a. 20%
b. 50%
c. 67%
d. 100%

54. The useful work W of the engine is determined from the relation
a. $W = Q_1 - Q_2$
b. $W = Q_1 + Q_2$
c. $W = Q_2 - Q_1$
d. $W = Q_1 \times Q_2$

55. A temperature of 30° on the Celsius scale is the same as a temperature on the Kelvin scale of
a. 243°
b. 273°
c. 303°
d. 373°

56. If the pressure of 10 g of an ideal gas at 50° C is 1 atm, the pressure of this gas at absolute zero is
a. 0 atm
b. 0.5 atm
c. 1 atm
d. 2 atm

heat energy decaying into an uncapturable (non-useful) state; $E_k = \frac{3}{2}kT = \frac{1}{2}mv^2$; $T = \frac{PV}{nR}$; $v = \sqrt{\frac{3PV}{mN}}$; $1 - \frac{5}{15}$, 0.67; $Q_1 - Q_2 = W$; $\frac{P_1}{T_1} = \frac{P_2}{T_2}$