IV. HEAT

1. The frequency at which black body radiation is a maximum depends

   a) only on the temperature

   b) on both volume and temperature

   c) on volume, temperature and pressure

   d) on the energy levels of the substances used to construct the black body

2. Does the heat capacity of a volume of an ideal gas enclosed in a rigid container depend on

   a) the molecular weight

   b) the chemical nature of the gas

   c) the number of atoms in the molecule

   d) the size of the molecules

3. In the equation, $PV = RT$ the dimensions of R are, (where Θ is the degrees of temperature and M, L, and T have the usual significances)

   a) $\frac{M^2L^2}{T^2\Theta}$

   b) $\frac{M\,L^2}{T^2\Theta}$

   c) $\frac{M\,L}{T^2\Theta}$

   d) $\frac{M\,L^2}{T\Theta}$

4. The change in entropy of a thermodynamic system is generally given by $\int \frac{dQ}{T}$, taken along

   a) an adiabatic path

   b) an isotherm

   c) a quasistatic path

   d) none of the above

5. the viscosity of gases

   a) increases with increasing temperature

   b) decreases with increasing temperature

   c) is almost independent of temperature

   d) varies as the fourth power of the pressure

6. An x-ray diffraction experiment was performed on a piece of unstretched rubber, and indicated an amorphous structure. When the piece of rubber was stretched, a crystalline structure was found. At the same temperature,

   a) the entropy of the unstretched rubber was <u>higher</u> than the entropy of the stretched rubber

   b) the entropy was the <u>same</u>

   c) the entropy of the unstretched rubber was <u>lower</u> than the entropy of the stretched rubber

   d) the x-ray diffraction experiment must be wrong

7. The fact that skating on ice is relatively frictionless is associated with which of the following properties of water?

   a) water has twice the specific heat of ice

   b) water has a high dielectric constant

   c) water expands on freezing

   d) ice is a crystalline solid

8. The average translational kinetic energy of a gas molecule at room temperature is closest to

   a) $\frac{1}{300}$ electron volt

   b) $\frac{1}{30}$ electron volt

   c) 3 electron volts

   d) 30 electron volts

9. A large concave mirror may be used to concentrate at point B light from a source located at point A. We now replace the source by a lump of ice. Putting our hand at point B

   a) nothing special happens

   b) we feel cold, because coldness is radiated from the ice

   c) we feel cold, because the mirror helps the ice absorb heat from our hand.

d) we feel heat, because the amount of heat radiated by the ice, small though it is, is concentrated by the mirror.

10. One gram of ice with a temperature of -10° is dropped into a large bucket of water with a temperature of +10° C. Compute to 10% accuracy the change of entropy of the whole system after equilibrium is established. The heat capacity of ice and water are 0.5 and 1.0 cal/gm respectively and the heat of fusion of water is 80 cal/gm.

a) +.35 cal/°

b) -.35 cal/°

c) .014 cal/°

d) 0

11. A gas at S.T.P. is initially confined by a piston to a volume V in a cylinder. The piston is withdrawn adiabatically until the volume is doubled. What is the change in temperature? The ratio of the specific heat at constant pressure to that at constant volume is 1.67.

a) -102° C

b) 15° C

c) -51° C

d) 0° C

12. A common means of bringing an object to very low temperature (less than 1°K) is:

a) placing the object in contact with liquid nitrogen

b) placing the object in a vacuum in the dark

c) adiabatic de-magetization of a paramagnetic salt around the object

d) none of these

13. In a gas of a mixture of helium (A = 4) and neon (A = 20) atoms at standard temperature and pressure, the ratio of the average kinetic energy of a helium atom to the average kinetic energy of a neon atom is about:

a) 1/25

b) 1/5

c) $\sqrt{5}$

d) 1

14. Stefans's law says that the rate of emission of radiant energy from a body depends on its temperature (T) as

a) $T^{4.5}$

b) T^4

c) T^3

d) T^2

15. The specific heat at <u>constant volume</u> of an ideal monatomic gas is $\frac{3R}{2}$. What is the specific heat at <u>constant pressure</u> of an ideal gas composed of rigid rotators which can rotate about two axes?

a) 3/2 R

b) 5/2 R

c) 7/2 R

d) 9/2 R

IV. <u>HEAT & SOUND</u>

16. At very low temperatures the lattice specific heat of solids is proportional to:

a) T^2

b) T^3

c) T

d) T^{-1}

17. A thermodynamic system is taken from equilibrium state A to equilibrium state B by various paths. Some of the paths are reversible and others are irreversible. Q is the heat absorbed by the system in going from state A to state B, E is the change of internal energy of the system in going from state A to State B, and S is the change of entropy of the system in going from state A to state B. Which of the following are independent of path?

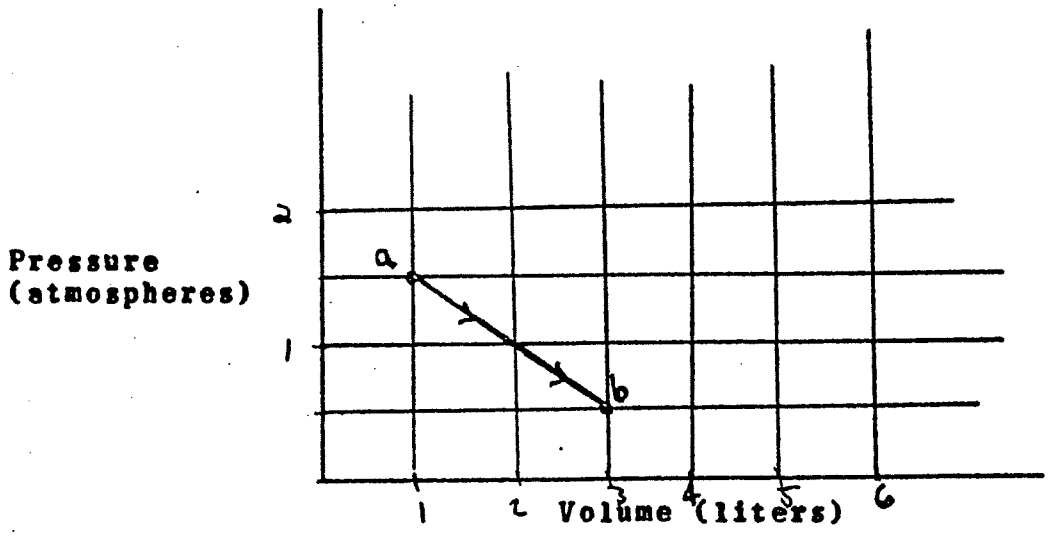
a) $\Delta Q, \Delta E$

b) $\Delta Q, \Delta S$

c) $\Delta E, \Delta S$

d) none of these.

18. One-tenth mole of an ideal, monatomic gas is taken through the process ab shown on the P-V diagram below. At point a, the temperature is 183 °K. What is the highest temperature of the gas during this process?



a) 244 °K

b) 183 °K

c) 1805 °K

d) none of these answers is correct.

19. If an insulated block of ice which is initially at -0.5 °C is subjected to a very high pressure, the block will:

a) start to melt and become slightly warmer.

b) start to melt and decrease in temperature.

c) start to melt and remain at the same temperature.

c) not melt but increase in temperature.

20. The van der Waal's equation of state is:

a) $pV = nRT$

b) $\left(p - \frac{a}{V}\right)(V + b) = nRT$

c) $pV = nR(T + aT^2 + bT^3)$

d) $\left(p + \frac{a}{V^2}\right)\ (V - b) = nRT$

21. A gas filled container is evacuated until there is only one atom of gas left in the container. The mass of the particle is m and it travels with a velocity v. The temperature of the particle

a) equals $1/2\ mv^2$

b) is proportional to $1/2\ mv^2$

c) is altered by collisions with the wall of the container.

d) cannot be defined.

22. A man standing beside a railroad track measures the pitch of an engine whistle. He finds the pitch changes from 220 cycles/sec as it approaches him to 200 cycles/sec as it recedes from him. What was the velocity of the engine? (Speed of sound = 1100 ft/sec)

a) 53 ft/sec.

b) 68 ft/sec.

c) 79 ft/sec.

d) 110 ft/sec.

23. The ratio of specific heats at constant pressure and constant volume of a gas is measured at room temperature to be C_p/C_v = v = 1.67. If it is a pure gas, its molecule consists of:

a) 1 atom.

b) 2 atoms.

c) 3 atoms.

d) no way of telling.

24. Two bodies are in thermodynamic equilibrium when they have equal

a) internal energies.

b) pressures.

c) temperatures.

d) entropies.

25. You wish to make an estimate of the heat capacity of 100 lbs. of iron. You have no tables readily available but recall that the atomic weight of iron is about 60, and that the universal gas constant is about 2 cals/mole- °K. Which of the following would one select on the basis of the above information:

a) 1500 cals/°C

b) 4500 cals/°C

c) 10 cals/°C

d) 6000 cals/°C

6. The average speed of gas molecules each of mass M at absolute temperature T and confined in a box of volume V is of the order:

a) cannot be estimated from the data given.

b) $(V)^{1/3} KT/\hbar$

c) $(\frac{KT}{M})^{1/2}$

d) KT

27. The quantum mechanical theory of a vibrating gas molecule, compared to classical statistical mechanics, predicts:

a) the same heat capacity.

b) greater heat capacity.

c) less heat capacity.

d) vanishing heat capacity.

28. Consider a slab of material having thickness t and cross sectional area A. If the temperature difference across the slab (ΔT) is held constant, the quantity of heat flowing through the slab (per unit time) is proportional to:

a) $a (\Delta T) / t^2$

b) $A (\Delta T)^2 / t$

c) $\frac{\Delta T}{At}$

d) $\frac{A (\Delta T)}{t}$

29. A thermally insulated volume of water does not spontaneously change into an amount of ice and an amount of steam because:

a) there is a very small probability that the H_2O molecules would arrange themselves in this way.

b) energy would not be conserved.

c) this would be an irreversible process.

d) it turns out that the laws of Newtonian mechanics, applied to all molecules, show that this is impossible.

30. During an adiabatic expansion the temperature of a perfect gas:

a) increases.

b) depends on the details of the expansion.

c) remains constant.

d) decreases.

31. The fundamental fixed point in the modern thermodynamic temperature scale is water's

a) boiling point

b) triple point

c) freezing point

d) submination point

32. What is responsible for the good heat conduction of metals?

a) the elasticity

b) the "electron gas"

c) the high density

d) the heat capacity

33. Planck's Law for Black Body Radiation always gives the same result as the Rayleigh-Jeans Law in the limit (T = temperature, γ = frequency)

a) $T \rightarrow 0$, $\gamma \rightarrow 0$

b) $T \rightarrow \infty$, $\gamma \rightarrow 0$

c) $T \rightarrow 0$, $\gamma \rightarrow \infty$

d) $T \rightarrow \infty$, $\gamma \rightarrow 0$

34. Assuming an environment at 0° K, the amount of energy radiated per unit time by a body at 200° C. is greater than that radiated by a body at 100° C. by a factor

a) 2

b) 2.6

c) 4

d) 16

35. The internal energy of a given mass of an ideal gas is a function of

a) its temperature only

b) its volume only

c) its pressure only

d) a combination of temperature and pressure

36. An organ pipe open at one end and closed at the other has a fundamental resonance at middle C at 273° K. What temperature change is required for the pitch to drop one whole octave? Assume air is a perfect gas.

a) $T = + 273°K$

b) $T = - 136° K$

c) $T = + 80° K$

d) $T = - 205° K$

37. A container holding a certain amount of an ideal gas is connected by a pipe with a valve to an empty container. The two tanks are thermally insulated from the surroundings. Opening the valve it is found that

a) both the temperature and the pressure of the gas remain unchanged

b) both the temperature and the pressure of the gas decrease

c) the temperature of the gas decreases, the pressure remaining unchanged

d) the pressure of the gas decreases, the temperature remaining unchanged

38. A block of ice of mass M, and latent heat of fusion L rests on a frictionless surface. A bullet of mass m and velocity v (parrallel to the frictionless surface) strikes the block of ice and becomes imbedded in it. Assuming negligible heat capacity for the bullet, how much of the ice will be melted?

a) $\frac{1}{2} \frac{(M + m)^2}{m} \frac{v^2}{L}$

b) $\frac{m^2}{M} \cdot \frac{v^2}{L}$

c) $\frac{1}{2} \frac{mM}{m+M} \frac{v^2}{L}$

d) $\frac{Mv^2}{L}$

39. A certain cyclical process is performed by traveling along a completely reversible thermodynamic path. The change of entropy per cycle is

a) < 0

b) $= 0$

c) > 0

d) depends on actual path used

40. The carnot cycle

a) can be used to define the absolute temperature scale

b) can be described in a P-V diagram in terms of nonadiabatic expansions and isothermal compression

c) is a four-wheeled laboratory vehicle driven by a Carnot engine

d) consists of four irreversible processes

1. 500 grams of water at 50° C. is mixed with 1000 grams of water at 20°C. The change in entropy is

a) zero since no heat is added or removed

b) zero since there is no mixing entropy when like substances are mixed

c) indeterminate since the process is not reversible

d) independent of the details of the mixing process, the entropy increasing by a fixed amount.

12. In the van der Waals equation of state $(p + a/v^2)(v - b) = RT$, p is the pressure, v is the molar volume, and T is the absolute temperature. R, a, and b are constants. Assume the force between molecules is the same as between hard impenetrable spheres of radius C. Then the constants a and b are given by

a) $a = \frac{16}{3} \pi C^3 N, \quad b = 0$

b) $a = 0, \ b = \frac{16}{3} \pi C^3 N$; Note: N = Avogadro's number

c) $a = 4\pi NC^6, \quad b = 8NC^3$

d) $a = 0, \ b = 0$

3. The third law of thermodynamics states that

a) the entropy of every substance is either zero or positive and finite at absolute zero.

b) all experiments necessarily have certain errors

c) fuel cells have a certain attainable efficiency

d) nuclear energy transformation are possible

44. A stationary underwater sound source operates at a frequency of 3×10^4 cycles/sec. A submarine when moving directly toward the source detects a frequency 100 cycles/sec higher than that picked up when the submarine is stationary. How fast is the submarine moving? The velocity of sound in water can be taken as 1.5×10^3 m/sec.

a) 10 m/sec

b) 5 m/sec

c) 1 m/sec

d) 0.5 m/sec

45. Classically each "degree of freedom" at absolute temperature T has an average kinetic energy of

a) kT

b) $\sqrt{3}$ kT

c) $\frac{3}{2}$ kT

d) $\frac{1}{2}$ kT