

Q1

The three phases of matter can exist together in equilibrium at the

critical point

triple point

A

melting point

evaporation point

neutral point

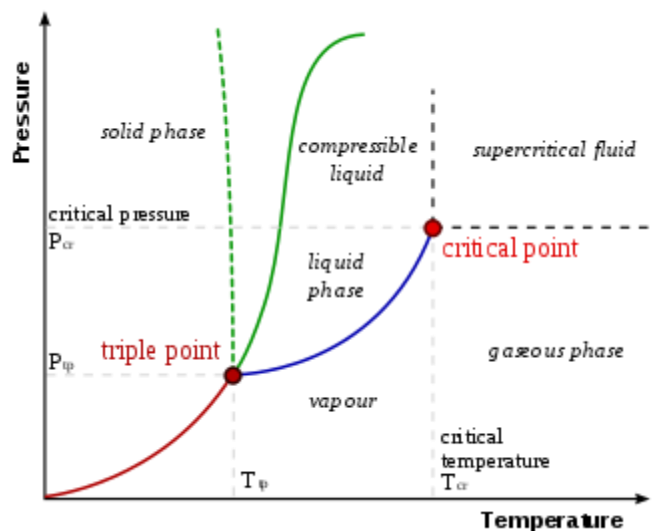
Explanation:

Neutral Point: The temperature at which the thermoelectric power of two metals is zero and which is midway between the temperature of the cold junction and the corresponding temperature of inversion.

Critical Point: The point at which a substance in one phase, as the liquid, has the same density, pressure, and temperature as in another phase, as the gaseous.

In a phase diagram, the critical point or critical state is the point at which two phases of a substance initially become indistinguishable from one another. The critical point is the end-point of a phase equilibrium curve, defined by a critical pressure P_c and critical temperature T_c . At this point, there is no phase boundary.

Triple Point: The temperature and pressure at which a substance can exist in equilibrium in the liquid, solid, and gaseous states. The triple point of pure water is at 0.01°C (273.16K , 32.01°F) and 4.58 mm (611.2Pa) of mercury and is used to calibrate thermometers.



Q2

When two different ideal gases, separated by a diathermic movable wall are in thermal equilibrium with each other, and the wall is not moving, we can say that:

They must have the same pressure P and the same number of moles n

The product of their pressure and volume i.e. PV must be the same.

Their molar volume must be the same

A

Their volume (V) and temperature (T) must be the same

Only their temperature (T) is the same.

Explanation:

As the wall is diathermic, heat can pass through it. At thermal equilibrium, their temperature must be the same.

As the wall is movable but not moving, the net force on the wall is zero and the pressure on it is the same on both sides.

Hence for these gasses, pressure (P) and temperature (T) are the same and thus the ratio $T/P = V/nR$ is the same. This implies, as R is a constant, $V_1/n_1 = V_2/n_2$ i.e. their molar volumes are the same.

Note that, the number of moles and the volume, individually, will not be the same, i.e. $V_1 \neq V_2$, $n_1 \neq n_2$ because the molar masses are not the same as the gases are different.

Q3

A number of constant volume gas thermometers, using different gases, all will indicate nearly the same temperature, when in contact with the same object if:

the volumes of gases is the same

the volumes of the gases is very small

the pressure of the gases is the same

the number of moles of the gases is the same

the particle number density of the gases is very small

A

Explanation: At very small particle number densities, all real gases behave like ideal gases and hence will give the same readings on the thermometer scale.

Q4

There is a temperature at which the reading on the Kelvin scale is numerically:

equal to that on the Celsius scale

lower than that on the Celsius scale

equal to the average of the Celsius reading and the Fahrenheit reading i.e. $(F+C)/2=K$

A

equal to the difference of the Celsius reading from the Fahrenheit reading i.e. $F-C = K$

less than -273.16

Explanation:

$$C = K - 273.15$$

$$F = (9/5)(K-273.15) + 32$$

$$(9/5)(K-273.15) + 32 = K \Rightarrow 5*(K-32) = 9*(K-273.15) \Rightarrow 4K = -160 + 2458.35 = 2298.35 \Rightarrow K = 574.5875$$

$$((K-273.15) + (9/5)(K-273.15) + 32)/2 = K \Rightarrow 2K - K - (9K/5) = 32 - 273.15 * (1+9/5) = -732.82$$

$$K(1-9/5) = -732.82 \Rightarrow -4K/5 = -732.82 \Rightarrow K = 407.1222$$

$$(9/5)(K-273.15) + 32 - (K-273.15) = (4/5)K + 32 + (1-9/5)*273.15 = (4/5)K - 186.52 = K$$

$$\Rightarrow K/5 = -186.52 \text{ impossible}$$

Negative Kelvin temperature is not defined.

Q5

According to the kinetic theory of gases, the pressure of a gas is due to:

the change of kinetic energy of the gas molecules as they strike the wall

the change of momentum of the molecules as they strike the wall A

the change of direction of the molecules as they strike each other

inelastic collision of the gas molecules

elastic collision between the gas molecules

Q6

A measure of the average kinetic energy of individual molecules is referred to as:

Internal energy

Thermal Energy

Heat

Entropy

Temperature A

Explanation: In general, the internal energy may have other forms of energy besides kinetic energy. Temperature is a measure of the average kinetic energy of the molecules, be it for gas or solid or liquid.

Q7

An ideal gas is compressed isothermally from 30 L to 20 L. During this process, 6.0 J of energy is expended by the external mechanism that compressed the gas. The container of the gas has diathermic (heat conducting) wall. What is the increase of internal energy for this gas?

Zero

A

6.0J

9.0 J

-6.0 J

-9.0 J

Explanation: As the compression is isothermal, and as the substance is an ideal gas, there is no change of internal energy.

Q8

A gas is quickly compressed in an isolated environment. Which one of the following is true:

$\Delta U = 0$ where U = internal energy

$\Delta T = 0$ where T = temperature

Work done $W = 0$

Heat transferred $Q = 0$

A

$\Delta P = 0$, where P = pressure

Explanation: Since the process is a very quick one, there is not enough time for heat transfer. Hence it is an adiabatic process.

Q9

Ten joules of heat energy are transferred to a sample of ideal gas at constant pressure. The volume of the gas doubles. As a result, the internal energy of the gas:

increases by 10 J

increases by less than 10 J

A

increases by more than 10 J

remains unchanged

cannot be said anything about the change of internal energy as the pressure is not given

Explanation: At constant pressure, some heat is converted into work to push the boundary of the container (may be a piston) so the increase of internal energy is less than 10 J, the heat supplied.

Q11

You put a thermometer in a pot of hot water and record the reading. Temperature of what have you recorded?

the temperature of the water

the temperature of the thermometer

A

an equally weighted average (i.e. simple average) of the temperatures of the water and thermometer

a weighted average of the temperatures of the water and thermometer, with more emphasis on the temperature of the water

a weighted average of the water and thermometer, with more emphasis on the temperature of the thermometer.

Explanation: Answer: (ii) A liquid-in-tube thermometer actually measures its own temperature. If the thermometer stays in the hot water long enough, it will come to thermal equilibrium with the water and its temperature will be the same as that of the water.

Q12

A gas is taken through the cycle illustrated here. During one cycle, how much work is done **on** the working substance in the engine?

8PV

-8PV

3PV

-3PV

A

4PV

Explanation: The gas expands from V to 4V at the higher pressure so that the gas **does work** on the environment equal to $2P(3V) = 6PV$

This is seen from the formula Work done ON the gas $W_{on-1} = - \int_{V_i}^{V_f} p dv = -(2P)(4V - V) = -6PV$, i.e. the work done on the gas is negative meaning the GAS DOES work on the environment.

The gas is compressed at a lower pressure so that work is done on the gas equal to :

$$W_{on-2} = - \int_{4V}^V p dv = -P(V - 4V) = +3PV$$

$$\text{Net work done on the gas} = W_{on-1} + W_{on-2} = -3PV$$

Q13

Consider the triatomic ozone molecule with rms speed v_0 . Suppose the temperature of gas is tripled and ozone dissociates into oxygen atoms. Then what will be the rms speed of atoms?

$$v_0 \sqrt{27}$$

$$3v_0$$

A

$$\sqrt{3}v_0$$

$$v_0/\sqrt{3}$$

$$v_0/3$$

Solution: Ozone has three identical atoms (O_3). Its rms speed is given by $v_0 = \sqrt{3kT/m}$.

After dissociation, its molecular mass become $m/3$.

$$\text{New rms speed} = \sqrt{3kT'/(m/3)} = \sqrt{9kT/(m/3)} = 3 \sqrt{3} \sqrt{kT/m} = 3 v_0$$

Q14

A sample of oxygen gas is at four times the Kelvin temperature of a sample of hydrogen gas. The ratio of the rms speed of the oxygen molecule to that of the hydrogen molecule is:

$$1/4$$

$$1/2$$

A

$$1/\sqrt{2}$$

$$1$$

$$\sqrt{2}$$

Ans: $1/2$

$$\text{Explanation: } v_{\text{rms}}^{\text{(O)}} : v_{\text{rms}}^{\text{(H)}} = \sqrt{3RT'/32} : \sqrt{3RT/2} = \sqrt{2 \cdot 4/32} = \sqrt{4/16} = \frac{1}{2}$$

(O_2 molar mass 32 g, H_2 molar mass 2 g)

Q15

When the first law of thermodynamics, $\Delta E_{int} = \Delta U = \Delta Q_{in} + W_{on}$, is applied to 1 gram of an ideal gas, we have in general:

$$\Delta T \propto (\Delta P)V$$

$$\Delta T = 0$$

$$\Delta U = 0$$

$$\Delta n = 0 \quad \text{A}$$

$$W = 0$$

Explanation: Since the mass is constant, so also the number of moles.

Q16

An gas in a container is allowed to expand to thrice its original volume as heat is added to it. Its pressure becomes one third to its original value. Its initial temperature is T_i . Which one is true for it:

$$\Delta T = 2T_i$$

$$\Delta T = T_i$$

$$W_{on} = -Q_{in} \quad \text{A}$$

$$\Delta v = \Delta \left(\frac{V}{n} \right) = 0$$

$$W_{on} = 0$$

Explanation: The temperature does not change as PV does not change. Hence $\Delta U = 0$ i.e. $Q_{in} + W_{on} = 0$

Q17

The temperature of low pressure hydrogen is reduced from 100 degree Celsius to 20 degree Celsius. The RMS speed of its molecules decreases by approximately:

80%

89%

46%

29%

11% A

$$\text{Answer: } \Delta v_{rms} = v_{rms}(373K) - v_{rms}(293) = \sqrt{\frac{3k}{m}} (\sqrt{373} - \sqrt{293})$$

Percentage decrease: $(\sqrt{373}-\sqrt{293})/\sqrt{373} = 0.1137$

Q18

Maxwell-Boltzmann law is for the _____

Distinguishable particles

A

Indistinguishable particles

Particles with half integral spin

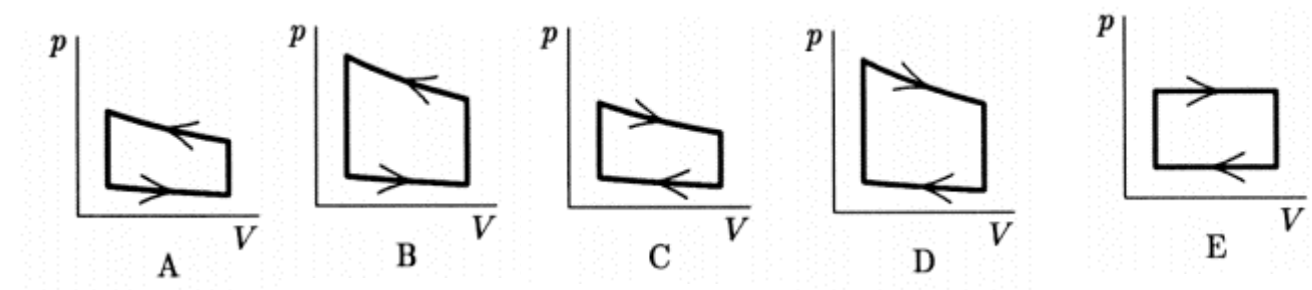
Particles with integral spin

Mass-less particles

Explanation: MB distribution is for classical particles, which are all distinguishable. That is we can put a tag on each molecule.

Q19

The pressure versus volume graphs for a certain gas undergoing five different cyclic processes are shown below. During which cycle does the gas do the least negative work?



Ans: A

For A and B, the compression occurs at higher pressures. So, the net work is negative.

The essential difference between B and D is in the sign of the work done. In D, the upper part has greater positive work done in the upper section of the cycle $W_{upper_ON} = -\int P dV$, $V=V_1$, $V=V_2$, Since $V_2=V_{final}>0$ we get $W_{ON}<0$, and $W_{BY}>0$.

The area enclosed by the cycle gives the amount of work done. The least negative area is for A.