Chapter 4:The Kinetic Theory of Gases

Avogadro's Number

Q1. A sample of an ideal gas exerts a pressure of 60 Pa when its temperature is 400 K and the number of molecules present per unit volume is n. A second sample of the same gas exerts a pressure of 30 Pa when its temperature is 300 K. How many molecules are present per unit volume of the second sample? Ans:2n/3

Ideal Gases

Q2. Which one of the graphs in Figure (1) best represents the variation of pressure with the volume of an ideal gas at constant temperature (isothermal process)? Ans:C.

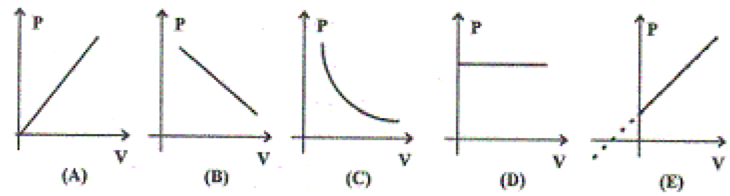
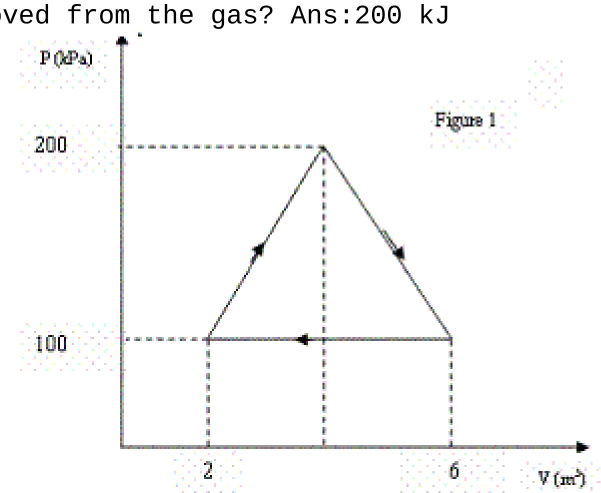


Figure # 1

Q3. One mole of an ideal monatomic gas at temperature of 290 K expands isothermally and reversibly from a pressure of 10 atmospheres to a final pressure of 2 atmospheres. What is the work done by the gas on the surroundings?Ans:3880 J.

Q4. Calculate the number of molecules of an ideal gas occupying a volume of 1 cm^3 at 27 degree Celsius and at a pressure of 1×10^{-10} Pa.Ans:2.4×10^4 molecules

Q5. An ideal gas is taken through the cyclic process shown in Figure 1. How much heat is added or removed from the gas? Ans:200 kJ



Q6. How much work is required to compress five moles of an ideal gas at 20 degrees-C and 1.0 atmosphere to half of its initial volume during an isothermal process?Ans:-8.4 kJ

Pressure, Temperature, and RMS Speed

Q7. Oxygen gas at 20 degrees Celsius is confined in a cube. What is the translational average kinetic energy per molecule?Ans:6.1×10^{-21} J

Q8. The mass of an oxygen molecule is 16 times that of a hydrogen molecule. At room temperature, the ratio of the rms speed of an oxygen molecule to that of a hydrogen molecule is:Ans:1/4

Q9. The mass of a hydrogen molecule is 3.3×10^{-27} kg. If 1.0×10^{23} hydrogen molecules per second strike 2.0 cm^2 of wall at an angle of 55 degrees with the normal when moving with a speed of 1.0×10^3 m/s, what pressure do they exert on the wall? Ans:1.9×10^3 Pa.

Q10. Find the rms speed of nitrogen molecules (M=28 g/mole) at 0 degree-C.Ans:4.9×10^2 m/s.

Q11. The average translation kinetic energy of an ideal gas of helium atoms at room temperature (300 Kelvin) is 5.54×10^{-21} J. The average translation kinetic energy of the ideal argon gas at room temperature is: [Atomic mass of helium = 2.0 Kg/Kmole, Atomic mass of argon = 8.0 Kg/Kmole]Ans:5.54×10^{-21} J.

Translational Kinetic Energy

Q12. Two moles of nitrogen are in a 6.0 Liter container at a pressure of 5.0×10^{5} Pa. Find the average transnational kinetic energy of a single molecule.Ans:3.7×10^{-21} J.

Q13. Two identical containers, one has 2.0 moles of type 1 molecules, of mass m_1, at 20 degrees Celsius. The other has 2.0 moles of type 2 molecules, of mass m_2 = $2m_1$, at 20 degrees Celsius. The ratio between the average translational kinetic energy of type 2 to that of type 1 is: Ans:1.

Q14. Two moles of nitrogen are in a 3-liter container at a pressure of 5.0×10^{6} Pa. Find the average translational kinetic energy of a molecule.Ans:1.9×10^{-20} J.

Q15. The average translational kinetic energy of the molecules of an ideal gas in a closed, rigid container is increased by a factor of 4. What happens to the pressure of the gas?Ans:it increases by a factor of 4.

The Molar Specific Heats of an Ideal Gas

Q16. 5.00 kg of water is to be cooled from 100 to 0 degrees-C. The quantity of ice needed is: [For water: the specific heat = 4.19 kJ/(kg.K) and the latent heat of fusion = 333 kJ/kg.] Ans:6.29 kg.

Q17. 300 grams of water at 25 degree-C are added to 100 grams of ice at zero degree-C. The final temperature of the mixture is:Ans:zero degree-C.

Q18. In a constant volume process, 209 J of heat is added to 1 mole of an ideal monatomic gas initially at 300 K. Find the final temperature of the gas.Ans:317 K.

Q19. Two moles of helium (monoatomic) gas are heated from 100 degrees Celsius to 250 degrees Celsius. How much heat is transferred to the gas if the process is isobaric?
Ans:6.23 kJ

Q20. One mole of an ideal diatomic gas (Cp = 7R/2) is cooled at constant pressure from 420 K to 300 K. Calculate the change in internal energy of the gas in calories.Ans:-596 cal

Q21. Consider 100 g of helium (He) gas at 77 K. How much heat energy must be supplied to the gas to increase its temperature to 24 degrees-C, if the process is isovolumetric? (M(He) = 4 g/mole and He is a monatomic gas.)Ans:69 kJ

Q22. Two moles of helium (monatomic) gas are heated from 100 degree Celsius to 250 degree Celsius. How much heat is transferred to the gas if the process is isobaric? Ans:6.23×10^{3} J

The Adiabatic Expansion of an Ideal Gas

Q23. Helium gas at 27 degrees C is compressed adiabatically to 1/2 of its initial volume. Find its temperature after compression. [gamma (helium) = 1.67]Ans:204 degree C.

Q24. An ideal gas (gamma = 1.40) expands slowly and adiabatically. If the final temperature is one third the initial temperature, by what factor does the volume change?Ans:15.6

Q25. A cylinder contains 4 moles of a diatomic ideal gas (Cv = 5R/2) at a temperature of 27 degrees-C and a pressure of 1.5 atm. temperature reaches 127 degrees-C. How much work is done by the gas in this process?Ans:794 calories

Q26. The air in an automobile engine at 20 degree-C is compressed from an initial pressure of 1 atm and a volume of 200 cm^3 to a final volume of 20 cm^3. Find the final temperature if the air behaves like an ideal gas (gamma = 1.4) and the compression is adiabatic.Ans:463 degree-C

Q27. An ideal gas (gamma = 1.3) is initially at V = V1, T = 273 K and P = 1.0 atm. The gas is compressed adiabatically to half its original volume. It is then cooled at a constant pressure to its original temperature. The ratio of the final volume to the initial volume is:Ans:0.4