# Lesson 1

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| **1.** | (a) | Describe the main postulates of the kinetic model of matter |
|  | (b) | What is an ideal gas? |
|  | (c) | Under which conditions is a gas most likely to display ideal behaviour? Which gases will show ideal behaviour over the widest range of conditions? |
| **2.** | (a) | State the ideal gas equation and use it to explain the meaning of the term “equation of state” |
|  | (b) | State three laws which can be combined to give the ideal gas equation |
|  | (c) | Calculate the volume occupied by one mole of a gas at 25 oC and 100 kPa |
|  | (d) | Calculate the temperature of a gas if 0.5 moles occupy 1.2 dm3 at a pressure of 200 kPa |
|  | (e) | Calculate the mass of a sample of carbon dioxide which occupies 20 dm3 at 27 oC and 100 kPa |
|  | (f) | Calculate the relative molecular mass of a gas if a 500 cm3 sample at 20 oC and 1 atm has a mass of 0.66 g |
|  | (g) | Calculate the density of nitrogen gas at 298 K and 100 kPa |
|  | (h) | A volatile organic compound weighing 0.2 g, on heating in Victor Meyer's tube, displaced 30 cm3 of air at 27oC; the pressure was found to be 98 kPa once the contribution of water vapour was removed; determine the molecular mass of the compound. |
|  | (i) | A sample of an unknown compound is vaporised at a pressure of 103 kPa in a flask which, when empty and evacuated, has a mass of 25.3478 g; when vaporisation is complete and excess gas has escaped, the temperature is found to be 98 oC. The flask is sealed and found to have a mass of 25.6803 g. The flask and contents are then cooled to 25 oC, emptied, cleaned, filled with water and found to have a mass of 128.12 g when filled with water (the density of water is 0.997 gcm-3 at 25 oC). Determine the relative molecular mass of the compound. |
|  | (j) | Calculate the total number of molecules remaining per cm3 if a vessel is evacuated until its pressure is 7.7 Pa  |

# Lessons 2 and 3

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| **3.** | (a) | By considering N molecules each of relative molecular mass mr moving with velocity v inside a cube of length l and volume V, derive the expression PV = $\frac{m\_{r}nv^{2}}{3}$  |
|  | (b) | Given that $\frac{mv^{2}}{2}$$∝$T is one of the postulates of the kinetic model, use the expression PV = $\frac{m\_{r}nu^{2}}{3}$ to derive the ideal gas equation |
|  | (c) | Use the ideal gas equation to derive Dalton’s law of partial pressures |
| **4.** | (a) | Use the ideal gas equation, the postulate $\frac{mv^{2}}{2}$$∝$T and the expression PV = $\frac{m\_{r}nu^{2}}{3}$ to show that for one mole of a gas, KE = $\frac{3RT}{2}$ |
|  | (b) | Hence derive expressions for the heat capacity of a gas at constant volume (Cv) and at constant pressure (Cp) |
|  | (c) | Deduce the root mean square velocity of a nitrogen molecule at 25 oC |
|  | (d) | Calculate the average kinetic energy in kJmol-1 of a sample of gas at 25 oC  |
| **5.** | (a) | Assuming that dry air contains 79% N2 and 21% O2 by volume, calculate the density of moist air at 298 K at an atmospheric pressure of 101 kPa given that the partial pressure of the water vapour in the air is 3.2 kPa |
|  | (b) | Calculate the total pressure in a 5 dm3 vessel containing 2 g of ethane and 3 g of carbon dioxide at 50 oC |

# Lessons 4 and 5

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| **6.** | (a) | Sketch the Maxwell-Boltzmann of molecular velocities in a sample of nitrogen gas at 25 oC |
|  | (b) | On the same axes, sketch the Maxwell-Boltzmann of molecular velocities in a sample of hydrogen gas at 25 oC |
|  | (c) | On the same axes, sketch the Maxwell-Boltzmann of molecular velocities in a sample of nitrogen gas at 0 oC |
| **7.** | (a) | Estimate the fraction of molecules at 300 K with a kinetic energy in excess of 50 kJmol-1 |
|  | (b) | Estimate the fraction of molecules at 310 K with a kinetic energy in excess of 50 kJmol-1 |
|  | (c) | Hence deduce the relative rates of reaction at 300 K and 310 K for a reaction with an activation energy of 50 kJmol-1 |
| **8.** | Calculate the root mean square velocity, average velocity and most probable velocity of the molecules in a sample of argon gas at 298 K. |
| **9.** | (a) | Show that the collision frequency Z between identical molecules in a container is given by $2d^{2}N^{2}\sqrt{\frac{πRT}{m\_{r}}}$ and state the meaning of the terms d and N. |
|  | (b) | An apparatus of volume 500 cm3 is evacuated at 298 K until the total pressure is just 7.0 Pa. Assuming that the remaining gas is oxygen, which has a diameter of 3.0 x 10-10 m, calculate: |
|  |  | (i) | The frequency with which the oxygen molecules collide in the apparatus |
|  |  | (ii) | The mean free path of the oxygen molecules in the apparatus |
| **10.** | (a) | Use your answer to 9 (a) to derive an expression for the collision frequency between two reacting particles A and B. |
|  | (b) | An apparatus of volume 500 cm3 is evacuated at 298 K until the total pressure is just 7.0 Pa. Assuming that the remaining gas is 80% nitrogen (d = 3.1 x 10-10 m) and 20% oxygen (d = 3.0 x 10-10 m, which has a diameter of 2.4 x 10-10 m, calculate the frequency of the collisions between nitrogen and oxygen atoms in the apparatus. |

# Lesson 6

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| **9.** | Explain what is meant by the “transport properties” of gases and give three examples. |
| **10.** | (a) | State Graham’s Law of diffusion |
|  | (b) | How many times faster will hydrogen effuse compared to neon? |
|  | (c) | A gas is found to effuse 6.0 times slower than hydrogen. Deduce the rmm of the gas and suggest its identity. |
| **11.** | Ammonia and hydrogen chloride react according to the following equation:NH3(g) + HCl(g) 🡪 NH4Cl(s)If both gases are allowed to diffuse towards each other from opposite ends of a cylinder, white fumes will be seen at the point at which the different gases come into contact. |
|  | (a) | What is the ratio of the rate of diffusion of ammonia to that of hydrogen chloride? |
|  | (b) | If the cylinder is 10 cm long, how far from the ammonia source should the white fumes be visible? |
| **12.** | (a) | Two identical porous containers are filled with neon and argon respectively. After 6 hours, two thirds of the neon has escaped from the first container. How long will it take for half of the argon to escape from the other container? |
|  |  | 2.278 x 10-4 mol of an unidentified gas effuses through a tiny hole in 95.70 s. Under identical conditions, 1.738 x 10-4 mol of argon gas takes 81.60 s to effuse. What is the molar mass of the unidentified gas? |
| **13.** | (a) | Given that the molecular diameter of propane is 4.3 x 10-10 m, calculate the coefficient of diffusion, the viscosity and the thermal conductivity of propane at 298 K and 100 kPa. |
|  | (b) | The viscosity of carbon dioxide is 1.38 x 10-5 kgm-1s-1 at 298 K. Estimate the molecular diameter of a carbon dioxide molecule. |
|  | (c) | The mean free path of an ammonia molecule is 4.4 x 10-8 m at 298 K and 100 kPa; estimate the molecular diameter of ammonia and the diffusion coefficient of ammonia under these conditions. |