

Solutions

2.1 The molecules are in constant random motion.

2.2 The temperature is related to the **average kinetic energy** of the molecules – a higher temperature means faster molecules on average.

2.3 The pressure increases: the warmer air's molecules move faster on average, so they collide with the tyre walls more often and harder, raising the force per unit area.

3.1 (a) The fixed volume keeps the wall area unchanged (implicit). Warming increases the molecules' average kinetic energy, so they move faster; faster molecules collide with the walls more frequently and each collision transfers a larger force, so the pressure increases. (b) At constant temperature the average molecular speed is unchanged, but the larger volume gives a larger wall area and the molecules travel farther between collisions; collisions per unit area per second fall, so the pressure decreases.

3.2 (a) Compressing does **work** on the gas – the piston forces the molecules closer and speeds them up as it moves in; the gas's internal energy increases, seen as greater average kinetic energy; the average kinetic energy sets the temperature, so the temperature rises. (b) In slow compression, energy has time to transfer out to the surroundings through the pump's walls; the internal energy – and temperature – stays near room temperature while the work done is carried away.

3.3 (a) Pressure increases **linearly** (equal steps of 7 kPa per 20 °C) with temperature at constant volume. (b) Continuing the pattern: 3.5 kPa per 10 °C below 20 °C gives $101 - 7 = \mathbf{94}$ kPa. (c) Higher temperature means greater average kinetic energy of the molecules; they hit the walls more often and harder; at constant volume the wall area is fixed, so force per unit area – pressure – rises in step with temperature. (d) The same temperature means the same average kinetic energy, so the lighter molecules move **faster** on average ($E_k = \frac{1}{2}mv^2$); faster molecules could hit the walls more often, but each carries less momentum – at GCSE the credited answer is that with equal average kinetic energy the pressures are comparable, and any difference must be justified through collision rate and momentum change.