

Solutions

2.1

$$p = \frac{400 \text{ kPa} \cdot \text{cm}^3}{25 \text{ cm}^3} = \mathbf{16 \text{ kPa}}$$

(rearrangement 1, answer with unit 1.)

2.2 The mass of gas is fixed (no gas enters or leaves) and the temperature is constant.

2.3 Pushing the plunger does work on the trapped air; the air's internal energy increases – its molecules gain kinetic energy; the temperature of the air rises, and the warm pump then heats your hand.

3.1 (a) Rearrange first.

$$p_2 = \frac{p_1 V_1}{V_2} = \frac{101 \times 250}{100} = \mathbf{253 \text{ kPa}} \text{ (3 s.f.)}$$

(rearrangement C1, substitution C1, answer A1.) (b) The same number of molecules now occupies a smaller volume; they collide with the walls more frequently because the wall area is smaller and the path between collisions shorter; the force per unit area – the pressure – increases.

3.2 (a) The molecules spread through a larger volume at the same average speed (constant temperature); the wall area is larger and each molecule travels farther between collisions; so collisions per second per unit area fall and the pressure decreases. (b) Outward (the plunger is pushed back in): the outside pressure exceeds the now-smaller inside pressure, giving a net outward... careful: pulling the plunger out **lowers** the inside pressure below 101 kPa, so the net force on the plunger acts **inward**, pushing it back towards its original position.

3.3 (a)

$$V_2 = \frac{p_1 V_1}{p_2} = \frac{405 \times 0.60}{101} = \mathbf{2.4 \text{ cm}^3}$$

(rearrangement C1, substitution C1, answer A1.) (b) Zero – $p_1 V_1 = p_2 V_2 = 243 \text{ kPa} \cdot \text{cm}^3$ for constant temperature; pV did not change. (c) The expanding gas **did work on the surrounding water** as it pushed it back; the energy transferred by that work was replaced by heat flowing in from the warmer surroundings, keeping the temperature – and pV – constant. (d) Pumping does work on the air (the pump forces molecules into the fixed volume against their pressure); the air's internal energy increases; the average kinetic energy of the molecules rises, so the temperature increases even though the volume is constant.