

Physics at Work Book 1 - Checkpoint and Practice Answers

New Senior Secondary Physics at Work, Second Edition: Heat and Gases.

Independently worked answers to all Checkpoint and Practice sections. This is not the publisher's official marking scheme. References use printed textbook page numbers, which sometimes differ from PDF page numbers. Approximate graph readings and sensible rounding are used.

Coverage

All 26 Checkpoints and all 11 Practice sections in Chapters 1-5. Answers retain the original question numbers and include numerical working, short explanations, and instructions for requested sketches.

Chapter 1: Checkpoints 1-2; Practices 1.1-1.2.

Chapter 2: Checkpoints 1-5; Practices 2.1-2.2.

Chapter 3: Checkpoints 1-6; Practices 3.1-3.2.

Chapter 4: Checkpoints 1-5; Practices 4.1-4.3.

Chapter 5: Checkpoints 1-8; Practices 5.1-5.2.

Chapter 1 - Temperature and Thermometers

Checkpoint 1 (p.6)

1. A: steam point and ice point.
2. C: other temperature scales exist, including Kelvin and Fahrenheit.

Practice 1.1 (p.6)

1. C: body temperature is neither fixed nor readily reproducible.
2. (a) Lower: 0 °C; upper: 100 °C. (b) Use pure melting ice and steam immediately above pure boiling water, both at normal atmospheric pressure.
3. II, IV, V, I, III: freezer < melting ice < normal human body < boiling water < 200 °C.
4. (a) Temperature measures the degree of hotness of an object. (b) The two points are reproducible and have definite temperatures under specified conditions. (c) Divide the interval from ice point to steam point into 1000 equal divisions, or each 1 °C division into ten equal parts. (d) Incomplete: steam can have various temperatures. Steam point is the temperature of steam over pure boiling water at normal atmospheric pressure.

Checkpoint 2 (p.13)

1. (a) 15 cm. (b) 80 °C. The plotted relation is approximately $L = 3 + 0.20T$, with L in cm and T in °C.

Practice 1.2 (p.14; placed earlier in the scan)

1. B: direct heating with a Bunsen flame is not a calibration step.
2. C: infra-red thermometer.
3. B: X and Z change with temperature; Y does not.
4. (a) Electrical resistance of the thermistor. (b) Its resistance decreases as temperature increases. Measure its resistance and convert it to temperature using its calibration.
5. $T = (80 - 35)/(120 - 35) \times 100 = 52.9$ °C.
6. (a-b) Any three suitable examples: liquid-in-glass - liquid volume; infra-red - intensity of emitted infra-red radiation; thermistor - electrical resistance; liquid crystal - colour.
7. (a) $T = (15.6 - 4.2)/(18.4 - 4.2) \times 100 = 80.3$ °C. (b) $L = 4.2 + 0.30(18.4 - 4.2) = 8.46$ cm.
8. (a) Straight line through (T,L) = (0,5) and (100,25): $L = 5 + 0.20T$. Label temperature / °C horizontally and column length / cm vertically. (b) 15 cm. (c) $(21 - 5)/0.20 = 80$ °C.

Chapter 2 - Heat and Internal Energy

Checkpoint 1 (p.24)

1. True: the average molecular kinetic energy increases.
2. A: $-300\text{ }^{\circ}\text{C}$ is below absolute zero.
3. C: temperature measures average molecular kinetic energy, not total kinetic energy.

Checkpoint 2 (p.28)

1. D: electrical energy supplied to the bulb.
2. A: heat.
3. B: $P = 540000 / (5 \times 60) = 1800\text{ W}$.
4. $E = 2000 \times 30 \times 60 = 3.6 \times 10^6\text{ J} = 1.0\text{ kWh}$.
5. $t = 1.2 / 2.5 = 0.48\text{ h} = 28.8\text{ min} = 1728\text{ s}$.

Practice 2.1 (p.28)

1. D: all three increase for a fixed body without a phase change.
2. C: heating and vigorous rubbing supply energy. A body with greater total internal energy need not be hotter.
3. B: the soup loses internal energy.
4. A: only (3) must be correct; mass also affects total internal energy and total kinetic energy.
5. (a) $5 \times 0.5 = 2.5\text{ kWh}$. (b) $9.0 \times 10^6\text{ J}$.
6. At constant power, $t = (1100/600) \times 10 = 18.3\text{ min} = 1100\text{ s}$.
7. (a) Incorrect: internal energy also depends on mass, material and state. A small hot object can have less internal energy than a large cooler one. (b) Incorrect: net heat flows spontaneously from higher temperature to lower temperature.

Checkpoint 3 (p.32)

1. B: $C = 240000 / 80 = 3000\text{ J }^{\circ}\text{C}^{-1}$.
2. A: $T = 30 + 500000 / 10000 = 80\text{ }^{\circ}\text{C}$.

Checkpoint 4 (p.38)

1. D: the block, thermometer and polystyrene tile all receive some energy.
2. $C = mc = 5 \times 480 = 2400\text{ J }^{\circ}\text{C}^{-1}$.
3. $Q = 0.5 \times 4200 \times (80 - 30) = 105000\text{ J} = 105\text{ kJ}$.

Checkpoint 5 (p.44)

1. (a) Correct. (b) Incorrect: equal temperatures do not imply equal internal energies. (c) Correct, with negligible energy exchange with the surroundings.
2. $0.5c(T - 5) = 0.25c(20 - T)$, giving $T = 10\text{ }^{\circ}\text{C}$.

Practice 2.2 (pp.45-46)

1. D: c values for P,Q,R,S are 129, 234, 384.7 and 523 J kg⁻¹ °C⁻¹ respectively.
2. C: R receives the most energy in the same time.
3. D, on the textbook assumption of comparable energy-loss rates: P cools more slowly and has larger heat capacity; equal masses imply larger specific heat capacity. P is hotter at time T and has greater average molecular KE. The cooling curves alone would not establish (1)-(2) if heat-loss conditions differed.
4. C: inland city R has the least maritime moderation.
5. C: (1) and (3). A water-rich filling has high heat capacity, and water is an effective coolant.
6. A: (1) and (2) are both at 20 °C.
7. B: approximately 24 °C; water's heat capacity is much larger than copper's.
8. $Q = 1.75 \times 3770 \times (60 - 20) = 263900 \text{ J} \approx 264 \text{ kJ}$.
9. Copper: $\Delta T = Q/(mc)$, and copper has the smaller specific heat capacity.
10. $T = 20 + (200 \times 300)/(0.5 \times 3500) = 54.3 \text{ °C}$.
11. $t = 2 \times 1970 \times (90 - 25)/1500 = 171 \text{ s} \approx 2.85 \text{ min}$.
12. Toast generally cools faster: its heat capacity is smaller than that of the water-rich soup, so a comparable energy loss produces a larger temperature decrease.
13. $0.5c(70 - 5) = 1 \times 4200 \times (90 - 70)$; $c = 2585 \text{ J kg}^{-1} \text{ °C}^{-1} \approx 2.58 \times 10^3 \text{ J kg}^{-1} \text{ °C}^{-1}$.
14. $0.20 \times 4200(90 - T) = 0.080 \times 2000(T - 20)$; $T = 78.8 \text{ °C}$.
15. $C = 50000/200 = 250 \text{ J °C}^{-1}$.
16. $c = (56000 - 34000)/[0.20(47 - 23)] = 4583 \text{ J kg}^{-1} \text{ °C}^{-1} \approx 4.58 \times 10^3 \text{ J kg}^{-1} \text{ °C}^{-1}$.
17. (a) $t = 130 \times 1000 \times 8/1500 = 693 \text{ s} \approx 11.6 \text{ min}$. (b) $T = 28 + 750 \times 300/(130 \times 1000) = 29.7 \text{ °C}$.
18. (a) From the hot metal to the cooler water. (b) $C(100 - 31.7) = 5 \times 4200(31.7 - 27)$; $C = 1445 \text{ J °C}^{-1} \approx 1.45 \times 10^3 \text{ J °C}^{-1}$.
19. $T = (2 \times 80 + 5 \times 30)/7 = 44.3 \text{ °C}$.
20. Water's high specific heat capacity allows it to absorb much energy with only a small temperature rise.
21. Water absorbs much of the supplied energy because of its high heat capacity, keeping the rubber relatively cool. The air-filled balloon's rubber heats up and weakens much more rapidly.

Chapter 3 - Change of State

Use $l_f(\text{ice}) = 3.34 \times 10^5 \text{ J kg}^{-1}$ and $l_v(\text{water}) = 2.26 \times 10^6 \text{ J kg}^{-1}$ except where the question asks you to calculate an experimental value.

Checkpoint 1 (p.64)

1. D: latent heat is released during the constant-temperature stage QR. The graph does not tell us whether this is freezing or condensation.
2. D: two states coexist during QR.

Checkpoint 2 (p.67)

1. Z: its constant-temperature melting section is highest.
2. Z: its melting plateau lasts longest, so for equal masses and equal heater powers its specific latent heat is greatest.
3. $Q = 0.7 \times 4200 \times 10 + 0.7 \times 334000 = 263200 \text{ J} \approx 263 \text{ kJ}$.
4. $l_f = 107000/0.3 = 3.57 \times 10^5 \text{ J kg}^{-1}$, using the supplied experimental data.

Checkpoint 3 (p.74)

1. Wrong: $mc\Delta T$ heats water to its boiling point; it does not vaporize it. Specific latent heat of vaporization requires the energy supplied during vaporization divided by the mass vaporized.
2. $Q = 1 \times 334000 + 1 \times 4200 \times 100 + 1 \times 2260000 = 3.014 \times 10^6 \text{ J}$.
3. $t = 2 \times 2260000/1500 = 3013 \text{ s} \approx 50.2 \text{ min}$.

Checkpoint 4 (p.77)

1. Melting: (a) KE unchanged, (b) PE increases, (c) internal energy increases, (d) temperature unchanged. Heating liquid water: (a) KE increases, (b) PE approximately unchanged in the textbook model, (c) internal energy increases, (d) temperature increases. Boiling: (a) KE unchanged, (b) PE increases, (c) internal energy increases, (d) temperature unchanged.

Practice 3.1 (pp.77-79)

1. C: average molecular kinetic energy remains constant during the phase change at fixed temperature.
2. A: molecular KE follows temperature and is constant during melting. Internal energy and molecular PE increase during the plateau.
3. A: energy left for boiling = $1000 \times 600 - 0.5 \times 4200 \times 80 = 432000 \text{ J}$; mass = $432000/2260000 = 0.191 \text{ kg}$.
4. A: only (1). Q's shorter melting plateau means less latent heat absorbed. The masses are unspecified, so specific latent heats cannot be compared. The graph shows P starts melting earlier.
5. B: cotton wool reduces heat loss. A lid can retain condensate and invalidate the mass-loss measurement; a lower heater power increases the fractional heat loss.
6. (a) 65°C , the freezing/melting point. (b) Incorrect: the substance releases latent heat while freezing. Molecular PE and internal energy decrease although temperature and average molecular KE remain constant.
7. (a) $Q = 10^8 \times 334000 = 3.34 \times 10^{13} \text{ J}$. (b) Include melting: $Q = 10^8(334000 + 4200 \times 4) = 3.508 \times 10^{13} \text{ J}$.

8. $t = 0.2[4200(100 - 10) + 2260000]/1200 = 440 \text{ s} \approx 7.33 \text{ min}$.
9. Let m be steam mass. $m \times 2260000 = (1 - m) \times 4200 \times 100$. Steam = 0.157 kg; initial water = 0.843 kg.
10. (a) $0.3 \times 5300(25 - T) = 0.1 \times 334000 + 0.1 \times 4200T$; $T = 3.16 \text{ }^\circ\text{C}$. All ice melts because the Coke can release 39750 J on cooling to $0 \text{ }^\circ\text{C}$, exceeding the 33400 J needed to melt the ice. (b) No heat exchange with the surroundings and negligible cup heat capacity; use water's specific heat capacity for melted ice. (c) Usually higher: the room and initially warm container supply additional energy to the cold mixture.
11. (a) Final temperature = $68 - 38 = 30 \text{ }^\circ\text{C}$. $0.3c \times 38 = 0.1 \times 334000 + 0.1 \times 4200 \times 30$; $c = 4.04 \times 10^3 \text{ J kg}^{-1} \text{ }^\circ\text{C}^{-1}$. (b) $m = 0.3c(68 - 15)/(334000 + 4200 \times 15) = 0.162 \text{ kg}$.
12. (a) $P = 0.3 \times 2260000/(5 \times 60) = 2260 \text{ W} = 2.26 \text{ kW}$. This is the useful heating power; actual input may be higher. (b) Average molecular KE remains constant; molecular PE increases.
13. Water bath: $T = (0.3 \times 50 + 1 \times 0)/1.3 = 11.5 \text{ }^\circ\text{C}$. Ice: cooling the water to $0 \text{ }^\circ\text{C}$ releases $0.3 \times 4200 \times 50 = 63000 \text{ J}$, which melts only $63000/334000 = 0.189 \text{ kg}$ of ice. Some ice remains and the final temperature is $0 \text{ }^\circ\text{C}$. The ice cools it further.
14. $m(2060 \times 4 + 334000) = 0.25 \times 4200 \times 80$; $m = 0.245 \text{ kg}$.
15. (a) $0.3 \times 4200(20 - 14) = 0.02l_f + 0.02 \times 4200 \times 14$; $l_f = 3.192 \times 10^5 \text{ J kg}^{-1}$. (b) Lower than $3.34 \times 10^5 \text{ J kg}^{-1}$ by about 4.4%. (c) Meltwater adhering to the ice is counted as ice but needs no latent heat, giving an underestimate. Dry the ice before adding it.
16. Suggested ticks for the illustrated methods (vaporization l_v / fusion l_f / specific heat capacity c):
- 16a. Temperature immediately after switching off: c only.
- 16b. Lid: c only; do not trap condensate in the mass-loss vaporization method or obstruct drainage from the ice funnel.
- 16c. Stirring: c only, to keep the measured water temperature uniform.
- 16d. Crushed material: l_f only, to ensure good contact with the heater.
- 16e. Melting material: l_f only, so the ice starts at $0 \text{ }^\circ\text{C}$.
- 16f. Heating element fully immersed/surrounded: l_v , l_f and c .
- 16g. Cotton-wool insulation: l_v and c for the illustrated arrangements. Insulating an ice funnel can also reduce unwanted environmental melting if drainage is unobstructed, though the matched control is the main correction in this method.
- 16h. Short connecting wires: l_v , l_f and c , to reduce unwanted wire heating where the meter includes that energy.
- 16i. Equal material quantities in experimental and control arrangements: l_f only.

Checkpoint 5 (p.84)

- Longer; slows down.
- B: boiling occurs at a definite boiling temperature at a given pressure; evaporation occurs over a range of temperatures.
- C: evaporation carries energy away from the liquid.
- Any two: temperature, exposed surface area, airflow, humidity or liquid type. Higher temperature, larger area, more airflow and lower humidity increase evaporation.

Checkpoint 6 (p.85)

- True: condensation releases latent heat.

2. $m = 5.2 \times 10^{19} / (2.26 \times 10^6) = 2.30 \times 10^{13} \text{ kg}.$

Practice 3.2 (p.86)

1. A: folding reduces exposed surface area.

2. C: faster molecules preferentially escape, lowering the average KE of those remaining.

3. C: (1) and (3).

4. $Q = 1.5 \times 2.26 \times 10^6 = 3.39 \times 10^6 \text{ J}.$

5. Water remaining on the skin evaporates, taking energy from the body. Wind removes humid air and increases evaporation and cooling.

6. (a) Warm humid outside air contacts the cold lenses and water vapour condenses into droplets. (b) The bathroom's warm humid air contacts the cooler lenses and condenses.

7. (a) $Q = 0.5 \times 2.26 \times 10^6 = 1.13 \times 10^6 \text{ J}.$ (b) $P = Q/3600 = 314 \text{ W}.$ (c) Any two factors listed in Checkpoint 5 Q4.

8. (a) $Q = 0.2 \times 2.26 \times 10^6 = 452000 \text{ J}.$ (b) $\Delta T = 452000 / (50 \times 3500) = 2.58 \text{ }^\circ\text{C}.$

9. Water vapour deposits as ice crystals on sufficiently cold surfaces below freezing. Water droplets already on the surfaces can also freeze; frost itself usually forms by direct vapour-to-ice deposition.

10. A's covering reduces the exposed water surface and traps humid air, slowing evaporation. Less water evaporates from A, so its final level is higher.

Chapter 4 - Transfer Processes

Checkpoint 1 (p.106)

1. C: from a region at higher temperature to one at lower temperature.
2. B: the copper rod conducts energy fastest.
3. Copper: good conductor. Plastic, water and air: good insulators (poor conductors).

Checkpoint 2 (p.108)

1. C: free electrons carry energy through metals efficiently.
2. A: only (2), interpreted as more free electrons per unit volume under comparable conditions. Lattice vibrations also transfer energy; metal atoms do not move freely through the solid.

Practice 4.1 (p.109)

1. C: aluminium removes energy from your hand faster, so the can feels colder.
2. C: fur slows X's cooling; it does not generate heat.
3. C: (1) and (2). Atoms in a solid vibrate around fixed positions rather than travelling from the hot end to the cold end.
4. (a) The insulating handle reduces conduction from the hot metal to the hand and prevents burns. (b) Wood or heat-resistant plastic.
5. Goose-down traps air. Air conducts heat poorly, and the small trapped pockets suppress convection, reducing energy loss from the body.
6. No: a vacuum has no particles to transfer energy by conduction.
7. Fat conducts heat poorly and slows energy transfer from the warm body to the cold surroundings.
8. Leave all three at the same room temperature, then touch them briefly under comparable conditions. The iron nail feels coldest and conducts heat fastest; paper feels warmest and conducts heat slowest; glass is intermediate. Touch is only a qualitative comparison because geometry and contact also affect the sensation.
9. (a) From your warmer hand to either railing. (b) Metal conducts energy away faster than wood, so your hand cools faster on metal.

Checkpoint 3 (p.117)

1. Draw arrows upward above the heated base, outward at the surface, downward at the cooler sides, then inward along the bottom. This gives two circulation loops if heating is central.
2. (a) Cold, denser air sinks; warmer air rises to replace it. (b) Shorter for occupants to feel cool, because the cooled air reaches their level sooner; cooling the entire room uniformly is a separate issue.

Practice 4.2 (p.118)

1. A: ordinary convection requires a fluid, not a solid.
2. (a) Water rises above the central burner, moves outward at the surface, sinks down both sides and returns along the base. (b) Air rises above the heater, spreads along the ceiling, descends at cooler walls and returns toward the heater at lower levels.
3. A vacuum contains no fluid to move and carry energy.

4. In microgravity there is negligible buoyancy-driven convection to pull hot gas upward. With oxygen supplied, fuel and oxygen diffuse in approximately all directions and the flame is approximately spherical.
5. Heat can accumulate because hot air cannot escape freely. The shade may overheat, become damaged or catch fire.
6. Hot air and vapour above tea tend to rise and escape, so a cover reduces convection and evaporation. In an open-top chest freezer, cold dense air remains low inside and warm air remains above it, limiting natural convection exchange.
7. (a) Intended immediate effect: he feels hotter without the jacket. (b) The initially cool jacket traps cool air and briefly slows heat transfer from the hot surroundings. Over longer periods it can trap metabolic heat and hinder cooling; a jacket does not keep him cool indefinitely.
8. (a) Air heated by the candle rises in its chimney, drawing replacement air and smoke downward through the other chimney. The smoke travels beneath the divider and rises with the warmed air above the candle. (b) Solid particles cannot undergo bulk circulation; they remain near fixed positions.

Checkpoint 4 (p.124)

1. Good; warmer.
2. D: all three increase the cooling rate under comparable conditions - stronger emission, greater exposed area per amount of soup, and a colder environment.

Checkpoint 5 (p.130)

1. A: the shiny stainless-steel wall reduces radiation transfer. A vacuum prevents conduction and convection, but not radiation.
2. (a) Metal. (b) Black. (c) Conduction, for transfer directly to the adjacent air; convection then carries the warmed air away. Increased surface area also increases radiative loss.

Practice 4.3 (p.132)

1. D: all objects above absolute zero emit thermal radiation.
2. D: all three use light surfaces to reduce absorption of sunlight in the textbook explanation.
3. (a) Net energy flows from the warmer surroundings to the ice. (b) The black-cloth-covered block: black absorbs more solar radiation and transfers more energy to the ice under comparable conditions.
4. A light, low-emissivity surface reduces radiation loss from the warm balloon, so less fuel is needed to maintain temperature. This is the textbook approximation; actual thermal-infrared emissivity depends on the coating as well as its visible colour.
5. (a) The black flask, because its surface emits thermal radiation more effectively. (b) Net energy flows from the hot water/flasks to the cooler surroundings in both cases.
6. Transparent plastic outside, black coat inside. Sunlight passes through the plastic and is absorbed by the black coat; the outer plastic reduces airflow and convective heat loss.
7. Light summer uniforms absorb less sunlight and help keep the wearer cooler. Dark winter uniforms absorb more sunlight and help keep the wearer warmer.
8. The white surface absorbs less incoming radiation and paper is a poor conductor. Cold dense air also tends to remain in the open-top box, limiting convection exchange.
9. (a) The shiny inner surfaces are poor emitters/absorbers of thermal radiation and reflect radiation, reducing radiative energy transfer to the cold drinks. (b) Yes: the insulation slows conduction/convection and the shiny lining reduces radiative loss from hot drinks.

Chapter 5 - Gases

Use Kelvin temperatures in all gas-law ratios: $T(\text{K}) = \text{temperature}(\text{°C}) + 273$. Use absolute pressures; $R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$ and $N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$.

Checkpoint 1 (p.151)

1. $F = pA = 110000 \times 0.25^2 = 6875 \text{ N} \approx 6.88 \times 10^3 \text{ N}$ on each wall.
2. (a) Bourdon gauge / pressure gauge. (b) Approximately $1.0 \times 10^5 \text{ N m}^{-2}$, using the indicated inner scale.

Checkpoint 2 (p.154)

1. (a) Yes. (b) Yes. (c) No: N m^2 is force multiplied by area, not force per area.
2. The remaining volume is 55% of its original value: $p_2 = 100/0.55 = 182 \text{ kPa}$, assuming constant temperature.
3. (a) Fixed amount/mass of gas at constant temperature, with ideal-gas behaviour. (b) $p_2 = 100 \times 50/45 = 111 \text{ kPa}$.

Checkpoint 3 (p.157)

1. A: only (3). The unit symbol is capital K, and $T_K = T_C + 273$.
2. Body temperature: 310 K. Mercury melting point: -39 °C .
3. $T_2 = 3 \times 300 = 900 \text{ K} = 627 \text{ °C}$.

Checkpoint 4 (p.160)

1. (a) Volume increases linearly with Celsius temperature, but is not directly proportional to it. Volume is directly proportional to Kelvin temperature at fixed pressure and gas amount. (b) Extend the line backward to $V = 0$ and mark the intercept -273 °C .
2. $V_2 = 1 \times (117 + 273)/(27 + 273) = 1.30 \text{ m}^3$.

Checkpoint 5 (p.164)

1. $p_2 = 100 \times (80/70) \times (306/300) = 116.6 \text{ kPa} \approx 117 \text{ kPa}$.
2. $V = 5 \times 7 \times 2.2 = 77 \text{ m}^3$. Taking atmospheric pressure as $1.0 \times 10^5 \text{ Pa}$, $n = pV/(RT) = 3109 \text{ mol} \approx 3.11 \times 10^3 \text{ mol}$. Using $1.013 \times 10^5 \text{ Pa}$ gives about $3.15 \times 10^3 \text{ mol}$.

Checkpoint 6 (p.166)

1. (a) -273 °C : the nonzero intercept at 0 indicates a Celsius-temperature axis. (b) Slope = nR/V , for a fixed container volume. (c) A steeper straight line with the same temperature-axis intercept at -273 °C ; its pressure at 0 °C is higher.

Practice 5.1 (pp.167-168)

1. B: only (2), because a change of 100 °C equals a change of 100 K .
2. A: approximately $290 \text{ K} = 17 \text{ °C}$.
3. C: the graph gives $p/T \approx 0.25 \text{ kPa K}^{-1}$, so $p \approx 150 \text{ kPa}$ at 600 K .
4. B: mol.

5. B: high temperature and low pressure.
6. B: $pV = 105000/0.70 = 150000 \text{ Pa m}^3$; $n = 150000/(8.31 \times 293) = 61.6 \text{ mol} \approx 62 \text{ mol}$.
7. $T_2 = 293 \times 100/90 = 325.6 \text{ K} = 52.6 \text{ }^\circ\text{C}$.
8. Atmospheric pressure on the underside provides an upward force that supports the plate and water. The sealed arrangement prevents free entry of air; the pressure just inside the plate is sufficiently lower for the upward pressure difference to support the load.
9. (a) Pressure increases as temperature rises in the closed cooker; steam production also contributes. (b) Excess pressure can exceed the cooker's strength, causing rupture and release of hot steam/water.
10. $p_2 = 50 \times (473/173)/1.02 = 134 \text{ kPa}$.
11. (a) It expands. (b) Pumping lowers the surrounding pressure, so the trapped gas expands; at approximately constant temperature, pV is constant for the trapped gas.
12. (a) At 120 kPa, $1/V \approx 100 \text{ m}^{-3}$; $V \approx 0.010 \text{ m}^3$. (b) p is proportional to $1/V$: the best-fit straight line extrapolates approximately through the origin, so pV is constant at the fixed temperature. For example, approximately $(1/V, p) = (100, 120)$ and $(125, 150)$ give $pV \approx 1200 \text{ Pa m}^3$ in each case.
13. (a) $p_2 = p_1 V_1/V_2$. (b) $p_3 = p_2 T_2/T_1 = p_1 V_1 T_2/(V_2 T_1)$. (c) The same $p_3 = p_1 V_1 T_2/(V_2 T_1)$; final pressure depends on the final state, not the route.
14. $N_X/N_Y = (V_X/T_X)/(V_Y/T_Y) = (1.2/293)/(0.9/298) = 1.36$. Thus $N_X:N_Y \approx 1.36:1$.
15. Draw a straight line through the origin with one-quarter the original slope. Since $V = (nR/p)T$, replacing n by $n/2$ and p by $2p$ makes the slope $nR/(4p)$.
16. Assume the temperature is maintained at its original value. (a) $p_X = (1.5/2.4)p_Y = 0.625p_Y$. (b) Each container finally has 1.95 mol, so $p_{\text{final}} = (1.95/2.4)p_Y = 0.8125p_Y$. (c) Increase in $X = (1.95 - 1.5)/1.5 \times 100\% = 30\%$.

Checkpoint 7 (p.175)

1. Mean square speed $= 3pV/M = 3 \times 120000 \times (40 \times 10^{-6})/(6.5 \times 10^{-5}) = 2.22 \times 10^5 \text{ m}^2 \text{ s}^{-2}$. This is mean square speed, not root-mean-square speed.
2. At $T = 298 \text{ K}$: (a) Total KE $= (3/2)nRT = 1.86 \times 10^3 \text{ J}$. (b) KE of one mole $= (3/2)RT = 3.71 \times 10^3 \text{ J}$. (c) Mean KE per molecule $= (3/2)RT/N_A = 6.17 \times 10^{-21} \text{ J}$.

Checkpoint 8 (p.179)

1. A: trapped air molecules bombard the water surface and exert pressure, preventing the glass from filling completely. Some water can enter as the trapped air compresses.
2. (a) Gas molecules. (b) Gas pressure / external load determining equilibrium gas pressure. (c) Gas temperature. (d) Gas volume.

Practice 5.2 (p.182)

1. C: increased temperature.
2. C: molecules have a distribution of speeds, not one common speed.
3. D under the usual interpretation: increase gas amount at fixed volume; increase density; or decrease volume at fixed gas amount. At fixed temperature, $p = (N/V)kT$, so each specified change increases number density under these conditions.
4. B: total translational KE $= (3/2)NkT$; more molecules give a larger slope.
5. $c_{\text{rms}} = \sqrt{3RT/(N_A m)} = \sqrt{3 \times 8.31 \times 373/(6.02 \times 10^{23} \times 3.34 \times 10^{-27})} = 2.15 \times 10^3 \text{ m s}^{-1}$.

6. (a) Continuous irregular, random zigzag motion (Brownian motion). (b) Gas molecules strike it unevenly from different directions; the resulting fluctuating force changes its motion. (c) Motion becomes less vigorous as the gas molecules have lower average kinetic energy.

7. (a) The average speed increases. (b) Faster molecules strike the walls more frequently and transfer more momentum per collision. The rate of momentum transfer per unit area increases, so pressure increases at fixed volume.

8. Pumping adds molecules into the same volume, increasing their collision rate with the tyre walls and therefore the force per unit area. Compression heating may increase pressure further temporarily.

9. $c_{\text{rms}} = \sqrt{3RT/M_{\text{molar}}} = \sqrt{3 \times 8.31 \times 298/0.0337} = 470 \text{ m s}^{-1}$.

10. $\Delta E = (3/2)(N/N_A)R\Delta T = (3/2)[7.28 \times 10^{24}/(6.02 \times 10^{23})] \times 8.31 \times (80 - 25) = 8.29 \times 10^3 \text{ J}$.

11. Since average molecular KE is proportional to Kelvin temperature, and T is proportional to pV for a fixed gas amount: (a) Triples. (b) Becomes nine times the initial value. (c) Unchanged.

12. (a) m = mass of one molecule; Nm = total mass of the gas. (b) Total translational KE $E = (1/2)Nm \text{ mean}(c^2) = (3/2)pV$. For one mole $pV = RT$, so $E = (3/2)RT$.