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IGCSE PHYSICS 0625 · TOPICAL PAST PAPERS

Kinetic Particle Model of Matter — Paper 2

Worked Solutions (Theory / Structured)

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Kinetic Particle Model of Matter — Paper 2 · Worked Solutions

Megalecture worked solutions — model answers with working; please verify before classroom use. These solutions for the **Kinetic Particle Model of Matter (IGCSE Physics 0625 / O Level 5054, Paper 2 Theory)** topical compilation were prepared from first principles by the Megalecture team. Gas-law calculations use $p_1V_1 = p_2V_2$ (Boyle's law, constant temperature) and $p = F/A$, with g taken as 10 N/kg unless a question states otherwise. Bold values with units are the final answers. Question numbers follow the order of the compilation.

Part A · States of Matter — Arrangement & Motion of Molecules

Question 1 — 5054/02/M/J/09 Q4

(a) One difference between the arrangement in a solid and in a liquid:

> In the **solid** the molecules are in a regular, ordered pattern (a lattice) and are touching, whereas in the **liquid** the molecules are arranged irregularly / randomly (still close together and touching, but with no fixed pattern). **Solid = regular arrangement; liquid = irregular arrangement.**

(b)(i) Why the molecules of a solid and of a liquid have different arrangements:

> In both states the molecules attract one another strongly because they are close together. In the solid the molecules have **too little kinetic energy to overcome the bonds**, so they only vibrate about fixed positions and stay in a regular lattice. In the liquid the molecules have **enough energy to break out of the fixed lattice** and slide/move past one another, so the arrangement becomes irregular. **More molecular energy in the liquid lets molecules move out of the ordered solid pattern.**

Question 2

5054/21/M/J/13 Q10

This compilation includes only parts (b)(iii) and (b)(iv) of the original question.

(b)(iii) 1. — molecules in liquid water:

> The molecules are **close together and touching**, arranged **irregularly / randomly**, and they **move about freely, sliding past one another** (they are not fixed in position). **Close-packed but disordered; moving and able to change places.**

(b)(iii) 2. — molecules in ice:

> The molecules are **close together in a fixed, regular (ordered) arrangement** and they **only vibrate about fixed positions**; they cannot move from place to place. **Regular lattice; vibrate about fixed points.**

(b)(iv) Ice at 0 °C becoming water at 0 °C:

> **kinetic energy:** stays the **same** (the temperature is unchanged, so average kinetic energy is unchanged).
> **potential energy:** **increases** (the supplied latent heat does work against the intermolecular forces, separating the molecules slightly and weakening the bonds, raising their potential energy).

Question 3

5054/22/M/J/13 Q9

(a) Why heating the air inside the flask increases its pressure:

> Heating gives the air molecules **more kinetic energy**, so they **move faster**. They therefore **hit the walls of the flask harder and more often (more frequent collisions)**. The rate of change of momentum at the walls increases, so the **average force on each unit area — the pressure — increases**. **Faster molecules → harder, more frequent wall collisions → greater pressure.**

Question 4

5054/21/M/J/15 Q10

(a) Two ways the student's diagram does not show the molecules of a liquid accurately:

> **1.** The molecules are drawn in a **regular, ordered pattern** (rows and columns); in a liquid the molecules are arranged **irregularly / randomly**.
> **2.** The molecules are drawn with **large, equal gaps between them** and all moving the same way; in a liquid they are **close together / touching, moving in random directions at random (different) speeds**.

(Either of these, plus e.g. the arrows should not all be the same length/direction, scores the marks.)

Question 5

5054/22/M/J/17 Q5

(a) Arrangement of molecules in the liquid (drawing):

> Draw the circles **close together and touching (about the same spacing as in the solid)** but in an **irregular / disordered arrangement with no fixed pattern**, and roughly the **same number / packing density** as the solid. **Close-packed but irregular — not a neat lattice, no large gaps.**

(b) Motion of the molecules:

> **solid:** molecules **vibrate about fixed positions** (do not move from place to place).
> **liquid:** molecules **move about / slide past one another** (move freely throughout the liquid but stay close together).
> **gas:** molecules **move very fast in random directions, far apart, with very few collisions** (free, rapid, random motion).

(c) Why a gas fills its container but a solid keeps a fixed shape:

> In a **solid** the molecules are held in fixed positions by **strong attractive forces**, so they cannot move apart and the solid keeps a fixed shape. In a **gas** the molecules are **far apart with negligible forces between them** and move **freely and rapidly in all directions**, so they spread out until they **fill the whole container**. **Strong fixed bonds (solid) vs free, fast-moving, widely-spaced molecules (gas).**

Part B · Pressure of a Gas & Boyle's Law (Constant Temperature)

Question 6

5054/21/M/J/19 Q4

(a) Why a liquid occupies a much smaller volume than a gas with the same number of molecules:

> In a **liquid** the molecules are **close together / touching**, while in a **gas** the molecules are **far apart** with large empty spaces between them. The same number of molecules therefore takes up far less space as a liquid. **Molecules are close-packed in a liquid but widely spaced in a gas.**

(b)(i) Formula relating the quantities:

> $p_1V_1 = p_2V_2$ (Boyle's law, fixed mass of gas at constant temperature).

(b)(ii) Final pressure of the gas:

$\text{Reduction in volume} = \text{distance moved} \times \text{area} = 8.0 \times 5.0 = 40\ \text{cm}^3$

$\text{New volume } V_2 = 100 - 40 = 60\ \text{cm}^3$

$p_2 = p_1V_1 / V_2 = (1.2 \times 10^5 \times 100) / 60$

> $p_2 = \mathbf{2.0 \times 10^5\ Pa}$

(b)(iii) Why the pressure of the gas changes:

> The volume is smaller, so the same number of molecules are in a **smaller space**. The molecules therefore **hit the walls more often (more frequent collisions per second)**, so the average force per unit area — the pressure — **increases**. **Smaller volume → more frequent wall collisions → higher pressure.**

Question 7

5054/02/O/N/02 Q7

The syringe is heated from 20 °C to 100 °C and the piston is free to move, so the gas pressure stays equal to constant atmospheric pressure throughout (constant-pressure heating). State whether each quantity increases, decreases or stays the same.

> • The average distance between gas molecules — **increases** (the gas expands, pushing the piston out).
> • The pressure of the gas after the piston stops — **the same** (piston is free to move, so it stays equal to atmospheric pressure).
> • The average speed of the gas molecules — **increases** (higher temperature → greater average kinetic energy).
> • The frequency of collisions between the gas molecules and the piston — **the same** (faster molecules, but spread through a larger volume, so the collision rate per unit area stays the same as the pressure is unchanged).

Question 8
5054/22/M/J/22 Q3

(a) Define pressure:

Pressure = force acting normally (perpendicular) per unit area (p = F / A).

(b) How the air molecules create a pressure:

The air molecules **move rapidly and randomly** and **collide with the walls of the syringe**. Each collision exerts a tiny force on the wall as the molecule's momentum changes (it rebounds). The **total force of the very many collisions, divided by the wall area, is the pressure**. **Fast random molecules colliding with the walls produce a force per unit area = pressure.**

(c)(i) Pressure of the air after the plunger stops:

$$\text{Extra pressure from the weight} = F / A = 10 / (1.2 \times 10^{-4}) = 83\ 333 \text{ Pa} \approx 8.3 \times 10^4 \text{ Pa}$$

$$\text{New pressure} = 1.0 \times 10^5 + 0.83 \times 10^5$$

p_2 = **1.83×10^5 Pa** (about 1.8×10^5 Pa)

(c)(ii) Volume of air after the plunger stops:

$$V_2 = p_1V_1 / p_2 = (1.0 \times 10^5 \times 50) / (1.83 \times 10^5)$$

V_2 = **27 cm^3** (27.3 cm^3)

Question 9
5054/02/O/N/02 Q6

Nitrogen data: melting point −210 °C, boiling point −195 °C.

(a) State of nitrogen at −209 °C:

−209 °C is just **above the melting point (−210 °C)** but well below the boiling point (−195 °C), so the nitrogen has melted but not yet boiled. It is a **liquid**.

Question 10
5054/02/O/N/07 Q6

(b) Changes to arrangement and motion of the atoms as the solid block becomes a liquid:

Arrangement: changes from a **regular / ordered lattice** to an **irregular / random arrangement**; the atoms stay close together but the spacing increases only slightly. **Motion:** instead of only **vibrating about fixed positions**, the atoms now **move about and slide past one another** (they can change places). **Regular → irregular arrangement; vibrating in fixed places → moving/sliding throughout the liquid.**

Question 11

5054/02/O/N/07 Q9

(c)(i) Pressure of the gas in the inflated air-bag:

$p_2 = p_1V_1 / V_2 = (1.4 \times 10^7 \times 600) / 30\ 000$

p_2 = **2.8×10^5 Pa**

(c)(ii) Why the pressure inside the cylinder decreases as the air-bag inflates:

As the gas escapes into the air-bag, it occupies a much **larger volume**, so the molecules are **more spread out (fewer molecules per unit volume)**. They therefore **hit the walls less often**, so the average force per unit area — the pressure — **decreases**. **Larger volume → fewer / less frequent wall collisions → lower pressure.**

Part C · Molecular Properties of Liquids & Gases

Question 12

5054/02/O/N/08 Q5

(a) Two differences between liquids and gases at normal pressure, explained in molecular terms:

Difference 1: A gas can be compressed easily but a liquid almost cannot.
Explanation 1: In a gas the molecules are **far apart with large spaces between them**, so they can be pushed closer together; in a liquid the molecules are **already close together / touching**, so there is almost no space to reduce. **Gas has spaces to compress; liquid does not.**

Difference 2: A gas has a much lower density than a liquid (and a gas fills its container while a liquid keeps a fixed volume).
Explanation 2: The widely-spaced gas molecules mean far less mass per unit volume (low density), and because the forces between gas molecules are negligible they **move freely and spread to fill the container**; in a liquid the close-packed molecules give a high density and the stronger attractive forces keep the liquid at a **fixed volume**. **Wide spacing & weak forces (gas) vs close packing & stronger forces (liquid).**

Question 13

5054/21/O/N/10 Q8

(a)(i) The driver's weight:

$W = mg = 70 \times 10$

W = **700 N**

(a)(ii) Average increase in the pressure of the gas in the cylinders:

$\text{The weight is shared by 4 pistons: extra force on each} = 700 / 4 = 175 \text{ N}$

$\text{Area of each piston} = 35 \text{ cm}^2 = 35 \times 10^{-4} \text{ m}^2$

$\Delta p = F / A = 175 / (35 \times 10^{-4})$

Δp = **5.0×10^4 Pa** (50 000 Pa)

(b)(i) How the trapped gas molecules exert a pressure on the cylinder:

The gas molecules **move rapidly and randomly** and **collide with the cylinder walls**. At each collision a molecule's momentum changes (it rebounds), so it exerts a small force on the wall. There are **very many molecules and very many collisions per second**, giving a steady total force. This **total force divided by the wall area is the pressure**. **Many fast random molecules colliding & rebounding from the walls → force per unit area = pressure.**

(b)(ii) Why the pressure increases as the piston moves further in (constant temperature):

The volume becomes smaller, so the molecules are in a **smaller space** and **hit the walls more often (more frequent collisions)** — their speed is unchanged (constant temperature) — so the pressure **increases**. **Smaller volume → more frequent collisions → higher pressure.**

(c)(i) Effect of the temperature rise on the gas molecules:

The molecules gain kinetic energy and **move faster (greater average speed)**.

(c)(ii) Effect of the higher gas temperature on the height of the car body:

The faster molecules hit the piston harder and more often, raising the gas pressure; the gas therefore **expands and pushes the pistons further out**, so the car body **rises higher above the road**. **Hotter gas → higher pressure / expansion → car body sits higher.**

Question 14

5054/21/O/N/11 Q11

(b)(i) Minimum value of the pressure of the gas in the cylinder:

For the piston to be in equilibrium, the gas pressure must at least balance the outside air pressure plus the pressure due to force F.

Pressure from F = F / A = 8200 / 0.0067 = 1.22×10^6 Pa

Minimum gas pressure = atmospheric + F/A = $1.0 \times 10^5 + 1.22 \times 10^6$

> p = **1.3×10^6 Pa** (1.32×10^6 Pa)

(b)(ii) Why, in practice, the gas pressure is greater than the value in (i):

> The calculation assumes the piston is in equilibrium with no other forces. In practice there is also **friction between the piston and the cylinder** (and the weight of the piston/rod), which acts as well, so the gas must push harder — a higher pressure — to produce the same force F. **Friction (and the piston's weight) means a larger gas pressure is needed.**

(c) What happens to force F as the piston moves out and the gas expands:

> As the gas expands its volume increases, so (at roughly constant temperature) its pressure **decreases**; the force on the piston, F = pA, therefore **decreases**.

(d) Why heating a gas at constant volume increases its pressure (molecular terms):

> Heating gives the molecules **more kinetic energy**, so they **move faster**. Because the volume is fixed, the faster molecules **hit the walls harder and more frequently**. The rate of change of momentum at the walls increases, so the average force per unit area — the pressure — **increases**. **Higher temperature → faster molecules → harder, more frequent collisions in a fixed volume → greater pressure.**

Question 15

5054/22/O/N/12 Q9

(a)(i) Pressure due to 15 m of water:

$$p = \rho gh = 1000 \times 10 \times 15$$

p = **1.5×10^5 Pa**

(a)(ii) Total pressure at 15 m below the surface:

$$\text{total} = \text{atmospheric} + \rho gh = 1.0 \times 10^5 + 1.5 \times 10^5$$

total pressure = **2.5×10^5 Pa**

(b)(i) Volume of the air in the balloon at the surface (atmospheric pressure):

$$V_2 = p_1V_1 \ / \ p_2 = (2.5 \times 10^5 \times 0.048) \ / \ (1.0 \times 10^5)$$

V_2 = **$0.12\ m^3$**

(b)(ii) Why the air pressure in the balloon is less at the surface than at 15 m:

At the surface the balloon has expanded to a **larger volume**, so the same air molecules are **more spread out** and **hit the balloon walls less often**. The average force per unit area — the pressure — is therefore **lower**. **Larger volume → less frequent wall collisions → lower pressure.**

(c) One difference between the arrangement of the water molecules and the air molecules in the balloon:

The **water (liquid) molecules are close together / touching**, whereas the **air (gas) molecules are far apart** with large spaces between them. **Liquid = close-packed; gas = widely spaced.**

Question 16

5054/21/O/N/15 Q2

(a) Advantage of painting the outside of the freezer white:

> A white (shiny/light) surface is a **poor absorber and good reflector of infra-red (thermal) radiation**, so it **absorbs less heat from the warm surroundings**. Less thermal energy enters the freezer, so it stays cold more easily and uses less electricity. **White reflects radiation → less heat absorbed from the surroundings.**

(b)(i) What happens to the pressure of the trapped air as it cools:

> The pressure **decreases**. As the air cools the molecules **lose kinetic energy and move more slowly**, so they **hit the walls less hard and less often**. The average force per unit area — the pressure — therefore falls. **Cooling → slower molecules → weaker, less frequent collisions → lower pressure.**

(b)(ii) Why the lid is harder to open at operating temperature:

> The pressure of the cooled air inside is now **lower than the atmospheric pressure outside**, so the larger outside pressure pushes the lid down. An extra (upward) force is needed to overcome this pressure difference, making the lid harder to lift. **Lower inside pressure → atmospheric pressure holds the lid shut.**

Question 17

5054/22/O/N/15 Q6

(a) Why heating the trapped gas increases its pressure (molecules):

> Heating gives the molecules **more kinetic energy**, so they **move faster**. As the volume is fixed (piston held by the rod), they **hit the walls harder and more often**, so the average force per unit area — the pressure — **increases**. **Faster molecules in a fixed volume → harder, more frequent collisions → higher pressure.**

(b) When the rod is pulled down and the piston is free to move (constant temperature):

> The gas now occupies a **larger volume**, so its **pressure decreases**. The molecules keep the same speed (temperature unchanged), but being more spread out in the larger space they **hit the walls less often**, so the average force per unit area — the pressure — falls until it equals the outside (atmospheric) pressure. **Larger volume → less frequent collisions → pressure decreases.**

Question 18

5054/22/O/N/15 Q9

(d) How ice differs from liquid water, in terms of molecules:

> In **ice** the molecules are in a **fixed, regular (ordered) arrangement** and **only vibrate about fixed positions**; in **liquid water** the molecules are arranged **irregularly / randomly** and can **move about and slide past one another**. (Also, in ice the molecules are slightly further apart on average, so ice is slightly less dense than water.) **Ice = regular, fixed, vibrating; water = irregular, moving / sliding.**

Question 19

5054/21/O/N/16 Q10

(a)(i) Why the density of the oil is much greater than that of a gas:

> In the **oil (liquid)** the molecules are **close together / touching**, so there is much more mass packed into each unit of volume; in a **gas** the molecules are **far apart**, so there is far less mass per unit volume. **Close-packed molecules (liquid) → much higher density than the widely-spaced gas.**

(a)(ii) Why the oil cannot be compressed:

> The oil molecules are **already close together / touching, with almost no space between them**, so they cannot be pushed any closer. **No empty space between the molecules → the liquid cannot be compressed.**

Question 20

5054/22/O/N/16 Q5

(a) How the gas exerts a pressure on the inside of the syringe:

> The gas molecules **move rapidly in random directions** and **collide with the inside walls of the syringe**. At each collision a molecule rebounds, so its momentum changes and it exerts a small force on the wall. The **combined force of the huge number of collisions per second, divided by the wall area, is the pressure**. **Many fast random molecules colliding with & rebounding from the walls → force per unit area = pressure.**

(b) New pressure of the gas when the volume becomes 110 cm^3:

$$p_2 = p_1V_1 \,/\, V_2 = (1.1 \times 10^5 \times 40) \,/\, 110$$

> p_2 = **4.0×10^4 Pa**

Question 21

5054/21/O/N/17 Q3

(a) Two ways the structure of gold at 1200 °C differs from at 1000 °C:

Melting point of gold = 1100 °C, so at 1000 °C the gold is a solid and at 1200 °C it is a liquid.

> **1. Arrangement:** at 1000 °C the atoms are in a **regular / ordered lattice**; at 1200 °C (liquid) they are arranged **irregularly / randomly**.
> **2. Motion:** at 1000 °C the atoms only **vibrate about fixed positions**; at 1200 °C they **move about / slide past one another** (they can change places).

Part D · Temperature, Boiling & Mixed Molecular Questions

Question 22

5054/21/O/N/19 Q9

(d)(i) Motion of the molecules in a liquid at uniform temperature:

> The molecules **move about randomly, sliding past one another**, while staying **close together**. They move at a **range of (random) speeds**, with a constant average speed because the temperature is uniform. **Random movement throughout the liquid; molecules slide past each other at random speeds.**

(d)(ii) What happens to the motion as the liquid's temperature decreases:

> The molecules **lose kinetic energy and move more slowly** (their average speed decreases). **Molecules slow down / average speed decreases.**

Question 23

5054/22/O/N/19 Q2

(a)(i) Force exerted on the piston by the trapped air in the pump:

$$F = p \times A = (3.8 \times 10^5) \times (6.1 \times 10^{-4})$$

F = **232 N** (231.8 N)

(a)(ii) Why the force exerted by the student is less than this value:

The trapped air also has **atmospheric pressure acting on the other side of the piston**, which pushes the piston inwards and helps the student. The student only has to provide the force needed for the **pressure difference (gas pressure − atmospheric pressure)**, so the push needed is less than the full force calculated above. **Atmospheric pressure on the outer face helps push the piston in.**

(b) Why the pressure of a gas increases when its volume decreases at constant temperature:

When the volume is reduced, the same number of molecules are in a **smaller space**. Their speed is unchanged (constant temperature), but they **hit the walls more often (more frequent collisions per second)**, so the average force per unit area — the pressure — **increases**. **Smaller volume → more frequent wall collisions → higher pressure.**

Question 24

5054/22/O/N/19 Q9

(a) What is meant by boiling point:

The **(fixed) temperature at which a liquid changes into a gas throughout its volume** (bubbles of vapour form in the bulk of the liquid) at a given pressure. **The temperature at which a liquid boils / turns to vapour throughout, at constant pressure.**

(b) Why energy must be supplied to turn a boiling liquid into a gas:

Energy (latent heat) is needed to do **work against the attractive forces between the molecules**, pulling them far apart to form a gas. The molecules must gain enough **potential energy to break free of their neighbours**; the temperature stays constant, so the energy goes entirely into separating the molecules, not into raising their speed. **Energy is used to break the bonds / separate the molecules against their attractive forces.**

(e) Does the upward force on the piston change as it moves up at constant speed?

No. The piston moves at **constant speed (no acceleration)**, so the resultant force on it is zero; the upward force from the gas must continue to balance the constant downward forces (the piston's weight + atmospheric pressure). The gas pressure therefore stays the same, so the **upward force on the piston stays constant**. **No change — constant speed means balanced forces, so the upward force is unchanged.**

Question 25

5054/21/O/N/20 Q8

(a) What is meant by pressure:

Pressure = force per unit area (force acting normally on a surface divided by the area, p = F / A).

(b)(i) Pressure due to 25 m of water:

$$p = \rho g h = 1000 \times 10 \times 25$$

p = **2.5×10^5 Pa**

(b)(ii) Atmospheric pressure:

$$\text{total} = \text{atmospheric} + \rho g h \;\Rightarrow\; \text{atmospheric} = 3.5 \times 10^5 - 2.5 \times 10^5$$

atmospheric pressure = **1.0×10^5 Pa**

(c)(i) Why the piston moves into the cylinder as the gauge is lowered:

As the gauge goes deeper, the **water pressure on the outer face of the piston increases** (p = atmospheric + ρgh). This outside pressure becomes greater than the trapped-gas pressure, so the **resultant force pushes the piston inwards**, compressing the gas until the pressures balance again. **Greater depth → higher water pressure on the piston → piston pushed in.**

(c)(ii) What happens to the pressure of the trapped gas (molecules):

The gas is compressed into a **smaller volume**, so the molecules (same speed, constant temperature) are in a smaller space and **hit the walls more often**; the average force per unit area — the pressure — **increases**. **Smaller volume → more frequent collisions → higher pressure.**

(c)(iii) Sketch of volume against depth:

A **smooth curve starting at V_0 on the volume axis (at depth = 0) and falling as depth increases**, getting **less steep** as it goes (a Boyle's-law curve: V ∝ 1/total pressure, and the pressure rises steadily with depth). **Downward curve from V_0, decreasing and levelling off — never reaching zero.**

(c)(iv) Why the needle must be re-set to zero at the surface each time:

The atmospheric pressure at the surface **varies from day to day (with weather/altitude)**, which changes the gas volume at the surface; re-zeroing makes sure the gauge reads the true depth and is not affected by the changing surface pressure. **Atmospheric pressure changes, so re-zeroing keeps the depth reading accurate.**

(c)(v) Why the density of the water stays constant (molecules):

The water molecules are **already close together / touching**, so the increased pressure cannot push them any closer — a liquid is virtually **incompressible**. The volume of a fixed mass of water is unchanged, so its density stays the same. **Liquid molecules cannot be compressed further → volume (and density) unchanged.**

Question 26 5054/21/O/N/19 Q3

(a) Three ways a gas differs from a liquid (molecules):

1. In a gas the molecules are **far apart**, while in a liquid they are close together / touching.
2. The gas molecules are arranged **completely randomly and spread out to fill the container**, whereas liquid molecules stay together with a fixed volume.
3. The gas molecules **move much faster, freely and randomly with few collisions**, while liquid molecules move more slowly, sliding past one another.

(b) Why energy must be supplied to turn a boiling liquid into a gas:

The energy supplied (latent heat of vaporisation) does **work against the attractive forces between the molecules**, separating them to the wide spacing of a gas. The molecules need extra **potential energy to break free of their neighbours**; the temperature stays constant while this happens. **Energy separates the molecules / breaks the bonds against their mutual attraction.**

Question 27 5054/21/O/N/21 Q9

(a)(i) Molecular structure of a liquid (drawing in the middle box):

Draw the circles **close together / touching (about the same spacing as the solid)** but in an **irregular / random arrangement**, filling the lower part of the box with **no neat rows and no large gaps**. **Close-packed but disordered — between the regular solid and the spread-out gas.**

(a)(ii) Why it is easier to compress a gas than a solid:

In a **gas** the molecules are **far apart with large spaces between them**, so they can be pushed closer together. In a **solid** the molecules are **already touching with almost no space** between them, so they cannot be pushed closer. **Gas has empty space to compress; a solid has none.**

(a)(iii) Two ways the liquid's molecules are affected as the thermometer's temperature increases:

1. The molecules gain kinetic energy and **move faster (greater average speed)**.
2. The molecules move **slightly further apart**, so the liquid expands (its volume increases) and rises up the thermometer.

Note from Megalecture. Some questions in this compilation are extracts (e.g. only certain parts of a longer exam question are reproduced); only the reproduced parts are answered here. All numerical answers were checked by calculation and use g = 10 N/kg unless stated. These are original Megalecture worked solutions for revision use — please verify before classroom use.