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Heat, Temperature and Kinetic Theory

Name: _____

Class: _____

1. A liquid-in-glass thermometer is being calibrated. The length of the liquid column is $2.0\ \text{cm}$ at the ice point and $22.0\ \text{cm}$ at the steam point. What temperature does the thermometer indicate when the length of the liquid column is $14.0\ \text{cm}$?

A. $50\ ^\circ\text{C}$

B. $60\ ^\circ\text{C}$

C. $63.6\ ^\circ\text{C}$

D. $70\ ^\circ\text{C}$

2. Which statement about temperature is correct?

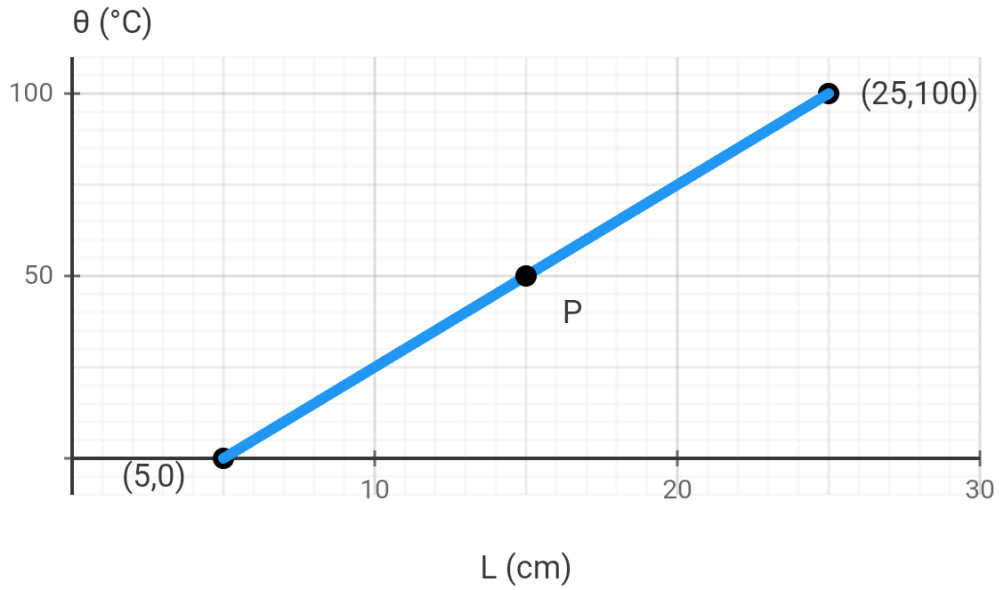
A. Temperature is a measure of the total internal energy of a body.

B. Temperature is a measure of the average kinetic energy of the molecules in a body.

C. Temperature is a measure of the heat capacity of a body.

D. Temperature is a measure of the mass of a body.

3. A student plots a calibration graph for an unmarked thermometer. The graph of temperature θ against the length of the liquid column L is a straight line. The liquid column is $5.0\ \text{cm}$ long in pure melting ice and $25.0\ \text{cm}$ long in steam at standard atmospheric pressure.



Point P on the graph corresponds to what temperature?

A. $40\ ^\circ\text{C}$

B. $50\ ^\circ\text{C}$

C. $60\ ^\circ\text{C}$

D. $75\ ^\circ\text{C}$

4. An ideal gas is sealed in a rigid container of fixed volume. Which of the following increases when the gas is heated?
I. The average kinetic energy of the gas molecules
II. The r.m.s. speed of the gas molecules
III. The pressure exerted by the gas

A. I only

B. I and II only

C. II and III only

D. I, II and III

5. A fixed mass of ideal gas is compressed slowly at constant temperature. Which statement is correct?

A. The average kinetic energy of the molecules decreases.

B. The pressure of the gas increases.

C. The r.m.s. speed of the molecules increases.

D. The density of the gas remains constant.

6. A metal block of mass $0.40\ \text{kg}$ and specific heat capacity $900\ \text{J kg}^{-1}\ ^{\circ}\text{C}^{-1}$ is heated by an immersion heater of power $180\ \text{W}$ for $2.0\ \text{minutes}$. The block is well insulated. What is the temperature rise of the block?

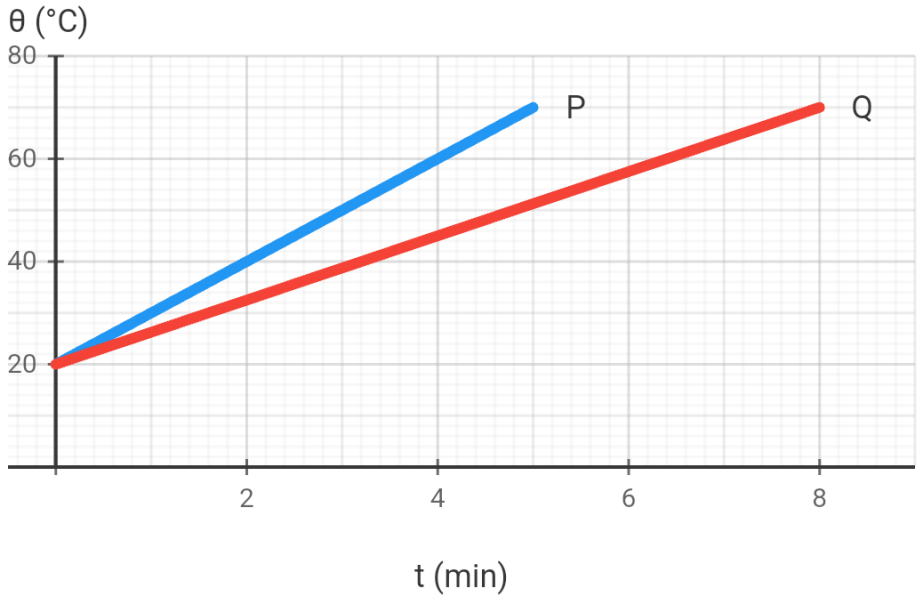
A. $30\ ^{\circ}\text{C}$

B. $45\ ^{\circ}\text{C}$

C. $60\ ^{\circ}\text{C}$

D. $90\ ^{\circ}\text{C}$

7. Two liquids, P and Q, have the same mass. They are heated separately by identical heaters of the same constant power. The graph shows how their temperatures change with time.



What is the ratio of the specific heat capacity of P to that of Q?

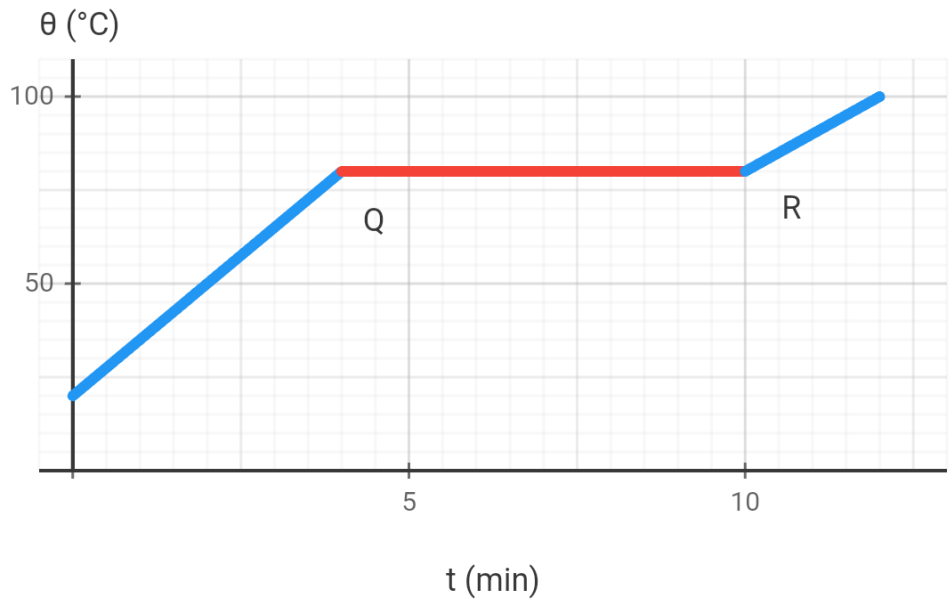
A. $5 : 8$

B. $8 : 5$

C. $5 : 13$

D. $1 : 1$

8. A solid of mass $0.25\ \text{kg}$ is heated by a heater of constant power $200\ \text{W}$. The temperature-time graph is shown below.



What is the specific latent heat of fusion of the solid?

A. $1.44 \times 10^5\ \text{J kg}^{-1}$

B. $2.40 \times 10^5\ \text{J kg}^{-1}$

C. $2.88 \times 10^5\ \text{J kg}^{-1}$

D. $4.80 \times 10^5\ \text{J kg}^{-1}$

9. In an experiment to find the specific latent heat of vaporisation of water, steam at $100\ ^\circ\text{C}$ is passed into water in a well-insulated calorimeter. Which of the following would cause the calculated value of the specific latent heat to be larger than the true value?

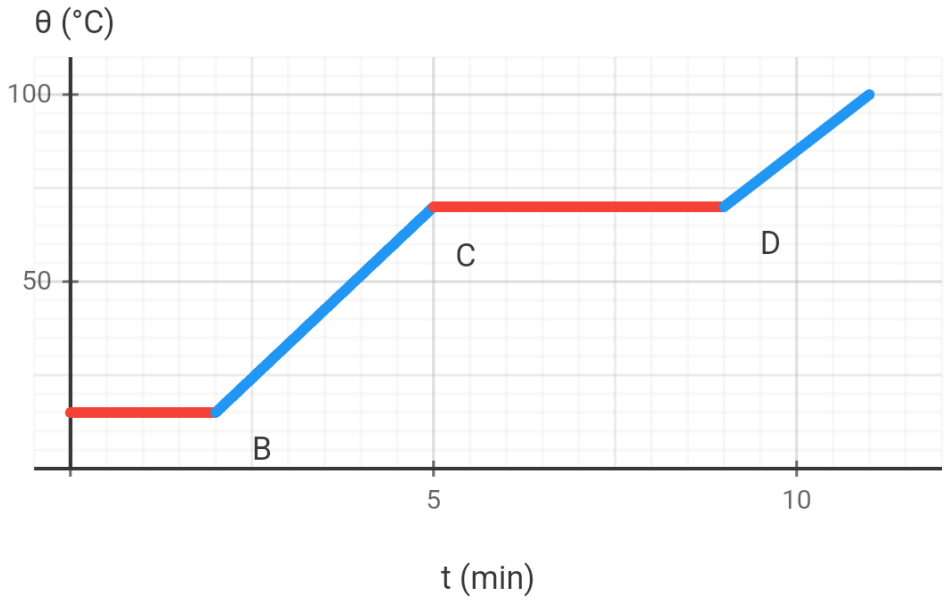
A. Heat is lost from the calorimeter to the surroundings.

B. Some steam condenses in the delivery tube and the resulting water is not collected in the calorimeter.

C. The steam contains water droplets (wet steam).

D. The heat capacity of the calorimeter is neglected in the calculation.

10. A pure substance is heated steadily. Its temperature-time graph is shown below.



During which interval is the substance boiling?

A. AB

B. BC

C. CD

D. DE

答案

1 B

On the Celsius scale the ice point is $0\ ^\circ\text{C}$ and the steam point is $100\ ^\circ\text{C}$.
Temperature is found by linear interpolation:

$$\theta = \frac{L_\theta - L_0}{L_{100} - L_0} \times 100\ ^\circ\text{C}$$

Substitute the given lengths:

$$\theta = \frac{14.0 - 2.0}{22.0 - 2.0} \times 100 = \frac{12.0}{20.0} \times 100 = 60\ ^\circ\text{C}.$$

2 B

Temperature measures the degree of hotness of a body and is directly related to the average kinetic energy of its molecules.
A higher average molecular KE corresponds to a higher temperature on the absolute (kelvin) scale. Total internal energy also depends on the number of molecules and potential energy, so it is not the same as temperature. Heat capacity and mass are separate properties and are not measures of temperature.

3 B

The graph is linear between the fixed points $(5.0\ \text{cm},\ 0\ ^\circ\text{C})$ and $(25.0\ \text{cm},\ 100\ ^\circ\text{C})$.
At $L = 15.0\ \text{cm}$ (midway in length change of $20\ \text{cm}$):

$$\theta = \frac{15 - 5}{25 - 5} \times 100 = \frac{10}{20} \times 100 = 50\ ^\circ\text{C}.$$

Point P therefore marks $50\ ^\circ\text{C}$.

4 D

For an ideal gas, absolute temperature is proportional to the average kinetic energy of the molecules. Heating therefore raises average KE, so statement I is correct.
Since average KE is proportional to c_{rms}^2, the r.m.s. speed also increases; statement II is correct.
At constant volume the pressure rises with temperature (more frequent and harder collisions with the walls); statement III is correct.
All three statements are correct.

5 B

At constant temperature the average kinetic energy of the molecules remains constant; intermolecular forces are neglected for an ideal gas, so internal energy does not change with volume.
Compression decreases volume, so molecular number density rises. Molecules hit the walls more often, therefore pressure increases (Boyle's law $pV = \text{constant}$).

The r.m.s. speed is fixed by temperature and does not change. Mass is constant, so density increases rather than stays constant.

6 C

Electrical energy supplied equals heat gained by the block:
$Pt = mc\Delta T$
$t = 2.0 \times 60 = 120\ \text{s}$
$180 \times 120 = 0.40 \times 900 \times \Delta T$
$21600 = 360\,\Delta T$
$\Delta T = 60\ ^\circ\text{C}.$

7 A

For equal mass and equal heater power, $P = mc\dfrac{\Delta\theta}{\Delta t}$, so $c \propto \dfrac{1}{\text{slope}}$.

Both liquids rise by $50\ ^\circ\text{C}$. P takes $5\ \text{min}$ and Q takes $8\ \text{min}$.

Slope of P : slope of Q = $\dfrac{50}{5} : \dfrac{50}{8} = 10 : 6.25 = 8 : 5.$

Therefore $c_P : c_Q = 5 : 8.$

8 C

The horizontal section QR is the melting process at constant temperature. Its duration is $10 - 4 = 6\ \text{min} = 360\ \text{s}.$

Energy supplied during melting = $Pt = 200 \times 360 = 72000\ \text{J}.$

Specific latent heat of fusion:

$L = \dfrac{Q}{m} = \dfrac{72000}{0.25} = 2.88 \times 10^5\ \text{J kg}^{-1}.$

9 B

Boiling is a change of state from liquid to gas. During boiling, the temperature stays constant even though heat is still being supplied, because the energy goes into separating molecules (increasing potential energy) rather than raising their kinetic energy.
On the graph, look for a plateau (horizontal section) that occurs after the substance has already been heated as a liquid, since boiling can only happen once a substance is a liquid.
Interval AB is a horizontal section at $15\ ^{\circ}\mathrm{C}$ right at the start – this is the substance melting from solid to liquid. Interval BC is a rising section, where the liquid is being heated up. Interval CD is the second horizontal section at $70\ ^{\circ}\mathrm{C}$ – this is where the liquid boils and turns to gas. Interval DE is a rising section where the gas (vapour) is being heated further.
Therefore, the substance is boiling during interval CD.

10 C

Boiling is a change of state from liquid to gas at constant temperature, shown as a horizontal section on a heating curve after the liquid has already been warmed.
The first plateau AB is freezing/melting region only if cooling; here the substance starts at constant temperature then rises—AB is melting of solid at $15\ ^{\circ}\mathrm{C}$. BC is heating of liquid. The second plateau CD at $70\ ^{\circ}\mathrm{C}$ is boiling. DE is heating of vapour.
Therefore boiling occurs during interval CD.