SL Paper 1

A sealed container contains water at 5 °C and ice at 0 °C. This system is thermally isolated from its surroundings. What happens to the total internal energy of the system?

A. It remains the same.

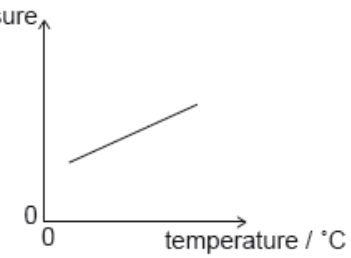
B. It decreases.

C. It increases until the ice melts and then remains the same.

D. It increases.

A fixed mass of an ideal gas is trapped in a cylinder of constant volume and its temperature is varied. Which graph shows the variation of the pressure of the gas with temperature in degrees Celsius?

A.



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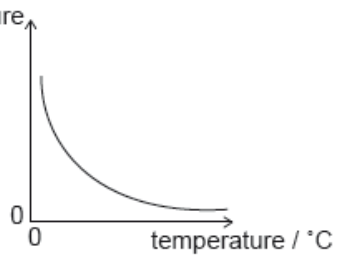

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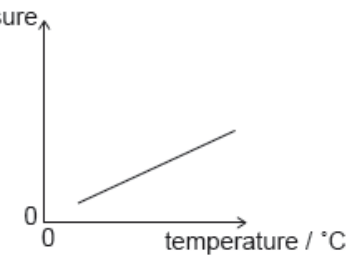

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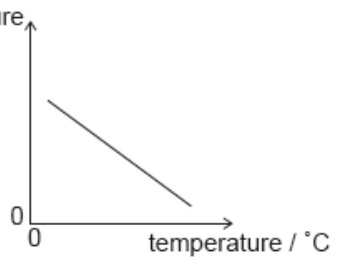


A mass m of ice at a temperature of –5 °C is changed into water at a temperature of 50 °C.

Specific heat capacity of ice = c_i
Specific heat capacity of water = c_w
Specific latent heat of fusion of ice = L

Which expression gives the energy needed for this change to occur?

A. $55\ m\ c_w + m\ L$

B. $55\ m\ c_i + 5\ m\ L$

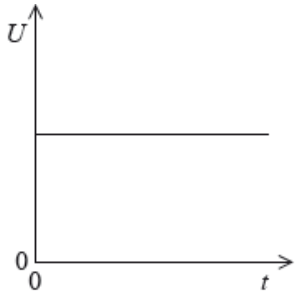
C. $5\ m\ c_i + 50\ m\ c_w + m\ L$

D. $5\ m\ c_i + 50\ m\ c_w + 5\ m\ L$

A system consists of an ice cube placed in a cup of water. The system is thermally insulated from its surroundings. The water is originally at 20 °C.

Which graph best shows the variation of total internal energy U of the system with time t?

A.



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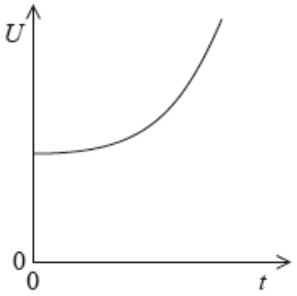

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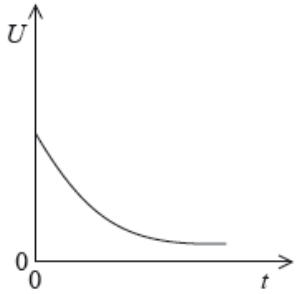

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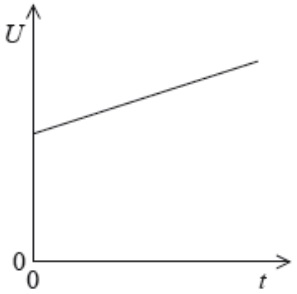


What is the definition of the *mole*?

A. The amount of substance that has the same mass as 6.02×10^{23} atoms of carbon-12.

B. The amount of substance that contains as many nuclei as the number of nuclei in 12 g of carbon-12.

C. The amount of substance that has the same mass as one atom of carbon-12.

D. The amount of substance that contains as many elementary entities as the number of atoms in 12 g of carbon-12.

Which of the following is an assumption made in the kinetic model of ideal gases?

A. Molecules have zero mass.

B. Forces between molecules are attractive.

C. Collisions between molecules are elastic.

D. Molecules move at high speed.

Equal masses of water at 80°C and paraffin at 20°C are mixed in a container of negligible thermal capacity. The specific heat capacity of water is twice that of paraffin. What is the final temperature of the mixture?

A. 30°C

B. 40°C

C. 50°C

D. 60°C

In the kinetic model of an ideal gas, which of the following is **not** assumed?

A. The molecules collide elastically.

B. The kinetic energy of a given molecule is constant.

C. The time taken for a molecular collision is much less than the time between collisions.

D. The intermolecular potential energy of the molecules is zero.

Thermal energy is transferred to a solid. Three properties of the solid are

I. volume
II. mass
III. specific heat capacity.

Which of the above properties determine the rise in temperature of the solid?

A. I and III only
B. II and III only
C. II only
D. III only

Tanya heats 100 g of a liquid with an electric heater which has a constant power output of 60 W. After 100 s the rise in temperature is 40 K. The specific heat capacity of the liquid in $\mathrm{J\,kg^{-1}K^{-1}}$ is calculated from which of the following?

A. $\frac{60\times100}{0.1\times40}$

B. $\frac{60\times0.1}{40}$

C. $\frac{0.1\times40}{60}$

D. $\frac{60}{40}$

Molar mass is defined as

A. the number of particles in one mole of a substance.
B. $\frac{1}{12}$ the mass of one atom of carbon-12.
C. the mass of one mole of a substance.
D. the number of particles in $\frac{1}{12}$ of a mole of carbon-12

Which of the following is equivalent to a temperature of 350 K?

A. –623°C
B. –77°C
C. +77°C
D. +623°C

A liquid-in-glass thermometer is in thermal equilibrium with some hot water. The thermometer is left in the water. The water cools to the temperature of the surroundings. Which of the following is **unlikely to be true** for the thermometer?

A. It is in thermal equilibrium with the water.
B. It is in thermal equilibrium with the surroundings.
C. It is at the same temperature as the water.
D. It has the same thermal capacity as the water.

A solid of mass m is initially at temperature ΔT below its melting point. The solid has specific heat capacity c and specific latent heat of fusion L. How much thermal energy must be transferred to the solid in order to melt it completely?

A. $mL+mc$
B. $mc+mL\Delta T$
C. $mc\Delta T+L\Delta T$
D. $mc\Delta T+mL$

A pure solid is heated at its melting point. While it is melting the

A. mean kinetic energy of the molecules of the solid increases.
B. mean potential energy of the molecules of the solid increases.
C. temperature of the solid increases.
D. temperature of the solid decreases.

Which of the following is an assumption of the kinetic model of an ideal gas?

A. The gas is at high pressure.

B. There are weak forces of attraction between the particles in the gas.

C. The collisions between the particles are elastic.

D. The energy of the particles is proportional to the absolute temperature.

A container holds 40 g of argon-40 $\left({}^{40}_{18}\mathrm{Ar}\right)$ and 8 g of helium-4 $\left({}^{4}_{2}\mathrm{He}\right)$.

What is the $\frac{\text{number of atoms of argon}}{\text{number of atoms of helium}}$ in the container?

A. $\frac{1}{2}$

B. $\frac{2}{9}$

C. $\frac{2}{1}$

D. $\frac{9}{2}$

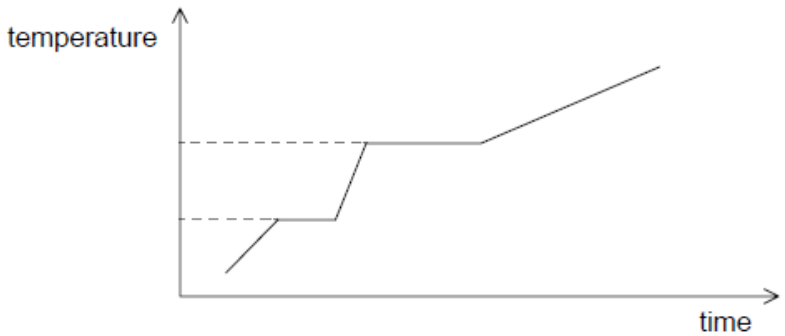
The following can be determined for a solid substance.

I. The average kinetic energy $E_{\mathrm{K_{ave}}}$ of the molecules
II. The total kinetic energy $E_{\mathrm{K_{tot}}}$ of the molecules
III. The total potential energy $E_{\mathrm{P_{tot}}}$ of the molecules

Which is/are equal to the internal energy of this solid substance?

A. I only
B. I and III only
C. II only
D. II and III only

Energy is supplied at a constant rate to a fixed mass of a material. The material begins as a solid. The graph shows the variation of the temperature of the material with time.



The specific heat capacities of the solid, liquid and gaseous forms of the material are c_s c_l and c_g respectively. What can be deduced about the values of c_s c_l and c_g?

A. $c_s > c_g > c_l$
B. $c_l > c_s > c_g$
C. $c_l > c_g > c_s$
D. $c_g > c_s > c_l$

The mole is defined as

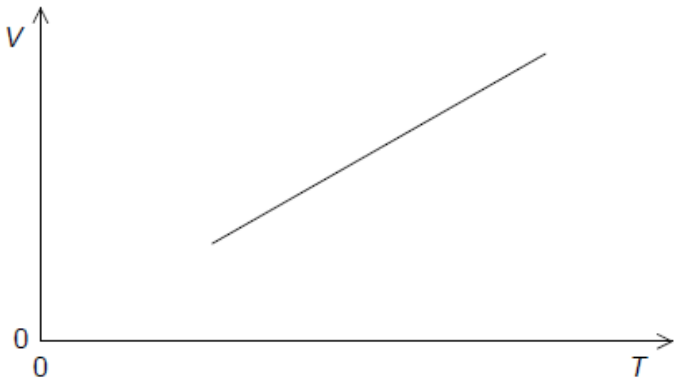
A. $\frac{1}{12}$ the mass of an atom of the isotope carbon-12.

B. the amount of a substance that contains as many elementary entities as the number of atoms in 12 g of the isotope carbon-12.

C. the mass of one atom of the isotope carbon-12.

D. the amount of a substance that contains as many nuclei as the number of nuclei in 12 g of the isotope carbon-12.

An ideal gas of *N* molecules is maintained at a constant pressure *p*. The graph shows how the volume *V* of the gas varies with absolute temperature *T*.



What is the gradient of the graph?

A. $\frac{N}{p}$

B. $\frac{NR}{p}$

C. $\frac{Nk_{\mathrm{B}}}{p}$

D. $\frac{N}{Rp}$

A temperature of 23 K is equivalent to a temperature of

A. -300 °C.

B. -250 °C.

C. $+250$ °C.

D. $+300$ °C.

A block of iron of mass 10 kg and temperature 10°C is brought into contact with a block of iron of mass 20 kg and temperature 70°C. No energy transfer takes place except between the two blocks. What will be the final temperature of both blocks?

A. 30°C
B. 40°C
C. 50°C
D. 60°C

What are the units of the ratio $\frac{\text{specific heat capacity of copper}}{\text{specific latent heat of vaporization of copper}}$?

A. no units

B. k

C. k^{-1}

D. k^{-2}

Two objects are in thermal contact and are at different temperatures. What is/are determined by the temperatures of the two objects?

I. The direction of thermal energy transfer between the objects

II. The quantity of internal energy stored by each object

III. The process by which energy is transferred between the objects

A. I only

B. II only

C. I and II only

D. I, II and III

When 1800 J of energy is supplied to a mass *m* of liquid in a container, the temperature of the liquid and the container changes by 10 K. When the mass of the liquid is doubled to 2*m*, 3000 J of energy is required to change the temperature of the liquid and container by 10 K. What is the specific heat capacity of the liquid in $\mathrm{J\,kg^{-1}K^{-1}}$?

A. $\frac{60}{m}$

B. $\frac{120}{m}$

C. $\frac{180}{m}$

D. $\frac{240}{m}$

Under what conditions of density and pressure is a real gas best described by the equation of state for an ideal gas?

A. Low density and low pressure

B. Low density and high pressure

C. High density and low pressure

D. High density and high pressure

A sealed container contains a mixture of oxygen and nitrogen gas.

The ratio $\frac{\text{mass of an oxygen molecule}}{\text{mass of a nitrogen molecule}}$ is $\frac{8}{7}$.

The ratio $\frac{\text{average kinetic energy of oxygen molecules}}{\text{average kinetic energy of nitrogen molecules}}$ is

A. 1.

B. $\frac{7}{8}$.

C. $\frac{8}{7}$.

D. dependent on the concentration of each gas.

In the kinetic model of an ideal gas, it is assumed that

A. the forces between the molecules of the gas and the container are always zero.

B. the intermolecular potential energy of the molecules of the gas is constant.

C. the kinetic energy of a given molecule of the gas is constant.

D. the momentum of a given molecule of the gas is constant.

The specific latent heat of a substance is defined as the energy required at constant temperature to

A. change the phase.
B. change the phase of 1 kg.
C. change the phase of 1 m^3.
D. change the phase of 1 kg every second.

A fixed mass of an ideal gas in a closed container with a movable piston initially occupies a volume *V*. The position of the piston is changed, so that the mean kinetic energy of the particles in the gas is doubled and the pressure remains constant.

What is the new volume of the gas?

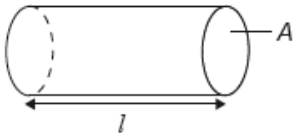
A. $\frac{V}{4}$

B. $\frac{V}{2}$

C. 2*V*

D. 4*V*

A sealed cylinder of length *l* and cross-sectional area *A* contains *N* molecules of an ideal gas at kelvin temperature *T*.



What is the force acting on the area of the cylinder marked *A* due to the gas?

A. $\frac{NRT}{l}$

B. $\frac{NRT}{lA}$

C. $\frac{Nk_BT}{lA}$

D. $\frac{Nk_BT}{l}$

Which of the following is equivalent to a temperature of –100°C?

A. –373 K

B. –173 K

C. 173 K

D. 373 K

What is the temperature, in K, that is equivalent to 57°C?

A. 220
B. 273
C. 330
D. 430

The volume of an ideal gas in a container is increased at constant temperature. Which of the following statements is/are correct about the molecules of the gas?

I. Their average speed remains constant.
II. The frequency of collisions of molecules with unit area of the container wall decreases.
III. The force between them decreases.

A. I only
B. I and II only
C. I and III only
D. II and III only

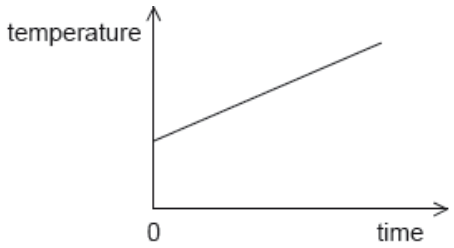
A container that contains a fixed mass of an ideal gas is at rest on a truck. The truck now moves away horizontally at a constant velocity. What is the change, if any, in the internal energy of the gas and the change, if any, in the temperature of the gas when the truck has been travelling for some time?

	Change in internal energy	Change in temperature
A.	unchanged	unchanged
B.	unchanged	increased
C.	increased	unchanged
D.	increased	increased

A mass of 0.20 kg of water at 20°C is mixed with 0.40 kg of water at 80°C. No thermal energy is transferred to the surroundings. What is the final temperature of the mixture?

A. 30°C
B. 40°C
C. 50°C
D. 60°C

The graph shows how the temperature of a liquid varies with time when energy is supplied to the liquid at a constant rate *P*. The gradient of the graph is *K* and the liquid has a specific heat capacity *c*.



What is the mass of the liquid?

A. $\frac{P}{cK}$
B. $\frac{PK}{c}$
C. $\frac{Pc}{K}$
D. $\frac{cK}{P}$

Oil with volume *V* has specific heat capacity *c* at temperature *T*. The density of oil is *ρ*. Which of the following is the thermal capacity of the oil?

A. *ρcV*
B. $\frac{cV}{\rho}$
C. *ρcVT*
D. $\frac{cV}{\rho T}$

What is the mass of carbon-12 that contains the same number of atoms as 14 g of silicon-28?

A. 6 g
B. 12 g
C. 14 g
D. 24 g

What does the constant n represent in the equation of state for an ideal gas $pV = nRT$?

A. The number of atoms in the gas

B. The number of moles of the gas

C. The number of molecules of the gas

D. The number of particles in the gas

The temperature of an object is -153°C. Its temperature is raised to 273°C. What is the temperature change of the object?

A. 699 K
B. 426 K
C. 153 K
D. 120 K

Carbon has a relative atomic mass of 12 and oxygen has a relative atomic mass of 16. A sample of 6 g of carbon has twice as many atoms as

A. 32 g of oxygen.

B. 8 g of oxygen.

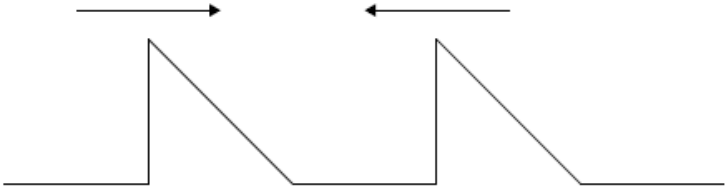
C. 4 g of oxygen.

D. 3 g of oxygen.

In the table below, which row shows the correct conversion between the Kelvin and Celsius temperature scales?

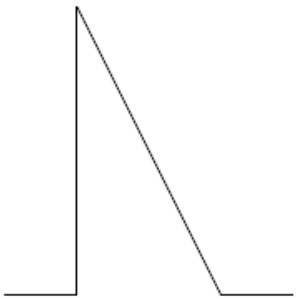
	Kelvin temperature / K	Celsius temperature / °C
A.	0	373
B.	100	−173
C.	173	100
D.	373	−100

Two pulses are travelling towards each other.



What is a possible pulse shape when the pulses overlap?

A.



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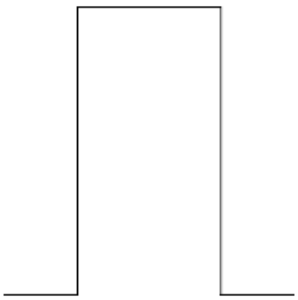
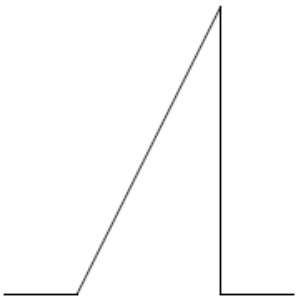
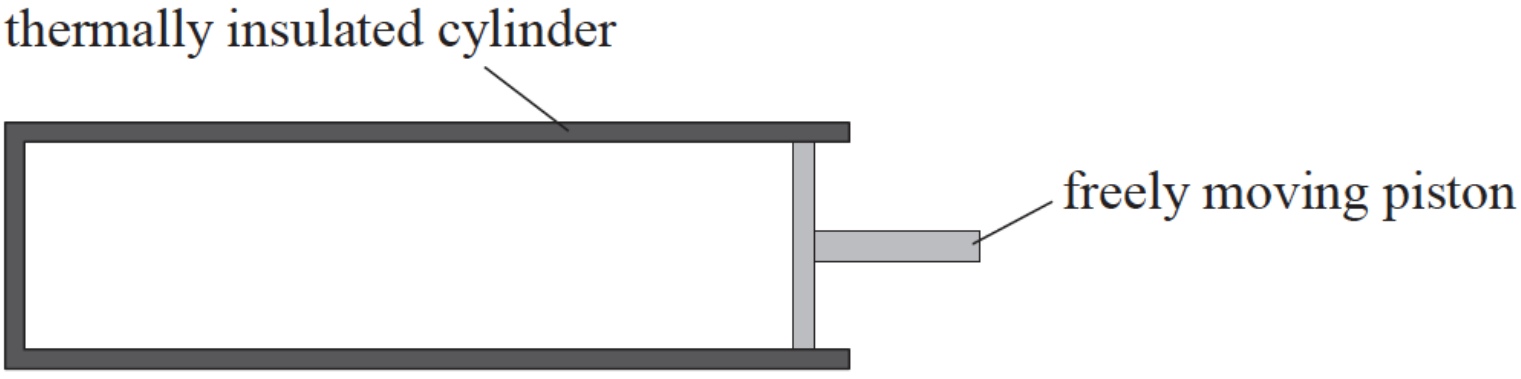


C.

D.



An ideal gas is contained in a thermally insulated cylinder by a freely moving piston.



The gas is compressed by the piston and as a result the temperature of the gas increases. What is the explanation for the temperature rise?

A. The rate of collision between the molecules increases.
B. Energy is transferred to the molecules by the moving piston.
C. The molecules of the gas are pushed closer together.
D. The rate of collision between the molecules and the walls of the cylinder increases.

An ideal gas has an absolute temperature T. The average random kinetic energy of the molecules of the gas is

A. independent of T.

B. equal to T.

C. proportional to T.

D. inversely proportional to T.

The total potential energy and random kinetic energy of the molecules of an object is equal to the

A. heat energy in the object.

B. internal energy of the object.

C. thermal energy in the object.

D. work stored in the object.

Two objects are in thermal contact, initially at different temperatures. Which of the following determines the transfer of thermal energy between the objects?

I. The mass of each object
II. The thermal capacity of the objects
III. The temperature of the objects

A. I only

B. I and II only

C. II and III only

D. III only

A 1.0 kW heater supplies energy to a liquid of mass 0.50 kg. The temperature of the liquid changes by 80 K in a time of 200 s. The specific heat capacity of the liquid is 4.0 kJ kg^{-1} K^{-1}. What is the average power lost by the liquid?

A. 0

B. 200 W

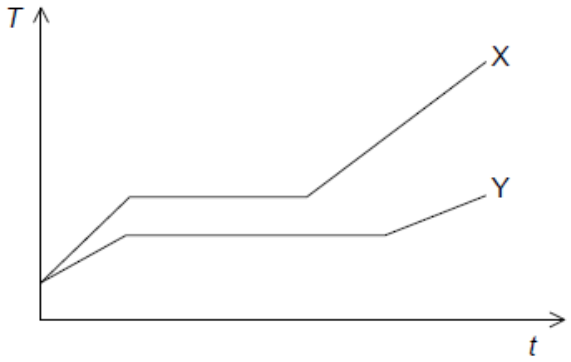
C. 800 W

D. 1600 W

Under what conditions of pressure and temperature does a real gas approximate to an ideal gas?

	Pressure	Temperature
A.	high	high
B.	high	low
C.	low	high
D.	low	low

The graph shows the variation with time t of the temperature T of two samples, X and Y. X and Y have the same mass and are initially in the solid phase. Thermal energy is being provided to X and Y at the same constant rate.



What is the correct comparison of the specific latent heats L_X and L_Y and specific heat capacities in the liquid phase c_X and c_Y of X and Y?

A.	$L_X > L_Y$	$c_X > c_Y$
B.	$L_X > L_Y$	$c_X < c_Y$
C.	$L_X < L_Y$	$c_X > c_Y$
D.	$L_X < L_Y$	$c_X < c_Y$

Which of the following is **not** an assumption of the kinetic model of ideal gases?

A. All particles in the gas have the same mass.

B. All particles in the gas have the same speed.

C. The duration of collisions between particles is very short.

D. Collisions with the walls of the container are elastic.

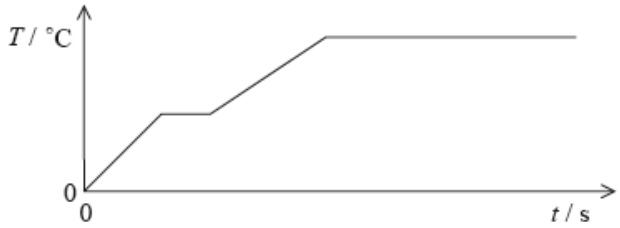
The pressure of a fixed mass of an ideal gas in a container is decreased at constant temperature. For the molecules of the gas there will be a decrease in

A. the mean square speed.
B. the number striking the container walls every second.
C. the force between them.
D. their diameter.

A solid piece of tungsten melts into liquid without a change in temperature. Which of the following is correct for the molecules in the liquid phase compared with the molecules in the solid phase?

	Kinetic energy	Potential energy
A.	same	greater
B.	same	same
C.	greater	greater
D.	greater	same

Thermal energy is added at a constant rate to a substance which is solid at time $t = 0$. The graph shows the variation with t of the temperature T.



Which of the statements are correct?

I. The specific latent heat of fusion is greater than the specific latent heat of vaporization.

II. The specific heat capacity of the solid is less than the specific heat capacity of the liquid.

A. I only

B. I and II

C. II only

D. Neither I nor II

The energy of the molecules of an ideal gas is

A. thermal only.

B. thermal and potential.

C. potential and kinetic.

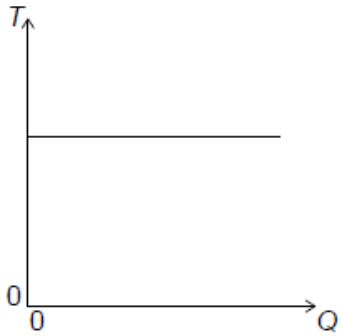
D. kinetic only.

The internal energy of any substance is made up of the

A. total random kinetic and potential energy of its molecules.
B. total potential energy of its molecules.
C. total random kinetic energy of its molecules.
D. total vibrational energy of its molecules.

A liquid is initially at its freezing point. Energy is removed at a uniform rate from the liquid until it freezes completely.

Which graph shows how the temperature *T* of the liquid varies with the energy *Q* removed from the liquid?

A.


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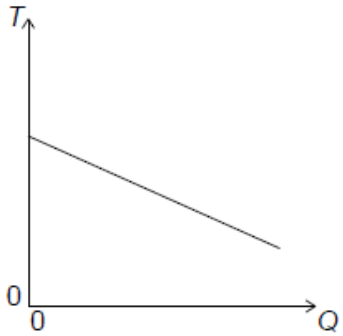
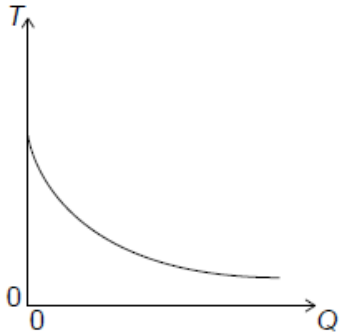


C.


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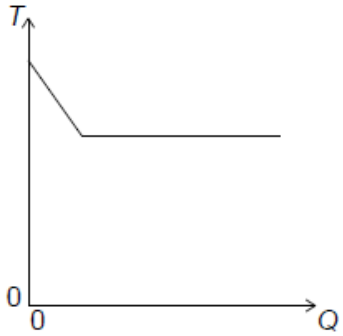
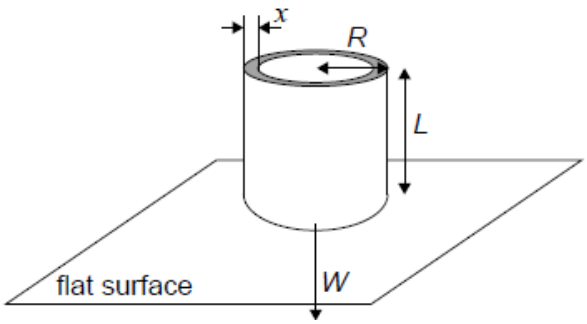


A thin-walled cylinder of weight *W*, open at both ends, rests on a flat surface. The cylinder has a height *L*, an average radius *R* and a thickness *x* where *R* is much greater than *x*.



What is the pressure exerted by the cylinder walls on the flat surface?

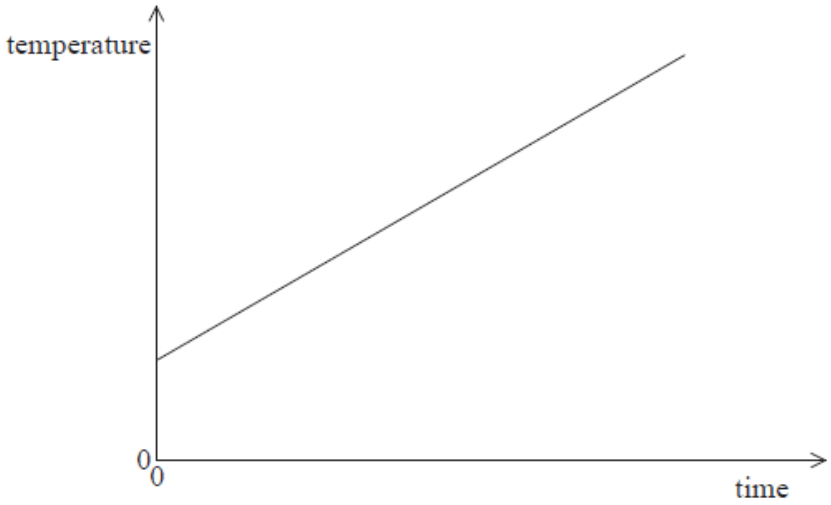
A. $\frac{W}{2\pi Rx}$

B. $\frac{W}{\pi R^2 x}$

C. $\frac{W}{\pi R^2}$

D. $\frac{W}{\pi R^2 L}$

A heater of constant power heats a liquid of mass *m* and specific heat capacity *c*. The graph below shows how the temperature of the liquid varies with time.



The gradient of the graph is k and no energy is lost to the surroundings. What is the power of the heater?

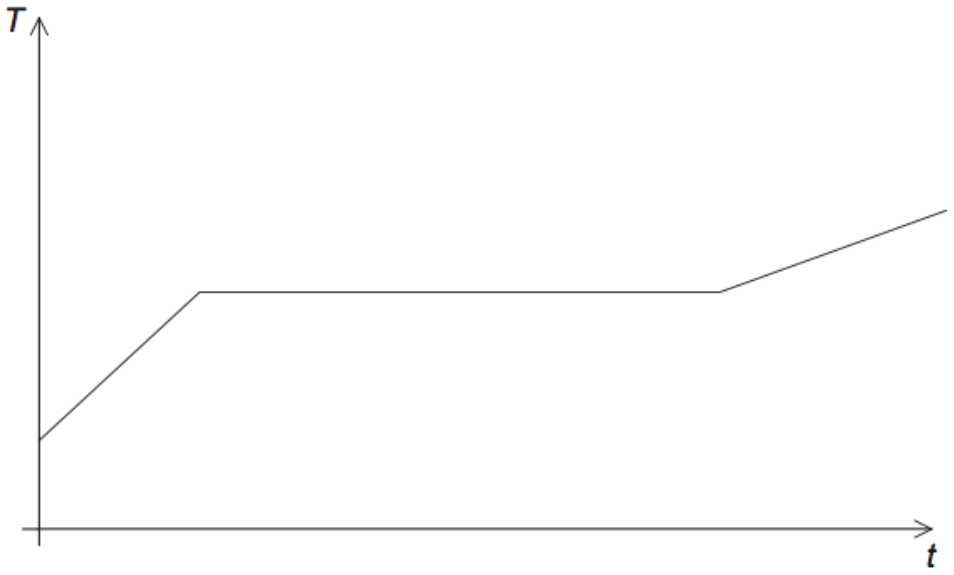
A. *kmc*

B. $\frac{k}{mc}$

C. $\frac{mc}{k}$

D. $\frac{1}{kmc}$

A substance is heated at constant power. The graph shows how the temperature *T* of the substance varies with time *t* as the state of the substance changes from liquid to gas.



What can be determined from the graph?

A. The specific heat capacity of the gas is smaller than the specific heat capacity of the liquid.

B. The specific heat capacity of the gas is larger than the specific heat capacity of the liquid.

C. The specific latent heat of fusion of the substance is less than its specific latent heat of vaporization.

D. The specific latent heat of fusion of the substance is larger than its specific latent heat of vaporization.

A fixed mass of water is heated by an electric heater of unknown power *P*. The following quantities are measured

I. mass of water
II. increase in water temperature
III. time for which water is heated.

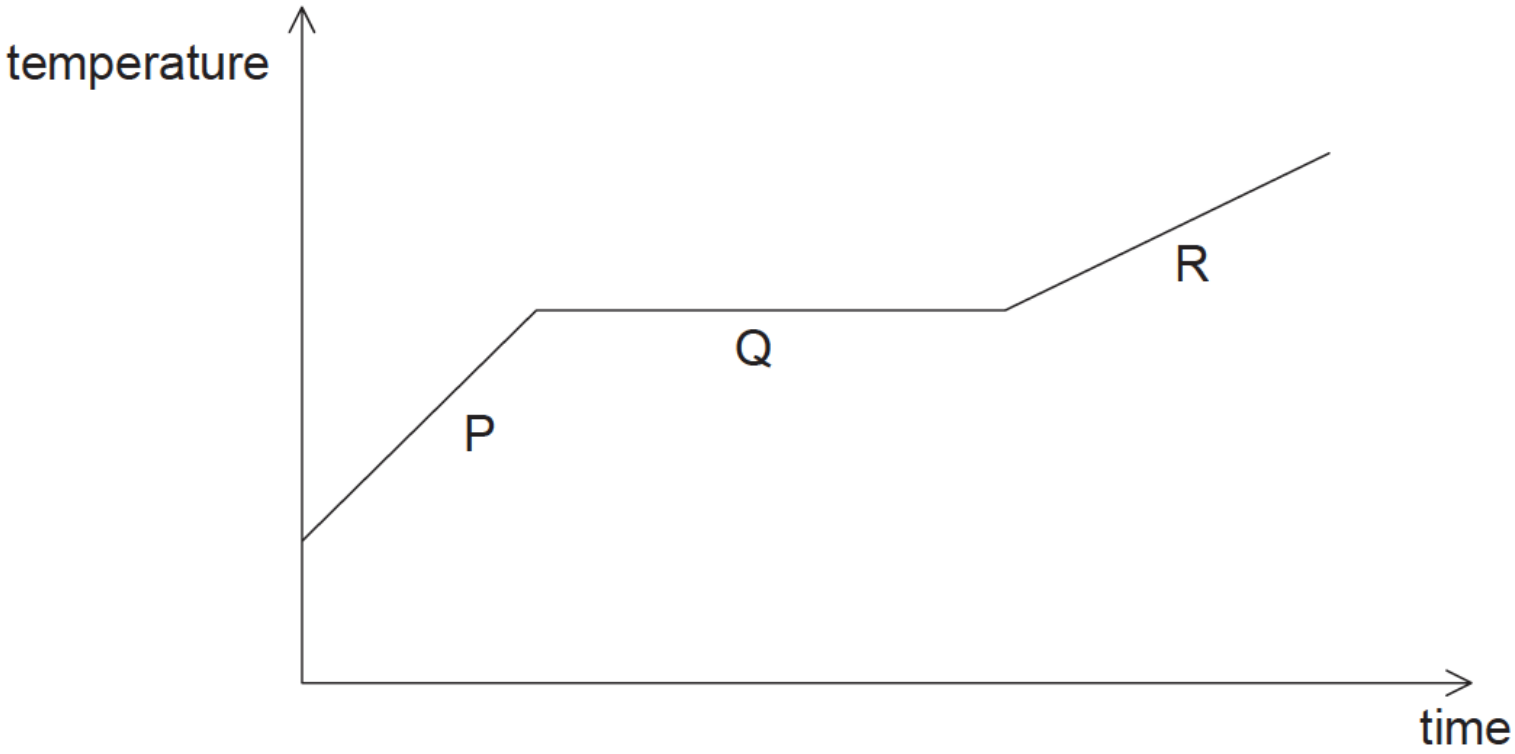
In order to calculate *P*, the specific heat capacity of the water is required. Which are also required?

A. I and II only
B. I and III only
C. II and III only
D. I, II and III

The specific latent heat is the energy required to change the phase of

A. one kilogram of a substance.
B. a substance at constant temperature.
C. a liquid at constant temperature.
D. one kilogram of a substance at constant temperature.

A sample of solid copper is heated beyond its melting point. The graph shows the variation of temperature with time.



During which stage(s) is/are there an increase in the internal energy of the copper?

A. P, Q and R

B. Q only

C. P and R only

D. Q and R only

Molecules leave a boiling liquid to form a vapour. The vapour and the liquid have the same temperature.

What is the change of the average potential energy and the change of the average random kinetic energy of these molecules when they move from the liquid to the vapour?

	Average potential energy	Average random kinetic energy
A.	increases	increases
B.	increases	no change
C.	no change	increases
D.	no change	no change