TEMPERATURE

Challenging **MCQ** questions by The Physics Cafe

Compiled and selected by The Physics Cafe

1 Argon and chlorine are gases. One mole of argon has mass 40 g and one mole of chlorine has mass 71 g.

What is the ratio of the $\frac{Number\ of\ atoms\ in\ 1\ mole\ of\ argon}{Number\ of\ molecules\ in\ 1\ mole\ of\ chlorine}$

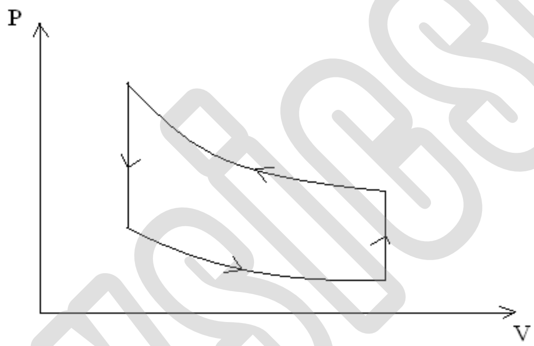
A 0.56

B 1

C 1.8

D 2

2 An ideal gas undergoes a cycle of processes as shown in the P-V diagram below.



Which statement correctly describes the situation?

A The internal energy of the gas increases over one complete cycle.

B The gas gives out more heat than it absorbs over the whole cycle.

C Over the entire cycle, the gas absorbs heat and does network on its environment.

D The two curved portions of the graph represent adiabatic process.

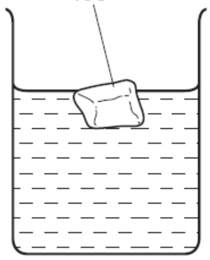
3 Equal masses of four different liquids (A, B, C and D) at 20°C are separately heated at the same rate. Their boiling points and specific heat capacities are as shown in the table below.

Liquid	Boiling Point / °C	Specific Heat Capacity / J kg^{-1} K^{-1}
A	50	1000
B	60	530
C	80	850
D	360	140

Which liquid will be the last to boil?

A Liquid A **B** Liquid B **C** Liquid C **D** Liquid D

4 The diagram shows an ice cube floating in water.



Both the ice cube and the water are at 0 °C. Which statement correctly compares the molecular properties of the ice and those of the water?

A The mean kinetic energies are the same for both the ice molecules and the water molecules.

B The mean inter-molecular separations are the same for both the ice and the water.

C The mean inter-molecular potential energies are the same for both the ice molecules and the water molecules.

D The mean total energies are the same for both the ice molecules and the water molecules.

5 Four different solids A, B, C and D of equal masses at 20 °C are separately heated at the same rate. Their melting points and specific heat capacities are as shown in the table below.

Which of these solids will start to melt first?

Liquid	Melting point / °C	Specific heat capacity / J kg^{-1} K^{-1}
A	80	1200
B	100	800
C	150	600
D	300	250

6 Container X contains neon gas and container Y contains argon gas. Container X has twice the volume of container Y. The temperatures of the gases in both containers are the same. What is the ratio of the mean kinetic energy of a neon atom to the mean kinetic energy of an argon atom?
[The relative atomic masses of neon and argon are 20 and 40 respectively.]

A 0.5 **B** 1 **C** 2 **D** 4

7 A cup contains 300 g of freshly brewed tea at 93°C. It cools at an average rate of 60 W and the heat capacity of tea is 1250 J K^{-1}.The tea is best consumed before it cools below 45°C.
What is the maximum amount of time a student has to enjoy his cup of freshly brewed tea?

A 300 s **B** 1000 s **C** 3300 s **D** 3600 s

8 Which statement about internal energy of an ideal gas is correct?

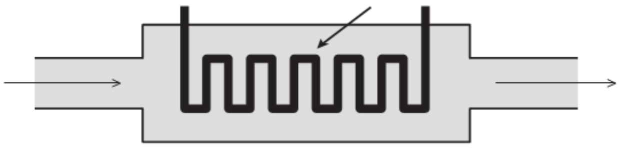
A It is the sum of kinetic energies due to random motion of gas particles.

B It is the sum of potential energies due to intermolecular attraction of gas particles.

C It is the sum of kinetic energies due to random motion and potential energies due to intermolecular attraction of gas particles.

D It is the average of kinetic energies due to random motion and potential energies due to intermolecular attraction of gas particles.

9 The power of an electrical immersion heater is 22.0 kW. Water flows through the heater at a rate of 0.12 kg s^{-1} as shown below.



The temperature of the water flowing into the heater is 25.0 °C and the temperature of the water flowing out of the heater is 40.0 °C.

Given that the specific heat capacity of water = 4200 J $kg^{-1}K^{-1}$, calculate the rate of heat lost to the surrounding.

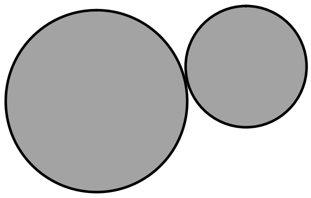
A 1.8 kW

B 5.6 kW

C 9.4 kW

D 14 kW

10 Two copper spheres of different radii are in thermal equilibrium as shown.



Which statement *must* be correct?

A Each sphere has the same internal energy.

B There is a no net transfer of thermal energy between the spheres.

C Both spheres have the same heat capacity.

D The larger sphere has a greater mean internal energy per atom than the smaller one.

11 A vapour lamp emits light when its temperature is 3000 K but not when its temperature is 300 K.

Assuming the vapour to be a monoatomic ideal gas, which of the following statements is **false**?

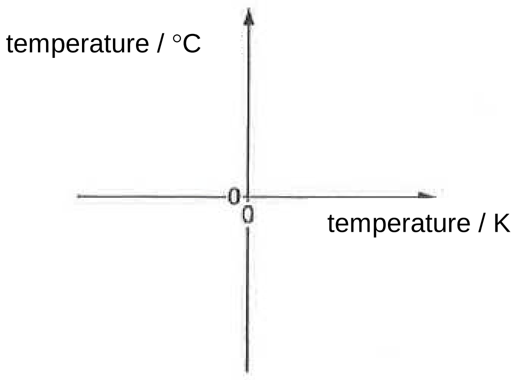
A At 3000 K, the average kinetic energy per molecule is 10 times greater than at 300 K.

B At 300 K, molecules have insufficient kinetic energy to cause excitation by collision.

C The vapour molecules excited by collision release photons when they return to the ground state.

D The molecules in the heated vapour lamp have a range of speeds but a mean kinetic energy of 0.0388 eV.

12 A student draws a linear graph on the axes shown in order to convert temperatures in kelvin to temperatures in degrees Celsius.



What is the intercept on the vertical axis and the gradient of the line?

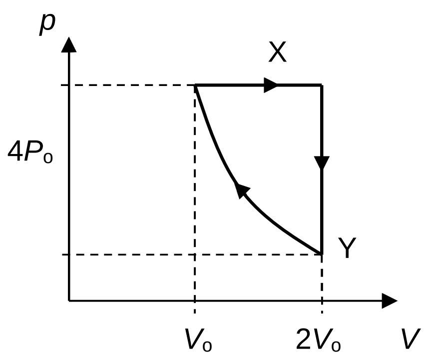
	intercept	gradient
A	0	1/273
B	-273	1
C	+273	1
D	0	273

13 The temperature of a hot liquid in a container of negligible heat capacity falls at a rate of 2 K per minute just before it begins to solidify. The temperature then remains steady for 20 minutes by which the liquid has all solidified.

What is the value of the ratio $\dfrac{\text{specific heat capacity of the liquid}}{\text{specific latent heat of fusion}}$?

A $\dfrac{1}{40}\,K^{-1}$ **B** $\dfrac{1}{10}\,K^{-1}$ **C** $10\,K^{-1}$ **D** $40\,K^{-1}$

14 A fixed mass of an ideal gas undergoes a constant pressure expansion to double its initial volume (process X). Its pressure is then reduced to a quarter of the original value at constant volume (process Y). The gas is then returned to its original internal energy in process Z as shown in the *p*-*V* graph below.



Which of the following statements is **false**?

A Temperature of the gas in degree Celsius is doubled in process Z.

B Heat is supplied to the gas in process X.

C Heat is removed from the gas in process Y.

D The net work done by the gas is positive and less than $3P_oV_o$.

15 Fig. 12 shows an arrangement that is used to measure the density of sand. The air in the cylinder is forced into the flask and the air pressure in the flask is measured by the pressure gauge P after the compression. The final pressure of the air in the flask is 140 kPa.

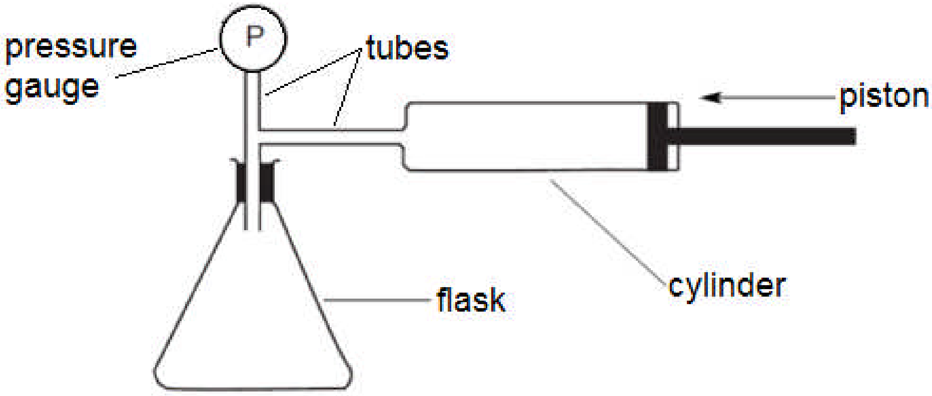


Fig. 12

The process is then repeated with 25 g of sand present in the flask. The final pressure of the air in the flask is 150 kPa.

Both processes are achieved at constant temperature,

Given that the volume of the empty flask is 2.50×10^{-4} m^3, what is the density of this amount of sand?

A 100 kg m^{-3}

B 107 kg m^{-3}

C 1400 kg m^{-3}

D 1500 kg m^{-3}

TEMPERATURE WORKED SOLUTIONS

Challenging **MCQ** questions by The Physics Cafe

Compiled and selected by The Physics Cafe

1 Ans: **B**
The Avogadro number is a constant.

2 Ans: **B**
As can be seen from the area under the graph, there is more work done on the gas than by the gas when expanding, hence, there is net heat loss by the gas each cycle.

3 Ans: **C**
By considering $Q = mc\Delta\theta$

4 Ans: **A**

As the ice and the water are at the same temperature, they have the same mean kinetic energy.
C is wrong as distance between molecules in ice is less than water. Hence inter-molecular potential energy of ice is less than water.
B is wrong as explained in A.
D is wrong as the ice and the water have different inter-molecular potential energy, they do not have the same total energy.

5 Ans: **B**
$Q = mc\Delta\Theta$
$= m(800)(100\text{-}20) = 64\,000m$ for **B**.
The heat required for liquid **B** to reach melting point is the lowest.

6 Ans: **B**
KE α T for ideal gas, since T is the same for both gases, mean KE is the same for both gases.

7 Ans: **B**

8 Ans: **A**

9 Ans: **D**

10 Ans: **B**

11 Ans: **D**

12 Ans: **B**
K = °C + 273.15
°C = K – 273.15
Therefore the graph is a straight line with gradient 1, and y-intercept of -273.15

13 Ans: **A**

For cooling, rate of heat loss $\frac{Q}{t}=\frac{mc\Delta\theta}{t}=mc(2)$ Jmin^{-1}

For solidification,
rate of heat loss is

$$\frac{Q}{t}=\frac{mL_f}{t}$$

$$mc(2)=\frac{mL_f}{20}$$

$$\frac{c}{L_f}=\frac{1}{40}$$

14 Ans: **A**

Process	Q (heat supplied to gas)	W (work done on gas)	U (increase in internal energy)
X	+ve	-ve	+ve
Y	-ve	0	-ve
Z	+ve	+ve	+ve
Net	+ve	-ve	0

Option A is false since only the thermodynamic temperature of the gas is doubled ($U=\frac{3}{2}nRT=\frac{3}{2}pV$ for ideal gas).

Note:
It is difficult but possible to deduce the sign of Q in process Z;
it requires using knowledge beyond the syllabus.

15 Ans: **D**

$p_1V_1 = p_2V_2 = nRT$

$(140 \times 10^3)(2.50 \times 10^{-4}) = (150 \times 10^3)V_2$

$V_2 = 2.33 \times 10^{-4}$ m^3

change in volume = $(2.50 – 2.33) \times 10^{-4} = 1.67 \times 10^{-5}$ m^3

density of sand = $\frac{0.025}{1.67\times10^{-5}}$ = 1500 kg m^{-3}