6 A fixed mass of gas occupies a volume V. The temperature of the gas increases so that the root mean square velocity of the gas molecules is doubled.
What will the new volume be if the pressure remains constant?

A	$\frac{V}{2}$	☐
B	$\frac{V}{\sqrt{2}}$	☐
C	$2V$	☐
D	$4V$	☒

$pV = \frac{1}{3} N m (c_{rms})^2$

$V \propto (c_{rms})^2$

$c_{rm} \times 2 \Rightarrow$

$V \times 4$

(Total 1 mark)

7 (a) 'The pressure of an ideal gas is inversely proportional to its volume', is an incomplete statement of Boyle's law.

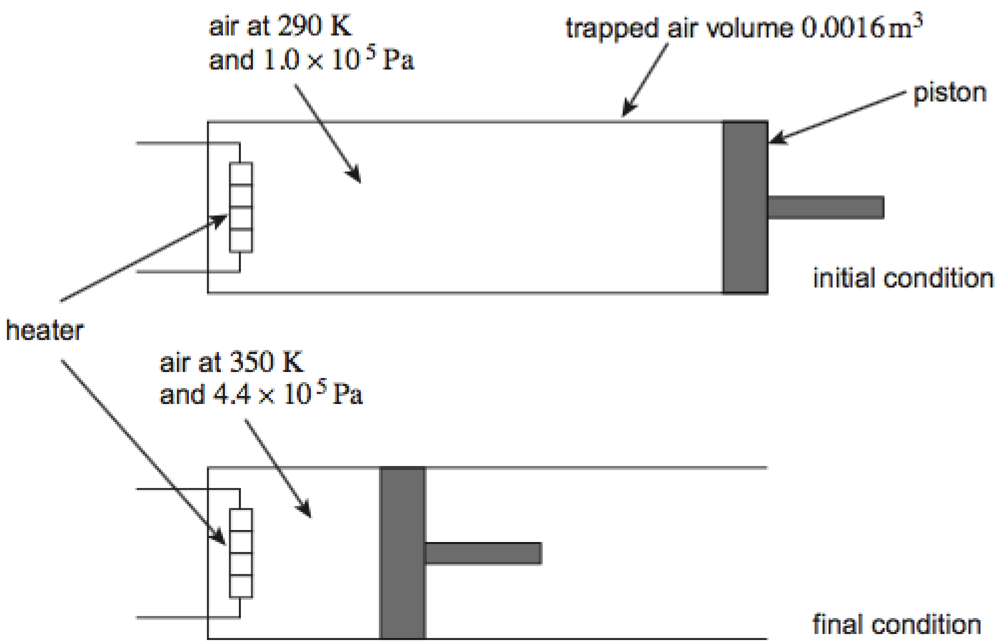
State **two** conditions necessary to complete the statement.

1. Fixed mass

2. Fixed T

(2)

(b) A volume of 0.0016 m^3 of air at a pressure of 1.0×10^5 Pa and a temperature of 290 K is trapped in a cylinder. Under these conditions the volume of air occupied by 1.0 mol is 0.024 m^3. The air in the cylinder is heated and at the same time compressed slowly by a piston. The initial condition and final condition of the trapped air are shown in the diagram.



In the following calculations treat air as an ideal gas having a molar mass of 0.029 kg mol^{-1}.

(i) Calculate the final volume of the air trapped in the cylinder.

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \Rightarrow \frac{P_1V_1T_2}{P_2} = V_2$$

volume of air = 4.4×10^{-4} m^3

(2)

$$\frac{1\times10^5 \times 350}{290} \frac{\times 0.0016}{\times 4.4\times10^5}$$

(ii) Calculate the number of moles of air in the cylinder.

initial conditions give 1 mol = 0.024 m^3

we have 0.0016 m^3 ∴ mols = $\frac{0.0016}{0.024}$

number of moles = 0.067

(1)

(iii) Calculate the initial density of air trapped in the cylinder.

$\rho = \frac{m}{V} = \frac{0.067 \times 0.029}{0.0016}$

density = 1.2 kg m^{-3}

(2)

(c) State and explain what happens to the speed of molecules in a gas as the temperature increases.

As T up the root mean square speed up
You must mention mean/average/rms as there is a range of speeds
(3/2)kT = 0.5m(crms)^2

(2)

(Total 9 marks)

8 (a) Lead has a specific heat capacity of 130 J kg^{-1} K^{-1}.

Explain what is meant by this statement.

130J of energy to raise 1Kg by 1K with no state change

(1)

(b) Lead of mass 0.75 kg is heated from 21 °C to its melting point and continues to be heated until it has all melted.

Calculate how much energy is supplied to the lead.
Give your answer to an appropriate number of significant figures.

melting point of lead = 327.5 °C
specific latent heat of fusion of lead = 23 000 J kg^{-1}

$mc\Delta\theta + mL$

$0.75 \times 130 \times (327.5 - 21) + 0.75 \times 23{,}000$

technically you should take away temp in kelvin of course, but you will get the same value for temp change

energy supplied 47K J

(3)

(Total 4 marks)

9 (a) Define the Avogadro constant.

Number of atoms in 1 mole of an element

(1)

(b) (i) Calculate the mean kinetic energy of krypton atoms in a sample of gas at a temperature of 22 °C.

$\frac{3}{2}kT = \frac{1}{2}m(c_{rms})^2$

$\frac{3}{2}k \times (22 + 273)$

1.38×10^{-23}

mean kinetic energy 6.1×10^{-21} J

(1)

(ii) Calculate the mean-square speed, $(c_{rms})^2$, of krypton atoms in a sample of gas at a temperature of 22 °C.
State an appropriate unit for your answer.

mass of 1 mole of krypton = 0.084 kg

$\frac{3}{\cancel{2}} kT = \frac{1}{\cancel{2}} m (c_{rms})^2$

$\frac{3kT}{m} = (c_{rms})^2$ $m = \frac{0.084 \text{ kg}}{N_A}$

mean-square speed 8.8×10^6 unit m^2/s^{-2}

(3)

(c) A sample of gas consists of a mixture of krypton and argon atoms.
The mass of a krypton atom is greater than that of an argon atom.
State and explain how the mean-square speed of krypton atoms in the gas compares with that of the argon atoms at the same temperature.

Both have same average Ek. So the higher mass the less the crms. Krypton slower

$m \propto \frac{1}{(c_{rms})^2}$ $\leftarrow$ $\left[\cancel{\frac{3}{2}} \cancel{kT} = \cancel{\frac{1}{2}} m (c_{rms})^2 \right.$

(2)

(Total 7 marks)

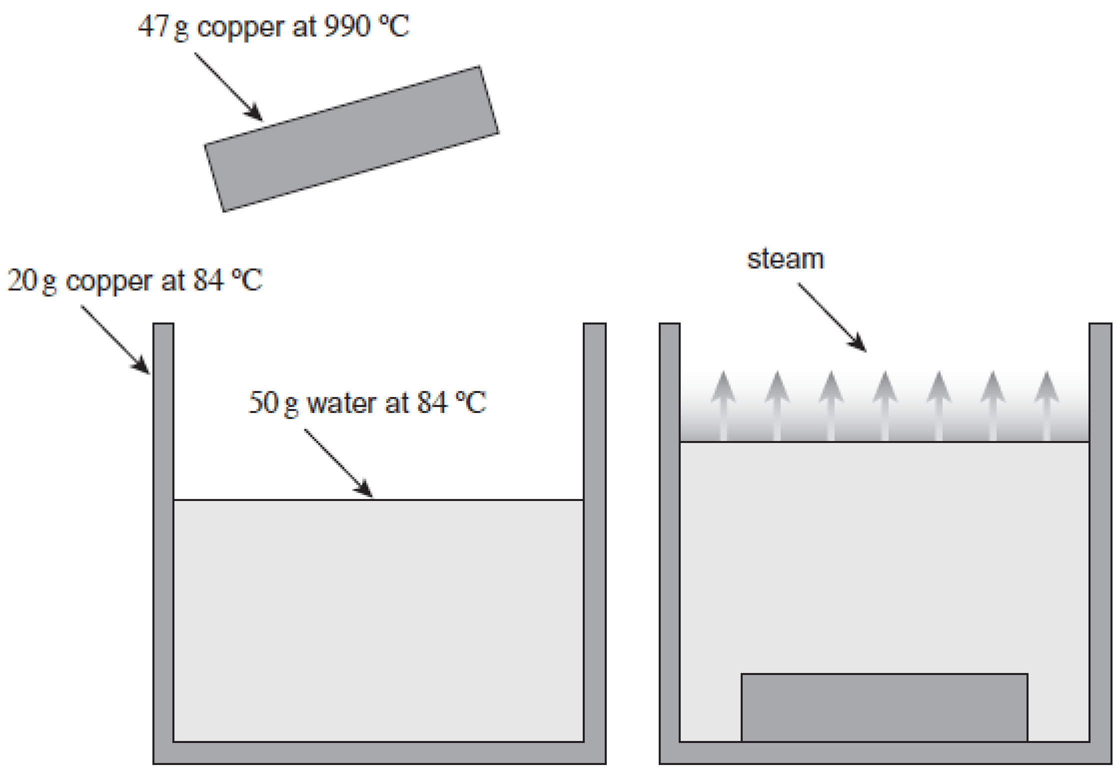
10 (a) Define the specific latent heat of vaporisation of water.

Energy required to turn 1kg of water at 100 degrees celcius to gas at 100 degrees.

(2)

(b) An insulated copper can of mass 20 g contains 50 g of water both at a temperature of 84 °C. A block of copper of mass 47 g at a temperature of 990 °C is lowered into the water as shown in the figure below. As a result, the temperature of the can and its contents reaches 100 °C and some of the water turns to steam.

specific heat capacity of copper = 390 $\mathrm{J\,kg^{-1}\,K^{-1}}$
specific heat capacity of water = 4200 $\mathrm{J\,kg^{-1}\,K^{-1}}$
specific latent heat of vaporisation of water = $2.3 \times 10^6\ \mathrm{J\,kg^{-1}}$



Before placement After placement

(i) Calculate how much thermal energy is transferred from the copper block as it cools to 100 °C.
Give your answer to an appropriate number of significant figures.

$\Delta E = mc\Delta\theta = 47 \times 10^{-3} \times 390 \times (990 - 100)$

thermal energy transferred 1.6×10^4 J

(2)

(ii) Calculate how much of this thermal energy is available to make steam.
Assume no heat is lost to the surroundings.

$m c \Delta\theta + m c \Delta\theta$
water copper

$\underbrace{(0{\cdot}05 \times 4200 \times 16) + (0{\cdot}02 \times 390 \times 16)}_{= 3500}$

Take from energy supplied

available thermal energy ______________________ J

$\therefore$ 12,500 J

(2)

(iii) Calculate the maximum mass of steam that may be produced.

ie 13 k5 25g

mass $\boxed{5.7 g}$ ______________________ kg

(1)

(Total 7 marks)

1 A student measures the power of a microwave oven. He places 200 g of water at 23 °C into the microwave and heats it on full power for 1 minute. When he removes it, the temperature of the water is 79 °C.

The specific heat capacity of water is 4200 J kg^{-1} K^{-1}.

What is the average rate at which thermal energy is gained by the water?

A 780 W

B 840 W

C 1.1 kW

D 4.6 kW

(Total 1 mark)

You may use a diagram to help make clear aspects of your answer.

energy loss of water in cup = energy gained by ice cube

$\underbrace{mc\Delta\theta}_{\text{water}} = \underbrace{mL + mc\Delta\theta}_{\text{for cube as it melts \& warms up.}}$

let θ be the final, equalibrium temperature

$mc(15-\theta) = mL + mc(\theta - 0)$

$0.1 \times 4200(15-\theta) = 0.01 \times 3.4 \times 10^5 + 0.01 \times 4200(\theta)$

$\theta = 6.3\,^\circ C \quad \therefore \quad \Delta\theta = 15 - 6.3$

$= 8.7\,^\circ C$

(Total 6 marks)

3 An ice cube of mass 0.010 kg at a temperature of 0 °C is dropped into a cup containing 0.10 kg of water at a temperature of 15 °C.

What is the maximum estimated change in temperature of the contents of the cup?

specific heat capacity of water = 4200 J kg^{-1} K^{-1}
specific latent heat of fusion of ice = 3.4 × 10^5 J kg^{-1}

A 1.5 K ☐

B 8.7 K ☐

C 13.5 K ☐

D 15.0 K ☐

there can be algebra issues here with is temp change negative???

bracket 1 decreases and therefore bracket 2 must increase - but since the starting temp for the ice is 0 is all falls out anyway.

(Total 1 mark)