Gas Laws — Basic Practice A Physics

- $PV = nRT$ Ideal Gas Equation
- Heat Energy, $E = n C_p \Delta T$ or $n C_v \Delta T$

DATA

1 atm. = 1×10^5 Pa

gas constant → $R = 8.3$ J mole^{-1} K^{-1}

$C_p = 28$ J mole^{-1} K^{-1}

$C_v = 20$ J mole^{-1} K^{-1}

This question is about a diver

1. The diver breathes in 200 cm^3 of air at 1 atmosphere at 20°C. In his lungs it's warmed at 1 atm. to 37°C

a) Show that 200 cm^3 = 2×10^{-4} m^3. (1)

b) Calculate the number of moles of air in 200 cm^3 at 1 atm. and 20°C (2)

c) Calculate the heat energy needed to warm this gas in the diver's lungs. (2)

d) What is the new volume of this mass of gas in the diver's lungs? (2)

e) The diver has a gas bottle, volume 12×10^{-3} m^3, containing gas at 20 atm. and 20°C

Calculate the number of moles of gas in the bottle (2)

f) The diver goes into the sea, where the water is at 5°C.

Calculate the gas pressure at this temperature (2)

g) A bubble of radius 1 cm escapes from the bottle in to the water at a pressure of 4 atmospheres and temperature 5°C.

What is the volume of this bubble? ($V_{sphere} = \frac{4}{3}\pi r^3$) (2)

h) How many moles of gas in it? (2)

i) The bubble floats up to the surface: temp 20°C, pressure 1 atm.

What is the new bubble volume? (2)

Total /17

TW

02.00

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1. a) $1\,cm = 1\times10^{-2}\,m$ so $1\,cm^2 = (1\times10^{-2})^2$ and $1\,cm^3 = (1\times10^{-2})^3 = 1\times10^{-6}\,m$

so $200\,cm^3 = 200\times10^{-6} = \underline{2\times10^{-4}\,m^3}$ (1)

b) $PV = nRT$ (1) $\rightarrow n = PV/RT = \dfrac{1\times10^5 \times 2\times10^{-4}}{8.3\times293} = \underline{0.0082\text{ moles}}$ (1)

c) Heat energy $= n\,C_p\,\Delta T$ (1) $= 0.0082\times28\times(37-20) = \underline{3.9\text{ Joules}}$ (2

← not Cv !

d) new volume ... use $PV = nRT$ (1)

so $V_{new} = nRT/P = \dfrac{0.0082\times8.3\times310}{1\times10^5}$ k!

$= \underline{2.1\times10^{-4}\,m^3}$ (1)

(or...) $V_1/T_1 = V_2/T_2$ (1)

so $V_{2\,new} = V_1 \times \dfrac{T_2}{T_1} = 2.0\times10^{-4} \times \dfrac{310}{293}$

$= \underline{2.1\times10^{-4}}$

(2 max

e) Gas in bottle ... $PV = nRT$ (1) $\rightarrow n = PV/RT = \dfrac{20\times10^5 \times 12\times10^{-3}}{8.3\times293} = \underline{9.87\text{ moles}}$ (1)

f) use $P_1/T_1 = P_2/T_2$ (1) $\rightarrow P_{2\,new} = P_1 \times \dfrac{T_2}{T_1} = 20\times10^5 \times \dfrac{278}{293} = \underline{19\times10^5\,Pa}$ (1)

g) Bubble ... $V = \frac{4}{3}\pi r^3$ (1) $= \frac{4}{3}\pi(1\times10^{-2})^3 = \frac{4}{3}\pi\times1\times10^{-6} = \underline{4.2\times10^{-6}\,m^3}$ (1)

h) moles of gas ... $PV = nRT$ (1) $\rightarrow n = PV/RT = \dfrac{4\times10^5 \times 4.2\times10^{-6}}{8.3\times278} =$

$= \underline{7.3\times10^{-4}\text{ moles}}$ (1)

i) use $PV = nRT$ (1)

so $V_{new} = \dfrac{nRT}{P}$

$= \dfrac{7.3\times10^{-4}\times8.3\times293}{1\times10^5}$

$= \underline{1.77\times10^{-5}\,m^3}$ (1)

or... $\dfrac{P_1V_1}{T_1} = \dfrac{P_2V_2}{T_2}$ (1)

so $V_{2\,new} = \dfrac{P_1}{P_2}\times\dfrac{T_2}{T_1}\times V_1$

$= \dfrac{4\times10^5}{1\times10^5}\times\dfrac{293}{278}\times4.2\times10^{-6}$

$= \underline{1.77\times10^{-5}\,m^3}$ (1)

(2 max

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Total 17