Thermodynamics (1) — A Physics

– Heating Gases: C_p & C_V

Data:

Gas constant R: 8.3 J/mol

1. The light bulb shown contains 40 cm^3 of argon at 50 kPa pressure when cold at 20 °C

(a) Show that the gas volume is 40×10^{-6} m^3. (1)

(b) Calculate the number of moles of argon gas in the bulb (2)

When the bulb is lit the gas temperature is 80 °C.

(c) Calculate the new gas pressure. (2)

(d) Explain why the gas pressure changes as the temperature increases (2)

(e) When the bulb is on the gas is constantly being heated by the filament. Explain why the gas temperature does not keep increasing (2)

(f) A Physics student wants to calculate the heat energy needed to heat the Argon gas to 80 °C. The data book has a torn page....

> Specific heat capacities for Argon: –
> C_p = 97.8 Joules / mole / K
> C_V =

(g) Calculate the value of C_V for Argon (2)

(h) Explain why C_p is different from C_V (2)

(i) Calculate the heat energy needed to heat the Argon to its working temperature (2) [15]

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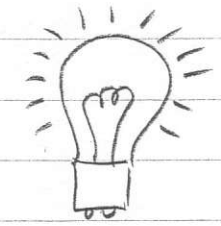
Thermodynamics ① Answers A Physics

1 a) Since 1 cm = 1×10^{-2} m

$1\,cm^3 = 1\times10^{-2} \times 1\times10^{-2} \times 1\times10^{-2} = 1\times10^{-6}\ m^3$

So $40\ cm^3 = 40\times10^{-6}\ m^3$ (1)



b) Use $PV = nRT \rightarrow n = PV/RT$ ①

$n = 50\times10^3 \times 40\times10^{-6} / 8.3 \times 293 = 0.82\times10^{-3}$ ① moles (8.2×10^{-4}) (

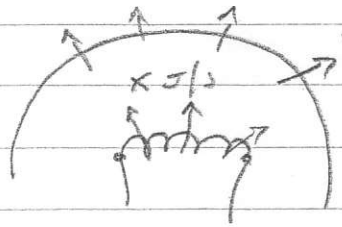
c) at 80°C = 353 k

Since P/T = constant, $P \propto T$ so $P_{new} = P_{old} \times \frac{353}{293} = 50\,000 \times 353/293$

(or ... use $P_1/T_1 = P_2/T_2$) $= 60,240$ ① Pa (2

d) Gas pressure increases because .... at higher temperature gas molecules have more k.e. ① .... hit walls harder, exert more force ① in rebounding (2

e) Bulb has steady temperature when



on because gas is losing heat ① to the surroundings as fast as it receives ① it from the filament (2

(f) –

(g) for 1 mole of gas $C_p - C_v = R$ ① $= 8.3$

So $C_v = C_p - R = 27.8 - 8.3 = 19.5$ ① J/mole (2

(h) In heating gas at constant volume (C_v) all heat Energy goes to increasing molecule k.e. ①

At constant pressure (C_p), some of heat energy is used in doing work expanding ① against atmosphere.

So it requires more heat energy to increase gas temp by 1°C at constant pressure than 1°C at constant volume (2

i) Heat energy $H = n\,C_v\,\Delta T$ ①

$= 0.82\times10^{-3} \times 19.5 \times (80-20)$

$= 0.96$ ① Joules (not a lot!) (1

[15]

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