Thermodynamics & the Ideal Gas

Thermodynamics · 5 questions · step-by-step answers at the end

Name: Date: Score: / 5

USEFUL EQUATIONS

$PV = nRT = Nk_BT$ $\Delta U = Q + W$ $W = -P\Delta V$ $U = (3/2)nRT$ $K_{\text{avg}} = (3/2)k_BT$

Questions

Show your working in the space under each question.

1. A gas is compressed isothermally, and 300 J of work is done on it. Find ΔU and Q.

2. 0.10 mol of a monatomic ideal gas at 300 K expands at constant pressure from 2.0 L to 4.0 L. Find P, the final temperature, W, ΔU and Q.

3. A rigid sealed container of gas is heated with 600 J. Find W and ΔU.

4. A gas is compressed slowly at constant temperature, with 500 J of work done on it. Find Q.

5. An engine takes in 1000 J and exhausts 650 J each cycle. Find its work output and efficiency.

Step-by-step answers

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1. Isothermal means $\Delta U = 0$, so $Q = -W =$ **-300 J**: 300 J of heat flows out.

2. 1. $P = nRT/V = (0.10)(8.31)(300)/(0.0020) =$ **125 kPa**.
2. At constant P, V doubles, so T doubles: $T_f =$ **600 K**.
3. W (on gas) $= -P\Delta V = -(1.25 \times 10^5)(0.0020) =$ **-249 J**. The gas does 249 J of work.
4. $\Delta U = (3/2)nR\Delta T = 1.5(0.10)(8.31)(300) =$ **374 J**.
5. $Q = \Delta U - W = 374 - (-249) =$ **623 J** of heat added.

Answer: P = 125 kPa, T = 600 K, W = −249 J, ΔU = 374 J, Q = 623 J

3. Rigid means $\Delta V = 0$, so **$W = 0$** and **$\Delta U = Q = 600$ J**. The temperature rises.

4. Isothermal means $\Delta U = 0$, so $Q = -W =$ **-500 J**: heat flows out.

5. $W = 1000 - 650 =$ **350 J**; $e =$ **35%**.