

Problem 1

You are driving at 36 km / hr when the road suddenly descends 16 m into a valley. You take your foot off the accelerator and coast down the hill. Just as you reach the bottom you see the police officer hiding behind the speed limit sign that reads "70km/hr" Are you going to get a speeding ticket?

So we start this problem by assuming that all of our potential energy initially becomes kinetic energy. We start with

$$KE_i + PE_i = KE_f + PE_f$$

Where PE_f we define to be zero.

$$\frac{1}{2} m v_i^2 + m g h = \frac{1}{2} m v_f^2$$

$$36 \frac{\text{km}}{\text{hr}} \cdot \frac{1000 \text{ m}}{\text{km}} \cdot \frac{\text{hr}}{3600 \text{ s}} = 10 \frac{\text{m}}{\text{s}}$$

$$\frac{1}{2} m v_f^2 = \frac{1}{2} m \left(10 \frac{\text{m}}{\text{s}} \right)^2 + m g (16 \text{ m})$$

$$v_f^2 = \left(10 \frac{\text{m}}{\text{s}} \right)^2 + 2 \left(10 \frac{\text{m}}{\text{s}^2} \right) (16 \text{ m})$$

$$v_f = \sqrt{420 \frac{\text{m}^2}{\text{s}^2}} = 20.5 \frac{\text{m}}{\text{s}}$$

$$20.5 \frac{\text{m}}{\text{s}} \cdot \frac{\text{km}}{1000 \text{ m}} \cdot \frac{3600 \text{ s}}{\text{hr}} = 72 \frac{\text{km}}{\text{hr}}$$

Problem 2

A heat engine does 15 J of work and exhaust 20 J of waste heat.

a. What is the engine efficiency?

b. If the cold reservoir temperature is 20 C

what is the minimum possible temperature in C of that hot reservoir?

So the total energy put in to the engine is 15 J + 20 J = 35 J

$$\text{Engine efficiency is defined to be } \frac{\text{work out}}{\text{what you put in}} = \frac{15 \text{ J}}{35 \text{ J}} = \frac{3}{7}$$

To operate at the efficiency given in part a

the minimum temperature of the hot reservoir is the following.

$$e = 1 - \frac{T_c}{T_H}$$

$$T_H = 35 \text{ C}$$

Problem 3

0.02 mol of argon gas is admitted to an evacuated 100 cm^3 container at 27°C . The gas then undergoes an isothermal expansion to a volume of 200 cm^3 .

- What is the final pressure of the gas?
- Show the process on a PV diagram. Include a proper scale on both axes.

Let's convert to a sane set of units.

$$V_i = 10^{-4} \text{ m}^3$$

$$V_f = 2 \times 10^{-4} \text{ m}^3$$

$$T = 300 \text{ K}$$

$$PV = nRT$$

$$P = \frac{(0.02 \text{ moles}) \left(8 \frac{\text{J}}{\text{mole K}}\right) (300 \text{ K})}{10^{-4} \text{ m}^3} = 4.8 \times 10^5 \text{ Pa} = 4.8 \text{ atm}$$

In an isothermal expansion $PV = \text{Constant}$

$$P_i V_i = P_f V_f$$

$$P_f = \frac{P_i V_i}{V_f} = \frac{(4.8 \times 10^5 \text{ Pa}) (10^{-4} \text{ m}^3)}{2 \times 10^{-4} \text{ m}^3} = 2.4 \text{ atm}$$