REMARKS:

$$Z = \frac{V_{ACTUAL}}{V_{IDEAL}}$$

for ideal gases, the internal energy U is a function of temperture only.

$$U = U(T)$$

so for a constant temperture (isothermal) in ideal gas situation, U = constant

or $\Delta T = 0$ so $\Delta U = 0$

EX.

GIVEN: air gas occupied in a room that has dimesions $4 \times 5 \times 6$ m. The air is at 100 kPa and $T = 25°C$

REQUIRED: Calculate the mass of air assuming air is a ideal gas.

DATA: table A.5 $R_{AIR} = 0.287$ kJ/kg·K

ANALYSIS: Air is treated as an ideal gas, thus one can use the ideal gas model.

$$P\forall = mRT$$

$$m = \frac{RT}{PV}$$

where $P = 100$ kPa
$\forall = 120\ m^3$
$T = 25° + 273.15 = 298$ K
$R = 0.287$ kJ/kg

$$m = 140.31 \text{ kg.}$$

EX. given: Refrigerant R-134A at 1MPa an 50°C

REQUIRED: determine $v = ?$ using
(A) ideal gas equation
(B) generalized compressibility chart.

SOLUTION:

(A) Assuming Ideal Gas.

$$Pv = RT$$

$$v = \frac{RT}{P}$$

from table A.5

$$R = 0.08149 \left(\frac{kPa \cdot m^3}{kg \cdot K}\right)$$

$$v = \frac{0.08149 \cdot (50 + 273.15)}{1000.}$$

$$= 0.02632 \ m^3/kg.$$

(B) In order to use the general compressibility chart, Figure D.1, we need P_R & T_R

$$P_R = \frac{P}{P_c} \qquad T_R = \frac{T}{T_c}$$

using table A.2 we can find P_c & T_R

$$T_c = 374.2 \ K$$

$$P_c = 4.06 \ MPa.$$

therefore.

$$P_R = \frac{1 \ MPa}{4.06} = 0.246$$

$$T_R = \frac{333.15}{374.2} = 0.8903$$

from table D.1

$$Z = 0.85$$

therefore we have the gas formula.

$$Pv = ZRT$$

$$v = \frac{ZRT}{P} = 0.02237 \ m^3/kg.$$

EX.

GIVEN: A balloon filled to helium (He) at a $P = 0.2\,MPa$ & $T = 20°C$. Assuming that the balloon is spherical state with $D = 6m$

REQUIRED: determine
A. the number of moles
B. the mass of He in the balloon.

ANALYSIS: assuming ideal gas behaviour.

$$n = ?$$

we have the relation.

$$P\forall = n\bar{R}T$$

$$n = \frac{P\forall}{\bar{R}T}$$

calculate the volume

$$\forall = \frac{4}{3}\pi\left(\frac{D}{2}\right)^3 = 113.04\ m^3$$

then we look into the previous eq.

$$n = \frac{(0.2 \times 1000)(113.04)}{(8.3145)(20+273)} = 9.28\ kmol$$

then finding the mass.

$$n = \frac{m}{M}$$

$$m = nM$$

we find M is the molecular mass found in table A.2

$$m = (9.28)\cdot(4.003) = 37.148\,kg.$$

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CHAPTER 4. ENERGY, HEAT, WORK.

energy can be defined as the capibility to do work (produce an effect). Energy can be stored within a system and can be transferred (as heat) from one system to another.

§ 4.1 WORK

can be defined as the product of a Force and the distance moved in the direction of the force.

mathimatically.

$$W = \int_{x_1}^{x_2} F\,dx$$

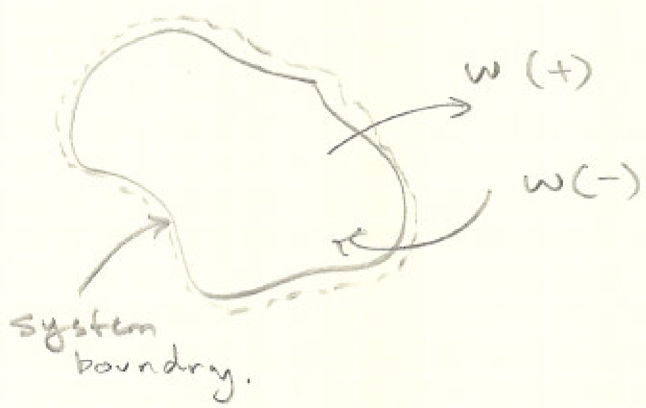
ie - force acting through a displacement x.

SIGN CONVENTION FOR WORK.

the sign convention for work, from a thermodynamic standpoint, is that

WORK IS POSITIVE: if work is performed on the surroundings

WORK IS NEGITIVE: if work is performed on the system from the surroundings



UNITS FOR WORK

N·m = J (SI)

lb·ft (ENGLISH)

- The rate of doing work is Power

$$\dot{W} = P = \text{Power}$$

- The units for Power in SI system is

$$\frac{J}{s} = \text{Watt} = W \qquad \frac{kJ}{s} = kW = \text{kilo Watt}.$$

- the english system is

$$\frac{lb \cdot ft}{s}$$

- The rate of work, can be expressed as

$$\dot{w} = \frac{\delta w}{\delta t}$$

- specific work (work per unit mass)

$$w = \frac{W}{m} \quad (kJ/kg)$$

FORMS, MODES OF WORK

- Mechanical forms of work

work done by a rotating shaft.

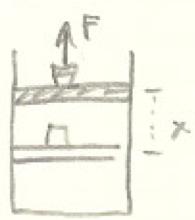
$$W = (T\omega)\Delta\tau$$

$$\dot{\omega} = (T\omega)$$

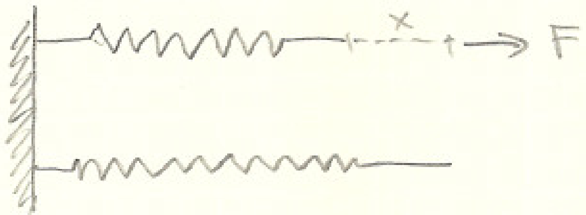
where, T = torque $(N \cdot m)$
ω = angular speed (rad/s)

- Boundry work.

work done by the movement of a system boundry, such as the work done by moving the piston in a cylindur.



• work done by a mechanical spring



$$W_{SPRING} = \int_{x_1}^{x_2} F\,dx \quad (J)$$

for a linear elastic spring, the displacement x, is proportional to the force applied

$$F = k_{SPRING}\, x.$$

where k_{SPRING} is the spring constant $\left(\frac{N}{m}\right)$

therefore work of a spring.

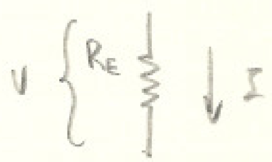
$$W = k_{SPRING}\int_{x_1}^{x_2} x\,dx$$

$$= \frac{1}{2} k_{SPRING}\left(x_1^2 - x_2^2\right)$$

• NON-MECHANICAL FORMS OF WORK.

electrical work.

in an electric field, electrons in a wire move under the effect of electromotive forces, doing work.



$$W_e = I\,q_o$$

$$\dot{W}_e = P_e = VI$$

In general, both V & I vary with time, and the electrical work done during this time

$$W_e = \int_{t_1}^{t_2} VI\,dt \quad (J)$$