CE 3305

EXERCISE SET # 1

(USES PROBLEMS FROM 10^{th} EDITION
ISBN 978-1-118-16429-7)

!!(PROBLEMS POSTED ON SERVER
APPEAR DIFFERENT FROM 10^{th} EDITION
ONLINE/SI VERSION)!!

PROBLEMS

1.10 pg 25

1.19 pg 26

1.34 pg 26

1.10) PROBLEM STATEMENT

FOR EACH VARIABLE, LIST THREE COMMON UNITS

SKETCH

FIND UNITS/DEFINITIONS IN THE TABLE

KNOWN

a) Q; VOLUMETRIC FLOW RATE $\quad$ $\dot{m}$; MASS FLOW RATE

p; PRESSURE

b) F; FORCE $\quad$ E; ENERGY

P; POWER

c) μ; VISCOSITY

GOVERNING EQUATION(S)

$$Q = \frac{L^3}{t} \qquad \dot{m} = \frac{M}{t} \qquad p = \frac{F}{A} = \frac{ML}{t^2 \cdot L^2} = \frac{M}{Lt^2}$$

$$F = \frac{ML}{t^2} \qquad E = F \cdot L = \frac{ML^2}{t^2} \qquad P = \frac{E}{t} = \frac{ML^2}{t^3}$$

$$\mu = \frac{M}{Lt}$$

UNKNOWN (FIND)

UNITS FOR: Q, $\dot{m}$, p

F, E, P

μ

SOLUTION

USING TABLE F.1

Q: $\frac{m^3}{s}$; $\frac{ft^3}{s}$; $\frac{gal}{min}$ ← VARIOUS UNITS FOR Q

$\dot{m}$: $\frac{kg}{s}$; $\frac{lbm}{s}$; $\underbrace{\frac{mg}{hr}}$ ← $\dot{m}$

COMMON IN MEDICAL APPLICATIONS

p: Pa ; psi ; atm ← p

F: N ; lbf ; dyne ← F

E: J ; ~~hp~~ Btu ; kWh ; ft·lbf ← E

P: W ; hp ; $\frac{ft \cdot lbf}{s}$ ← P

μ: Pa·s ; $\frac{lbf \cdot s}{ft^2}$; poise ← μ

DISCUSSION

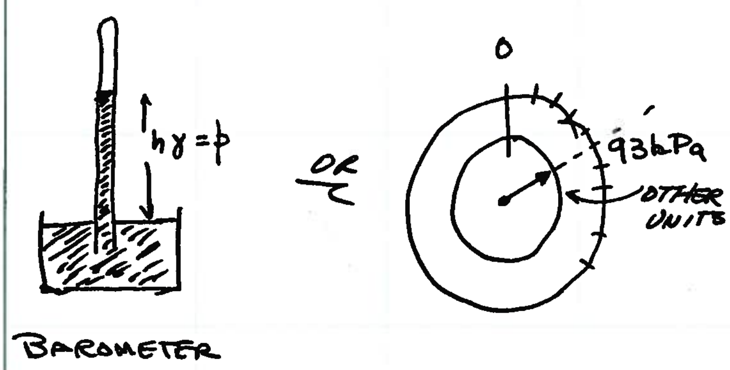
PURPOSE OF THIS EXERCISE IS TO FAMILARIZE WITH TABLE F.1 IN BOOK, AND TO REVIEW DERIVED UNITS BASED ON PRIMARY UNITS AND DIMENSIONS

HARDEST PART THIS EXERCISE IS FOLLOWING THE PROBLEM SOLVING FORMAT!

1.19) PROBLEM STATEMENT

IF THE LOCAL ATMOSPHERIC PRESSURE IS 93 kPa, FIND PRESSURE IN OTHER UNITS BELOW

SKETCH



KNOWN

$p = 93\,kPa$ (ASSUMED ABSOLUTE; OTHERWISE PROBLEM DOES NOT MAKE SENSE)

GOVERNING EQUATION(S)

$p_{NEW} = p_{GIVEN} \cdot$ UNIT CONVERSION

USE CONVERSIONS ON TABLE F.1

UNKNOWN (FIND)

a) psia b) psf c) bar

d) atm e) feet H_2O f) inches Hg

SOLUTION

a) $psi_a = 93 \cdot 10^3 Pa \cdot \dfrac{1.45 \cdot 10^{-4}\, lbf/in^2}{1\,Pa} = \underline{13.485\, psia}$ ← (a)

b) $psf = 13.485 \dfrac{lbf}{in^2} \cdot \dfrac{144\, in^2}{1\, ft^2} = 1941.84 \dfrac{lbf}{ft^2} = \underline{1941.84\, psf}$ ← (b)

c) $bar = 93 \cdot 10^3 Pa \dfrac{10^{-5}\, bar}{1\, Pa} = \underline{0.93\, bar}$ ← (c)

d) $atm = 93 \cdot 10^3 Pa \, \dfrac{1\, atm}{101.3 \cdot 10^3 Pa} = \underline{0.92\, atm} \longleftarrow$ (d)

e) $feet_{H_2O} = 0.92\, atm \, \dfrac{33.90\, ft_{H_2O}}{1\, atm} = \underline{31.23\, ft_{H_2O}} \longleftarrow$ (e)

f) $in_{Hg} = 0.92\, atm \, \dfrac{\overset{29.92}{\cancel{29.92}}\, in_{Hg}}{1\, atm} = 27.554\, in_{Hg} \longleftarrow$ (f)

DISCUSSION

- PURPOSE OF PROBLEM IS TO APPLY METHODS OF UNIT CONVERSION USING UNITY FACTORS IN TABLE F.1

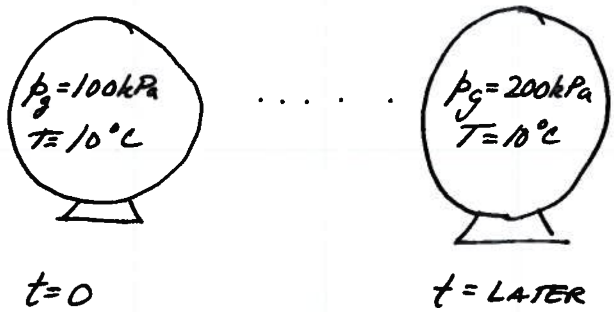
- NOTICE USE OF INTERMEDIATE UNITS ALLOWED FEWER CONVERSIONS THAN IF STARTED EACH TIME WITH ORIGINAL PRESSURE UNITS (kPa)

- NOTICE CONVERSION OF kPa TO 10^3 Pa WITHOUT SHOWING INTERMEDIATE STEP; OK FOR VERY COMMON CONVERSION (WHERE POWERS OF 10 CHANGE)

1.34 PROBLEM STATEMENT

NATURAL GAS STORED IN A SPHERICAL TANK

SKETCH



KNOWN

PRESSURE & TEMPERATURE $t=0$; $t=$ LATER

$p_{atm} = 100 kPa$

$p_{t=0} = 100 kPa$, $T_{t=0} = 10°C$

$p_{t=LATER} = 200 kPa$, $T_{t=LATER} = 10°C$

GOVERNING EQUATIONS

$p V = \frac{m}{M} R T$ (ASSUME IDEAL GAS LAW APPLIES)

UNKNOWN (FIND)

RATIO OF FINAL MASS TO INITAL MASS IN THE TANK

$$\frac{m_{t=LATER}}{m_{t=0}}$$

SOLUTION.

LET ① ⇒ $t=0$

② ⇒ $t=$ LATER

$$p_1 \forall_1 = \frac{m_1}{M} R T_1$$

$$p_2 \forall_2 = \frac{m_2}{M} R T_2$$

TAKE RATIO ②/①

$$\frac{p_2 \cancel{\forall_2}}{p_1 \cancel{\forall_1}} = \frac{\frac{m_2}{\cancel{M}} \cancel{R} \cancel{T_2}}{\frac{m_1}{\cancel{M}} \cancel{R} \cancel{T_1}}$$

CANCEL $\forall_2 = \forall_1$; $M = M$; $R =$ CONSTANT ; $T_2 = T_1$

$$\frac{m_2}{m_1} = \frac{p_2}{p_1} = \frac{200\,kPa}{100\,kPa} = \underline{\underline{2}} \longleftarrow \frac{m_2}{m_1}$$

DISCUSSION

- PROBLEM ILLUSTRATES USE OF VALUE CANCELLATION AND ALGEBRA TO FIND RESULTING RATIO
- READ "FIND" CAREFULLY; WITHOUT ACTUAL VOLUME WOULD BE ~~HARD~~ HARD TO FIND ACTUAL MASSES; BUT ~~RATIOS~~ RATIOS ARE STRAIGHTFORWARD
- THE RESULT IS ALSO THE MOLE ~~RATIOS~~ RATIO IN THIS CASE!