Mole

1 mole = $6.02 \cdot 10^{23}$ ≈ number of atoms in a gram of hydrogen

really is Molar mass (Molecular mass refers to specific isotope)

$$\boxed{(\text{mass}) = (\text{molecular mass}) \times (\#\text{ of moles})}$$

in gram

Example: $\frac{kg}{kmol} = \frac{g}{mol}$ (table lists as ~~standard~~ atomic mass (?))

2kmoles (= 1 kilo mole ~~s~~ = 10^3 mole) of Carbon atoms (atomic ~~mass~~ 12) ~~weighs~~ has mass

$12 \times 2 \times 10^3$ gram = ~~24~~ kg

$12 \frac{kg}{kmol} \cdot 2 kmol = 24$ kg

Units

SI and British

British system uses wrong unit of mass: ~~lbm~~

Correct unit would be $1 \frac{lbf\, sec^2}{ft} = 1$ slug

1/10/end

Fixed conversion factor

$$\cancel{\boxed{g_c = 32.2 \frac{lbm\, ft}{lbf\, sec^2}}} \quad \cancel{32.2} \frac{lbm}{slug}$$

~~Whenever a lbm is used in an equation, it must be divided by g_c to set units to match up~~

$$\boxed{1 = \frac{1\, lbf}{32.2\, lbm\, ft/s^2}}$$

Example:

SI: $F = ma$

British $F = \frac{m}{g_c} a$

lbf, lbm, ft/s², 32.17... really

Note that $g_c \approx g$, but g depends a bit on location

I.2a.

2.24 Apple "weighs" 80g, has volume 100 cm^3. Asked: density. What
2.17 is intensive, what extensive?

"weighs" 80g $\Rightarrow$ $m = 80g$.

Proper unit is kg. ~~k = 10^3~~ "multiply by 1" to convert g to kg:

$$k = 10^3 \quad \text{so} \quad 1 = \frac{k}{10^3}$$

$$m = 80\,g = 80\,g \cdot 1 = 80\,g\,\frac{k}{10^3} = \frac{80}{1000}\,kg = \underline{0.08\,kg}$$

volume is 100 cm^3

Proper unit is m^3. Appendix A1 page 654: 1cm = 0.01m

$$\text{so} \quad 1 = \frac{0.01\,m}{1\,cm}$$

$$V = 100\,cm^3 \times \left(\frac{0.01\,m}{1\,cm}\right)^3 = \underline{10^{-4}\,m^3}$$

density $\rho = \frac{m}{V} = \frac{0.08\,kg}{10^{-4}\,m^3} = \underline{\underline{800\,kg/m^3}}$

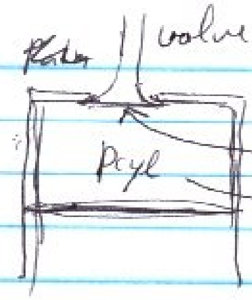
Extensive: m, V. above

Intensive: ρ above, temperature $T = 8°C$, specific volume $= \frac{1}{\rho} = .00125\frac{m^3}{kg}$
pressure is 1 atmosphere $\approx$ ~~[illegible]~~ 1 bar

I.6a

2.47
2.33

Piston valve



99 kPa = patm

$A = 11\ cm^2$

735 kPa

Force to open valve?

$F = (p_{cyl} - p_a) A$ ~~735~~

multiply by one : Appendix A
1 cm = 0.01 m so
$1 = \frac{0.01 m}{1 cm}$
$1 = \left(\frac{0.01 m}{1 cm}\right)^2$

$= (735 - 99)\, kPa \;\; 11\, cm^2 \left(\frac{0.01\, m}{cm}\right)^2$

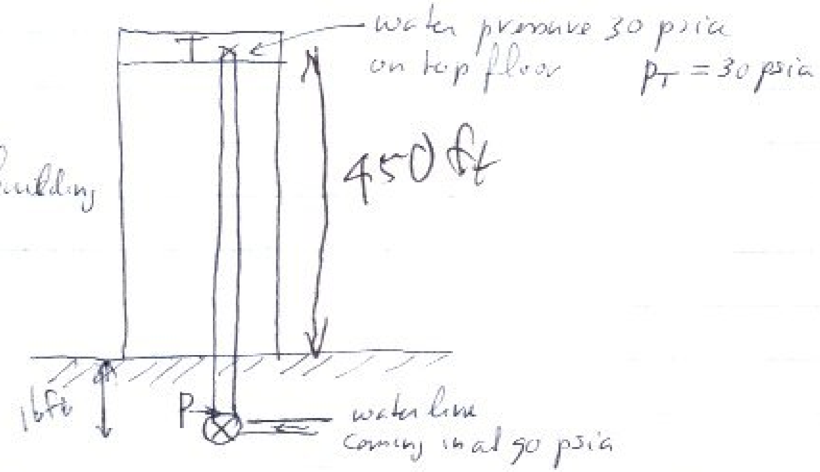
$= 0.6996\ kN \;\; = 700 N$

since $k = 10^3 = 1000$

I 5 l

2.102

X



Asked: the pressure $p_P - 90$ psia added by the pump

Answer: Formula $p_T - p_P = \rho g (H_p - H_T)$

Put in all known numbers

from Appendix A1 — from Appendix F.3

$$30 \frac{lbf}{in^2} \, 144 \frac{in^2}{ft^2} - p_P = 62.2 \frac{lbm}{ft^3} \, 32.2 \frac{ft}{sec^2} (-16 - 450) \, ft \, \frac{1 \, lbf}{32.2 \, lbm \, ft/s^2}$$

Note: $\frac{144 \, in^2}{1 \, ft^2} = 1$, so I multiply by one

Recognize as one equation in one unknown: can find p_P from it.

$$30 \; 144 \frac{lbf}{ft^2} - p_P = 62.2 \, (-16 - 450) \frac{lbf}{ft^2}$$

change sign!

Units O.K.!

Take known terms to RHS (right hand side)
unknown terms to LHS

$$-p_P = \left[62.2 \, (-16 - 450) - 30 \; 144\right] \frac{lbf}{ft^2}$$

$$p_P = \frac{62.2 \, (-16 - 450) - 30 \; 144}{-1} \frac{lbf}{ft^2}$$

$$= 33305.2 \frac{lbf}{ft^2} \underset{\uparrow}{=} 33305 \frac{lbf}{ft^2} \frac{1 \, ft^2}{144 \, in^2} = 231 \frac{lbf}{in^2} = 231 \text{ psi} \;\; \| \; p_P$$

multiply by one

units OK!

Pump pressure difference: $p_P - 90$ psia $= 231$ psia $- 90$ psi $= \underline{141 \text{ psia}}$

Temperature

1) Measures the random motion of the molecules,
Hotter → molecules have more kinetic energy (if ideal gas)

2) Heat flows from hot to cold until the temperatures become equal

	Centigrade	Kelvin	Fahrenheit	Rankine
Absolute zero temperature (molecules at rest if ideal gas)	−273	0	−460	0
Water freezes	0	273	32	492
Water boils	100	373	212	672

$$\boxed{F = 32 + \frac{9}{5}C \qquad C = (F - 32)\frac{5}{9}}$$

I 6a

2.1.09: Given $T_{atm} = 518 - 3.84 \times 10^{-3} H$
where ~~E~~ H is the elevation in feet, and
T_{atm} is the athmospheric temperature ~~pressure~~ in ?
Asked: What is the atmospheric temperature at
~~Well~~ 32000 ft in Fahrenheit?

Answer: at sea level, the temperature is not
518 F but 518 R.
So the correct formula is

$$T_{atm} = 518\,R - 3.84\; 10^{-3} \frac{R}{ft} H$$

at 32,000 ft

$$T_{atm} = 518 - 3.84\; 10^{-3} \frac{R}{ft} 32{,}000\,ft$$

$$= 395\,R$$

Appendix A1: $TF = TR - 459.7$

Temp in F, Temp in R

$$T_{atm} = (395 - 459.7)\,F = -64.7\,F$$