FACULTY OF ENGINEERING
DEPARTMENT OF CHEMICAL ENGINEERING

INTRODUCTION TO CHEMICAL ENGINEERING
CEN 101

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SAMPLE PROBLEMS WITH SOLUTIONS

Convert the following values to desired units.

$$\textbf{a)}\ 554\ \frac{m^4}{day.kg} \longrightarrow \frac{cm^4}{min.g}$$

$$\textbf{b)}\ 5.37\text{x}10^3\ \frac{kJ}{min} \longrightarrow hP$$

$$\textbf{c)}\ 760\ \frac{miles}{h} \longrightarrow \frac{m}{s}$$

$$\textbf{d)}\ 921\ \frac{kg}{m^3} \longrightarrow \frac{lbm}{ft^3}$$

$$\textbf{e)}\ 800\ mmHg \longrightarrow psia, \quad kPa\ \ and\ \ atm$$

$$\textbf{f)}\ -25\ °\text{F} \longrightarrow K$$

$$\textbf{g)}\ 23\frac{lbm.ft}{min^2} \longrightarrow \frac{kg.cm}{s^2}$$

$$\textbf{h)}\ 0.981\frac{Btu}{lbm.℃} \longrightarrow \frac{J}{g.℃}$$

$$\textbf{i)}\ 8.314\frac{J}{mol.K} \longrightarrow \frac{cm^3.bar}{mol.K}$$

$$\textbf{j)}\ 0.052\frac{kg}{m.s} \longrightarrow \frac{lbm}{ft.h}$$

$$\textbf{a)}\quad 554\ \frac{m^4}{day.kg}\cdot\frac{10^8 cm^4}{1m^4}\cdot\frac{1\ day}{1440\ min}\cdot\frac{1\ kg}{1000\ g} = 38472.2\frac{cm^4}{min.g}$$

$$\textbf{b)}\quad 5.37\text{x}10^3\ \frac{kJ}{min}\cdot\frac{0.02235\ hP}{1\ \left(\frac{kJ}{min}\right)} = 120\ hP$$

$$\textbf{c)}\quad 760\ \frac{miles}{h}\cdot\frac{1609\ m}{1\ mile}\cdot\frac{1\ h}{3600\ s} = 340\frac{m}{s}$$

$$\textbf{d)}\quad 921\ \frac{kg}{m^3}\cdot\frac{2.2046\ lbm}{1\ kg}\cdot\frac{1\ m^3}{35.315\ ft^3} = 57.5\ \frac{lbm}{ft^3}$$

e) $800\ mmHg.\dfrac{0.0193\ psia}{1\ mmHg} = 15.44\ psia$

$800\ mmHg.\dfrac{0.1333\ kPa}{1\ mmHg} = 106.64\ kPa$

$800\ mmHg.\dfrac{1\ atm}{760\ mmHg} = 1.05\ atm$

f) $-25\ °F = (-25\ °F + 459.67).\dfrac{5}{9} = 241.48\ K$

g) $23\dfrac{lbm.ft}{min^2}.\dfrac{1\ kg}{2.2046\ lbm}.\dfrac{30.48\ cm}{1\ ft}.\dfrac{1\ min^2}{60^2 s} = 0.088\ \dfrac{kg.cm}{s^2}$

h) $0.981\dfrac{Btu}{lbm.°C}.\dfrac{1055.06\ J}{1\ Btu}.\dfrac{2.2046\ lbm}{1000\ g} = 2.28\ \dfrac{J}{g.°C}$

i) $8.314\dfrac{J}{mol.K}.\dfrac{10\ cm^3.bar}{1\ J} = \dfrac{83.14\ cm^3.bar}{mol.K}$

j) $0.052\dfrac{kg}{m.s}.\dfrac{2.2046\ lbm}{1\ kg}.\dfrac{1\ m}{3.28\ ft}.\dfrac{3600\ s}{1\ h} = 125.8\ \dfrac{lbm}{ft.h}$

Fill in the table given below

°C	°F	K	°R
-40	?	?	?
?	77	?	?
?	?	698	?
?	?	?	69.8

°F = 32 + 1.8°C

K = °C + 273.15

°R = °F + 459.67 = 491.67 + 1.8°C

-40 °C = -40 °F = 233.15 K = 419.67 °R

77 °F = 25 °C = 298.15 K = 536.67 °R

698 K = 424.85 °C = 796.73 °F = 1256.4 °R

69.8 °R = -234.37 °C = -389.87 °F = 38.78 K

°C	°F	K	°R
-40	-40	233.15	419.67
25	77	298.15	536.67
424.85	796.73	698	1256.4
-234.37	536.67	38.78	69.8

In the production of a drug having a molecular weight of **192 kg/kmol**, the exit stream from the reactor flows at a rate of **10.5 L/min**. The drug concentration is **41.2%** (in water), and the specific gravity of the solution is **1.024**. Calculate;

a) the concentration of the drug (in **kg/L**) in the exit stream,
(Hint: assume that the amount of the total solution in the exit stream is 100 kg)
b) and the flow rate of the drug in **kg mol/min**.

Total exit stream amount 100 kg solution

Density of drug solution:

$$SG_{solution} = 1.024 = \frac{\rho_{solution}}{\rho_{water}}$$

$$\Rightarrow \rho_{solution} = 1000\ \frac{kg}{m^3}.1.024 = 1024\ \frac{kg}{m^3}$$

The solution at the reactor exit contains % 41.2 (41.2 wt %) water by weight;
Hence, there is 41.2 kg water and 58.8 kg drug in the solution.

Drug concentration in the drug solution

$$1024\ \frac{kg\ solution}{m^3}.\frac{58.8\ kg\ drug}{100\ kg\ solution}.\frac{1\ m^3}{1000\ L} = 0.602\ \frac{kg\ drug}{L\ solution}$$

Molar flow rate;

$$\dot{n} = 10.5\frac{L\ solution}{min}.0.602\frac{kg\ drug}{L\ solution}.\frac{1\ kmol\ drug}{192\ kg\ drug} = 0.033\frac{kmol\ ilaç}{min}$$