

FACULTY OF ENGINEERING DEPARTMENT OF CHEMICAL ENGINEERING

## INTRODUCTION TO CHEMICAL ENGINEERING CEN 101

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## SAMPLE PROBLEMS WITH SOLUTIONS

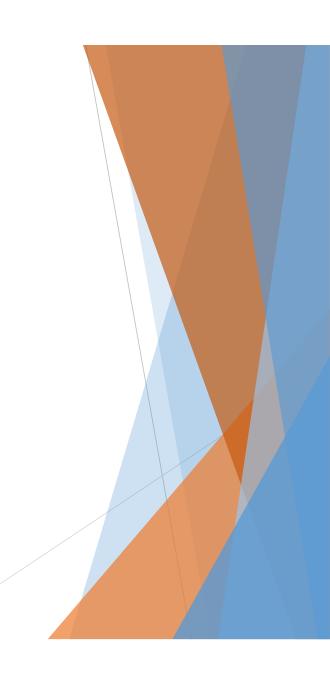
Convert the following values to desired units.

a) 
$$554 \frac{m^4}{day.kg} \rightarrow \frac{cm^4}{min.g}$$
  
b)  $5.37 \times 10^3 \frac{kJ}{min} \rightarrow hP$   
c)  $760 \frac{miles}{h} \rightarrow \frac{m}{s}$   
d)  $921 \frac{kg}{m^3} \rightarrow \frac{lbm}{ft^3}$ 

e)  $800 \text{ mmHg} \rightarrow psia$ , kPa and atm

f) 
$$-25 \,^{\circ}\text{F} \rightarrow K$$

$$\begin{array}{l} \mathbf{g} ) \quad 23 \frac{lbm. ft}{min^2} \rightarrow \frac{kg. cm}{s^2} \\ \mathbf{h} ) \quad 0.981 \frac{Btu}{lbm. c} \rightarrow \frac{J}{g. c} \\ \mathbf{i} ) \quad 8.314 \frac{J}{mol. K} \rightarrow \frac{cm^3. bar}{mol. K} \\ \mathbf{j} ) \quad 0.052 \frac{kg}{m. s} \rightarrow \frac{lbm}{ft. h} \end{array}$$



a) 
$$554 \frac{m^4}{day.kg} \cdot \frac{10^8 cm^4}{1m^4} \cdot \frac{1 \, day}{1440 \, min} \cdot \frac{1 \, kg}{1000 \, g} = 38472.2 \frac{cm^4}{min. g}$$
  
b)  $5.37 \times 10^3 \frac{kJ}{min} \cdot \frac{0.02235 \, hP}{1 \left(\frac{kJ}{min}\right)} = 120 \, hP$   
c)  $760 \frac{miles}{h} \cdot \frac{1609 \, m}{1 \, mile} \cdot \frac{1 \, h}{3600 \, s} = 340 \frac{m}{s}$   
d)  $921 \frac{kg}{m^3} \cdot \frac{2.2046 \, lbm}{1 \, kg} \cdot \frac{1 \, m^3}{35.315 \, ft^3} = 57.5 \, \frac{lbm}{ft^3}$ 

e) 
$$800 \ mmHg. \frac{0.0193 \ psia}{1 \ mmHg} = 15.44 \ psia$$
  
 $800 \ mmHg. \frac{0.1333 \ kPa}{1 \ mmHg} = 106.64 \ kPa$   
 $800 \ mmHg. \frac{1 \ atm}{760 \ mmHg} = 1.05 \ atm$   
f)  $-25 \ {}^{\circ}F = (-25 \ {}^{\circ}F + 459.67). \frac{5}{9} = 241.48 \ K$ 

$$\begin{array}{l} \textbf{g} ) \quad 23 \frac{lbm.\,ft}{min^2} \cdot \frac{1 \, kg}{2.2046 \, lbm} \cdot \frac{30.48 \, cm}{1 \, ft} \cdot \frac{1 \, min^2}{60^2 \, s} = 0.088 \, \frac{kg.\,cm}{s^2} \\ \textbf{h} ) \quad 0.981 \frac{Btu}{lbm.\,^{\circ}\text{C}} \cdot \frac{1055.06 \, J}{1 \, Btu} \cdot \frac{2.2046 \, lbm}{1000 \, g} = 2.28 \, \frac{J}{g.\,^{\circ}\text{C}} \\ \textbf{i} ) \quad 8.314 \frac{J}{mol.\,K} \cdot \frac{10 \, cm^3.\, bar}{1 \, J} = \frac{83.14 \, cm^3.\, bar}{mol.\,K} \\ \textbf{j} ) \quad 0.052 \frac{kg}{m.\,s} \cdot \frac{2.2046 \, lbm}{1 \, kg} \cdot \frac{1 \, m}{3.28 \, ft} \cdot \frac{3600 \, s}{1 \, h} = 125.8 \, \frac{lbm}{ft.\,h} \end{array}$$

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

## Fill in the table given below

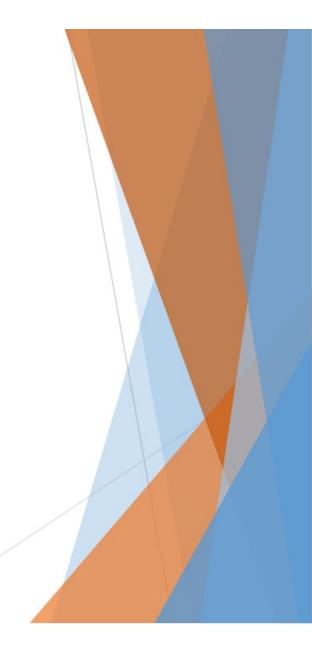
 $^{\circ}F = 32 + 1.8 ^{\circ}C$ 

K = °C + 273.15

 $^{\circ}R = ^{\circ}F + 459.67 = 491.67 + 1.8^{\circ}C$ 

-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:

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

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

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

Molar flow rate;

$$\dot{n} = 10.5 \frac{L \text{ solution}}{\min} \cdot 0.602 \frac{kg \, drug}{L \text{ solution}} \cdot \frac{1 \, kmol \, drug}{192 \, kg \, drug} = 0.033 \frac{kmol \, ilac}{min}$$