FACULTY OF ENGINEERING
DEPARTMENT OF CHEMICAL ENGINEERING

INTRODUCTION TO CHEMICAL ENGINEERING
CEN 101

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SAMPLE PROBLEMS WITH SOLUTIONS

A waste treatment pond is **50 m** long and **15 m** wide, and has an average depth of **2 m**. The density of the waste is **85.3 lbm/ft^3**. Calculate the ***weight of the pond contents*** in ***lbf***.

Volume of the waste treatment pond

V = 50 m x 15 m x 2 m = 1500 m^3

$$1500\ m^3 . \frac{35.288\ ft^3}{1\ m^3} = 52932\ ft^3$$

Weight of the waste water

W = 85.3 lbm/ft^3 x 52932 ft^3 = 4515100 **lbm**

4.515x10^6 lbm x 32.174 ft/s^2 = **116566 lbf**

The specific gravity of gasoline is approximately **0.70**

a) Determine the mass (kg) of **50 liters** of gasoline.
b) The mass flow rate of gasoline exiting a refinery tank is **1150 kg/min**. Estimate the ***volumetric flow rate*** in **m^3/min.**

Reference density of water is assumed to be 1000 kg/m^3

Density of the gasoline;

$$SG_{gasoline} = 0.7 = \frac{\rho_{gasoline}}{\rho_{ref(water)}}$$

$$\Rightarrow \rho_{gasoline} = 1000\ \frac{kg}{m^3}.0.7 = 700\ \frac{kg}{m^3}$$

Mass of the 50 L gasoline;

$$700\ \frac{kg}{m^3}.50L.\frac{1\ m^3}{1000\ L} = 35\ kg$$

Volumetric flow rate, q (m^3/min)

$$q = \frac{1150\ \frac{kg}{min}}{700\ \frac{kg}{m^3}} = \mathbf{1.64}\ \frac{\mathbf{m^3}}{\mathbf{min}}$$

A pressure gauge on a welder's tank gives a reading of **22.4 psig.** The barometric pressure is **28.6 in Hg.** Calculate the ***absolute pressure in the tank*** in;

a) **lbf/ft^2**.
b) **N/m^2**.

Absolute pressure in the tank is the sum of the gauge and atmospheric (barometric) pressures, and they should be in the same units.

Barometric pressure is 28.6 in Hg.

$$P_{atm} = 28.6\, in.Hg.\frac{1\, psi}{2.036\, in.Hg} = 14.05\, psi$$

Absolute pressure in the tank :

$$P_{absolute} = 14.05\, psi + 22.4\, psig = 36.45\, psia$$

$$P_{absolute} = 36.45\, psi.\frac{144\,\frac{lbf}{ft^2}}{1\, psi} = \mathbf{5249}\ \frac{\boldsymbol{lbf}}{\boldsymbol{ft^2}}$$

$$P_{absolute} = 36.45\, psi.\frac{6894.75\,\frac{N}{m^2}}{1\, psi} = \mathbf{251314}\ \frac{\boldsymbol{N}}{\boldsymbol{m^2}}$$

The enthalpy values of the vapour phase of the saturated water vapour at different temperature are given in the table.

Calculate the enthalpy of the saturated vapour at 90 ℃.

Table. Temperature-enthalpy values for saturated vapour

T, ℃	65	80	95	105
H, kJ/kg	2618.3	2643.7	2668.1	2683.8

Enthalpy of water at 90 ℃ **cannot** be read from the table directly. The desired enthalpy value is in the range of 2643.7 - 2668.1 kJ/kg, which corresponds to a temperature range of 80 to 95 ℃.

It is assumed that the temperature changes **linearly** with the enthalpy in the 80 - 95 ℃ temperature range and the value sought is calculated by interpolation.

$$x_1 = 80\ \text{°C} \quad \Longrightarrow \quad y_1 = 2643.7\ kJ/kg$$
$$x_2 = 95\ \text{°C} \quad \Longrightarrow \quad y_2 = 2668.1\ kJ/kg$$
$$x = 90\ \text{°C} \quad \Longrightarrow \quad y = ?$$

$$H = 2643.7 + \frac{90 - 80\ (\text{°C})}{95 - 80\ (\text{°C})}(2668.1 - 2643.7)(kJ/kg) = \mathbf{2660\ kJ/kg}$$