1-1. Represent each of the following quantities with combinations of units in the correct SI form, using an appropriate prefix: (a) GN • mm, (b) kg / mm, (c) N / ks^2, (d) kN / ms.

SOLUTION

a) GN • mm = (10^9)N(10^{-6})m = 10^3 N • m = kN • m **Ans.**

b) kg / mm = (10^3)g / (10^{-6})m = 10^9 g / m = Gg / m **Ans.**

c) N / ks^2 = N / $(10^3\ s)^2$ = 10^{-6} N / s^2 = mN / s^2 **Ans.**

d) kN / ms = (10^3)N / (10^{-6})s = 10^9 N/s = GN / s **Ans.**

Ans:
a) kN • m
b) Gg / m
c) pN / s^2
d) GN / s

1–2. Evaluate each of the following to three significant figures, and express each answer in SI units using an appropriate prefix: (a) $(425\text{ mN})^2$, (b) $(67\,300\text{ ms})^2$, (c) $\left[723(10^6)\right]^{1/2}$ mm.

SOLUTION

a) $(425\text{ mN})^2 = \left[425(10^{-3})\text{ N}\right]^2 = 0.181\text{ N}^2$ **Ans.**

b) $(67\,300\text{ ms})^2 = \left[67.3(10^3)(10^{-3})\text{ s}\right]^2 = 4.53(10^3)\text{ s}^2$ **Ans.**

c) $\left[723(10^6)\right]^{1/2}\text{ mm} = \left[723(10^6)\right]^{1/2}(10^{-3})\text{ m} = 26.9\text{ m}$ **Ans.**

Ans:
a) 0.181 N^2
b) $4.53(10^3)\text{ s}^2$
c) 26.9 m

1–3. Evaluate each of the following to three significant figures, and express each answer in SI units using an appropriate prefix: (a) 749 μm/63 ms, (b) (34 mm)(0.0763 Ms)/263 mg, (c) (4.78 mm)(263 Mg).

SOLUTION

a) $749\ \mu\text{m}/63\ \text{ms} = 749(10^{-6})\ \text{m}/63(10^{-3})\ \text{s} = 11.88(10^{-3})\ \text{m/s}$
$= 11.9\ \text{mm/s}$ **Ans.**

b) $(34\ \text{mm})(0.0763\ \text{Ms})/263\ \text{mg} = \left[34(10^{-3})\ \text{m}\right]\left[0.0763(10^{6})\ \text{s}\right]/\left[263(10^{-6})(10^{3})\ \text{g}\right]$
$= 9.86(10^{6})\ \text{m}\cdot\text{s/kg} = 9.86\ \text{Mm}\cdot\text{s/kg}$ **Ans.**

c) $(4.78\ \text{mm})(263\ \text{Mg}) = \left[4.78(10^{-3})\ \text{m}\right]\left[263(10^{6})\ \text{g}\right]$
$= 1.257(10^{6})\ \text{g}\cdot\text{m} = 1.26\ \text{Mg}\cdot\text{m}$ **Ans.**

Ans:
a) 11.9 mm/**s**
b) 9.86 Mm · s/kg
c) 1.26 Mg · m

***1–4.** Convert the following temperatures: (a) 20°C to degrees Fahrenheit, (b) 500 K to degrees Celsius, (c) 125°F to degrees Rankine, (d) 215°F to degrees Celsius.

SOLUTION

a) $T_C = \frac{5}{9}(T_F - 32)$

$20°\text{C} = \frac{5}{9}(T_F - 32)$

$T_F = 68.0°\text{F}$ **Ans.**

b) $T_K = T_C + 273$

$500\text{ K} = T_C + 273$

$T_C = 227°\text{C}$ **Ans.**

c) $T_R = T_F + 460$

$T_R = 125°\text{F} + 460 = 585°\text{R}$ **Ans.**

d) $T_C = \frac{5}{9}(T_F - 32)$

$T_C = \frac{5}{9}(215°\text{F} - 32) = 102°\text{C}$ **Ans.**

1–5. Mercury has a specific weight of 133 kN/m^3 when the temperature is 20°C. Determine its density and specific gravity at this temperature.

SOLUTION

$\gamma = \rho g$

$133(10^3)\ \text{N/m}^3 = \rho_{\text{Hg}}(9.81\ \text{m/s}^2)$

$\rho_{\text{Hg}} = 13\,558\ \text{kg/m}^3 = 13.6\ \text{Mg/m}^3$ **Ans.**

$S_{\text{Hg}} = \dfrac{\rho_{\text{Hg}}}{\rho_w} = \dfrac{13\,558\ \text{kg/m}^3}{1000\ \text{kg/m}^3} = 13.6$ **Ans.**

Ans:
$\rho_{\text{Hg}} = 13.6\ \text{Mg/m}^3$
$S_{\text{Hg}} = 13.6$

1–6. The fuel for a jet engine has a density of 1.32 slug/ft^3. If the total volume of fuel tanks A is 50 ft^3, determine the weight of the fuel when the tanks are completely full.

SOLUTION

The specific weight of the fuel is

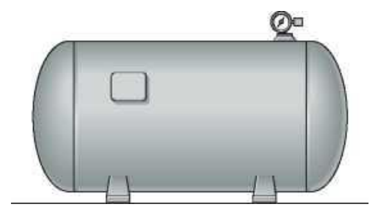
$$\gamma = \rho g = \left(1.32 \text{ slug/ft}^3\right)\left(32.2 \text{ ft/s}^2\right) = 42.504 \text{ lb/ft}^3$$

Then, the weight of the fuel is

$$W = \gamma \forall = \left(42.504 \text{ lb/ft}^3\right)\left(50 \text{ ft}^3\right) = 2.13\left(10^3\right) \text{ lb} = 2.13 \text{ kip}$$ **Ans.**

Ans:
$\gamma = 42.5 \text{ lb/ft}^3$
$W = 2.13 \text{ kip}$

1–7. If air within the tank is at an absolute pressure of 680 kPa and a temperature of 70°C, determine the weight of the air inside the tank. The tank has an interior volume of 1.35 m^3.



SOLUTION

From the table in Appendix A, the gas constant for air is $R = 286.9\ \text{J/kg}\cdot\text{K}$.

$$p = \rho R T$$

$$680(10^3)\ \text{N/m}^2 = \rho(286.9\ \text{J/kg}\cdot\text{K})(70^\circ + 273)\ \text{K}$$

$$\rho = 6.910\ \text{kg/m}^3$$

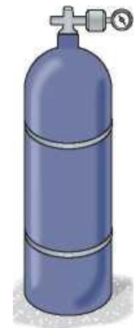
The weight of the air in the tank is

$$W = \rho g \forall = (6.910\ \text{kg/m}^3)(9.81\ \text{m/s}^2)(1.35\ \text{m}^3)$$

$$= 91.5\ \text{N}$$ **Ans.**

Ans:
91.5 N

***1–8.** The bottle tank has a volume of 1.12 m^3 and contains oxygen at an absolute pressure of 12 MPa and a temperature of 30°C. Determine the mass of oxygen in the tank.



SOLUTION

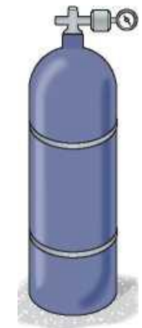
From the table in Appendix A, the gas constant for oxygen is $R = 259.8\ \mathrm{J/kg \cdot K}$.

$$p = \rho RT$$
$$12(10^6)\ \mathrm{N/m^2} = \rho(259.8\ \mathrm{J/kg \cdot K})(30° + 273)\ \mathrm{K}$$
$$\rho = 152.44\ \mathrm{kg/m^3}$$

The mass of oxygen in the tank is

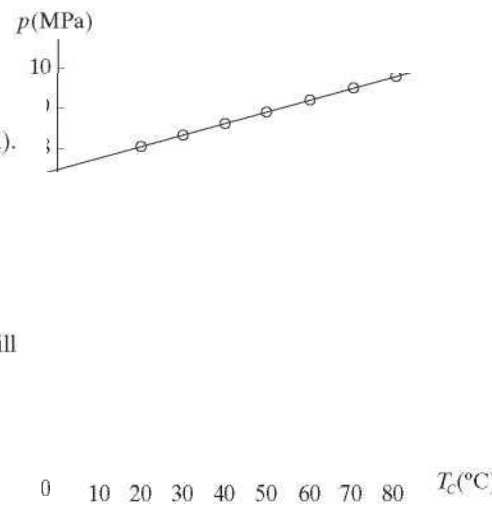
$$m = \rho V = (152.44\ \mathrm{kg/m^3})(0.12\ \mathrm{m^3})$$
$$= 18.3\ \mathrm{kg} \qquad \textbf{Ans.}$$

1–9. The bottle tank has a volume of $0.12\ m^3$ and contains oxygen at an absolute pressure of 8 MPa and temperature of 20°C. Plot the variation of the temperature in the tank (horizontal axis) versus the pressure for $20°C \leq T \leq 80°C$. Report values in increments of $\Delta T = 10°C$.



SOLUTION

T_C(°C)	20	30	40	50	60	70	80
p(MPa)	8.00	8.27	8.55	8.82	9.09	9.37	9.64



(a)

From the table in Appendix A, the gas constant for oxygen is $R = 259.8\ J/(kg \cdot K)$. For $T = (20°C + 273)\ K = 293\ K$,

$$p = \rho RT$$
$$8(10^6)\ N/m^2 = \rho[259.8\ J/(kg \cdot K)](293\ K)$$
$$\rho = 105.10\ kg/m^3$$

Since the mass and volume of the oxygen in the tank remain constant, its density will also be constant.

$$p = \rho RT$$
$$p = (105.10\ kg/m^3)[259.8\ J/(kg \cdot K)](T_C + 273)$$
$$p = (0.02730\ T_C + 7.4539)(10^6)\ Pa$$
$$p = (0.02730T_C + 7.4539)\ MPa \text{ where } T_C \text{ is in °C.}$$

The plot of p vs T_C is shown in Fig. *a*.

Ans:
$p = (0.0273\ T_c + 7.45)$ MPa, where T_c is in C°

1-10. Determine the specific weight of carbon dioxide when the temperature is 100°C and the absolute pressure is 400 kPa.

SOLUTION

From the table in Appendix A, the gas constant for carbon dioxide is R = 188.9 J / kg • K.

$p = p^R T$

$400(10^3)$ N/m^2 = p(188.9 J/kg • K)(100° + 273) K p =

5.677 kg / m^3

The specific weight of carbon dioxide is

g = pg = (5.677 kg / m^3)(9.81 m / s^2)
= 55.7 N/m^3 **Ans.**

Ans:
55.7 N / m^3