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.

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

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

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) $11.9\ \text{mm/s}$
b) $9.86\ \text{Mm}\cdot\text{s/kg}$
c) $1.26\ \text{Mg}\cdot\text{m}$

***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

$\gamma = \rho g$

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

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

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

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

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

SOLUTION

The specific weight of the fuel is

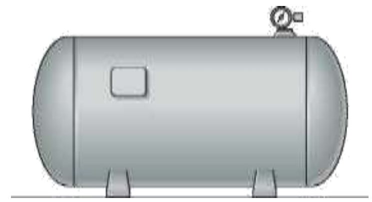
$$\gamma = \rho g = \left(1.32\ \text{slug/ft}^3\right)\left(32.2\ \text{ft/s}^2\right) = 42.504\ \text{lb/ft}^3$$

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 $R = 286.9\ \mathrm{J/kg \cdot K}$.

$$p = \rho RT$$

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

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

The weight of the air in the tank is

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

$$= 91.5\ \mathrm{N} \qquad \textbf{Ans.}$$

Ans:
91.5 N

***1–8.** The bottle tank has a volume of $1.12\ \text{m}^3$ 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 $R = 259.8\ \text{J/kg}\cdot\text{K}$.

$$p = \rho RT$$

$$12\left(10^6\right)\ \text{N/m}^2 = \rho(259.8\ \text{J/kg}\cdot\text{K})(30° + 273)\ \text{K}$$

$$\rho = 152.44\ \text{kg/m}^3$$

The mass of oxygen in the tank is

$$m = \rho V\!\!\!\!/ = \left(152.44\ \text{kg/m}^3\right)\left(0.12\ \text{m}^3\right)$$

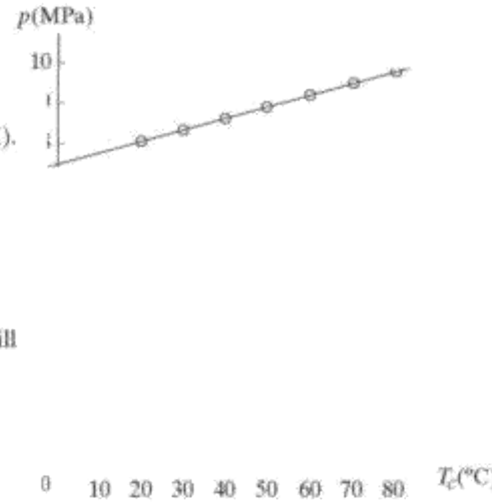
$$= 18.3\ \text{kg} \qquad \textbf{Ans.}$$

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 ... $\le 80°C$. Report ... $\Delta T = 10°C$.

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

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 $T = (20°C + 273)\ K = 293\ K$,

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

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

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

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

SOLUTION

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

$$p = \rho R T$$
$$400(10^3)\ N/m^2 = \rho(188.9\ J/kg \cdot K)(100° + 273)\ K \quad \rho = 5.677\ kg/m^3$$

The specific weight of carbon dioxide is

$$\gamma = \rho g = (5.677\ kg/m^3)(9.81\ m/s^2)$$
$$= 55.7\ N/m^3$$ **Ans.**

Ans:
55.7 N / m^3

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