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Phys 221 (Section 6)
Quiz #6

1. A trumpet player in an open automobile plays a note of frequency 392 Hz on his horn. A stationary observer directly ahead of the auto hears a note of frequency 440 Hz. What is the speed of the automobile?

If frequency f is emitted by a source moving toward a stationary observer then the latter hears a frequency

$$f' = \left(\frac{v}{v - v_s}\right) f$$ where v_s is the speed of the source, v is the speed of sound.

solving for v_s,

$$\left(\frac{v}{v - v_s}\right) = \frac{f'}{f} = \frac{440}{392} = 1.12$$

$$v = 1.12\,(v - v_s)$$

$$1.12\, v_s = 0.122\, v$$

$$\rightarrow v_s = 0.109\, v = 0.109\left(343 \tfrac{m}{s}\right) = \boxed{37.4 \tfrac{m}{s}}$$

2. What mass of He (Helium) gas is contained in a volume of 0.3 m^3 at a pressure of 2.0 atm and a temperature of 20.0°C? (Take He to be an ideal gas.)

$P = 2.0$ atm, $V = 0.3\ m^3 = 0.3 \times 10^3\ L$ $T = (20 + 273.15)\,K = 293\ K$

From the ideal gas law, the number of moles of He contained is

$$n = \frac{PV}{RT} = \frac{(2.0\ atm)(0.3 \times 10^3\ L)}{\left(0.0821 \frac{L \cdot atm}{mol \cdot K}\right)(293\ K)} = 24.9\ moles$$

The mass of the amount of helium is

$$m = nM = (24.9\ mole)\left(\frac{4.0\ g}{mol}\right) = \boxed{99.8\ g} = 0.0998\ kg$$

3. How much heat is required to convert 3.0 g of ice at 0.0°C to water at 25.0°C?

Heat required to change Ice, 0°C → Water, 0°C

$$Q_1 = mL_{fus} = (3.0 \times 10^{-3}\ kg)\left(3.33 \times 10^5 \frac{J}{kg}\right) = 999\ J$$

Heat required to change Water, 0°C → Water, 25°C

$$Q_2 = mc\Delta T = \left(3.0 \times 10^{-3}\ kg\right)\left(4186 \frac{J}{kg\,C^\circ}\right)(25\ C^\circ) = 314\ J$$

Total is

$$Q = Q_1 + Q_2 = \boxed{1313\ J}$$

Speed of sound = $343 \frac{m}{s}$ $R = 0.0821 \frac{L \cdot atm}{mol \cdot K}$ $N_A = 6.022 \times 10^{23}\ mol^{-1}$

Helium: $M = 4.0 \frac{g}{mol}$ Ice: $c = 2090 \frac{J}{kg \cdot C^\circ}$ Water: $c = 4186 \frac{J}{kg \cdot C^\circ}$

Water (H_2O): $L_{fus} = 3.33 \times 10^5 \frac{J}{kg}$ $L_{vap} = 2.26 \times 10^6 \frac{J}{kg}$ $T_C = T - 273.15$

$1.0\ L = 10^3\ cm^3$