AP® Physics B
2002 Sample Student Responses
Form B

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6. (10 points)

A sealed steel canister is being used to store neon gas (atomic mass = 20.2 u). The mass of the steel canister alone is 12.0 kg, and it has an interior volume of 8.00 liters = $8.00 \times 10^{-3}\ m^3$. There are 4.50 moles of neon gas in the canister, and the temperature of the entire system is 300 K.

Reference information:

Specific heat of steel = $448\ J\ kg^{-1}K^{-1}$

Specific heat of neon = $12.5\ J\ mole^{-1}K^{-1}$

Specific heat of water = $4186\ J\ kg^{-1}K^{-1}$

Heat of fusion of water = $3.33 \times 10^5\ J\ kg^{-1}$

Density of water = $1.00 \times 10^3\ kg\ m^{-3}$

Density of ice = $0.917 \times 10^3\ kg\ m^{-3}$

(a) Determine the pressure within the cylinder.

$PV = nRT \rightarrow P = \frac{nRT}{V} = \frac{(4.5)(8.31)(300)}{8.00 \times 10^{-3}}$

$= 1.40 \times 10^6\ Pa$

The sealed cylinder is now placed in a large tank containing a mixture of ice and water at 273 K. You may neglect any change in the volume of the cylinder.

(b) Determine the pressure of the neon gas after the cylinder and its contents have reached thermal equilibrium with the ice-water mixture.

$PV = nRT$ → constant $\rightarrow \frac{P_1}{T_1} = \frac{P_2}{T_2}$

$\rightarrow \frac{1.40 \times 10^6}{300} = \frac{P_2}{273} \rightarrow P_2 = 1.27 \times 10^6\ Pa$

GO ON TO THE NEXT PAGE.

(c) Determine the mass of the ice that melts during the equilibration of the cylinder.

Energy lost by the cylinder = Energy gained by ice water

$\Rightarrow Q = mc\Delta T \qquad Q = mL_f$

$\rightarrow m_w L_f = m_s C_s \Delta T_s + m_N C_N \Delta T_N$

$\rightarrow m_w (3.33 \times 10^5) = (12.0)(448)(300-273) + (4.50)(12.5)(300-273)$

$\rightarrow m_w (3.33 \times 10^5) = 1.466775 \times 10^5$

$\rightarrow m_w = 0.44 kg$

GO ON TO THE NEXT PAGE.

6. (10 points)

A sealed steel canister is being used to store neon gas (atomic mass = 20.2 u). The mass of the steel canister alone is 12.0 kg, and it has an interior volume of 8.00 liters = $8.00 \times 10^{-3}\ m^3$. There are 4.50 moles of neon gas in the canister, and the temperature of the entire system is 300 K.

Reference information:

Specific heat of steel = $448\ J\ kg^{-1}\ K^{-1}$

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Heat of fusion of water = $3.33 \times 10^5\ J\ kg^{-1}$

Density of water = $1.00 \times 10^3\ kg\ m^{-3}$

Density of ice = $0.917 \times 10^3\ kg\ m^{-3}$

(a) Determine the pressure within the cylinder.

$PV = nRT$

$8P = (4.5)(300)(.0821)$

$P = 13.85\ atm$

$PV = nRT$

$8 \times 10^{-3}\ P = 4.5\left(8.31\ \frac{J}{mol \cdot K}\right)$

The sealed cylinder is now placed in a large tank containing a mixture of ice and water at 273 K. You may neglect any change in the volume of the cylinder.

(b) Determine the pressure of the neon gas after the cylinder and its contents have reached thermal equilibrium with the ice-water mixture.

Before E

$T = 300\ K$

$V = 8\ L$

$P =$

$n = 4.5$

Eqwil

$T = 273$

$V = 8\ L$

$P =$

$n = 4.5$

Since thermal equilibrium is reached, the cylinder has a temperature of 273 K as well.

$PV = nRT$

$8\ L(P) = (4.5)\left(.0821\ \frac{L \cdot atm}{mol\ K}\right)(273)$

$P = 12.607\ atm$

GO ON TO THE NEXT PAGE.

(c) Determine the mass of the ice that melts during the equilibration of the cylinder.

$$M_{cyl}\Delta T \frac{448\ J}{kg\ K} + M_{mean}\Delta T \frac{12.5\ J}{kg\ K} = M_{ice} \cdot \frac{3.33\times10^5\ J}{kg}$$

$$12\ kg\,(+23)(448) + (4.5)(20.2)(12.5)(+23) = M_{ice}\ \frac{3.33\times10^5\ J}{kg}$$

$$123648\ J + 26133\ J = \frac{3.33\times10^5\ J}{kg} M_{ice}$$

$$\frac{149781\ J}{3.33\times10^5\ \frac{J}{kg}} = \boxed{.450\ kg\ ice\ were\ melted}$$

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