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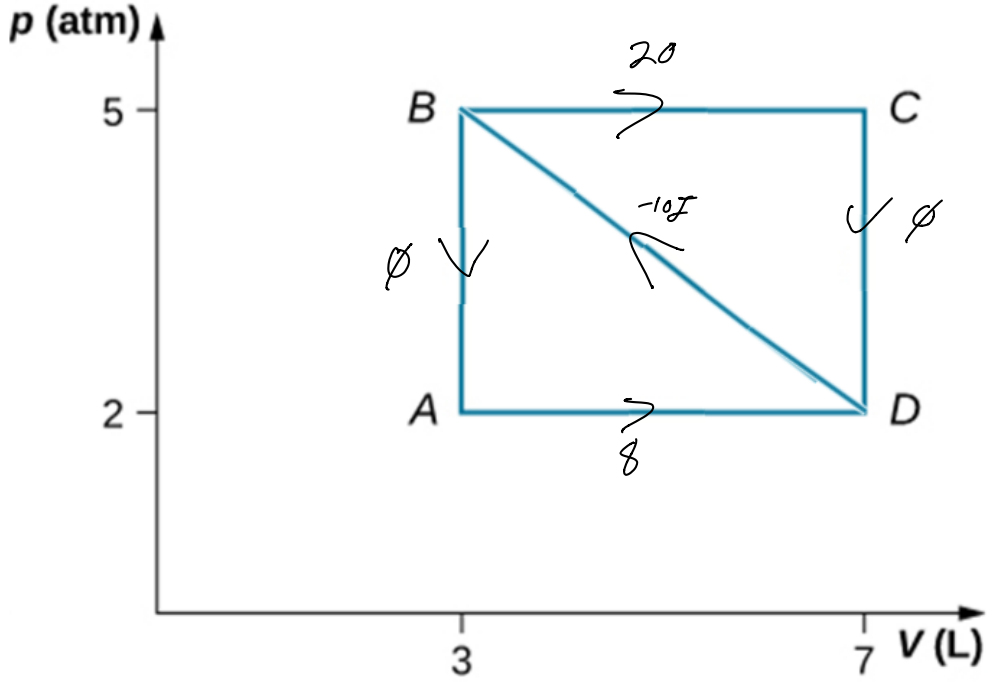
Thermal Physics – Take Home Portion

Instructions: For the following problem, show all work including all equations used, numbers entered into the equations, and then circle your final answer complete with units. **You are expected to do your own work!**

1. For the PV Diagram below, determine the work done in Joules along the following paths: (a) D-B-A-D (b) D-B-C-D (c) D-C-B-A-D.



$W = P\Delta V$

$W = 5(7-3)$

$W = 20J$

a) $D-B = \frac{1}{2}(7-7)(5-2)$

$\frac{1}{2}(-4)(5)$

$D-B = -10\ J$

$+ 8\ J$

$+ \emptyset\ J$

$D-B-A-D = -2J$

b) $D-B = -10J$

$B-C = 20J$

$C-D = \emptyset J$

$D-B-C-D = 10J$

c) $D-C = \emptyset J$

$C-B = -20J$

$B-A = \emptyset J$

$A-D = 8J$

$D-C-B-A-D = -12J$

2. When the barista makes a customer's coffee, she adds 650 g of coffee at 195 °F to a 350 g ceramic coffee cup with a specific heat capacity of 850 J/Kg °C. The cup is initially at 70 °F. Assume the specific heat of coffee is the same as water. The customer has requested that the coffee be cooled to 155 °F. How much ice at 25 °F must be added to the coffee to meet the customer's request?

F	C
195°	90.6°
70°	21.1°
155°	68.3°
25°	-3.89°

$Q = \emptyset$

$Q = Q_{coffee} + Q_{cup} + Q_{ice\ -3.89° \to 0°} + Q_{ice\ L_f} + Q_{ice\ water\ 0° \to 68.3}$

$[m_{cof} c_{cof} \Delta T_{cof}] + [m_{cup} c_{cup} \Delta T_{cup}] + [m_i c_i (-3.89°)] + [m_i L_{f\ ice}] + [m_i c_{water} (68.3)]$

$[0.65\,kg\,(4186\,J/kg°C)(68.3° - 90.6°)] + [0.35\,kg\,(850\,J/kg°C)(68.3° - 21.1°)] + [m_i\,(2090\,J/kg°C)(-3.89°)] + [m_i\,(3.33 \times 10^5\,J/kg)] + [m_i\,(4186\,J/kg°C)(68.3)]$

$-60,676 \qquad +14,042 \qquad -8,130\,m_i \qquad +333,000\,m_i \qquad +285,903\,m_i$

$-46634 + 610,772\,m_i = \emptyset$

$610,772\,m_i = 46634$

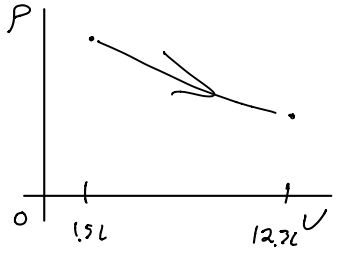
$m_i = 0.0763\,kg$

76.3 g of ice

3. A 2.5 mole sample of an ideal gas remains at 10 °C during an expansion from 1.50 L to 12.3 L. (a) How much work is done on the gas during the expansion? (b) How much energy transfer by heat occurs between the gas and its surroundings in this process?

$n = 2.5\ mol$

$T = 10°C = 283°K$



a)

$$W = \int_{V_1}^{V_2} P\,dV$$

$$= \int_{V_1}^{V_2} \frac{nRT}{V}\,dV$$

$$W = nRT \int_{V_1}^{V_2} \frac{1}{V}\,dV$$

$$W = nRT\left[\ln(V_f) - \ln(V_i)\right]$$

$$W = nRT \ln\left(\frac{V_f}{V_i}\right)$$

$$W = 2.5\ mol\,(8.314\ J/mol\cdot K)(283°K)\ln\left(\frac{12.7}{1.5}\right)$$

$$W = 12{,}376\ J$$

b) For isothermal

$$\Delta U = Q - W = 0$$

$$Q = -W$$

$$Q = -12{,}376\ J$$