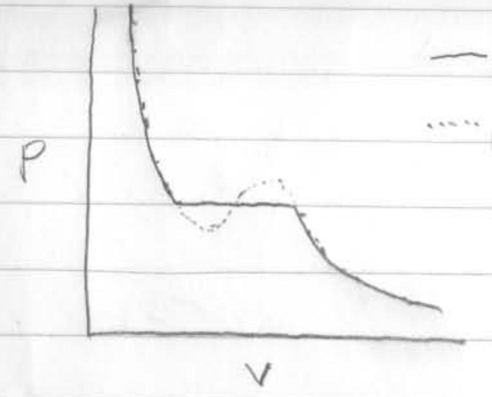
1. isolated: no interaction with surroundings

closed: energy interactions, but no matter exchange, with surroundings

open: Full interaction with surroundings

2. "Memory foam" found in mattresses: pushing one's hand into the foam and pulling it back out – on the way in the force is high, on the way out it's almost zero

3.



— p-V isotherm of real gas

····· p-V isotherm of vdW gas

4(i) $pV = NRT$ $\quad V = 43.8\,L \quad N = \frac{m}{M} \quad m = 16.0\,kg$

$T = 298.0\,K \qquad M = 32\,g/mol$

$$p = \frac{NRT}{V} = \frac{(16{,}000/32)\,mol \cdot 0.08314\,bar\,L/K\,mol \cdot 298.0\,K}{43.8\,L}$$

$$\boxed{= 282.8\ bar}$$

(ii) $\left(p + a\frac{N^2}{V^2}\right)(V - Nb) = NRT$ $\qquad a = 1.378\ \frac{L^2 atm}{mol^2}$

$b = 0.0318\ \frac{L}{mol}$

$$\left(p + \left[1.378 \cdot \frac{(500)^2}{(43.8)^2}\right] atm\right)\left(43.8\,L - [0.0318 \cdot 500]\,L\right) = 500 \cdot 0.0820$$

$$(p + 179.57\,atm)(27.9\,L) = 12226.94\ L \cdot atm$$

$$p = (438.24 - 179.57)\,atm = \boxed{258.67\ atm}$$

5. the constant "b" indicates how big a molecule is. Since CO_2 is bigger (in volume) than He, its "b" will be larger, i.e. $4.267 \times 10^{-2}\ L/mol$

6. [like problem 2.7]

We know $C_p - C_V = \left[p + \left(\frac{\partial U}{\partial V}\right)_T\right]\left(\frac{\partial V}{\partial T}\right)_p$

and $U = \frac{5}{2}NRT - a\frac{N^2}{V^2}$ + $\left(p + \frac{aN^2}{V^2}\right)(V - bN) = NRT$

so $\left(\frac{\partial U}{\partial V}\right)_T = \frac{2aN^2}{V^3}$ and $\left(\frac{\partial V}{\partial T}\right)_p$ is found by

differentiating: $\frac{2aN^2}{V^3}\left(\frac{\partial V}{\partial T}\right)_p[V - Nb] + \left[p + \frac{aN^2}{V^2}\right]\left(\frac{\partial V}{\partial T}\right)_p = NR$

Solving for $\left(\frac{\partial V}{\partial T}\right)_p = \dfrac{NR}{p + \underbrace{\frac{aN^2}{V^2} - \frac{2aN^2}{V^2}}_{= -\frac{aN^2}{V^2}} + \frac{2aN^3b}{V^3}}$

combine terms

substituting: $C_p - C_V = \left[p - \frac{2aN^2}{V^3}\right] \cdot \dfrac{NR}{\left[p - \frac{aN^2}{V^3}(V - 2Nb)\right]}$

(when comparing $C_p + C_V$ for the same sample, $N = 1$)

7. $C_{sound} = \sqrt{\frac{\gamma RT}{M}}$, $259\ m/s = \sqrt{\frac{1.304 \cdot 8.314 \frac{m^2 kg}{s^2 mol K} 27}{M}}$

$\frac{1}{M} = \frac{67081\ m^2/s^2}{2959.72\ m^2/s^2 \cdot \frac{kg}{mol}}$

$M = 44\ g/mol$ $\boxed{CO_2}$

8. $N_{O_2}: \nu_{O_2} = 1$, $N_{H_2}: \nu_{H_2} = 2$, $N_{H_2O}\ \nu_{H_2O} = 2$

9. Hess mixed sulfuric acid and ammonia, then diluted. later he diluted first then mixed acid and ammonia. The initial states were the same (acid, ammonia, water) and the final states were the same (acid + ammonia + water). Since the heat evolved from initial to final states was the same in both experiments, Hess concluded that the heat of reaction (now called enthalpy) is independent of path, i.e. H is a state function

10. $F = \frac{\text{impulse}}{\text{time}} \frac{\left[(mv+mv)\left(\Delta x A \frac{n}{2}\right)\right]}{[\Delta t]} = \frac{2}{2} m v \cdot \frac{\Delta x}{\Delta t} nA = m v_{x_{avg}}^2 n A$

$m V_{x_{avg}} + m V_{x_{avg}}$ because of the elastic collision

$\frac{n}{2}$ because half ($\frac{n}{2}$) the molecules collide

$\Delta x A \rightarrow$ this is the layer of molecules that could collide in time Δt $\quad V_{x_{avg}} = \Delta x / \Delta t$

11. Change in Volume (pressure) without heat flow from surroundings.

The pressure (volume) changes are too fast for substantial heat flow

12. $\Delta U = \Delta Q + \Delta W \quad \Delta W = \Delta K.E. = \frac{1}{2} m V_f^2 - \frac{1}{2} m V_i^2 = 10000 - 4000000$

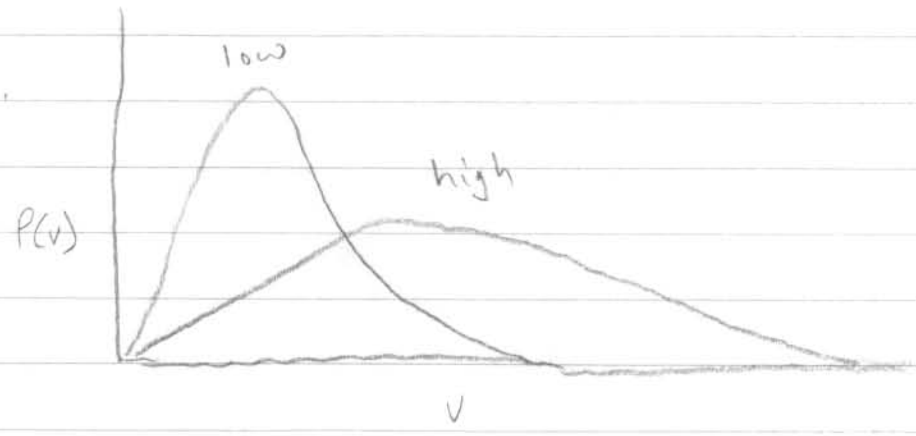
$\Delta U = 0 = \Delta Q + \Delta W \quad \Delta Q = -\Delta W = 3{,}990{,}000\ J$

13. $\langle v \rangle = \sqrt{\frac{8RT}{\pi M}} \qquad \frac{V_1}{V_2} = \sqrt{\frac{T_1}{T_2}}$

$V_1 = 425.3\ m/s \quad T_1 = 300K \quad T_2 = 600K$

$V_2 = V_1 \sqrt{\frac{T_2}{T_1}} = \boxed{601.5\ m/s}$

14.



15. $C_2H_5OH + 3O_2 \rightarrow 2 CO_2 + 3H_2O$

$\Delta H^\circ_{rxn} = \Delta H^\circ_f(\text{products} - \text{reactants}) = \overbrace{2 \cdot (-393.51)}^{-787.02} + 3(-285.83) - (-277.69)$

$\boxed{= -1366.82\ kJ/mol}$