Answer the questions in the spaces provided on the question sheets. If you run out of room for an answer, continue on the back of the page.

Name and section: _____

Instructors name: _____

1. A piston with 0.2 mol of Ar with an initial volume of 0.3 L is allowed to expand by 0.1 L against constant pressure of 30 kPa. How much expansion work is done? [3]

Solution:

$$dw = -PdV$$
$$= -0.1 \times 101.325$$
$$= 10.1$$

2. A piston with 0.2 mol of Ar with an initial volume of 0.3 L is allowed to expand by 0.1 L reversibly and isothermally. How much expansion work is done? [3]

Solution:

$$w = -nRT\ln\left(\frac{V_f}{V_i}\right)$$
$$= -0.2 \times 8.314 \times 298 \times \ln\left(\frac{0.3}{0.4}\right)$$
$$= -142$$

3. Define heat and work [2]

Solution: Heat is the random movement of molecules caused by a change in T

Work is the controlled or directed movement, as useful energy

4. Define the systems, open, closed and isolated [3]

Solution: Open, free to exchange mass and energy

Closed exchanges energy but not mass

Isolated exchanges neither energy or matter

5. When do thermodynamic properties have negative signs? [1]

Solution: When leaving the system

6. How much energy is required to heat 50 g of water by 10 °C, ($C_{p,m}$75 J K^{-1} mol^{-1})? [3]

Solution:

$$q = C\Delta T$$
$$\frac{50}{18} = 2.77$$
$$2.77 \times 10 = 27.7\,\text{J}$$

7. How does enthalpy differ from internal energy? [1]

Solution: Enthalpy includes the work leaked back to the environment

8. Why do we often use enthalpy and not internal energy? [1]

Solution: It is easier to measure

9. At constant pressure what does enthalpy become? [1]

Solution: At constant pressure enthalpy becomes

$$\Delta H = q$$

10. A Sample of nitrogen gas of volume 20.0 L at 5.00 kPa is heated from 20 °C to 400 °C at a const volume. What is the change in entropy of the nitrogen? [3]
$Cv = 20.81\,\text{J K}^{-1}\,\text{mol}^{-1}$, $R = 8.314\,\text{J K}^{-1}\,\text{mol}^{-1}$ and ideal behaviour is assumed

Solution:

$$T_1 = 293$$
$$T_2 = 673$$
$$PV = nRT$$
$$n = \frac{PV}{RT} = 0.0409$$
$$\Delta S = nC_v \ln\left(\frac{T_2}{T_1}\right) = 0.71\,\text{J K}^{-1}$$

11. What is the entropy change when 2 mol of an ideal gas is allowed to expand isothermally from 1.5 L to 2.4 L [2]

Solution:

$$V_1 = 1.5$$

$$V_2 = 2.4$$

$$n = 2$$

$$\Delta S = nR\ln\left(\frac{V_2}{V_1}\right) = 7.8\,\mathrm{J\,K^{-1}}$$

12. 1 mol of Ar (g) is compressed suddenly (and irreversibly) from 5.00 L to 1.00 L by driving a piston (bicycle pump), in the process temp increases from 20.0 °C to 25.2 °C. What is the change in Entropy of the gas? $R = 8.314\,\mathrm{J\,K^{-1}\,mol^{-1}}$, $C_V = 12.47\,\mathrm{J\,K^{-1}\,mol^{-1}}$ [4]

Solution:

$$V_1 = 5$$

$$V_2 = 1$$

$$n = 1$$

$$\Delta S = nR\ln\left(\frac{V_2}{V_1}\right) = -13.4\,\mathrm{J\,K^{-1}}$$

$$T_1 = 2932$$

$$T_2 = 298.2$$

$$n = 1$$

$$\Delta S = nC_v\ln\left(\frac{T_2}{T_1}\right) = 0.22\,\mathrm{J\,K^{-1}}$$

$$\Delta S = -13.4 + 0.22 = -13.2$$