Homework 2 – The First Law

Name: _____

Exercise 2A.4(a) (5 points)

A sample consisting of 1.00 *mol* Ar is expanded isothermally at 20 $^{\circ}C$ from 10.0 dm^3 to 30.0 dm^3 (i) reversibly, (ii) against a constant external pressure equal to the final pressure of the gas, and (iii) freely (against zero external pressure). For the three processes calculate q, w, and ΔU.

Exercise 2A.5(a) (5 points)

A sample consisting of 1.00 *mol* of perfect gas atoms, for with $C_{V,m} = \frac{3}{2}R$, initially at $p_1 = 1.00\ atm$ and $T_1 = 300\ K$, is heated reversibly to 400.0 K at constant volume. Calculate the final pressure, ΔU, q, and w.

Exercise 2B.3(a) (5 points)

When 3.0 *mol* O_2 is heated at a constant pressure of 3.25 *atm*, its temperature increases from 260 K to 285 K. Given that the molar heat capacity of O_2 at constant pressure is $29.4 \frac{J}{mol\ K}$, calculate q, ΔH, and ΔU.

Exercise 2C.3(b) (10 points)

From the following data, determine $\Delta_f H^{\ominus}$ for diborane, $B_2H_6(g)$, at 298 K:

(1) $B_2H_6(g) + 3\,O_2(g) \longrightarrow B_2O_3(s) + 3\,H_2O(g)$ $\quad \Delta_{rxn}H^{\ominus} = -1941^{kJ}/_{mol}$

(2) $2\,B(s) + \frac{3}{2}\,O_2(g) \longrightarrow B_2O_3(s)$ $\quad \Delta_{rxn}H^{\ominus} = -2368^{kJ}/_{mol}$

(3) $H_2(g) + \frac{1}{2}\,O_2(g) \longrightarrow H_2O(g)$ $\quad \Delta_{rxn}H^{\ominus} = -241.8^{kJ}/_{mol}$

Exercise 2D.1(a) (10 points)

Estimate the internal pressure, π_T, of water vapor at 1.00 *bar* and 400.0 K, treating it as a van der Waals gas, where $\pi_T = \frac{a}{V_m^2}$. *Hint*: Simplify the approach by estimating the molar volume by treating the gas as perfect.

Exercise 2D.4(a) (5 points)

The isothermal compressibility of water at 293 K is $2.21 \times 10^{-6} atm^{-1}$. Calculate the pressure that must be applied in order to increase its density by 0.10 %.

Discussion Question 2E.1 (5 points)

Why are adiabats steeper than isotherms?

Exercise 2E.3(a) (5 points)

A sample consisting of 1.0 mol of perfect gas molecules with $C_V = 20.8 \frac{J}{K}$ is initially at 4.25 atm and 300.0 K. It undergoes reversible adiabatic expansion until its pressure reaches 2.50 atm. Calculate the final volume and temperature and the work done.

Holy Sonnets: Death, be not proud

By John Donne

Death, be not proud, though some have called thee
Mighty and dreadful, for thou art not so;
For those whom thou think'st thou dost overthrow
Die not, poor Death, nor yet canst thou kill me.
From rest and sleep, which but thy pictures be,
Much pleasure; then from thee much more must flow,
And soonest our best men with thee do go,
Rest of their bones, and soul's delivery.
Thou art slave to fate, chance, kings, and desperate men,
And dost with poison, war, and sickness dwell,
And poppy or charms can make us sleep as well
And better than thy stroke; why swell'st thou then?
One short sleep past, we wake eternally
And death shall be no more; Death, thou shalt die.